ENGINEERING DYNAMICS COMPANY

GATB

HVE Human Vehicle Environment

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

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GATB — Graphical Articulated Total Body

Version 5.56

Updated Markdown edition, converted from the Fifth Edition manual (December 2013; manual printed December 30, 2013) and revised to match the behavior of the current HVE release.

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How to Use This Manual

This manual is the user's manual for the GATB simulation model. The manual describes the model features and use. Input parameters and output reports are described at a high level. This manual is intended to be used in conjunction with the HVE Operations Manual. The HVE Operations Manual provides in-depth coverage of the human, vehicle and environment models, as well as the HVE Event Editor and Playback Editor. For specific model definitions, the user is referred to the HVE Operations Manual (see also the updated pages under Humans dialog reference).

If You Have Questions

Engineering Dynamics Company, LLC provides technical assistance for supported users. The questions may relate to general usage or to specific engineering applications. When you call, you should have the following information available:

- Your user ID number
- HVE Version Information (available from the HVE Help System)
- GATB Version Information

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- 1 — Program Description
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(The original Chapter 8, Index, is omitted from this edition — Markdown files are text-searchable.)

Chapter 1 — Program Description

Overview

GATB (**G**raphical **A**rticulated **T**otal **B**ody) is a computer model based on the computer program ATB (Articulated Total Body). GATB is a graphical version of the computer program ATB. The ATB model was originally developed to model the dynamic response of crash test dummies and, with later modifications, the dynamic response of a human in a crash [1]. The ATB model is very generic in nature and can be used to model any system of rigid bodies connected by a variety of different joints. The GATB implementation of this model is used to model human response to a crash environment. The generic nature of the ATB model should not intimidate the user. All of the standard data inputs are automatically generated by the GATB implementation. This allows the user to concentrate on analyzing the problem and not being concerned with which option to use or exactly how to set up the human, contact panels, etc.

GATB computes a number of values: human kinematics (position, velocity, and acceleration vs time), joint angles and torques, contact forces between the human and contact panels attached to the vehicle, contact forces between humans or between a single human's limbs.

The GATB model may be used to study occupants or pedestrians involved in motor vehicle collisions. There may be up to four human occupants studied in the same GATB run, either restrained or unrestrained. The restraint model is based upon the harness routines in the ATB-V.1 program.

The GATB and ATB programs are based on the original work done by Calspan Corporation in 1975 when the Crash Victim Simulator (CVS) was developed [2, 3]. In 1980, Calspan modified the earlier versions of ATB and CVS, combined them, and formed version 20 of CVS and version II of ATB. These versions were thoroughly documented in a four volume set of manuals [4]. Since that time, further development of the ATB model has been conducted at Wright-Patterson Air Force Base [1]. This version of GATB is based upon ATB-V.1 released in June, 1998 [5].

The GATB program uses the human model in HVE. This human model consists of 15 segments and 14 joints as shown in Table 1-1. The position and orientation of the Pelvis segment along with orientations of the other 14 segments produces a model with 48 degrees-of-freedom for each human. The vehicle motion is defined and therefore not a degree-of-freedom in the model.

Segment Name	Joint Name	Segment Connections
Pelvis	L5-S1	Pelvis to Abdomen
Abdomen	T12-L1	Abdomen to Chest
Chest	C7-T1	Chest to Neck
Neck	Atlas	Neck to Head
Head		
Right Upper Leg	Right Hip	Pelvis to Right Upper Leg
Right Lower Leg	Right Knee	Right Upper Leg to Right Lower Leg
Right Foot	Right Ankle	Right Lower Leg to Right Foot
Left Upper Leg	Left Hip	Pelvis to Left Upper Leg
Left Lower Leg	Left Knee	Left Upper Leg to Left Lower Leg
Left Foot	Left Ankle	Left Lower Leg to Left Foot
Right Upper Arm	Right Shoulder	Chest to Right Upper Arm
Right Lower Arm	Right Elbow	Right Upper Arm to Right Lower Arm
Left Upper Arm	Left Shoulder	Chest to Left Upper Arm
Left Lower Arm	Left Elbow	Left Upper Arm to Left Lower Arm

Table 1-1: List of HVE human segments and joints

(Note: the 15-segment/14-joint model matches the current HVE human, which allows up to 3 contact ellipsoids and up to 4 joints per segment.)

Model Inputs

GATB inputs include at least one human (up to four), one vehicle, and an optional environment. Event set-up parameters for the human(s) include initial position, seat location (left-front, center-rear, pedestrian, etc.), restraint usage, etc. Parameters for the vehicle include vehicle initial position, velocity, acceleration pulse, etc. The vehicle movement is defined by the initial 6 degree-of-freedom (dof) data (X, Y, Z, Roll, Pitch, Yaw), linear and angular, velocity vector, and the acceleration pulse. The acceleration pulse, or collision pulse, may be entered by the user or obtained directly from another HVE event, such as an EDSMAC run, as shown in Figure 1-1. The human motion is then calculated as the human body segments interact with the contact panels that are attached to the vehicle. Figure 1-2 shows a right front seat passenger response to a frontal impact.

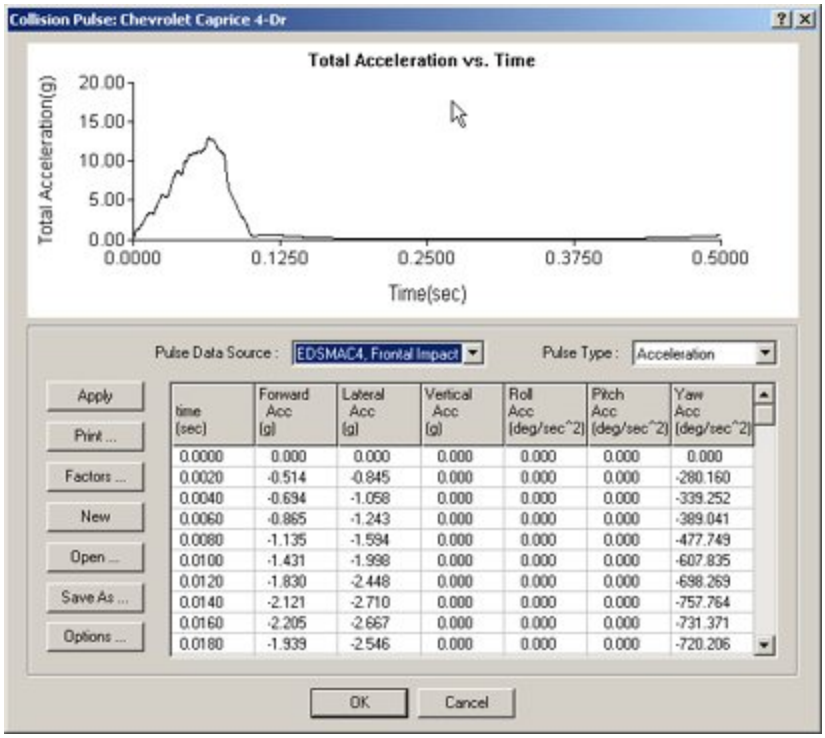


Figure 1-1: Example of EDSMAC collision pulse.

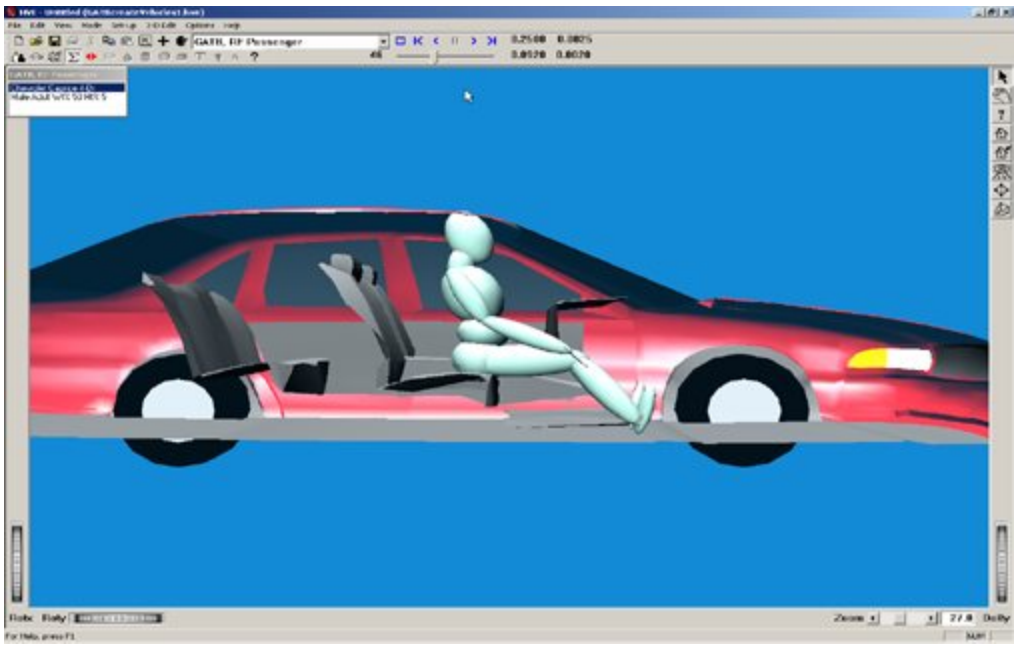


Figure 1-2: GATB run showing right front occupant in frontal impact.

Model Outputs

GATB output reports include Accident History, Human Data, Injury Data, Messages, Program Data, Results, Trajectory Simulation, Variable Output Tables, and Vehicle Data.

Validation

GATB was validated against several ATB runs. The GATB program basically extracts all the data from HVE, creates an ATB program input file, and then executes a version of the ATB program. The basic validation consisted of checking that the correct data was being extracted from HVE and that the data being returned to HVE was being correctly identified. The validation effort confirmed that GATB produces the same results as the ATB program. The ATB program has been previously validated to produce reasonable predictions of human response to motor vehicle collisions [1, 4, 5].

Basic Operation

The procedure for using GATB is substantially the same as using any reconstruction or simulation model in the HVE environment:

- Use the Human Editor to add one or more humans to the case. Edit the human properties to match specific case information.
- Use the Vehicle Editor to add one or more vehicles to the case. Edit the vehicle properties to match specific case information.

> **NOTE:** Review the following chapter, GATB Program Input, to confirm those parameters that affect the GATB program results; many physical parameters are not used by GATB, and therefore, do not affect the results.

- Use the Environment Editor to create a visual environment.
- Use the Event Editor to set up and execute the GATB calculation model by performing the following steps:
- Choose at least one human and one vehicle from the list of humans and vehicles created earlier.
- Choose the GATB calculation model.
- Position the vehicle and human at the Initial Position.
- Enter or select an Acceleration Pulse.
- Execute the GATB simulation event.
- Modify the inputs as required to achieve the desired match between the simulation results and the actual event.
- Finally, use the Playback Editor to view the various reports and trajectory simulations. If desired, produce a video output of the simulation.

Chapter 2 — Program Input

This chapter defines the objects (humans, vehicles and environment) and the event set-up parameters (positions, velocities, acceleration pulse, etc.) used by the GATB analysis. In general, the chapter is divided into the following sections:

- **Objects** — The number of humans and vehicles, and the specific human and vehicle parameters actually used by GATB.
- **Events** — The various HVE options available for setting up and executing a GATB event.

Objects Overview

The objects used by the GATB model are:

- **Humans** — At least 1 human, either an occupant or a pedestrian, may be studied by GATB. Up to 4 humans can be studied in the same GATB run.
- **Vehicles** — 1 vehicle may be studied by GATB.
- **Environment** — GATB uses an environment if present, but it is not required.

> **NOTE:** The environment is used in any HVE-compatible reconstruction or simulation model.

The following sections describe how the human, vehicle, and environment provide the required inputs to the GATB calculation models.

Human

GATB uses humans created using the HVE Human Editor (see Figure 2-1). Humans are selected from the Human Database by choosing the following attributes:

- **Location** — The user may choose from any available occupant position (i.e., R/F, L/F) or, alternatively, choose Pedestrian.

> **NOTE:** HVE displays the human motion relative to the vehicle.

- **Sex** — The user may choose Male or Female.
- **Age** — The user may choose Adult or from a list of child ages. See Table 2-1 and Table 2-2.
- **Weight Percentile** — The user may choose from a list of available percentiles. See Table 2-2 and Appendix A (GEBOD Data Pages).
- **Height Percentile** — The user may choose from a list of available percentiles. See Table 2-2 and Appendix A (GEBOD Data Pages).

*(updated: As of HVE Version 10, new humans are added to the case using the GEBOD Human Information dialog rather than the classic database-driven dialog described above. In the GEBOD dialog the user selects a **Subject Type** (Child, Female, Male or User-defined) and a **Basis** for the body generation (Age, Weight, Height, or All — i.e. age, weight and height together); the GEBOD body generator then produces the full 15-segment data set for the requested subject. The classic dialog is still shown when editing humans created from the pre-Version 10 human database. See Human Information Dialog for full dialog details.)*

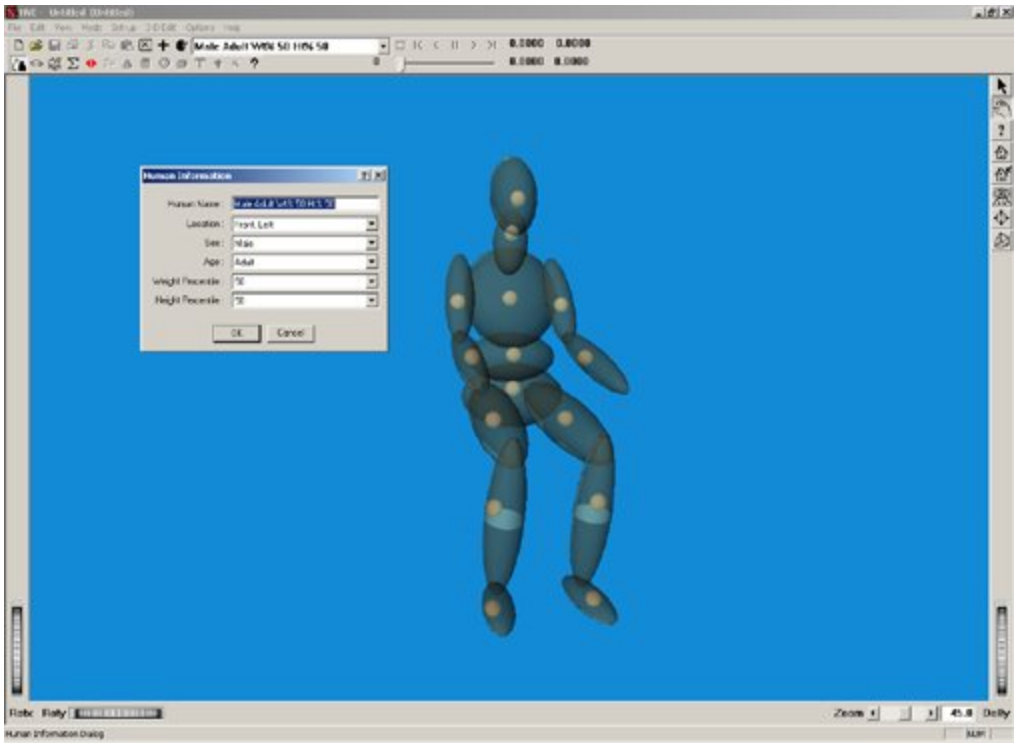


Figure 2-1: Scene Image of HVE Human Editor.

Child Ages	Standing Height (inches)	Weight (lbs)
3 yr. old	38.94	23.08

Table 2-1: List of available HVE human children

(updated: the classic human database also includes 6-, 9- and 12-year-old children; the GEBOD Human Information dialog can generate a child of any age from regression data.)

Weight %'s	Height %'s
2.5, 50, 97.5	2.5, 5.0, 50.0, 95.0, 97.5

Table 2-2: List of available HVE human adults (available weight and height percentiles)

(updated: the original table listed only the 2.5 weight percentile; the classic database provides 2.5, 50 and 97.5 weight percentiles, and the GEBOD dialog accepts arbitrary values when the Basis includes Weight and/or Height.)

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

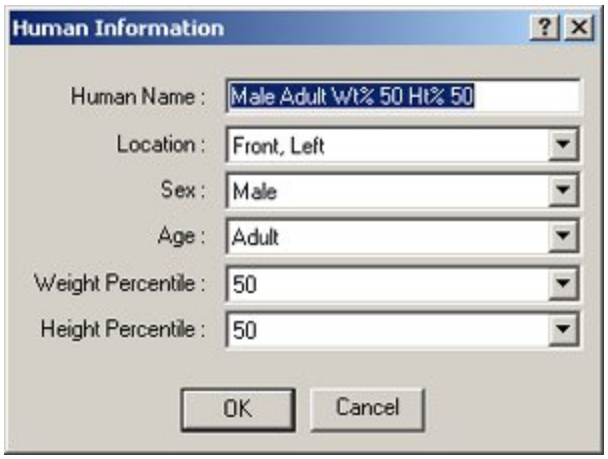


Figure 2-2: Human Information dialog box.

- Choose Human Mode. The Human Editor is displayed.
- Click on the (+) sign on the tool bar to add a human. The Human Information dialog is displayed — Figure 2-2.
- Click on the *Location* option list and select a location for the current human.

> **NOTE:** For information about using the Human Editor refer to the HVE Operations Manual.
>
> **NOTE:** If you choose R/F, L/F, etc., the human will be a vehicle occupant. If you choose Pedestrian, the human will be a pedestrian.

- Click on the *Sex, Age, Weight Percentile* and *Height Percentile* option buttons to choose a human from the database. *(updated: in the GEBOD dialog, choose the Subject Type and Basis, then enter the age, weight and/or height values.)*
- Enter a name for the current human. A default name is supplied for each selected human. This name is user-editable and does not affect calculations.

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

- Click OK to add the human to the current case.

The following Human Parameter groups are used by GATB:

- Inertias
- Ellipsoids
- Joints

The GATB human is modeled with 15 mass segments connected by 14 joints. Refer to

Chapter 4, Calculation Method

, for important details describing how the GATB human model is derived. See Table 1-1 and the GEBOD Data Pages.

The specific data in each of the above parameter groups that are actually used by GATB are defined in Tables 2-3, 2-4, and 2-5.

Inertias

The Human Inertial Data used by GATB are shown in Table 2-3. This data is obtained from the GEBOD program [6]. See Tables 2-1, 2-2 and the GEBOD Data Pages for a complete list of humans.

Parameter	Description
Segment Weight	Weight of each of the 15 body segments.
Segment Principal Moments of Inertia (X, Y, Z)	Rotational inertias of each segment about its principal axes.

Table 2-3: List of Inertial Data used in GATB

(updated: the table body was blank in the printed manual; the parameters above are the per-segment inertial data carried by the HVE human — the segment mass together with its three principal rotational inertias — and shown in the GATB Human Data output report.)

Ellipsoids

Ellipsoids are used for predicting contact forces between the human and vehicle. Penetration of an ellipsoid into a vehicle contact surface results in the calculation of force on the human.

The Human Ellipsoid Data used by GATB are shown in Table 2-4. HVE allows up to 3 ellipsoids per HVE segment.

(updated: the original manual marked this "Not Implemented Yet"; the current HVE human implements up to 3 contact ellipsoids per segment.)

> **NOTE:** If principal axes are rotated and you choose to show contact surfaces, you will not be looking at a true picture of the human-vehicle interaction. However, the forces will be correctly calculated according to the inputs being considered.

Parameter	Description
Ellipsoid Name	Up to 30 characters, used to identify the ellipsoid.
Ellipsoid Center Coordinates	Segment-fixed x, y, z coordinates of the ellipsoid center.
Ellipsoid Semiaxes	Semi-axis lengths of the ellipsoid along its principal axes.
Ellipsoid Principal Axes	Yaw, pitch and roll orientation of the ellipsoid principal axes relative to the segment axes.

Table 2-4: List of Ellipsoid Data used in GATB

(updated: the printed table listed only the Ellipsoid Name row; the center coordinates, semiaxes and principal-axis rows above are the ellipsoid data actually carried by the HVE human — the ellipsoid name, its center coordinates, its three semi-axis lengths, its principal-axis orientation and its contact material — and echoed in the GATB Human Data report.)

Joints

Joints are used to connect together each of the 15 segments. The Human Joint Data used by GATB are shown in Table 2-5.

Parameter	Description
Joint k Location	Distance from segment CG to joint along the segment-fixed k axis.
Joint yaw, pitch, and roll stop angles	Articulation yaw, pitch, and roll angles at which joint stop properties are applied.
Stop elasticity — i, j, k axes	Elasticity of the joint stops for yaw, pitch, and roll rotations. Applies to both (+) and (−) directions.
Linear Elastic Coefficient	Elastic properties of the joint in the normal range of motion (i.e., between the joint stops).

Table 2-5: Human Joint Parameters used in GATB

(Cross-reference: the full set of joint properties available in HVE — joint type, stop angles and elasticities in both directions, energy dissipation, linear/quadratic/cubic elastic coefficients, damping, and injury tolerance angles — is described in Human Joint Properties Dialog. Each segment may carry up to 4 joints.)

Vehicle

GATB uses 1 vehicle created using the HVE Vehicle Editor (see Figure 2-3). Vehicles are selected from the Vehicle Database by choosing the following attributes:

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

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

- **Driver Location** — The driver location is used by GATB to determine if the airbag is a driver-type or a passenger-type airbag.
- **Engine Location** — The engine location is not used by GATB.
- **Number of Axles** — GATB supports 2- and 3-axled vehicles.
- **Drive Axle(s)** — The drive axle attribute is not used by GATB.

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

- Choose Vehicle Mode. The Vehicle Editor is displayed.
- Click on the (+) sign to add a new vehicle. The Vehicle Information dialog is shown. (See Figure 2-4)
- Click on the *Type*, *Make*, *Model*, *Year* and *Body Style* option buttons to select a vehicle from the database.
- If desired, modify the *Driver Location, Engine Location, Number of Axles* and *Drive Axle(s)* for the current vehicle.

Enter a name for the current vehicle. A default name is supplied for each selected vehicle. This name is user-editable, and does not affect calculations.

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

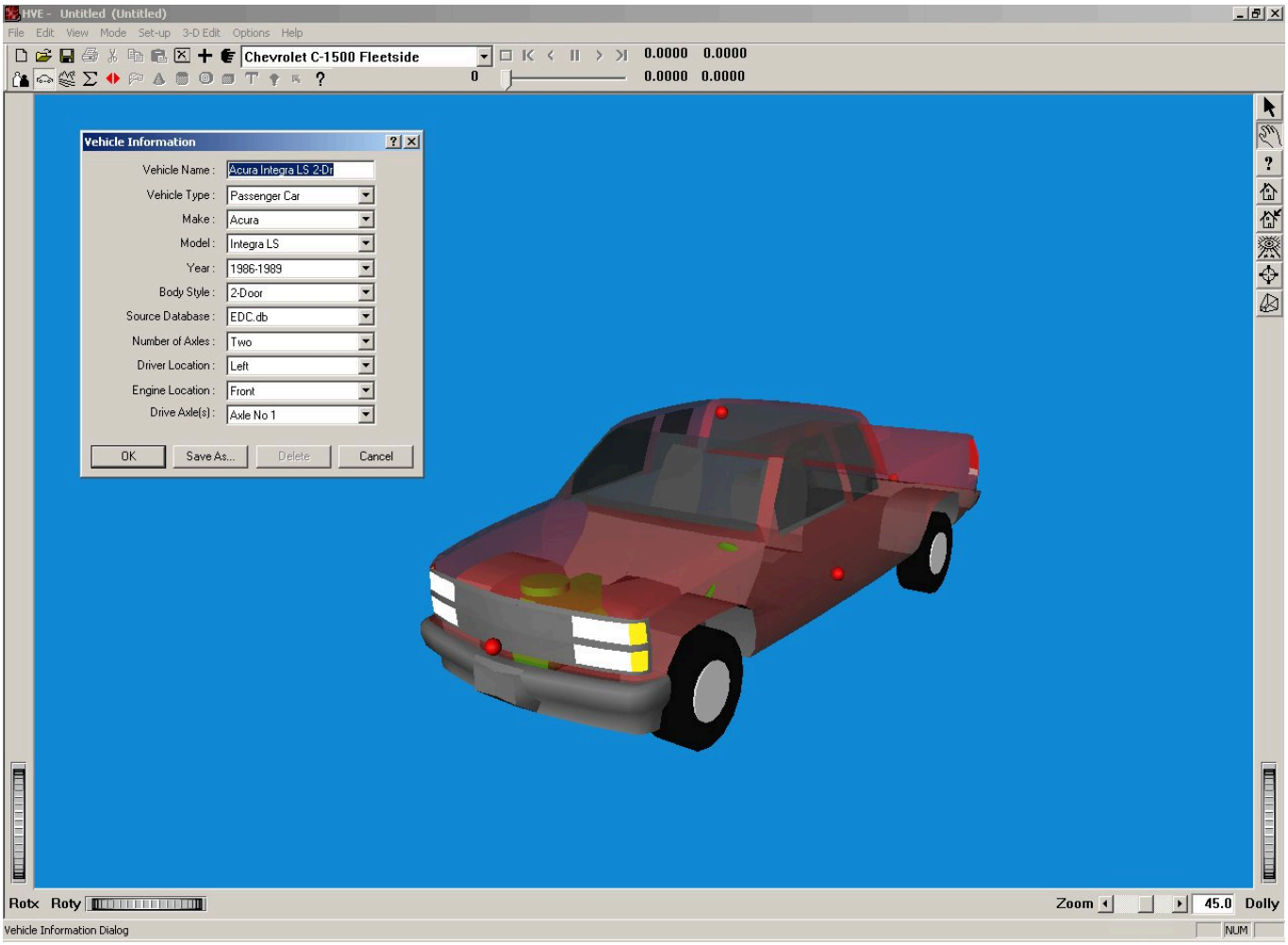


Figure 2-3: Using the Vehicle Editor.

- Click OK to add the vehicle to the current case.

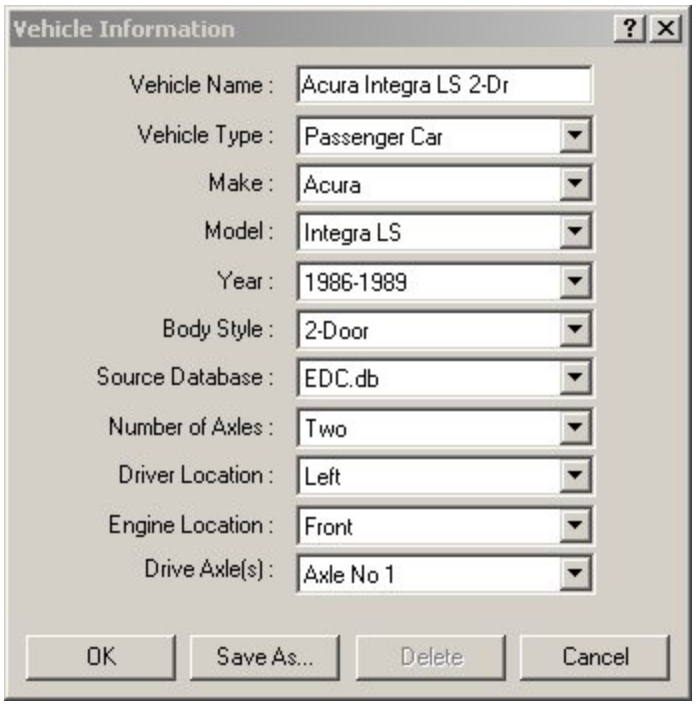


Figure 2-4: Vehicle Information dialog.

The following Vehicle Parameter groups are used by GATB:

- Move CG
- Contact Surfaces
- Belt Restraints
- Airbag Restraints

The specific data used in each of the above parameter groups are defined in Tables 2-6 through 2-8.

Sprung Mass

Remember, GATB is not a

vehicle

simulator! The motion of the vehicle is determined by a user-supplied collision (acceleration) pulse, along with initial vehicle position and velocity. Therefore, the vehicle data required by GATB is limited to that which is required to establish interaction forces between the human and vehicle.

Inertias

Inertial parameters are not used by GATB. The vehicle's motion is supplied by assigning an initial velocity and a collision pulse (see Event Editor later in chapter).

Move CG

Move CG is not directly used by GATB. 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, y, z coordinates for the contact surfaces, belt anchor points and airbag location are updated to reflect the new location.

Geometry File

The geometry file plays no role in the GATB calculations. However, there are some smart things that may be done for occupant simulation. Remembering that an occupant is inside the vehicle, and may be difficult to see, the following two suggestions will help greatly:

- Choose NoBody.h3d as the geometry file. As its name implies, NoBody.h3d is a null geometry file (it has all the required data structures, but no surface polygons), or
- Edit the vehicle's geometry file and remove the roof and roof supports.

> **NOTE:** Remember to save the file with a new name, such as PCFordTaurus4DrSNoRoof.xxx, to avoid losing the original geometry file!

Contact Surfaces

Vehicle contact surfaces are the surfaces that interact with human ellipsoids to produce forces on the human. Up to 25 contact surfaces are allowed by GATB, the properties for which are shown in Table 2-6.

Parameter	Description
Contact Surface Name	Up to 30 characters, used to identify the surface.
Contact Surface Location	Interior or Exterior; provides the default status that determines whether a contact surface is allowed or ignored during force calculations.
Contact Surface x, y, z corner coordinates	Vehicle-fixed x, y, z coordinates for three consecutive corners of the current contact surface, supplied in a counter-clockwise order. The positive side of the surface is specified by the right-hand rule.
Contact Surface Quadratic Stiffness	Second-order stiffness of the ellipsoid vs. contact surface pair.
Contact Surface Cubic Stiffness	Third-order stiffness of the ellipsoid vs. contact surface pair.
Contact Surface Damping Constant	Velocity-dependent damping properties between the ellipsoid and contact surface.

Table 2-6: HVE contact surface information used in GATB

Belt Restraints

Belt restraints are an extremely important aspect of GATB's functionality. The ability to study the effect of restraint system usage (or non-usage) is an important one.

A belt restraint system may be supplied for up to nine seat positions. Although HVE assigns default positions for each belt system, these are arbitrary and may be replaced by user-entered information. Belt Parameters used by GATB are shown in Table 2-7.

> **NOTE:** At this point, you are saying the vehicle has a belt installed at a specific location. Whether or not the belt is used is event-dependent! See Event Set-up, Restraints later in this chapter for more information.

Parameter	Description
Seat Position	Seat position within vehicle (R/F, L/F, etc.).
Belt Section	Torso or lap.
Belt Anchor Point x, y, z Coordinates	Vehicle-fixed x, y, z coordinates for one end of the belt (the other end of the belt is attached to a human segment).
Belt Linear Stretch Rate	Linear stretch rate of the belt material.
Belt Quadratic Stretch Rate	Second-order stretch rate of the belt material.

Table 2-7: HVE belt restraint data used in GATB

(Note: each belt system has separate left and right lap and torso sections; the human's belt injury tolerances are likewise carried as separate left lap, left torso, right lap and right torso values.)

Airbag Restraints

Like belt restraints, airbag restraints are also an extremely important aspect of GATB's functionality.

An airbag restraint system may be supplied for up to nine seat positions. Like belt restraints, default positions for each airbag may be replaced by user-entered information. Airbag Parameters used by GATB are shown in Table 2-8.

> **NOTE:** At this point, you are saying the vehicle has an airbag installed at a specific location. Whether or not the airbag deploys is event-dependent! See Event Set-up, Restraints later in this chapter for more information.

Parameter	Description
Seat Position for Current Airbag	Seat position within vehicle (R/F, L/F, etc.).
Bag Anchor Point x, y, z Coordinates	Vehicle-fixed x, y, z coordinates of the airbag.
Initial Bag Radius	Initial radius of airbag.
Passenger Bag Length	If a passenger seat position (i.e., no steering column), the airbag length.
Initial Bag Pressure	Initial pressure inside of the airbag.
Bag Membrane Thickness	Thickness of the airbag material.
Bag Full Inflation Volume	Volume of the airbag at full inflation.
Bag Vent Discharge Coefficient	Thermodynamic discharge coefficient of vent.
Bag Vent Area	Area of the vent.
Force Convergence Criterion	Allowable difference between force on airbag and force on human.

Table 2-8: Airbag restraint data used in GATB

(Note: the printed manual labeled the vent-area row "Bag Penetration for Force"; the description — area of the vent — identifies it as the bag vent area.)

Inter-vehicle Connections

Inter-vehicle connections are not used by GATB.

Drag Forces

Drag forces are not used by GATB.

Unsprung Mass

Unsprung Mass parameters (Wheel Location, Tire, Suspension and Brakes) are not used by GATB.

> **NOTE:** Wheel location and tire size are used to visualize the vehicle, but play no role in GATB simulation calculations.

Exterior

The Vehicle Exterior Data (Exterior Dimensions, Stiffness) are not used by GATB.

Steering System Data

Steering System Data are not used by GATB.

Brake System Data

Brake System Data are not used by GATB.

Environment

GATB uses the environment created by the HVE Environment Editor (see Figure 2-5). The environment is created by defining the following groups of attributes:

- Visual Data
- Physical Data

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.
- **Angle of X Axis** — The angle of the earth-fixed X axis relative to true north.

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).

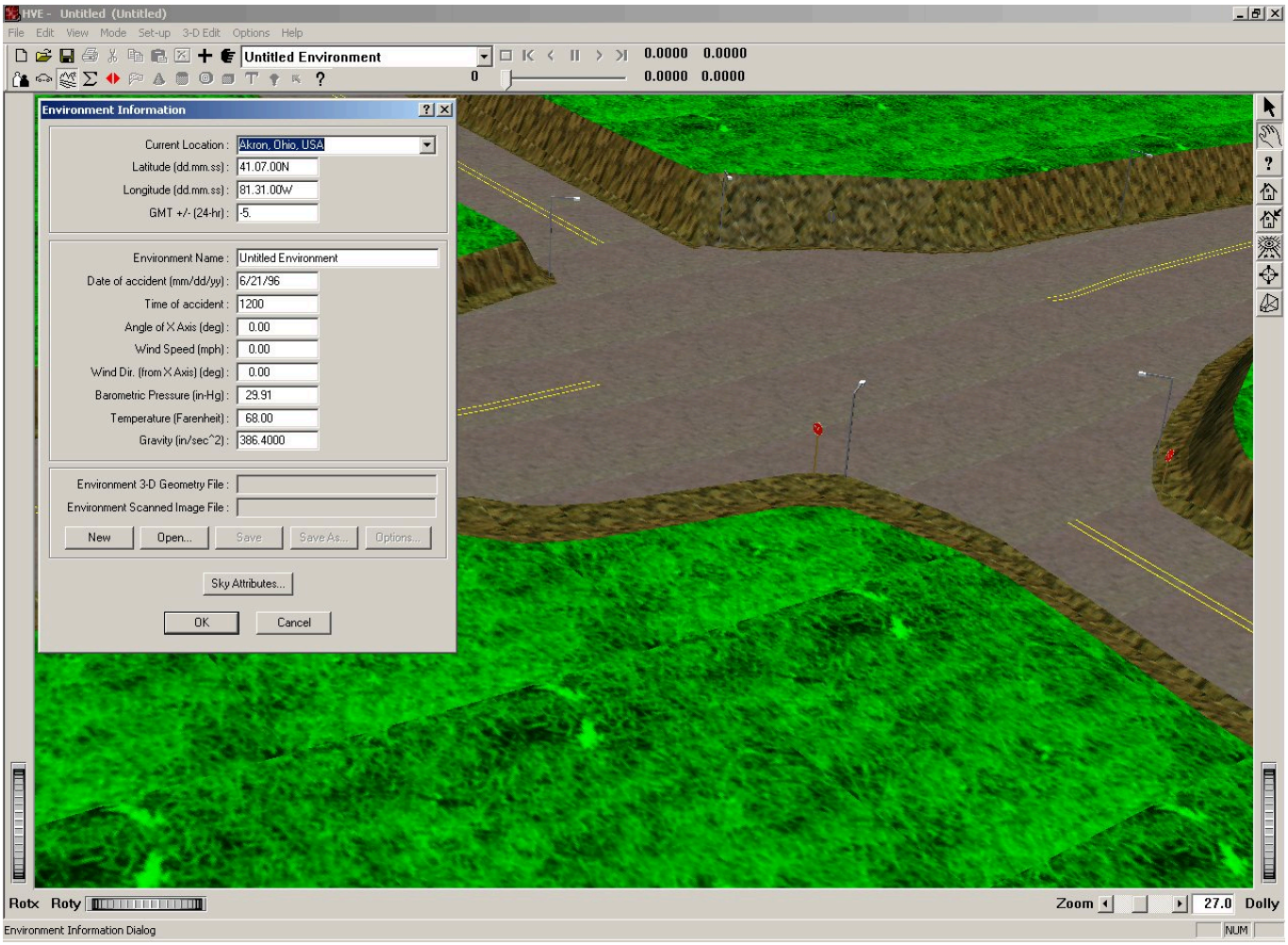


Figure 2-5: HVE Environment Editor.

> **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:

- Wind Speed and Direction
- Atmospheric Temperature and Pressure
- Gravity Constant
- 3-D Surface Geometry

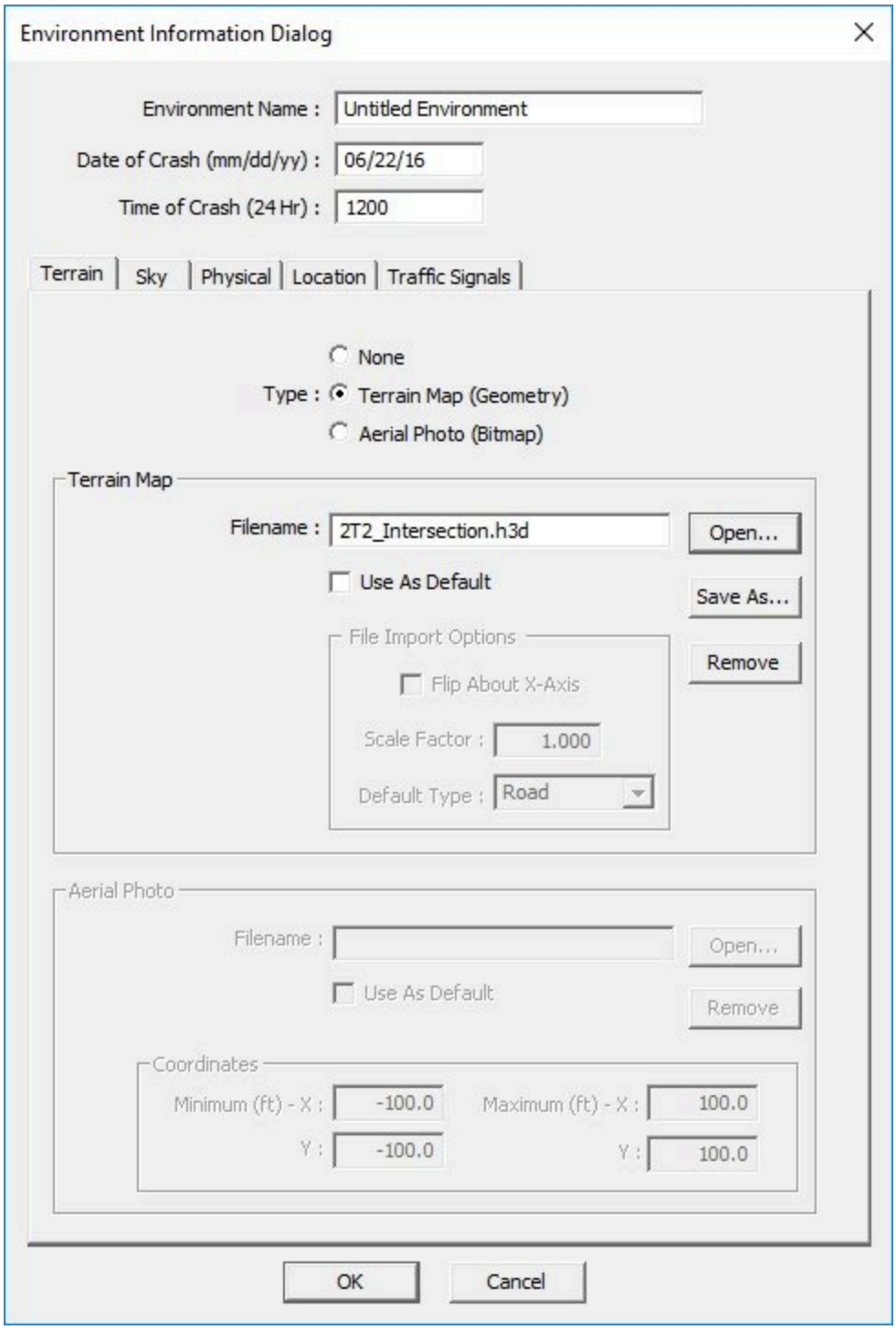


Figure 2-6: Environment Information dialog.

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

- Choose Environment Mode. The Environment Editor is displayed.
- Click on the (+) sign on the toolbar to add a new environment. The Environment Information dialog is displayed, Figure 2-6.
- Enter an environment name at the top of the dialog. A default name is supplied for the current environment. The name is user-editable, and does not affect calculations.

- Enter the *Date of Crash* and *Time of Crash* for the event, also at the top of the dialog.
- Click the *Location* tab and select the desired *Current Location*; the associated latitude, longitude and GMT offset are filled in.
- Click the *Physical* tab and enter the *Angle of X-Axis, Wind Speed, Wind Direction, Barometric Pressure* and *Temperature* for the event.
- On the same tab, enter the *Gravity Constant* for the event.
- Click OK to add the environment to the current case.

Visual parameters are not used by GATB. The specific physical environment data used by GATB are described below.

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 correction factor before entering this angle.
>
> **NOTE:** The angle of the X axis affects how you visualize a GATB event, but does not affect any calculations.

Wind Speed and Direction

Wind Speed and Direction are not used by GATB.

Atmospheric Temperature and Pressure

Atmospheric Temperature and Pressure are not used by GATB.

Gravity Constant

The gravity 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.

3-D Surface Geometry

The 3-D Surface Geometry is not used by GATB.

> **NOTE:** If a contact panel named GROUND is defined, the program builds a flat contact panel 200 ft × 200 ft, centered at the vehicle x, y position and at z = 0.

Event

GATB uses the HVE Event Editor (see Figure 2-7) to create, set up and execute an event. Each of these topics is described below.

Creating a GATB Event

A GATB event is created using the Event Information dialog. To create a GATB event:

- Choose Event Mode. The Event Editor is displayed.

- Click on the (+) sign on the toolbar to add an event. The Event Information dialog is displayed, Figure 2-8.
- Select at least 1 human from the Active Humans list.
- Select 1 vehicle from the Active Vehicles list.
- Select *GATB* from the Calculation Method options list.
- Enter an event name. A default name is supplied for the selected event. The name is user-editable, and does not affect calculations.

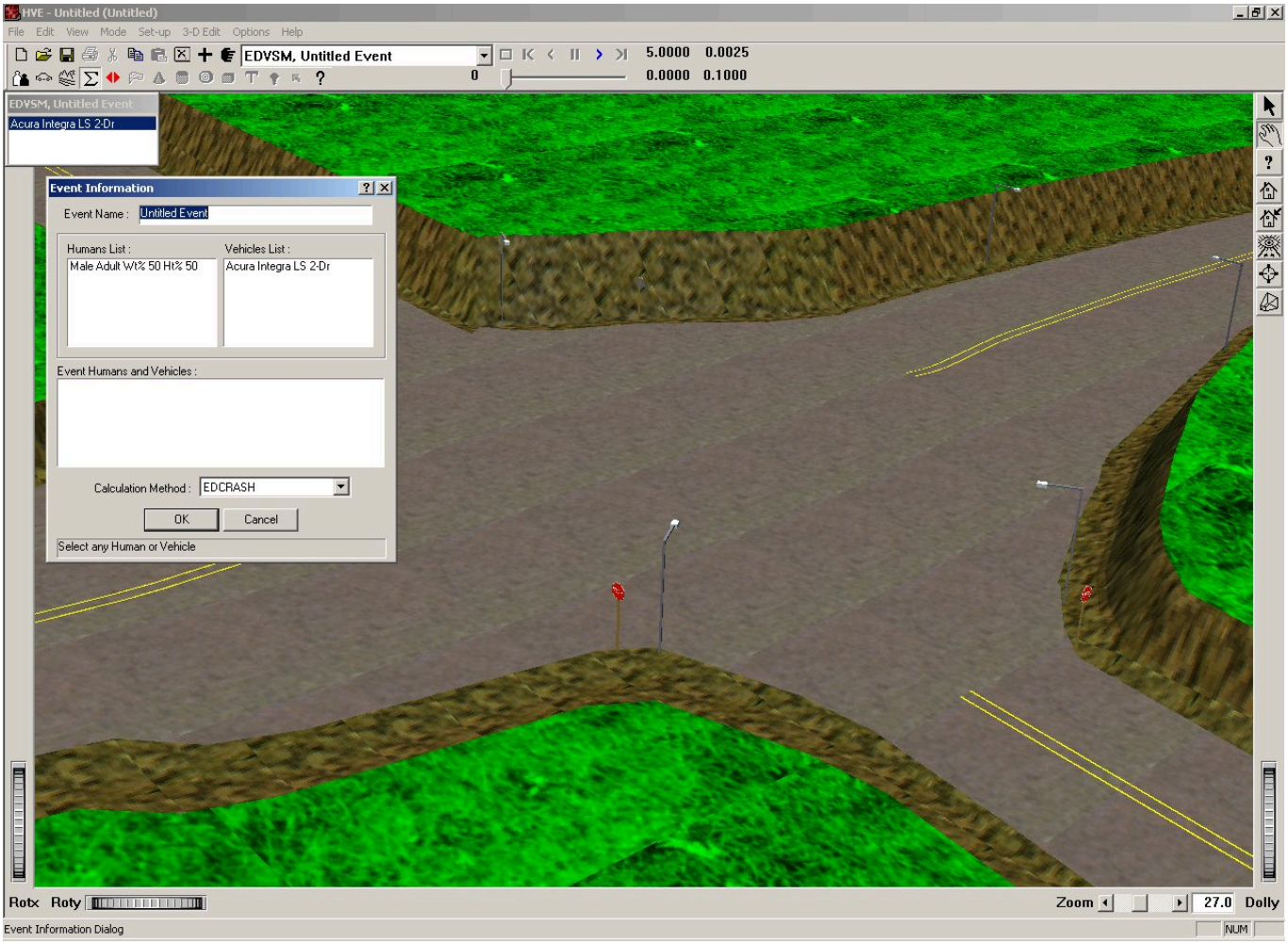


Figure 2-7: Event Editor in HVE.

> **NOTE:** Duplicate event names are not allowed.

- Click OK to create the GATB event.

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

Setting Up a GATB Event

GATB uses the following

event set-up

options:

- Initial Position/Velocity
- Collision Pulse
- Contacts
- Restraints
- Calculation Options

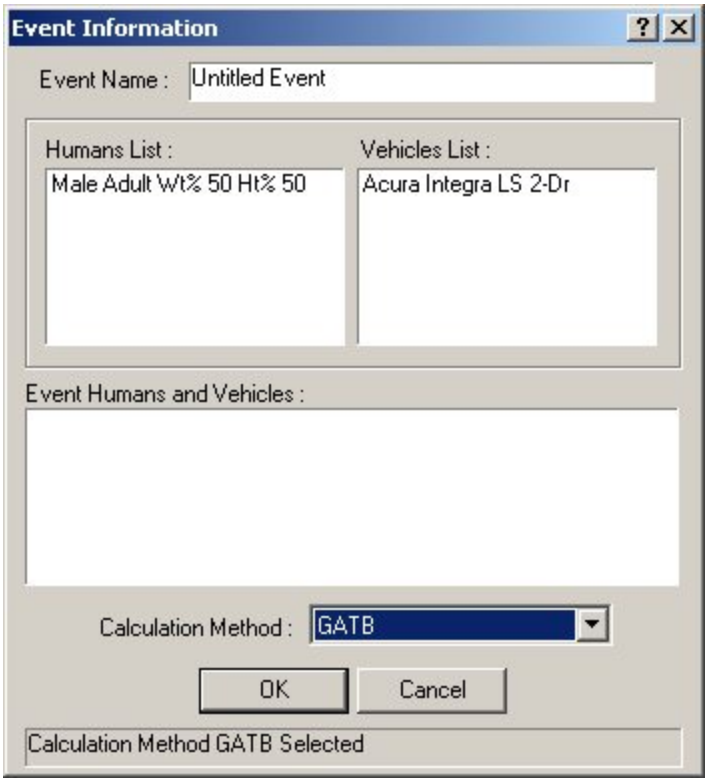


Figure 2-8: Adding a new event.

The specific Event Set-up data used by GATB are defined in Table 2-9.

Parameter	Description
Initial Position / Velocity	Vehicle and human initial conditions.
Vehicle Collision Pulse	Time-dependent table of the vehicle forward, lateral, and vertical components of linear acceleration, and the yaw, pitch, and roll angular accelerations.
Contacts	A table of allowable interactions between human ellipsoids and vehicle contact surfaces.
Belt Restraints In-Use Switch	Determines whether the selected belt restraint system (torso or lap) is in use.
Segment Attachment	The name of the segment to which the belt ends are attached.
Attachment Coordinates	The segment-fixed i, j, k coordinates for the belt attachment point.
Belt Slack	Initial slack in the belt.

Table 2-9: List of Event Data

Position/Velocity

Like all simulations, GATB requires initial positions and velocities to be supplied by the user.

The vehicle is positioned relative to the earth-fixed coordinate system by supplying the X, Y, Z coordinates of its CG, and roll (Φ), pitch (Θ) and yaw (Ψ) angles about vehicle x, y, and z axes, respectively. The vehicle velocities are supplied in the form of a total velocity, sideslip angle and vertical velocity.

> **NOTE:** The vehicle-fixed u (forward) and v (side) velocity components are calculated using the total velocity and sideslip angle.

Human positions and velocities are assigned relative to the vehicle-fixed coordinate system.

> **NOTE:** The same is true for output reports: all the kinematic data displayed in Variable Output is reported relative to the vehicle for humans.

The position of a human is defined by the center of gravity of its pelvis segment (this is called the *main segment*). Thus, the positions and velocities are actually those assigned for the pelvis. (However, human positions may be further defined for each additional segment (i.e., *Head*, *Left Upper Leg*, and so forth) by Φ, Θ, Ψ articulations (supplied in that order) at the joints. Angular velocities may be supplied as well.)

GATB is a 15-mass, 14-joint model. Articulation angular positions and velocities may be entered by clicking on the neck segment (to set the initial conditions for the C7-T1, or Neck, joint), and by clicking on the Right and Left Upper Leg segments (to set the initial conditions for the Hip joint). These joints are modeled by GATB and their motion will be affected by subsequent human-vehicle interaction. Any of the other segment positions may be supplied as well. Position/Velocity Data used by GATB are shown in Table 2-10.

Parameter	Description
Vehicle Initial Position	The earth-fixed x, y, z coordinates and the roll, pitch, and yaw orientations of the vehicle at the start of the run.
Vehicle Initial Velocity	The forward, lateral, and vertical linear velocities, and the roll, pitch, and yaw angular velocities of the vehicle at the start of the run.

Table 2-10: Position and velocity data used in GATB

(Note: the second row was mislabeled "Vehicle Initial Position" in the printed manual; its description identifies it as the initial velocity.)

Driver Controls

The Driver Controls Data are not used by GATB.

Damage Profile

The Damage Profile Data are not used by GATB.

Payload

The Payload Data are not used by GATB.

Collision Pulse

The collision pulse provides the vehicle acceleration vs. time history for the event. The data are provided in the form of a table. The current value of forward, side and vertical linear accelerations, and roll, pitch and yaw angular accelerations is obtained from this table using linear interpolation. Once obtained, the accelerations are integrated during each time step to determine vehicle velocity and position.

> **NOTE:** HVE allows you to supply a collision pulse directly from a previously run EDSMAC event, or any physics program that produces a collision pulse, as well as from a directory of user-saved collision pulses. See Reference 5 for additional information.
>
> **NOTE:** There are also options available to define the vehicle motion using a velocity-time data file or a position-time data file.
>
> **NOTE:** Because of the significant difference in the mass of a human compared to a vehicle, a collision pulse is not normally required for a pedestrian impact simulation.

Contacts

The Contacts dialog allows the user to selectively remove specific human ellipsoid vs vehicle contact surface interactions for consideration by the event. This practice is useful because every interaction requires computational overhead. Removing unnecessary calculations reduces calculation time.

By default, the Contacts dialog assumes interaction between every human ellipsoid and vehicle contact surface. When an ellipsoid name is selected from the ellipsoids list box, all the vehicle contact surface names will be highlighted in the Contacts list box. Click on any highlighted contact surface to remove it from consideration.

> **NOTE:** Actually, GATB does some pre-screening: If the current human is an occupant, only interior contact surfaces will be highlighted; if the current human is a pedestrian, only exterior surfaces will be highlighted.

Restraints

The Restraints dialog determines if a belt or airbag restraint system is in use for the current event.

> **NOTE:** If the current vehicle does not have a restraint system installed at the position specified for the current human, no restraints will be available for selection. If necessary, use the Vehicle Editor to install a restraint system at the desired seat position.

For belt restraint systems, Torso and Lap belt sections may be supplied individually. The following in-use parameters are required for each belt section:

- **Attached To** — The name of the human segment (Pelvis, Abdomen, Chest…) to which the belt is attached.
- **Attachment Coordinates** — The segment-fixed coordinates of the anchor point for the left and right belt sections.
- **Belt Slack** — The initial slack in the belt for the left and right belt sections.

> **NOTE:** Negative slack may be supplied to model belt pre-loading.

For airbag restraint systems, the following in-use parameters may be supplied:

- **Deployment Time** — The simulation time at which the bag begins to inflate.
- **Fill Duration** — The time interval during which airbag filling occurs.

Simulation Controls

GATB uses the current simulation control parameters in the Simulation Controls dialog (see Options Menu, Simulation Controls). The Simulation parameters used by GATB are shown in Table 2-11.

Parameter	Description
Human Collision Integration Time Step	Not adjustable — set to 0.0005 sec.

Table 2-11: Simulation control data used in GATB

Calculation Options

There are several calculation options available in GATB. Each of these options allows for special situations where the default data may not sufficiently model the event being analyzed.

Use External File — This option is used when the user wants to make detailed changes to the existing input file (gatb.ain) and have this input file used again without regenerating all the data. This is useful when very specific data in the input file needs to be changed, but the GATB implementation does not allow the user a dialog to enter it. It is also useful when running someone else's .ain file. Use this option with extreme care; there is no error checking on the input values outside of the ATB model and unexpected results may cause computational errors that are not handled by HVE. Before making any changes to a .ain file or using this option, the user must be very familiar with ATB and all the options available in the base version of ATB.

Use Pulse File — This option is available to allow users to utilize an external pulse file. This allows someone to produce a pulse file using a non-HVE program and then to use it in the GATB run. The basic format of the pulse file is: Time, X, Y, Z, Yaw, Pitch, Roll for position-based pulse in seconds, inches, and degrees; Time, V-x, V-y, V-z, Roll velocity, Pitch velocity, Yaw velocity for velocity-based pulse in seconds, in/sec, deg/sec; Time, A-x, A-y, A-z, Roll acceleration, Pitch acceleration, Yaw acceleration in seconds, g's, and deg/sec^2.

> **NOTE:** The input data is in a different order for position-based pulse than for velocity-based or acceleration-based pulse file.

Belt Contacts — This option allows the user to determine how the restraint contact points are moved during the simulation. GATB automatically generates additional contact points based on the 2 points entered by the user for each segment. These points consist of a point on the centerline of the segments, for the pelvis and torso, and a point on the top of the shoulder for the torso belt. These points can all move along the surface of the segments but stay in the same place along the belt webbing (option 1 — All Slide), or the user-entered points can move along the surface while the additional points generated can stay in the same place on the segment, but move along the belt webbing (option 2 — Some Slide), or all the points used, both those entered and those generated, can stay at the same place on the segment but move along the webbing (option 3 — None Slide).

> **NOTE:** If the belt points are allowed to move on the surface of the segment some of the points may be "dropped" from the belt as they "slide" off the segment. Setting the option to None Slide prevents this, but may not model the belt interaction as accurately.

Executing An Event

To execute a GATB event, use the Event Controller, shown in Figure 2-7 as a component of the Event Editor, and again in Figure 2-9, below. The Event Controller's buttons have the following functions:

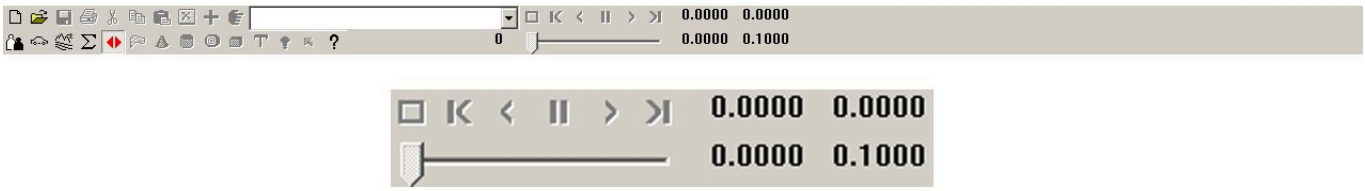


Figure 2-9: Simulation control buttons.

- **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.
- **Execute** — 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 event set-up options (see previous section), those changes will have no effect unless you press Reset before pressing Execute.
>
> **NOTE:** Remember to use HVE's Options Menu to choose useful options, such as Key Results, Axes, Velocity Vectors and Contacts.

Chapter 3 — Program Output

This chapter defines the outputs available from a GATB event. The reports produced by GATB are available in the HVE Playback Editor.

Overview

GATB 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, 3-D visual simulations.

> **NOTE:** Each of these reports may be printed on the system printer. To print a report, select the report in the Playback Editor's Active Windows list, then choose Print from HVE's Files menu. Refer to the HVE Operations Manual for further details.

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

- Choose Playback Mode by clicking the Playback button on the tool bar. The Playback Editor is displayed.
- Click on the (+) sign on the tool bar to add a Playback Report. The Preview Window Information dialog is displayed, showing a list of all the current events in the case.
- Select a GATB event from the list. Once an event is selected, the Report Type list is displayed containing all the available reports for the selected event. See Table 3-1.

Available Output Options
Accident History
Human Data
Injury Data

Table 3-1: Available GATB Event Output Options

- 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.
- Enter a Preview Window Name. A default name is supplied for the selected preview window. The name is user-editable, and does not affect calculations.

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

- Click OK to display the report.

Alpha-Numeric Reports

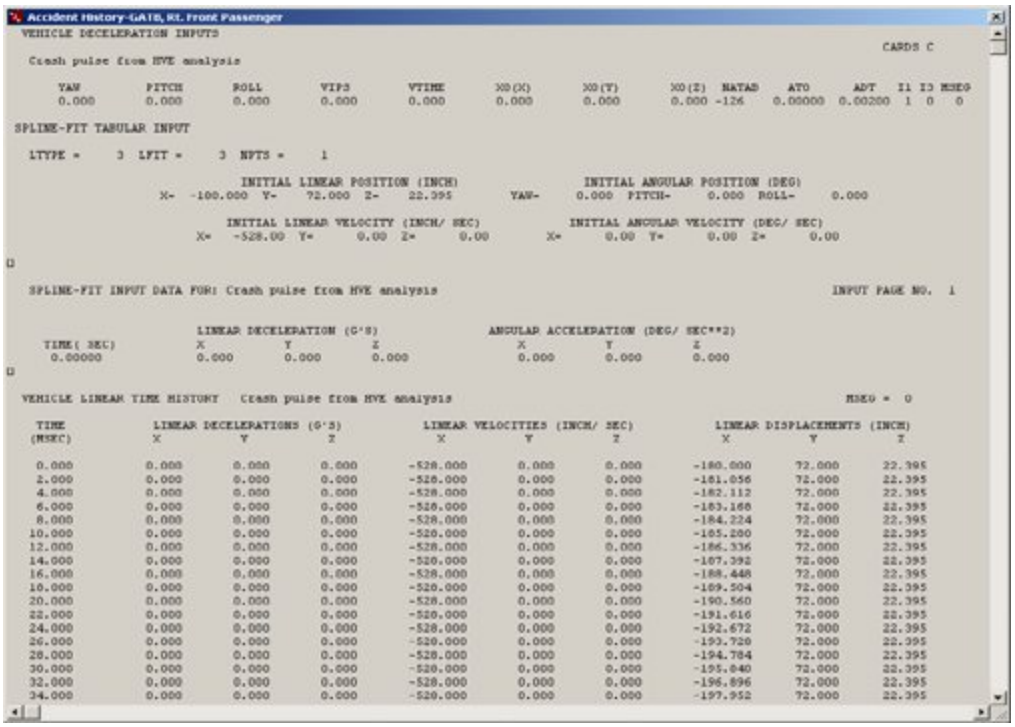
GATB produces the following alpha-numeric reports:

- **Accident History** — A table of initial and final positions and velocities.
- **Human Data** — A series of tables containing the human data used by GATB.
- **Injury Data** — A table containing the HIC and CSI for each human.
- **Messages** — A list of messages produced by the current run.
- **Program Data** — A table containing program control information for the current run.
- **Results** — Tables containing human segment and joint data printed at approximately ten timesteps.
- **Vehicle Data** — A series of tables containing the vehicle data used by GATB.

An example of each of these numeric output reports from GATB is shown on the following pages.

Accident History

The Accident History Report displays a table of initial and final positions and velocities for the human and vehicle. A typical Accident History Report is shown in Figure 3-1.



Accident History-GATB, Rt. Front Passenger

VEHICLE DECELERATION INPUTS

CARDS C

Crash pulse from HVE analysis

YAW	PITCH	ROLL	VIPS	VTIME	XD(X)	XD(Y)	XD(Z)	NATAB	ATO	ADT	I1	I2	MSEG
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-126	0.00000	0.00200	1	0	0

SPLINE-FIT TABULAR INPUT

LTYPE = 3 LFIT = 3 NPTS = 1

INITIAL LINEAR POSITION (INCH) INITIAL ANGULAR POSITION (DEG)

X= -100.000 Y= 72.000 Z= 22.395 YAW= 0.000 PITCH= 0.000 ROLL= 0.000

INITIAL LINEAR VELOCITY (INCH/ SEC) INITIAL ANGULAR VELOCITY (DEG/ SEC)

X= -528.00 Y= 0.00 Z= 0.00 X= 0.00 Y= 0.00 Z= 0.00

SPLINE-FIT INPUT DATA FOR: Crash pulse from HVE analysis INPUT PAGE NO. 1

	LINEAR DECELERATION (G'S)			ANGULAR ACCELERATION (DEG/ SEC**2)		
TIME(SEC)	X	Y	Z	X	Y	Z
0.00000	0.000	0.000	0.000	0.000	0.000	0.000

VEHICLE LINEAR TIME HISTORY Crash pulse from HVE analysis MSEG = 0

TIME (MSEC)	LINEAR DECELERATIONS (G'S) X	Y	Z	LINEAR VELOCITIES (INCH/ SEC) X	Y	Z	LINEAR DISPLACEMENTS (INCH) X	Y	Z
0.000	0.000	0.000	0.000	-528.000	0.000	0.000	-100.000	72.000	22.395
2.000	0.000	0.000	0.000	-528.000	0.000	0.000	-101.056	72.000	22.395
4.000	0.000	0.000	0.000	-528.000	0.000	0.000	-102.112	72.000	22.395
6.000	0.000	0.000	0.000	-528.000	0.000	0.000	-103.168	72.000	22.395
8.000	0.000	0.000	0.000	-528.000	0.000	0.000	-104.224	72.000	22.395
10.000	0.000	0.000	0.000	-528.000	0.000	0.000	-105.280	72.000	22.395
12.000	0.000	0.000	0.000	-528.000	0.000	0.000	-106.336	72.000	22.395
14.000	0.000	0.000	0.000	-528.000	0.000	0.000	-107.392	72.000	22.395
16.000	0.000	0.000	0.000	-528.000	0.000	0.000	-108.448	72.000	22.395
18.000	0.000	0.000	0.000	-528.000	0.000	0.000	-109.504	72.000	22.395
20.000	0.000	0.000	0.000	-528.000	0.000	0.000	-190.560	72.000	22.395
22.000	0.000	0.000	0.000	-528.000	0.000	0.000	-191.616	72.000	22.395
24.000	0.000	0.000	0.000	-528.000	0.000	0.000	-192.672	72.000	22.395
26.000	0.000	0.000	0.000	-528.000	0.000	0.000	-193.728	72.000	22.395
28.000	0.000	0.000	0.000	-528.000	0.000	0.000	-194.784	72.000	22.395
30.000	0.000	0.000	0.000	-528.000	0.000	0.000	-195.840	72.000	22.395
32.000	0.000	0.000	0.000	-528.000	0.000	0.000	-196.896	72.000	22.395
34.000	0.000	0.000	0.000	-528.000	0.000	0.000	-197.952	72.000	22.395

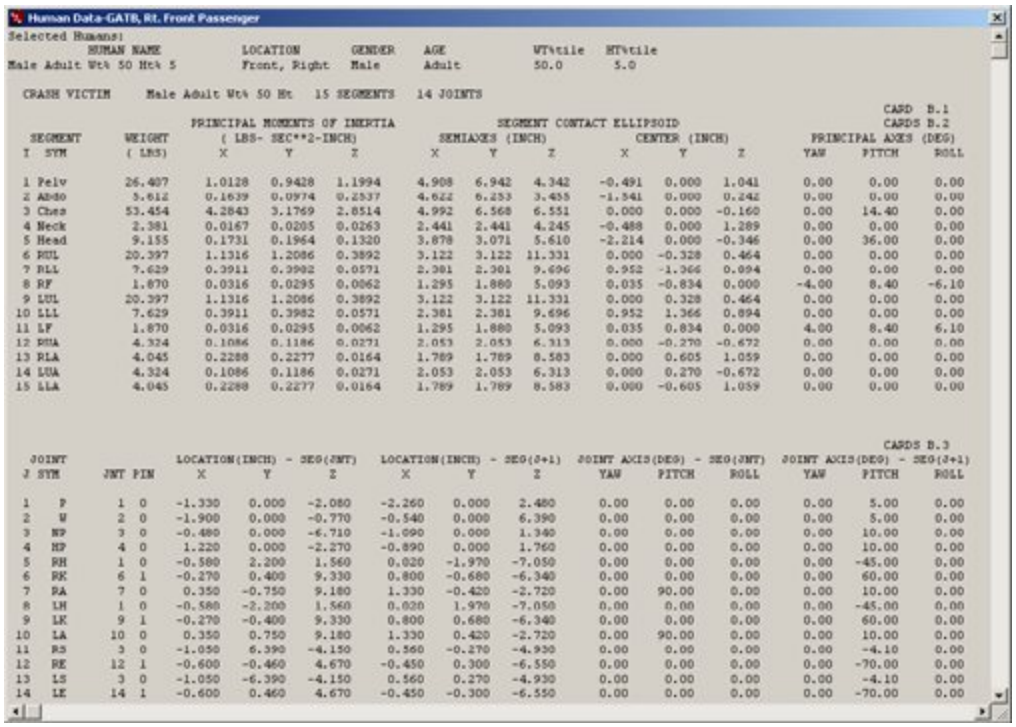
Figure 3-1: Example of GATB Accident History output report.

Human Data

The Human Data Report includes the following information:

- **Segment Properties** — Inertial properties and joint locations for the Head, Torso, and Leg segments.
- **Joint Properties** — Elastic, damping, and stop angles for the Neck and Hip joints.
- **Ellipsoid Properties** — Name, Segment, center coordinates, and semi-axis lengths for each human ellipsoid.

A typical Human Data Report is shown in Figure 3-2. The report echoes the ATB "Crash Victim" input cards (Cards B.1–B.3): for each of the 15 segments it lists the weight, principal moments of inertia, contact ellipsoid semiaxes and center offsets, and principal-axis yaw/pitch/roll; for each of the 14 joints it lists the joint pin locations in both connected segments and the joint axis orientations.



Human Data-GATB, Rt. Front Passenger

Selected Humans:

HUMAN NAME	LOCATION	GENDER	AGE	WT%tile	HT%tile
Male Adult Wt% 50 Ht% 5	Front, Right	Male	Adult	50.0	5.0

CRASH VICTIM Male Adult Wt% 50 Ht 15 SEGMENTS 14 JOINTS

CARD B.1 / CARDS B.2

SEGMENT I	SYM	WEIGHT (LBS)	PRINCIPAL MOMENTS OF INERTIA (LBS-SEC**2-INCH) X	Y	Z	SEGMENT CONTACT ELLIPSOID SEMIAXES (INCH) X	Y	Z	CENTER (INCH) X	Y	Z	PRINCIPAL AXES (DEG) YAW	PITCH	ROLL
1	Pelv	26.407	1.0128	0.9428	1.1994	4.908	6.942	4.342	-0.491	0.000	1.041	0.00	0.00	0.00
2	Abdo	5.612	0.1639	0.0974	0.2537	4.622	6.253	3.455	-1.541	0.000	0.242	0.00	0.00	0.00
3	Ches	53.454	4.2843	3.1769	2.8514	4.992	6.568	6.551	0.000	0.000	-0.160	0.00	14.40	0.00
4	Neck	2.381	0.0167	0.0205	0.0263	2.441	2.441	4.245	-0.488	0.000	1.289	0.00	0.00	0.00
5	Head	9.155	0.1731	0.1964	0.1320	3.878	3.071	5.610	-2.214	0.000	-0.346	0.00	36.00	0.00
6	RUL	20.397	1.1316	1.2086	0.3892	3.122	3.122	11.331	0.000	-0.328	0.464	0.00	0.00	0.00
7	RLL	7.629	0.3911	0.3982	0.0571	2.381	2.381	9.696	0.952	-1.366	0.894	0.00	0.00	0.00
8	RF	1.870	0.0316	0.0295	0.0062	1.295	1.880	5.093	0.035	-0.834	0.000	-4.00	8.40	-6.10
9	LUL	20.397	1.1316	1.2086	0.3892	3.122	3.122	11.331	0.000	0.328	0.464	0.00	0.00	0.00
10	LLL	7.629	0.3911	0.3982	0.0571	2.381	2.381	9.696	0.952	1.366	0.894	0.00	0.00	0.00
11	LF	1.870	0.0316	0.0295	0.0062	1.295	1.880	5.093	0.035	0.834	0.000	4.00	8.40	6.10
12	RUA	4.324	0.1086	0.1186	0.0271	2.053	2.053	6.313	0.000	-0.270	-0.672	0.00	0.00	0.00
13	RLA	4.045	0.2288	0.2277	0.0164	1.789	1.789	8.583	0.000	0.605	1.059	0.00	0.00	0.00
14	LUA	4.324	0.1086	0.1186	0.0271	2.053	2.053	6.313	0.000	0.270	-0.672	0.00	0.00	0.00
15	LLA	4.045	0.2288	0.2277	0.0164	1.789	1.789	8.583	0.000	-0.605	1.059	0.00	0.00	0.00

CARDS B.3

JOINT J	SYM	JNT	PIN	LOCATION(INCH) - SEG(JNT) X	Y	Z	LOCATION(INCH) - SEG(J+1) X	Y	Z	JOINT AXIS(DEG) - SEG(JNT) YAW	PITCH	ROLL	JOINT AXIS(DEG) - SEG(J+1) YAW	PITCH	ROLL
1	P	1	0	-1.330	0.000	-2.080	-2.260	0.000	2.480	0.00	0.00	0.00	0.00	5.00	0.00
2	W	2	0	-1.900	0.000	-0.770	-0.540	0.000	6.390	0.00	0.00	0.00	0.00	5.00	0.00
3	NP	3	0	-0.480	0.000	-6.710	-1.690	0.000	1.340	0.00	0.00	0.00	0.00	10.00	0.00
4	NP	4	0	1.220	0.000	-2.270	-0.890	0.000	1.760	0.00	0.00	0.00	0.00	10.00	0.00
5	RH	1	0	-0.580	2.200	1.560	0.020	-1.970	-7.050	0.00	0.00	0.00	0.00	-45.00	0.00
6	RK	6	1	-0.270	0.400	9.330	0.800	-0.680	-6.340	0.00	0.00	0.00	0.00	60.00	0.00
7	RA	7	0	0.350	-0.750	9.180	1.330	-0.420	-2.720	0.00	90.00	0.00	0.00	10.00	0.00
8	LH	1	0	-0.580	-2.200	1.560	0.020	1.970	-7.050	0.00	0.00	0.00	0.00	-45.00	0.00
9	LK	9	1	-0.270	-0.400	9.330	0.800	0.680	-6.340	0.00	0.00	0.00	0.00	60.00	0.00
10	LA	10	0	0.350	0.750	9.180	1.330	0.420	-2.720	0.00	90.00	0.00	0.00	10.00	0.00
11	RS	3	0	-1.050	6.390	-4.150	0.560	-0.270	-4.930	0.00	0.00	0.00	0.00	-4.10	0.00
12	RE	12	1	-0.600	-0.460	4.670	-0.450	0.300	-6.550	0.00	0.00	0.00	0.00	-70.00	0.00
13	LS	3	0	-1.050	-6.390	-4.150	0.560	0.270	-4.930	0.00	0.00	0.00	0.00	-4.10	0.00
14	LE	14	1	-0.600	0.460	4.670	-0.450	-0.300	-6.550	0.00	0.00	0.00	0.00	-70.00	0.00

Figure 3-2: Typical GATB Human Data output report.

Injury Data

The Injury Data Report includes the HIC (Head Injury Criterion), HSI (Head Severity Index) and CSI (Chest Severity Index) results for each human: the HIC value with its time duration and average head resultant acceleration, the HSI value with the maximum head resultant acceleration and its time, and the CSI value with the maximum chest resultant acceleration and its time.

A typical Injury Data Report is shown in Figure 3-3.

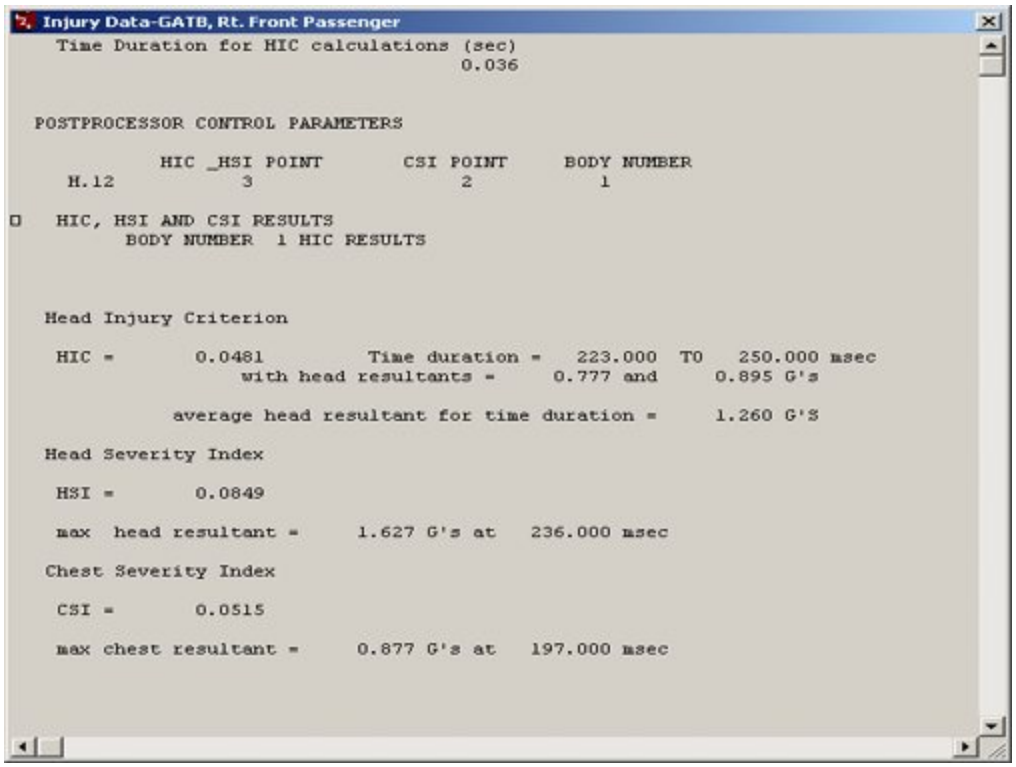


Figure 3-3: Typical GATB Injury Data output report.

Message

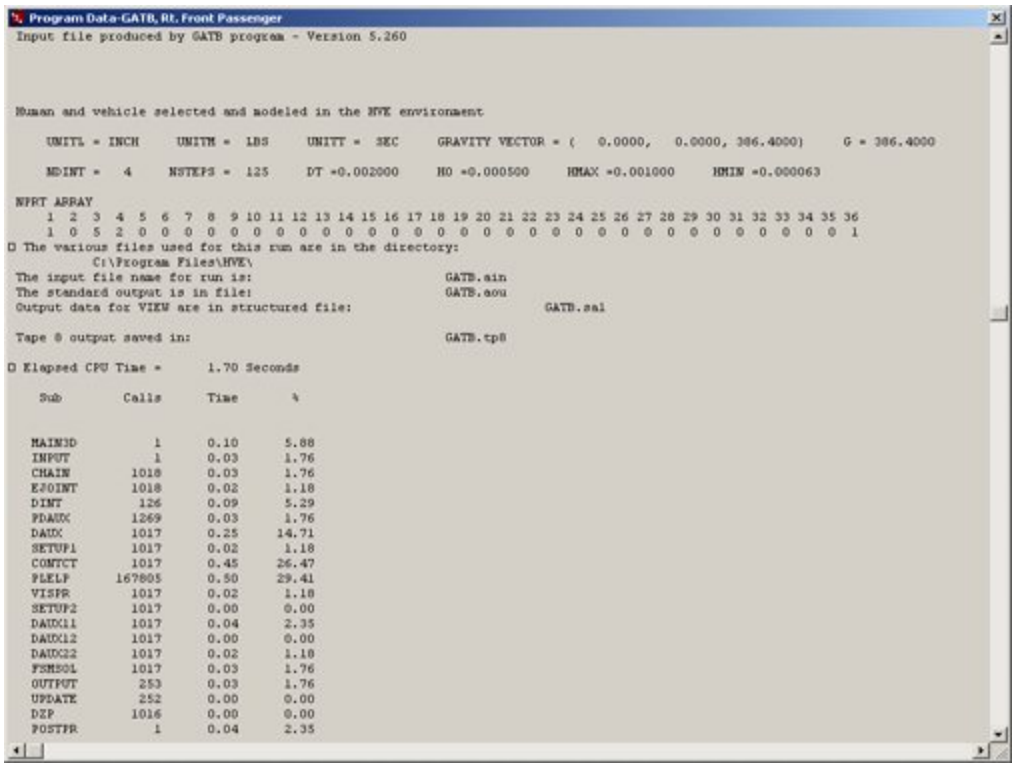
For a complete listing of messages issued by GATB, see Chapter 6, Messages.

Program Data

The Program Data Report includes the following information:

- **Simulation Controls** — Integration parameters used for the current event.
- **Collision Pulse** — The acceleration vs. time history for the current event.
- **Contacts** — A list of all human ellipsoid vs. vehicle contact surface interactions that were ignored for the current event.

A typical Program Data Report is shown in Figure 3-4. The report also lists the GATB program version, unit system, gravity vector, integration parameters (NDINT, NSTEPS, DT, H0, HMAX, HMIN), the NPRT print-control array, the working file names (gatb.ain input file, gatb.aou standard output, .sal structured output for VIEW, and tape 8 output), and a table of elapsed CPU time by subroutine.



Program Data-GATB, Rt. Front Passenger

```
 Input file produced by GATB program - Version 5.260



 Human and vehicle selected and modeled in the HVE environment

     UNITL = INCH     UNITM =  LBS     UNITT =  SEC     GRAVITY VECTOR = (   0.0000,   0.0000, 386.4000)     G = 386.4000

     MDINT =   4     NSTEPS =  125     DT =0.002000     H0 =0.000500     HMAX =0.001000     HMIN =0.000063

 NPRT ARRAY
     1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
     1  0  5  2  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1
 The various files used for this run are in the directory:
          C:\Program Files\HVE\
 The input file name for run is:                          GATB.ain
 The standard output is in file:                          GATB.aou
 Output data for VIEW are in structured file:                      GATB.sal

 Tape 8 output saved in:                                  GATB.tp8

 Elapsed CPU Time =      1.70 Seconds

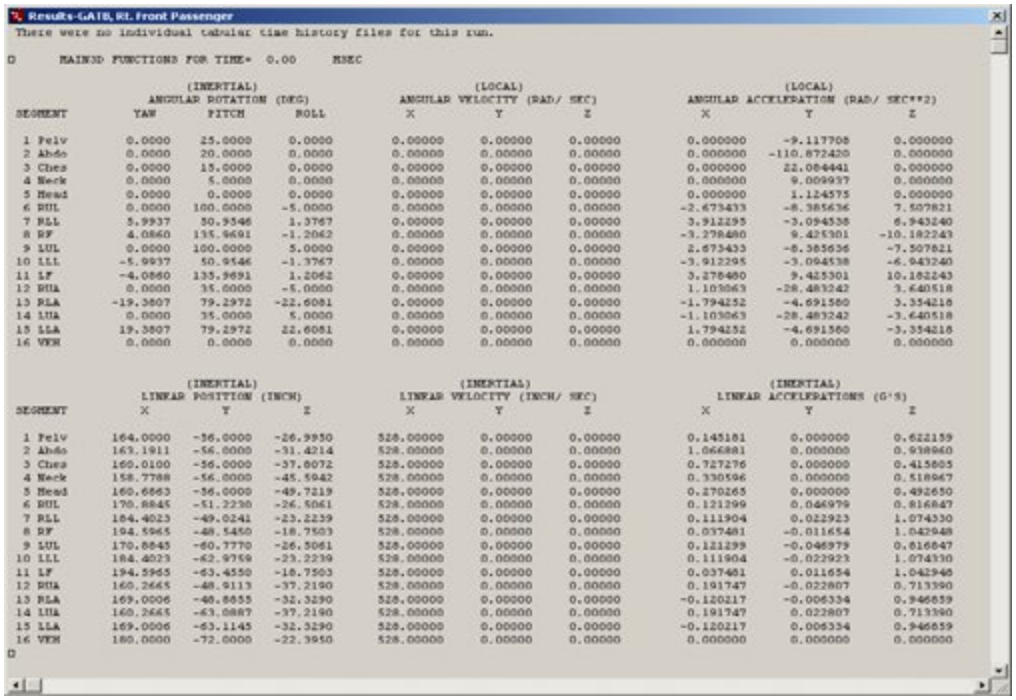
    Sub         Calls      Time       %


   MAIN3D           1      0.10      5.88
   INPUT            1      0.03      1.76
   CHAIN         1018      0.03      1.76
   EJOINT        1018      0.02      1.18
   DINT           126      0.09      5.29
   PDAUX         1269      0.03      1.76
   DAUX          1017      0.25     14.71
   SETUP1        1017      0.02      1.18
   CONTCT        1017      0.45     26.47
   PLELP       167805      0.50     29.41
   VISPR         1017      0.02      1.18
   SETUP2        1017      0.00      0.00
   DAUX11        1017      0.04      2.35
   DAUX12        1017      0.00      0.00
   DAUX22        1017      0.02      1.18
   FSMSOL        1017      0.03      1.76
   OUTPUT         253      0.03      1.76
   UPDATE         252      0.00      0.00
   DZP           1016      0.00      0.00
   POSTPR           1      0.04      2.35
```

Figure 3-4: Typical GATB Program Data output report.

Results

The Results Data Report includes tables containing human segment linear and angular positions, velocities, and accelerations, along with joint forces and torques. These tables are produced every 5 to 10 printout time intervals (i.e., output time interval = 0.002 sec; a table is produced every 10 to 20 msec, depending on maximum termination time selected). See Figure 3-5 for an example of a Results window.



Results-GATB, Rt. Front Passenger

```
 There were no individual tabular time history files for this run.

      MAIN3D FUNCTIONS FOR TIME=  0.00     MSEC

                          (INERTIAL)                                (LOCAL)                                   (LOCAL)
                  ANGULAR ROTATION (DEG)                  ANGULAR VELOCITY (RAD/ SEC)             ANGULAR ACCELERATION (RAD/ SEC**2)
 SEGMENT          YAW          PITCH          ROLL          X             Y             Z           X             Y             Z

   1 Pelv       0.0000       25.0000        0.0000      0.00000       0.00000       0.00000       0.000000     -9.117708      0.000000
   2 Abdo       0.0000       20.0000        0.0000      0.00000       0.00000       0.00000       0.000000   -110.872420      0.000000
   3 Ches       0.0000       15.0000        0.0000      0.00000       0.00000       0.00000       0.000000     22.084441      0.000000
   4 Neck       0.0000        5.0000        0.0000      0.00000       0.00000       0.00000       0.000000      9.009937      0.000000
   5 Head       0.0000        0.0000        0.0000      0.00000       0.00000       0.00000       0.000000      1.124575      0.000000
   6 RUL        0.0000      100.5000       -5.0000      0.00000       0.00000       0.00000      -2.673433     -8.385636      7.507821
   7 RLL        5.9937       50.9546        1.3767      0.00000       0.00000       0.00000       3.912295     -3.094538      6.943240
   8 RF         4.0860      135.9691       -1.2062      0.00000       0.00000       0.00000      -3.278480      9.425301    -10.182243
   9 LUL        0.0000      100.0000        5.0000      0.00000       0.00000       0.00000       2.673433     -8.385636      7.507821
  10 LLL       -5.9937       50.9546       -1.3767      0.00000       0.00000       0.00000      -3.912295     -3.094538     -6.943240
  11 LF        -4.0860      135.9691        1.2062      0.00000       0.00000       0.00000       3.278480      9.425301     10.182243
  12 RUA        0.0000       35.0000       -5.0000      0.00000       0.00000       0.00000       1.103063    -28.483242      3.640518
  13 RLA      -19.3807       79.2972      -22.6081      0.00000       0.00000       0.00000      -1.794252     -4.691580      3.354218
  14 LUA        0.0000       35.0000        5.0000      0.00000       0.00000       0.00000      -1.103063    -28.483242     -3.640518
  15 LLA       19.3807       79.2972       22.6081      0.00000       0.00000       0.00000       1.794252     -4.691580     -3.354218
  16 VEH        0.0000        0.0000        0.0000      0.00000       0.00000       0.00000       0.000000      0.000000      0.000000

                          (INERTIAL)                                (INERTIAL)                                (INERTIAL)
                  LINEAR POSITION (INCH)                  LINEAR VELOCITY (INCH/ SEC)             LINEAR ACCELERATIONS (G'S)
 SEGMENT          X             Y             Z           X             Y             Z           X             Y             Z

   1 Pelv     164.0000      -56.0000      -26.9950    528.00000       0.00000       0.00000       0.145181      0.000000      0.622159
   2 Abdo     163.1911      -56.0000      -31.4214    528.00000       0.00000       0.00000       1.066881      0.000000      0.938960
   3 Ches     160.0100      -56.0000      -37.8072    528.00000       0.00000       0.00000       0.727276      0.000000      0.415805
   4 Neck     158.7788      -56.0000      -45.5942    528.00000       0.00000       0.00000       0.330596      0.000000      0.518967
   5 Head     160.6863      -56.0000      -49.7219    528.00000       0.00000       0.00000       0.270265      0.000000      0.492650
   6 RUL      170.8845      -51.2230      -26.5061    528.00000       0.00000       0.00000       0.121299      0.046979      0.816847
   7 RLL      184.4023      -49.0241      -23.2239    528.00000       0.00000       0.00000       0.111904      0.022923      1.074330
   8 RF       194.5965      -48.5450      -18.7503    528.00000       0.00000       0.00000       0.037481     -0.011654      1.042948
   9 LUL      170.8845      -60.7770      -26.5061    528.00000       0.00000       0.00000       0.121299     -0.046979      0.816847
  10 LLL      184.4023      -62.9759      -23.2239    528.00000       0.00000       0.00000       0.111904     -0.022923      1.074330
  11 LF       194.5965      -63.4550      -18.7503    528.00000       0.00000       0.00000       0.037481      0.011654      1.042948
  12 RUA      160.2665      -48.9113      -37.2190    528.00000       0.00000       0.00000       0.191747     -0.022807      0.713390
  13 RLA      169.0006      -48.8655      -32.3290    528.00000       0.00000       0.00000      -0.120217     -0.006334      0.946859
  14 LUA      160.2665      -63.0887      -37.2190    528.00000       0.00000       0.00000       0.191747      0.022807      0.713390
  15 LLA      169.0006      -63.1145      -32.3290    528.00000       0.00000       0.00000      -0.120217      0.006334      0.946859
  16 VEH      180.0000      -72.0000      -22.3950    528.00000       0.00000       0.00000       0.000000      0.000000      0.000000
```

Figure 3-5: Example of GATB Results output report.

Vehicle Data

The Vehicle Data Report includes the following information:

- **Contact Surface Properties** — Name, elastic and damping properties, penetration limit, edge constant, maximum force, unloading slope, and relative initial position of the human with respect to the contact surface.
- **Contact Surface Location** — Name and corner coordinates for each contact surface.
- **Belt Restraints** — If in use, this section displays the name, location, and mechanical properties for each installed belt segment. In addition, this section also displays the human attachment point and initial belt slack.
- **Airbag Restraints** — If in use, this section displays the location, mechanical, and thermodynamic properties of the airbag, as well as its deployment time and fill duration.

A typical Vehicle Data report is shown in Figure 3-6.

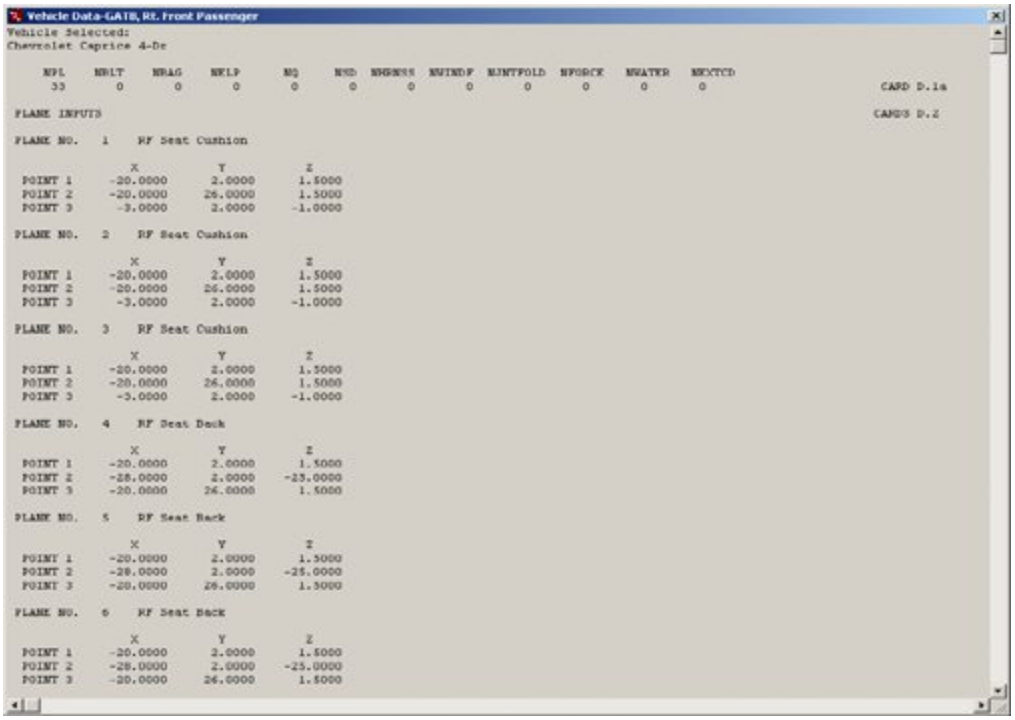


Figure 3-6: Typical GATB Vehicle Data output report.

Variable Output Table

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

Human Output Groups

Parameter	Description
Human Kinematic Data (for Hip, Head, and Leg segments)	x, y, z coordinates; ϕ, θ, ψ angles; total velocity, fwd, side, vert components; $\dot{\phi}, \dot{\theta}, \dot{\psi}$ angular velocities; total acceleration, fwd, side, vert components; $\ddot{\phi}, \ddot{\theta}, \ddot{\psi}$ angular accelerations (see note below).
Joint Data (for Neck and Hip joints)	ϕ, θ, ψ joint articulation angles; ϕ, θ, ψ joint elastic moments.

Table 3-2: Human Variable Output Data

> **NOTE:** For humans, the human segment kinematics are defined relative to the vehicle-fixed coordinate system.

- **Human Kinematics** — Position, velocity, acceleration, and kinetic energy for each human segment.
- **Joints** — Articulation angles and torques for the Neck and Hip joints.
- **Contacts** — Contact force, deflection, and x, y contact coordinate for each human ellipsoid vs. vehicle contact impingement.
- **Belts** — Belt tension and stretch for each belt segment.
- **Airbag** — Airbag pressure, radius, contact force, and deflection.

Vehicle Output Groups

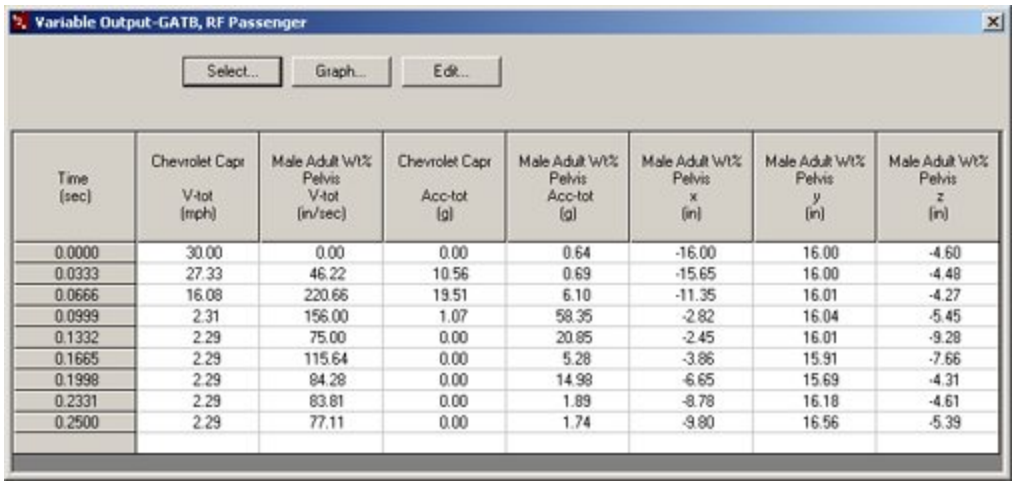
Parameter	Description
Vehicle Kinematic Data	x, y, z coordinates; ϕ, θ, ψ orientation; total linear velocity, u, v, w components; sideslip, course angles; p, q, r angular velocity; total linear acceleration, fwd, side, vert components; $\dot{u}, \dot{v}, \dot{w}$ linear components; $\dot{p}, \dot{q}, \dot{r}$ angular components.
Wheel Data	x, y, z location of each wheel.

Table 3-3: Vehicle Variable Output Data

- **Vehicle Kinematics** — Position, velocity, and acceleration for the vehicle.
- **Wheel** — The position of each wheel (required only to visualize the wheels during an event; not used in the calculations).
- **Contacts** — Contact force, deflection, and x, y contact coordinate for each human ellipsoid vs. vehicle contact impingement.
- **Belts** — Belt tension and stretch for each belt segment.
- **Airbag** — Airbag pressure, radius, contact force, and deflection.

> **NOTE:** The Contacts, Belts, and Airbag results for Human and Vehicle output groups are identical (Newton's 3rd law at work!)

An example of a Variable Output table is shown in Figure 3-7. A detailed listing of each Variable Output parameter produced by GATB is found in Tables 3-2 and 3-3.



Time (sec)	Chevrolet Capr V-tot (mph)	Male Adult Wt% Pelvis V-tot (in/sec)	Chevrolet Capr Acc-tot (g)	Male Adult Wt% Pelvis Acc-tot (g)	Male Adult Wt% Pelvis x (in)	Male Adult Wt% Pelvis y (in)	Male Adult Wt% Pelvis z (in)
0.0000	30.00	0.00	0.00	0.64	-16.00	16.00	-4.60
0.0333	27.33	46.22	10.56	0.69	-15.65	16.00	-4.48
0.0666	16.08	220.66	19.51	6.10	-11.35	16.01	-4.27
0.0999	2.31	156.00	1.07	58.35	-2.82	16.04	-5.45
0.1332	2.29	75.00	0.00	20.85	-2.45	16.01	-9.28
0.1665	2.29	115.64	0.00	5.28	-3.86	15.91	-7.66
0.1998	2.29	84.28	0.00	14.98	-6.65	15.69	-4.31
0.2331	2.29	83.81	0.00	1.89	-8.78	16.18	-4.61
0.2500	2.29	77.11	0.00	1.74	-9.80	16.56	-5.39

Figure 3-7: Example of Variable Output report.

Trajectory Simulations

GATB produces a trajectory simulation of the current event. The trajectory simulation is a 3-D visualization of the data displayed in the Variable Output table (see previous section).

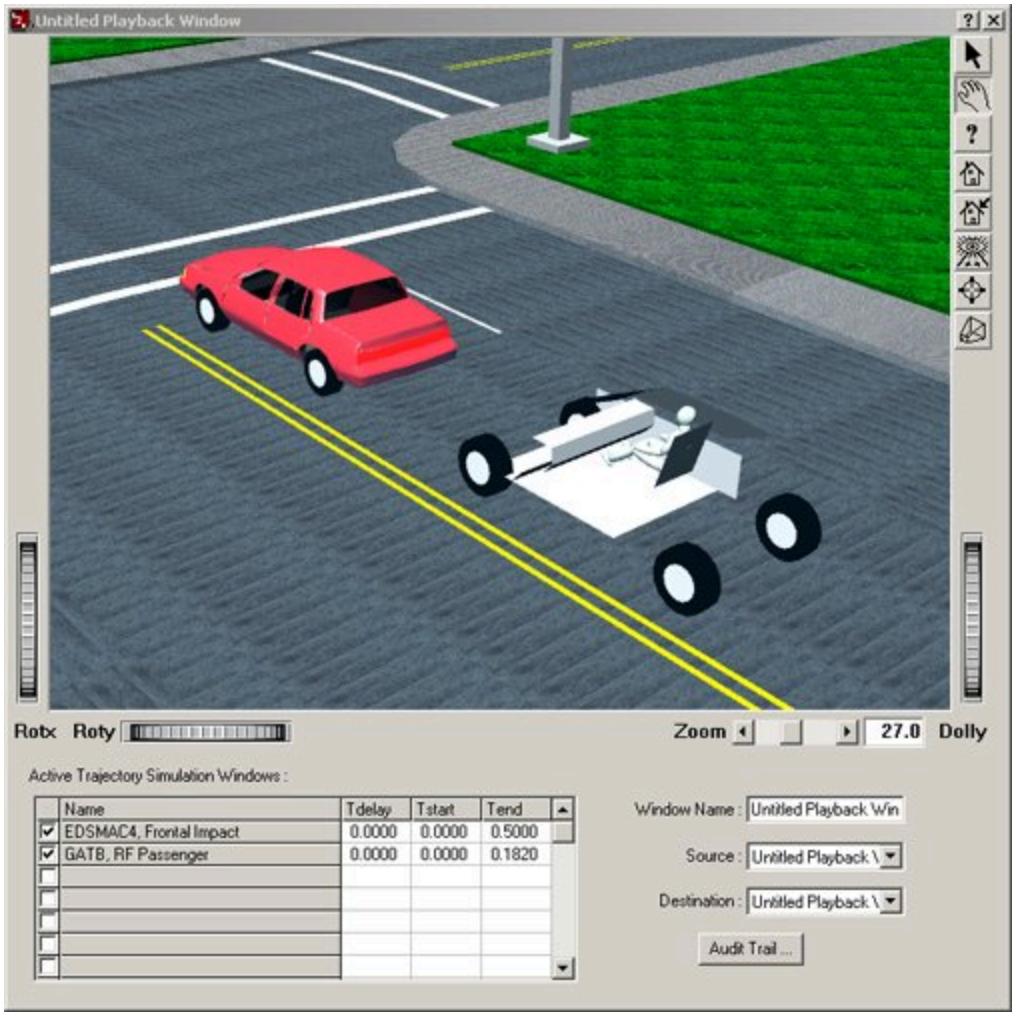


Figure 3-8: Example of Trajectory Simulation graphical view.

Displaying a Trajectory Simulation

The Trajectory Simulation is controlled using the Playback Controller (see Figure 3-9). The Playback Controller's buttons have the following functions:

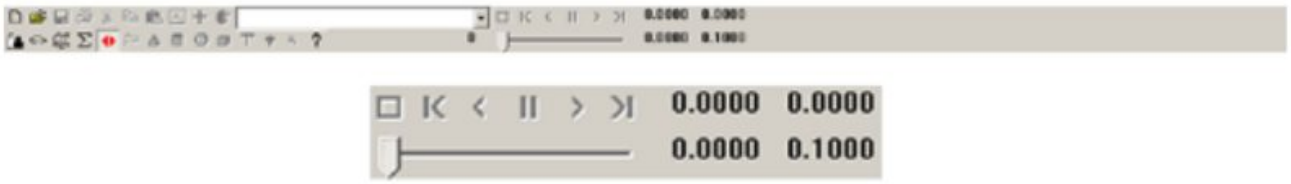


Figure 3-9: Playback controller buttons.

- **Reset** — Returns to the start of the simulation and reinitializes the video output device (this applies a hardware reset and is otherwise the same as the Rewind to Start button, below).
- **Rewind to Start** — Return to the start of the simulation.
- **Reverse** — Play the simulation backwards.
- **Pause** — Pause the simulation.
- **Execute** — Execute the event or play the simulation forwards.
- **Advance to End** — Advance to the end of the simulation.

> **NOTE:** The Playback Controller also includes additional features used for creating video. Refer to the HVE Operations Manual, Playback Editor, and Video Output sections for further details.

Chapter 4 — Calculation Method

(This section was marked "to be added" in the printed Fifth Edition manual. The summary below is drawn from Chapter 1 and from the behavior of the current GATB release.)

Overview of the GATB Calculation Pipeline

GATB is a graphical HVE front-end for the ATB (Articulated Total Body) rigid-body dynamics program (this version is based upon ATB-V.1, June 1998). The calculation proceeds as follows:

1. **Data extraction** — GATB extracts the human, vehicle, environment and event data from HVE and writes a complete ATB input file (`gatb.ain`), automatically selecting the appropriate ATB options, card images (A-, B-, C-, D-, F- and H-cards), contact panels, belt/harness and airbag data.
2. **ATB solution** — The embedded ATB solver integrates the equations of motion of the 15-segment, 14-joint articulated body. Segment-vs-panel, segment-vs-segment, belt and airbag forces are evaluated each time step. GATB always uses a fixed ATB integration time step of 0.002 sec, which it writes into the time-step field of the A4 card; the number of steps is the maximum simulation time divided by 0.002. The other values on the A4 card (.00050, .00100, .0000625) are ATB minimum-time-step and print/integration-control fields — the .00050 is *not* a "human-collision" step. Within each step the integration is handled by the variable-step Runge-Kutta/predictor-corrector integrator internal to ATB.
3. **Output return** — The solver's standard output (`gatb.aou`), structured output (`.sal`) and time-history (tape 8) files are read back and converted into the HVE reports described in Chapter 3 (Accident History, Human Data, Injury Data, Program Data, Results, Vehicle Data, Variable Output and Trajectory Simulation).

The human model is the HVE human data set: 15 mass segments, each with up to 3 contact ellipsoids, connected by 14 joints (up to 4 joints attach to a single segment). Injury measures (HIC, HSI, CSI) are computed by the ATB post-processor.

What GATB computes, and what ATB computes

The division is worth being explicit about, because it determines where to look when a result is questioned.

ATB computes all of the physics: the equations of motion of the articulated body, the joint models, the segment-versus-panel and segment-versus-segment contact forces, and the harness and airbag models. None of that is GATB's, and none of it is described in this manual — see the CVS/ATB documentation.

GATB computes the translation from HVE's data model into ATB's. Most of that translation is a direct transfer of a value from one place to another, with unit conversion where the two differ — ATB takes angles in degrees, for instance, where HVE stores them in radians. A few quantities, however, are genuinely constructed by GATB, and those are given below because they are not recoverable from either program's documentation alone.

Contact panels

An HVE contact surface is stored as three corner points. ATB expects a panel expressed as semi-axis lengths, so GATB forms them from the edge lengths:

$$a = \frac{|\mathbf{P}_3 - \mathbf{P}_2|}{2}, \qquad b = \frac{|\mathbf{P}_1 - \mathbf{P}_2|}{2}$$

> **NOTE:** The panel's third semi-axis — its thickness — is not derived from the HVE surface. It is set to a fixed 2 inches for every panel. A contact surface whose real thickness differs substantially from that will behave accordingly in the ATB contact model.

The lap belt contact ellipsoid

ATB applies a lap belt against a contact ellipsoid, and HVE's human carries no such ellipsoid. Where a lap belt is in use, GATB synthesizes one from the segments either side of it: the two transverse semi-axes are taken from the abdomen ellipsoid, and the vertical semi-axis is twice that of the pelvis ellipsoid:

$$a = a_{Abdomen}, \qquad b = b_{Abdomen}, \qquad c = 2\,c_{Pelvis}$$

It is centred on the pelvis ellipsoid, offset downward by the pelvis semi-axis:

$$z = z_{Pelvis} - c_{Pelvis}$$

The result is a single ellipsoid spanning the abdomen and pelvis, which is what the lap belt bears against. It exists only for the belt calculation and is not part of the human's own contact geometry.

Integration timestep

GATB always writes a fixed ATB integration timestep of 0.002 sec, and the number of steps is the maximum simulation time divided by it. Within each step, ATB's own variable-step Runge-Kutta/predictor-corrector integrator controls the solution.

For the underlying theory of the ATB model — the equations of motion, joint models, contact force model and restraint (harness and airbag) models — see the four-volume CVS/ATB documentation and the ATB-V.1 documentation listed in Chapter 7, Technical References.

Chapter 5 — Tutorial

This tutorial provides examples illustrating two common applications of GATB: occupant modeling and pedestrian modeling.

Creating GATB events involves the following basic steps:

- Create the humans.
- Create the vehicles.
- Create the environment.
- Create and execute the GATB event.

Once the event has been executed, output reports can be viewed in the Playback Editor. These reports were discussed in Chapter 3, Program Output.

The basic procedure for creating GATB events is described in detail in this tutorial.

> **NOTE:** It is assumed that HVE is up and running, and that the user is familiar with HVE's basic features. The purpose of this tutorial is to illustrate these features while setting up and executing a GATB event.
>
> **NOTE:** Environments are not required in the creation of a GATB event and are not discussed here. Review the HVE Operations Manual if you have questions regarding the creation of environments.

*(Updated: the dialogs referenced below — Human Information, Vehicle Information, Contact Surfaces, Position/Velocity, Collision Pulse, Contact Interactions, Simulation Controls — are the current HVE dialogs. The human-creation dialog is now the GEBOD-based **Human Information** dialog documented under Humans dialog reference. The workflow below matches the current release; only cosmetic dialog details may differ from the Fifth Edition screenshots.)*

Getting Started

The first step is to set the user parameters.

> **NOTE:** Most options simply affect the appearance in a viewing window during Event or Playback mode. However, some options affect the data used in the analysis. For example, if AutoPosition is On, the vehicle position conforms to the local surface; otherwise, the position is set by the Position/Velocity dialog.
>
> **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:

- Show Key Results
- Hide Axes
- Show Contacts
- Show Belt Anchors
- Hide Velocity Vectors
- Show Skid marks

- Hide Targets
- Turn AutoPosition On
- Units equals US
- Hide Grid

Render Options:

- Show Humans and Vehicles as Actual.
- Phong Render Shading Mode.
- Complexity equals Object.
- Render Quality equals 5.
- Texture Quality equals 1.
- Anti-Aliasing equals 1.

Set Playback to 0.0333 sec.

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

Occupant Simulation Tutorial

Creating the Humans

To create the human occupant in the collision, perform the following steps:

- If the HVE Human Editor is not the current editor, choose Human Mode by clicking the Human Mode button on the tool bar.

First, let's add the human occupant to the case.

- Click on the (+) sign in the tool bar to add a human. The **Human Information** dialog is displayed. The Human Information dialog includes option buttons allowing the user to select a seat position within the vehicle (alternatively, Pedestrian could be selected), and assign the human's attributes according to Sex, Age, Weight Percentile, and Height Percentile.

Use the option buttons to choose the following human attributes (Figure 5-1):

- Location = Front, Right
- Sex = Male
- Age = Adult
- Weight Percentile = 50
- Height Percentile = 5

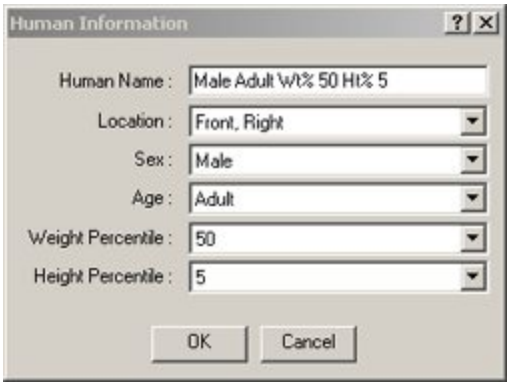


Figure 5-1: Human Information dialog.

> **NOTE:** The passenger's position is assumed to be on the right side of the vehicle.
>
> **NOTE:** Notice the human comes into the editor in a seated position. If Pedestrian had been selected as the Location for the human, then the human would appear in a standing position.
>
> *(Updated: in the current release the human is created through the GEBOD Human Information dialog. Subject Type may be Child, Female, Male or User, and the Basis of the anthropometry may be set to Age, Weight, Height or All. The Location/Sex/Age/Weight-Percentile/Height-Percentile choices used in this tutorial map onto that dialog. See the human-creation documentation under Humans dialog reference for the full set of current controls.)*
>
> **NOTE:** If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateHuman` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Creating the Vehicles

Now that we have our human, let's add our vehicles.

- Choose Vehicle Mode by clicking on the Vehicle Mode button on the tool bar. The Vehicle Editor is displayed.
- Click the (+) sign on the tool bar to add a vehicle. 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 affect the basic vehicle configuration and do not need to be changed for our tutorial.

Using the Option buttons, click each button to choose the following vehicle from the database:

- Type = Passenger Car
- Make = Buick
- Model = Skylark
- Year = 1985-1991
- Body Style = 4-Door
- Click OK to add Buick Skylark 4-Dr to the active vehicles list.
- Manipulate the view in the 3D viewing window to appear similar to that in Figure 5-2.

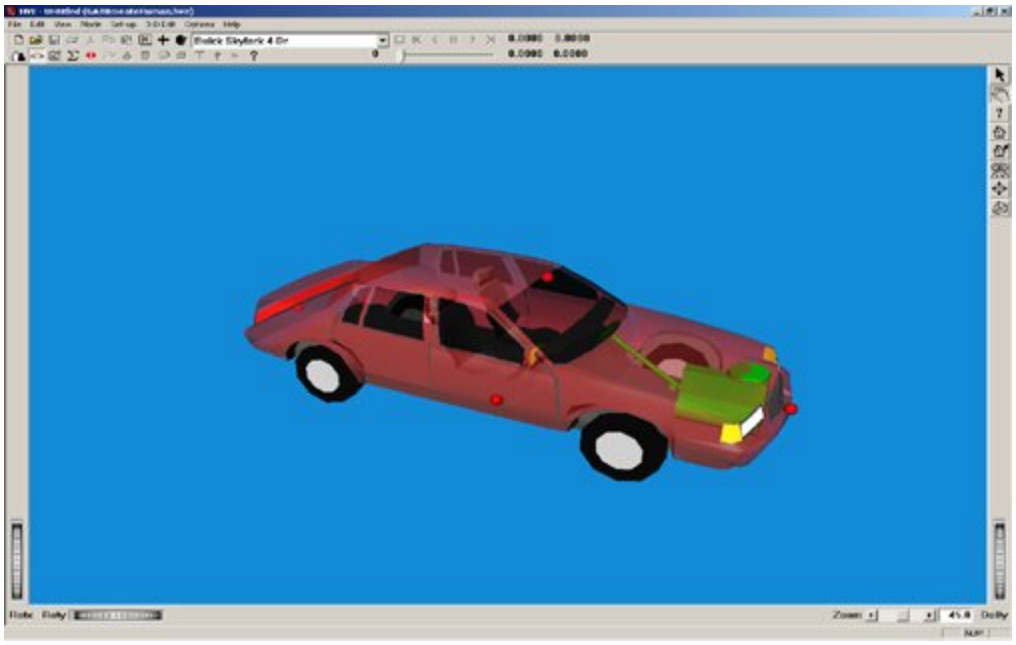


Figure 5-2: View of Buick Skylark.

> **NOTE:** This view is in the 2 o'clock position (the camera is at the right front corner of the vehicle, approximately 10-15 degrees above the XY plane), making the vehicle clearly visible. Now, let's add the second vehicle involved in our collision for this tutorial.

- Click the (+) sign on the tool bar to add another vehicle.

Using the Option buttons, click each button to choose the following vehicle from the database:

- Type = Passenger Car
- Make = Chevrolet
- Model = Caprice
- Year = 1991-1997
- Body Style = 4-Door
- Click OK to add Chevrolet Caprice 4-Dr to the active vehicles list.
- Manipulate the view in the 3D viewing window to appear similar to that in Figure 5-3.

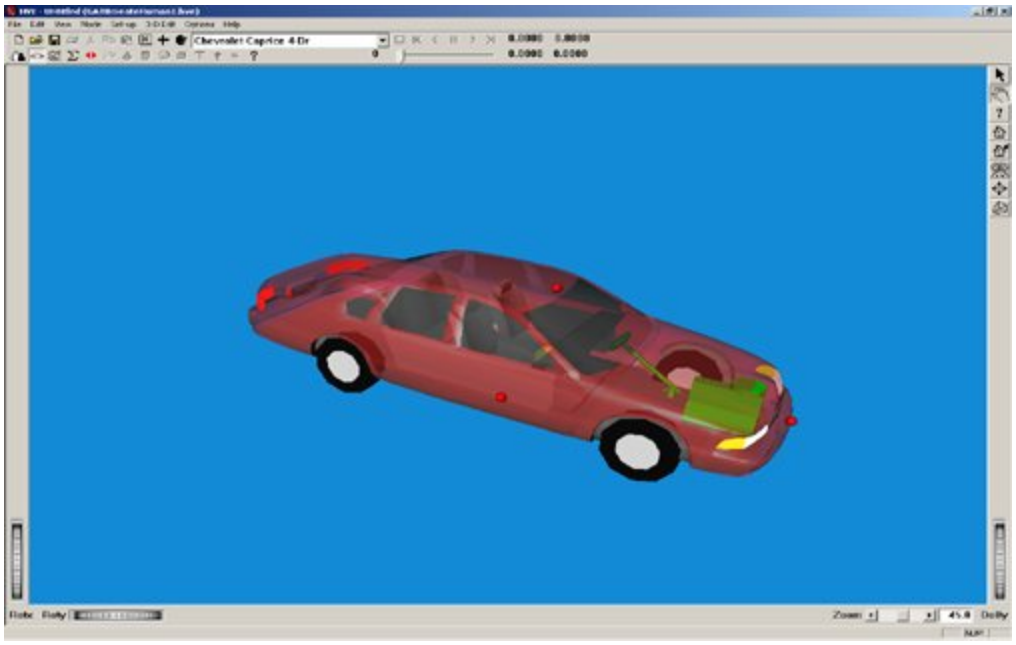


Figure 5-3: View of Chevrolet Caprice.

- Next, with the hand manipulator selected from the right toolbar, move the camera position closer to the vehicle by pushing the left and middle mouse buttons at the same time. Alternatively, use the dolly thumb wheel located on the right lower portion of the viewer to slowly move closer to the vehicle until you are just inside the outer shell or mesh of the vehicle. Your view will look similar to Figure 5-4.

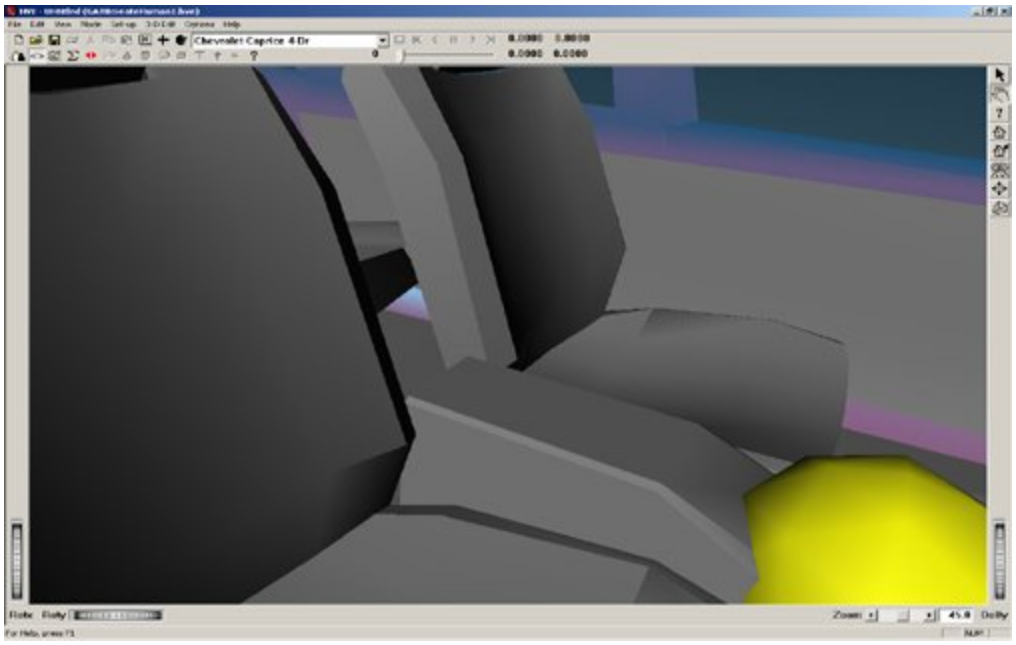


Figure 5-4: Close-up view of vehicle interior.

- Adjust the zoom slider located on the bottom right portion of the viewing window, or enter a number of approximately 100, to generate a wide angle view inside the vehicle similar to Figure 5-5.

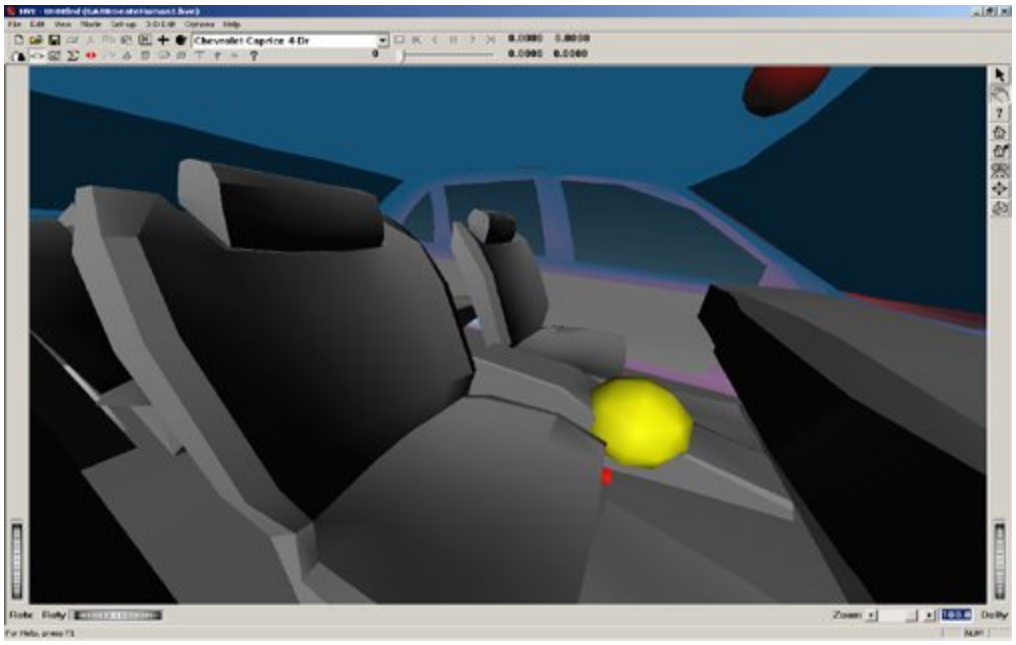


Figure 5-5: Close-up, wide-angle view of vehicle interior.

> **NOTE:** If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateVehicles` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Contact Panels

The contact panels will be entered for the right front seat position in this Chevrolet Caprice. This can be done using numerical values from the computer mesh if it has been measured in a CAD package such as AutoCAD. AutoCAD can be used to examine the mesh and extract detailed measurements of the interior, or it can be done visually, which is the way we will proceed in this tutorial. We will first position a contact panel for the seat cushion on the right front seat.

- Select the pointer mouse icon from the right toolbar.
- Click on the yellow ball representing the vehicle's center of mass.
- Select Contact Surfaces. This brings up the Contact Surfaces dialog box (Figure 5-6).
- Click on Add to add a contact surface.
- Enter the name `RF Seat Cushion`. Hit Enter.

> **NOTE:** One of the options available on the Contact Surfaces dialog box is the Material properties button. For the purposes of this tutorial, the default material will be used for all surfaces (Figure 5-7).

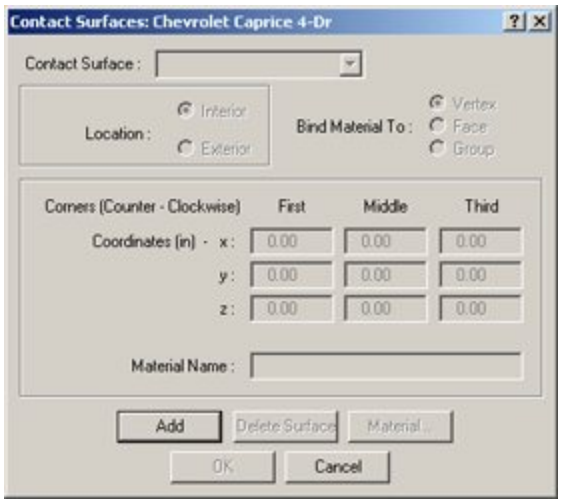


Figure 5-6: Contact Surfaces dialog in Vehicle Editor.

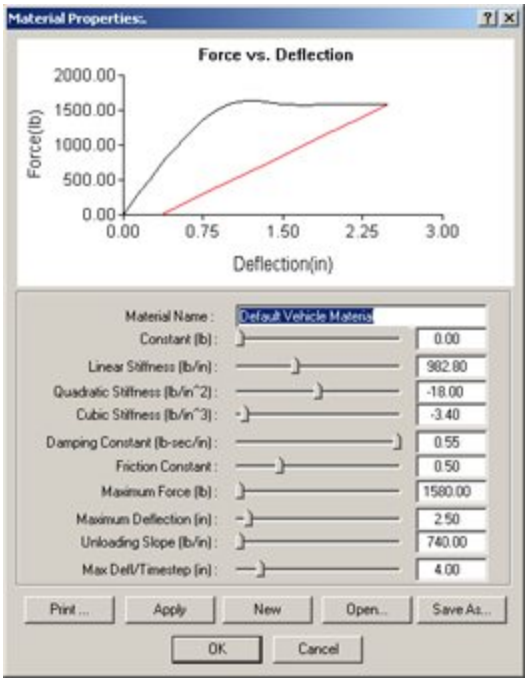


Figure 5-7: Material Properties dialog in Vehicle Editor.

> **NOTE:** The material values may not be exactly the same, but choose the default material.

To create the surface for the right front seat cushion, the following three points generate a surface with the correct orientation when viewed from the top:

Corner (selection order)	x (in)	y (in)	z (in)
Left front corner of seat (First)	-2	2	-2
Left rear corner of seat (Second)	-18	2	1
Right rear corner of seat (Third)	-18	22	1

See Figures 5-8 and 5-9.

- Click OK to accept the coordinates for this contact surface.

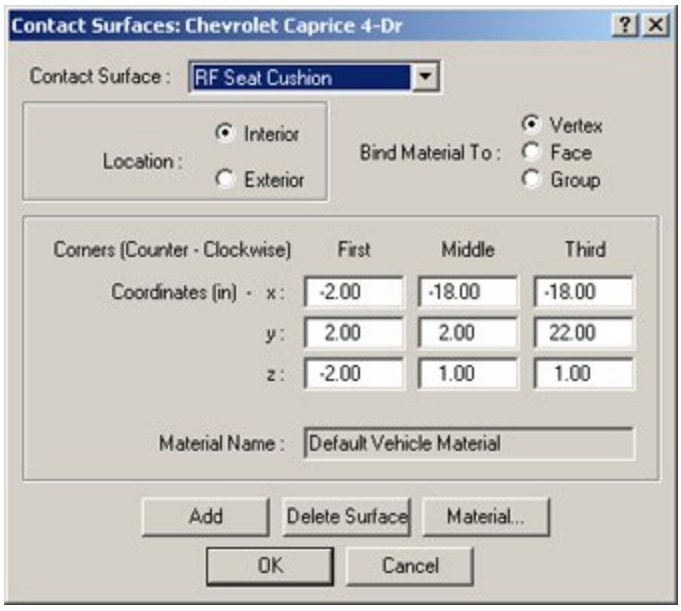


Figure 5-8: Setting up RF Seat Cushion contact surface.

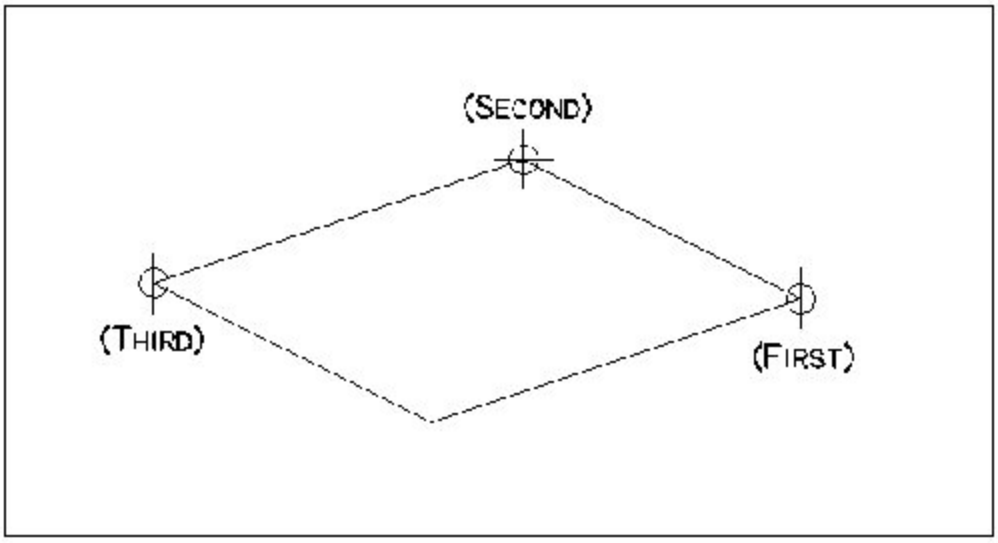
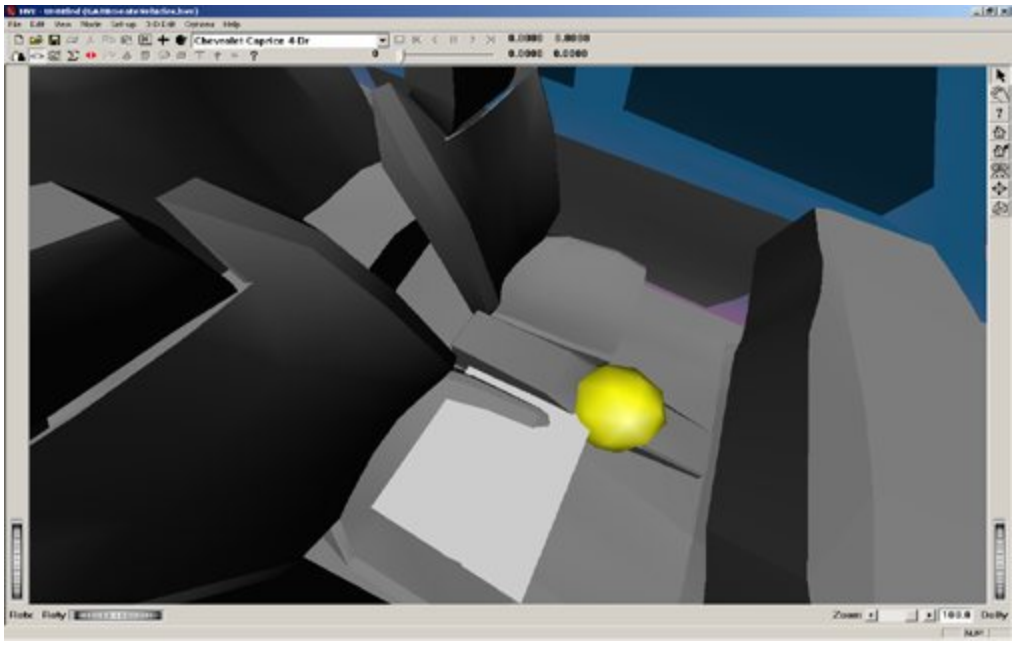
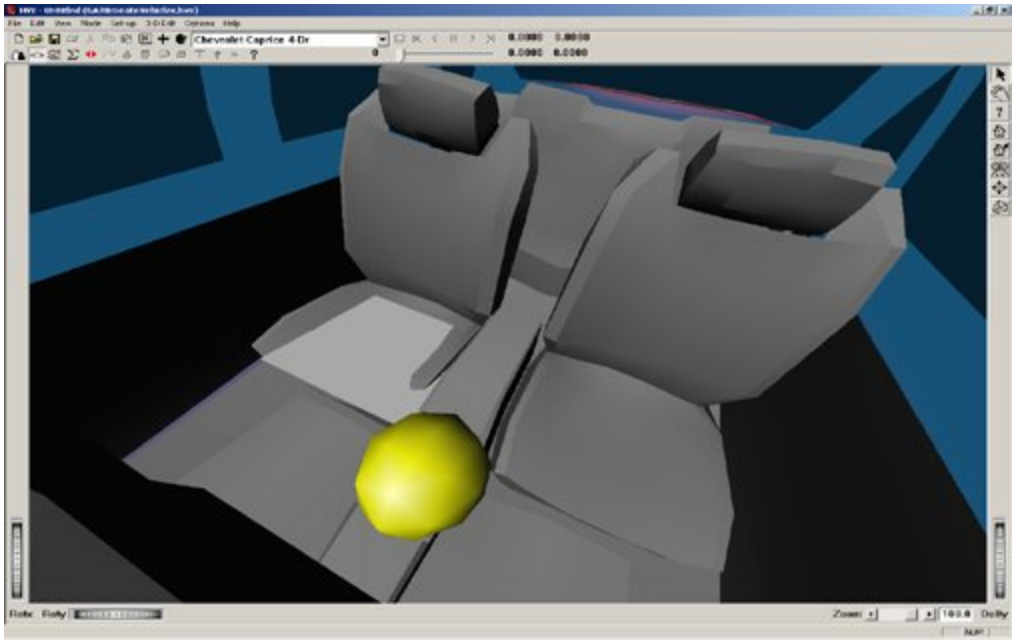


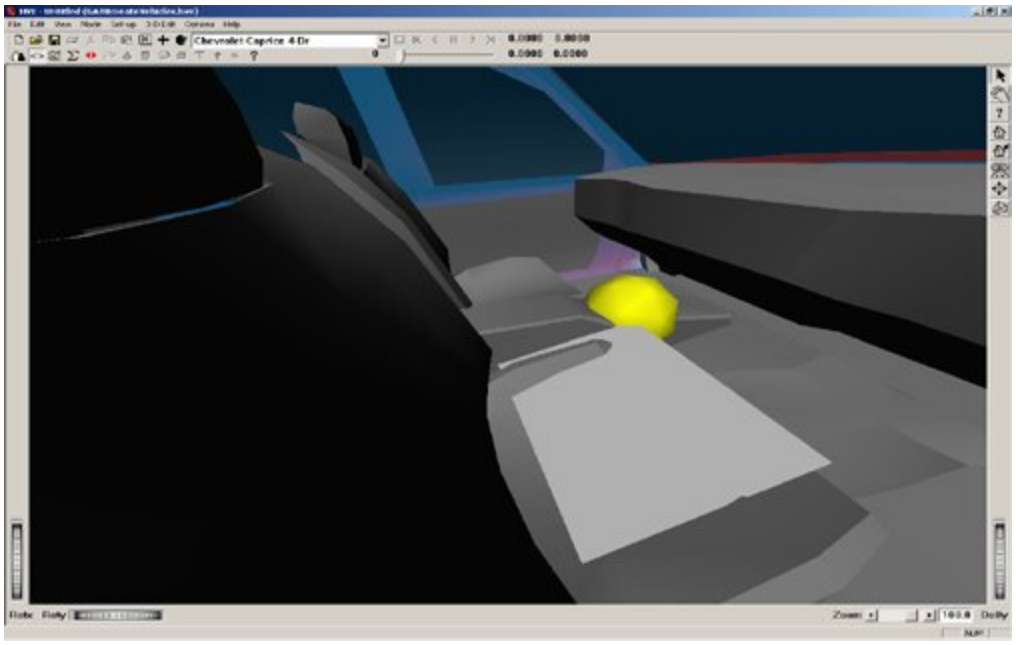
Figure 5-9: Contact Surface corners and selection order.

> **NOTE:** Figure 5-9 depicts the proper order for entering the corner coordinates. These corners must be entered in a counter-clockwise order in order to create the positive side of the surface facing upward. The positive side of the surface is the side of the surface that will be pushing the object.
>
> **NOTE:** There are other combinations that would produce a correctly oriented contact panel.

See Figures 5-10 through 5-12 for differing views of the contact panel just created.







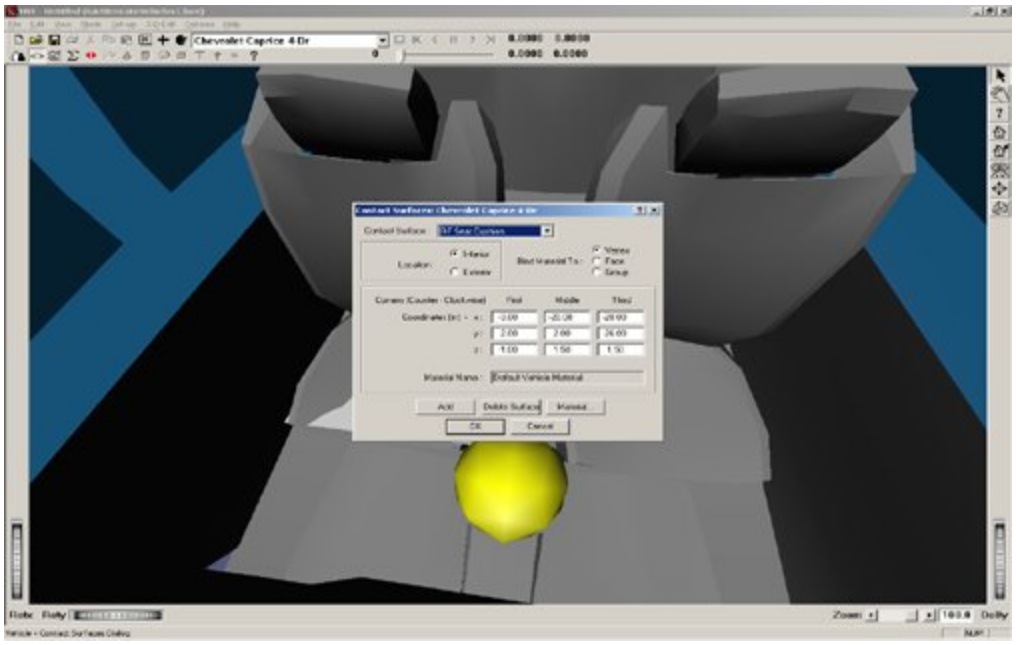
Figures 5-10 through 5-12: Views of RF Seat Cushion contact surface.

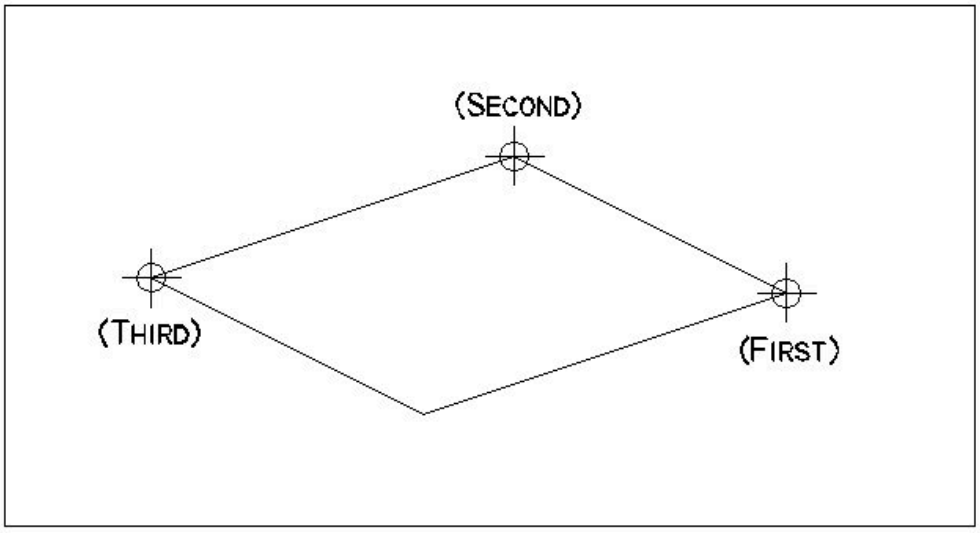
It is obvious that this first attempt at making the Right Front Seat Cushion contact panel creates a surface that is too narrow and does not extend rearward enough. This panel is also slightly above the seat cushion. By modifying one of the corner positions at a time, the correct seat panel can be determined visually.

Adjust the following corner coordinates to make the panel appear similar to Figure 5-15:

Corner (selection order)	**x (in)**	**y (in)**	**z (in)**
Left front corner of seat (First)	-3	2	-1
Left rear corner of seat (Second)	-20	2	1.5
Right rear corner of seat (Third)	-20	26	1.5

- Click OK to accept the coordinates for this contact surface.





Figures 5-13 and 5-14: Editing RF Seat Cushion contact surface and corner points.

The visualization of the contact panel is shown in Figure 5-15. You can see that the flat contact panel does an adequate job of approximating the complex surface geometry of the seat cushion.

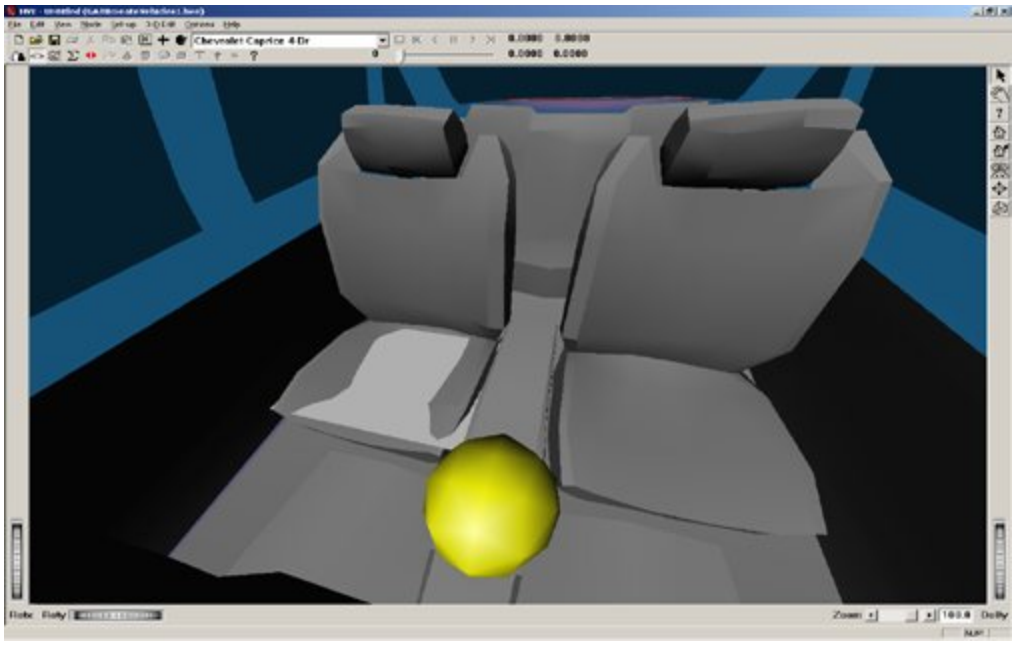


Figure 5-15: Revised RF Seat Cushion contact surface.

Create the remaining contact panels in the same manner as the Right Front Seat Cushion panel. The names and coordinates for the remaining panels are given in Table 5-1.

Table 5-1: List of Contact Surface corner points

Name	Coord	First	Middle	Third	Material
RF Seat Back	X	-20.0	-20.0	-28.0	Default Vehicle
	Y	26.0	2.0	2.0	
	Z	1.5	1.5	-25.0	
Floor	X	45.0	-30.0	-30.0	Default Vehicle
	Y	-32.0	-32.0	32.0	
	Z	8.5	8.5	8.5	
Toe Pan	X	34.0	30.0	30.0	Default Vehicle
	Y	-32.0	-32.0	32.0	
	Z	2.0	8.5	8.5	
Rt. Side	X	44.0	44.0	-40.0	Default Vehicle
	Y	32.0	32.0	32.0	
	Z	-12.0	8.5	8.5	

> **NOTE:** The 3 points entered for each contact surface define a parallelogram contact surface. For example, the side window contact surface in this example is not rectangular in shape.
>
> **NOTE:** The GATB program will not calculate a force if the contact occurs in the areas of no contact demonstrated in Figure 5-16.

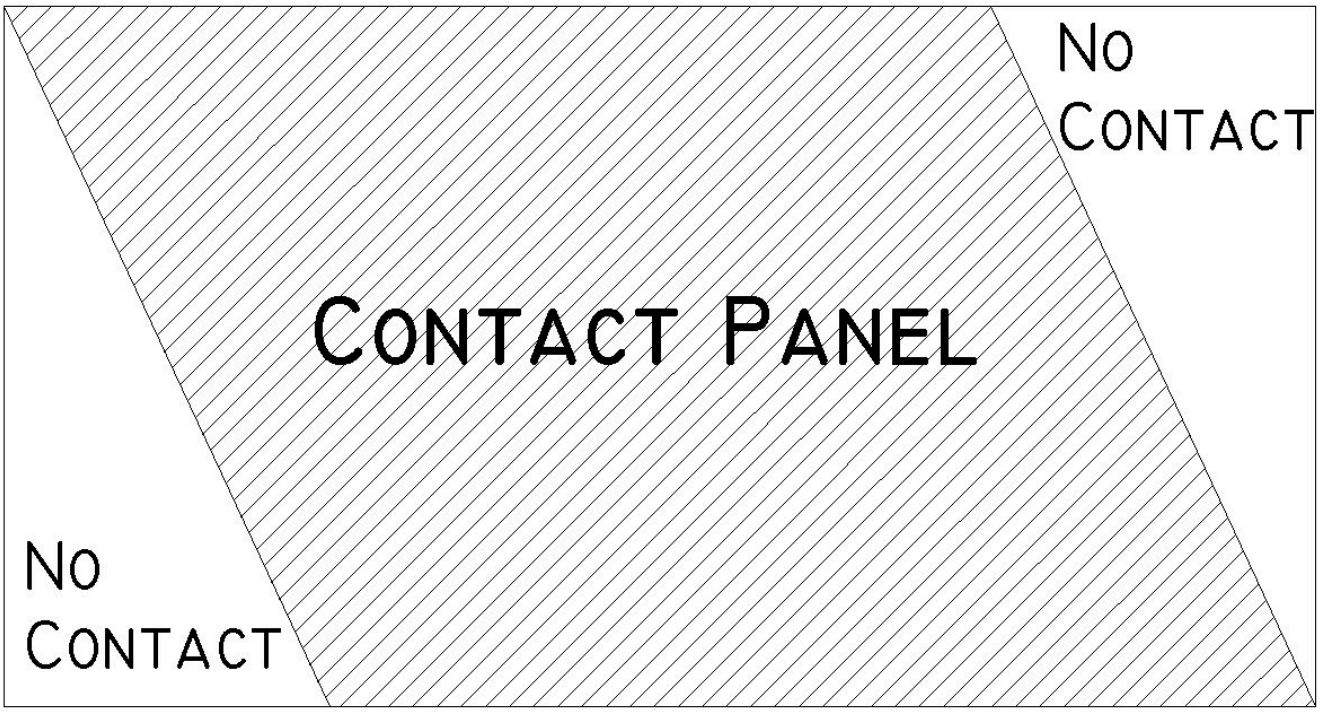
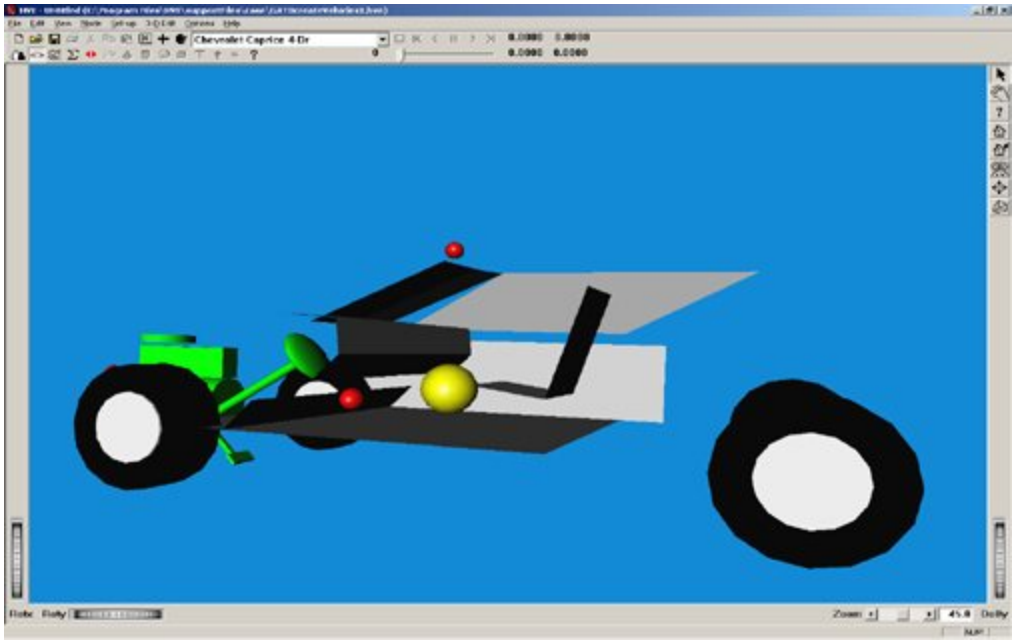
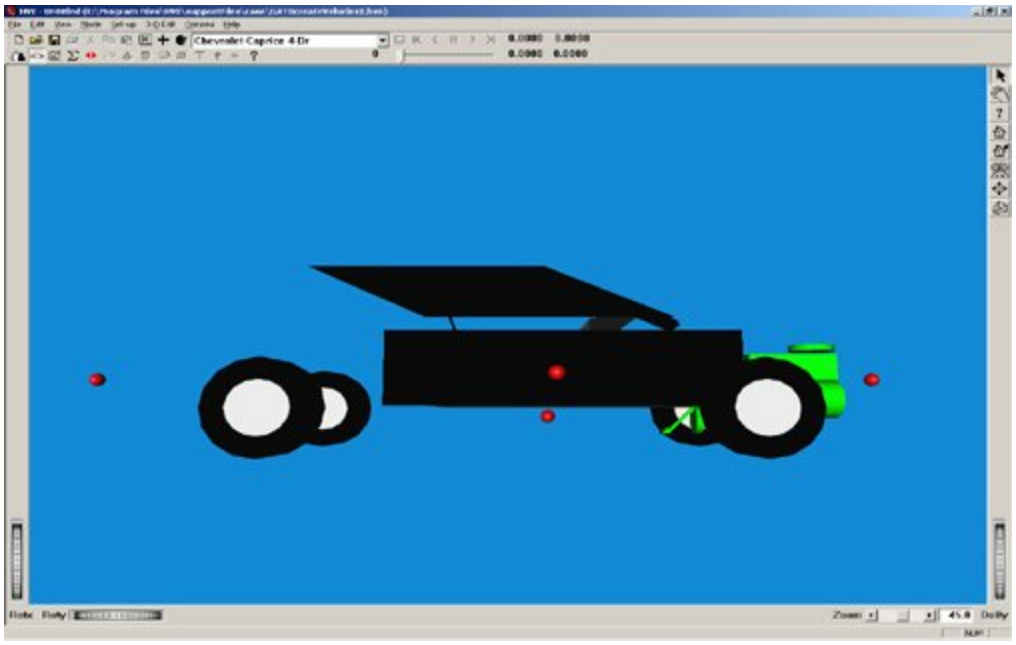


Figure 5-16: Parallelogram contact surface.

For purposes of illustrating the contact panels we have set the vehicle geometry to `NoBody.h3d`. Two different views of these completed contact panels are shown in Figures 5-17 and 5-18. If you choose to view the contact panels using the `NoBody.h3d` geometry file, you may return to the original geometry file by selecting the `PCChevroletImpala954-Dr.h3d` geometry file.





Figures 5-17 and 5-18: Oblique and side views of contact surfaces.

> **NOTE:** If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateContactPanels` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Creating and executing the Events

We will now create the simulations necessary for a head-on collision. The collision pulse needed can be directly obtained by using the EDSMAC4 collision simulator.

> **NOTE:** If you don't have EDSMAC4 on your HVE system, you may skip the EDSMAC4 event. The collision pulse for this event is shipped with GATB and may be loaded by selecting `GATBTutorialPulse1` from the Collision Pulse File Selection dialog.

- Choose Event Editor by clicking on the Event Editor button on the tool bar.
- Click on the (+) sign on the tool bar to add an event. The **Event Information** dialog is displayed (Figure 5-19).
- Select Buick Skylark 4-Dr and the Chevrolet Caprice 4-Dr from the Active Vehicles list.
- Select EDSMAC4 from the Calculation Method options list.
- Enter a name for the event: `Frontal Impact`.
- Press OK to display the Event Editor.

> **NOTE:** HVE will append the name of the calculation method to the event name, thus the complete event name will become "EDSMAC4, Frontal Impact".

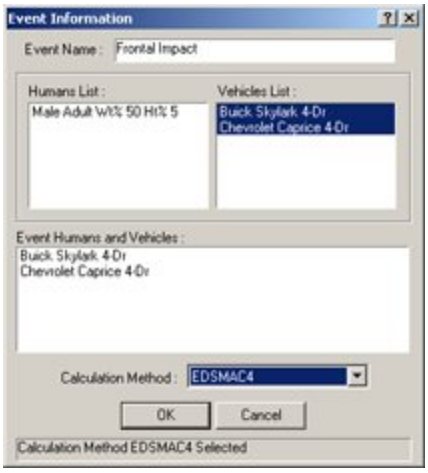


Figure 5-19: Setting up EDSMAC4 event.

Now we're ready to set up the event.

- Using the Event Editor dialog, select Buick Skylark 4-Dr from the Event Humans & Vehicles list.
- Choose Set-up from the menu bar.
- Select Position/Velocity and select Initial. The Buick is displayed at the earth-fixed origin.

In the Set Position/Velocity dialog for the Buick Skylark, enter:

- x (ft) = 30
- y (ft) = -6
- yaw (deg) = 180
- Click the Velocity is Assigned box in the Set Position/Velocity dialog and enter: Total (mph) = 25.
- Click Apply.

> **NOTE:** Be sure to press <Enter> or click Apply for the newly entered values in the Position/Velocity dialog to take effect.

- Select Chevrolet Caprice 4-Dr from the Event Humans & Vehicles list.
- Choose Set-up from the menu bar.
- Select Position/Velocity and select Initial. The Chevrolet is displayed at the earth-fixed origin.

In the Set Position/Velocity dialog for the Chevrolet Caprice, enter:

- x (ft) = 15
- y (ft) = -6
- yaw (deg) = 0
- Click the Velocity is Assigned box and enter: Total (mph) = 30.
- Click Apply.

Choose Simulation Controls from the Options menu and change the following options:

- Vehicle separation (s) = 0.001

- Vehicle trajectory (s) = 0.001
- Output time interval (s) = 0.002
- Maximum time (s) = 0.5
- Click OK.

> **NOTE:** We reduced the output interval because we're going to use the acceleration output from this simulation as the collision pulse for our occupant simulation. Because we want more detail, we select the smaller output interval. This provides the acceleration at 0.002 second increments rather than the default value, 0.1 second.
>
> **NOTE:** The entire duration of a collision is only about 0.1 second, so the default interval might actually skip over the entire collision!

- Using the Event Controller, click Execute on the tool bar to execute the event. Allow the event to run until just after the vehicles separate; then click Stop on the tool bar to end the event.

> **NOTE:** The complete EDSMAC4 printouts for this tutorial are found in Appendix A of the printed manual.
>
> **NOTE:** If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateEDSMAC4` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Occupant Simulation

The EDSMAC4 event has provided us with the collision pulse. Now, let's use GATB to study the passenger's behavior during impact.

- Click the (+) sign on the tool bar to add an event. The Event Information dialog is displayed.
- Select Chevrolet Caprice 4-Dr and the Male Adult Passenger from the Active Vehicles list and Active Human list, respectively.
- Select GATB from the Calculation Methods options list (Figure 5-20).
- Enter the name `RF Passenger` for the event.
- Press OK to display the event editor.

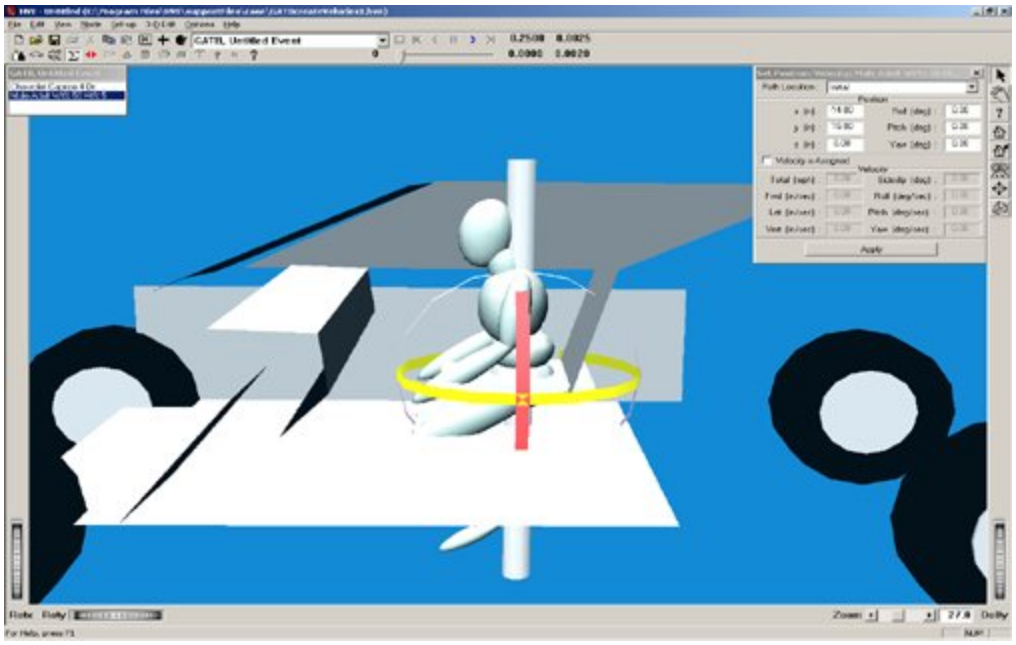


Figure 5-20: Setting up the GATB event.

Now, let's set up and execute the occupant simulation event using GATB.

- Using the Event Editor dialog, select Chevrolet Caprice 4-Dr from the Event Humans & Vehicles list.
- Select Set-up from the menu bar.
- Select Position/Velocity and select Initial. The Chevrolet is displayed at the earth-fixed origin.

In the Set Initial Position/Velocity dialog for the Chevrolet Caprice, enter:

- x (ft) = 15
- y (ft) = -6
- yaw (deg) = 0
- Click the Velocity is Assigned box and enter: Total (mph) = 0. Click Apply.
- Select Male Adult Human from the Event Humans & Vehicles list.
- Select Set-up from the menu bar.
- Select Position/Velocity and select Initial. The human will be displayed at the vehicle-fixed origin.

The human will be placed in the environment relative to the vehicle and will have an initial position of x = 0, y = 0, z = 0. This is the position of the human pelvis center of mass with respect to the vehicle center of mass.

> **NOTE:** The Position/Velocity dialog displays the current position and orientation of the human relative to the vehicle-fixed coordinate system. Also note that the units for position are in inches.

In the Set Initial Position/Velocity dialog for the human, enter:

- x (in) = -14
- y (in) = 16

- Click Apply. You will now see the human has moved from the center of mass of the vehicle to a position approximately in the right front seat of the vehicle (Figure 5-21).

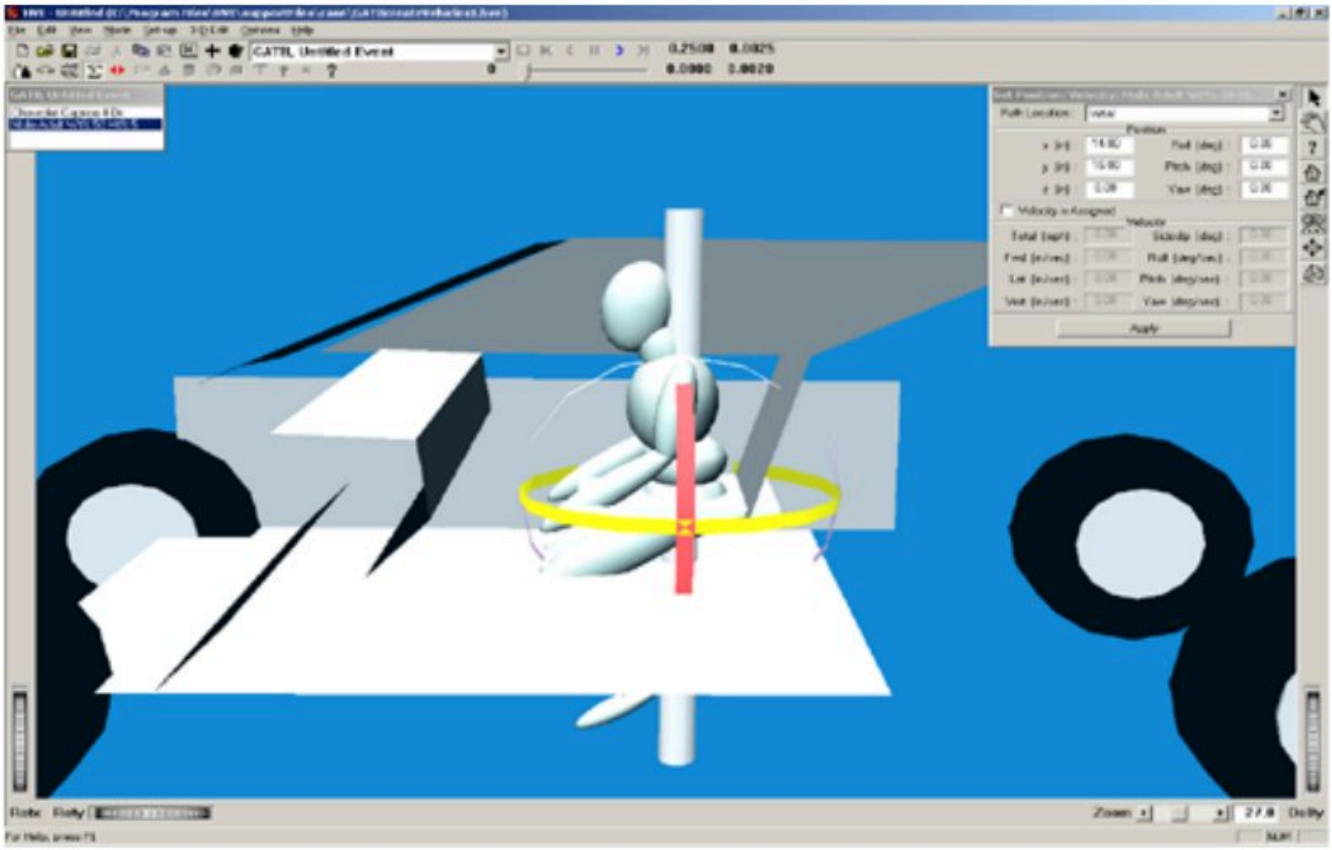


Figure 5-21: Setting up Initial Human Position.

> **NOTE:** The legs are embedded in the floor and the human is not in a normal seated position where the torso is in an approximately parallel position with the seat back.

- Change the pitch angle of the pelvis to 25 degrees.
- Select the Left Upper Leg of the human by using the mouse pointer icon to click on the ellipsoid.
- Enter a pitch angle of 80 degrees in the dialog box.
- Select the Left Lower Leg of the human and change its pitch angle to -50 degrees.
- Make the same changes to the Right Upper Leg (80 degrees) and Right Lower Leg (-50 degrees).

This will produce an initial positioning similar to Figure 5-22.

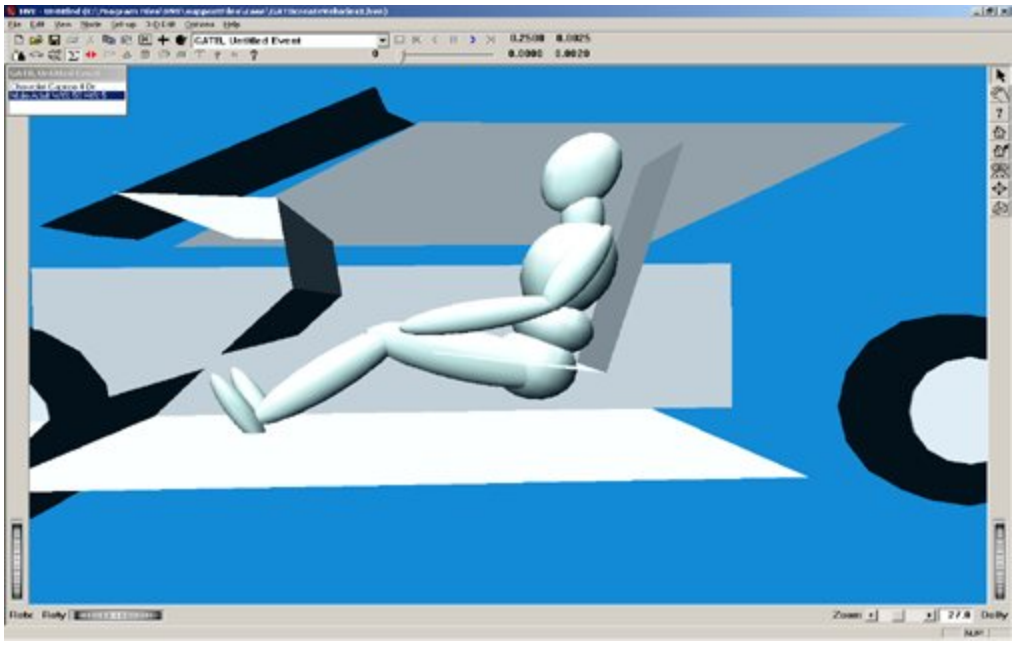


Figure 5-22: Initial Position of RF Occupant.

Notice that the pelvis is embedded in the seat cushion and that it needs to be moved upward. To correct this problem:

- Select the pelvis ellipsoid and change the vertical position to z = -4.6 in.

Notice the pelvis and chest are also forward, or in front of, the seat back.

- Select the pelvis ellipsoid and change its position to x = -16 in.
- Select the Velocity Is Assigned checkbox in the Position/Velocity dialog, and enter a forward velocity of 0.0 in/sec.

> **NOTE:** Because the human is defined as an occupant (as opposed to a pedestrian), the initial velocity is defined relative to the vehicle.

- Adjust the pitch angle of the Right and Left Upper Legs to 75 degrees.

Let's attach a camera to the vehicle to better see the human.

> **NOTE:** This tip really helps while positioning occupants because it allows you to move the camera relative to the vehicle; thus you can quickly focus on the interaction between the human and the seat cushion, an important part of placing the human in an equilibrium position.

- Choose Set Camera from the View menu. The Camera Setup dialog is displayed.
- Click the View From option list and choose Chevrolet Caprice 4-Dr.

Enter the following coordinates in the available fields:

- Camera Coordinates: x = -1.0, y = -10.0, z = -1.0
- Picture Center: x = 0.0, y = 0.0, z = -1.0
- Depth of Field: near = 2.0, far = 5000
- Focal Length: 50 mm

- Click Apply.

The new view of the vehicle and occupant for the vehicle-affixed camera is shown in Figure 5-23.

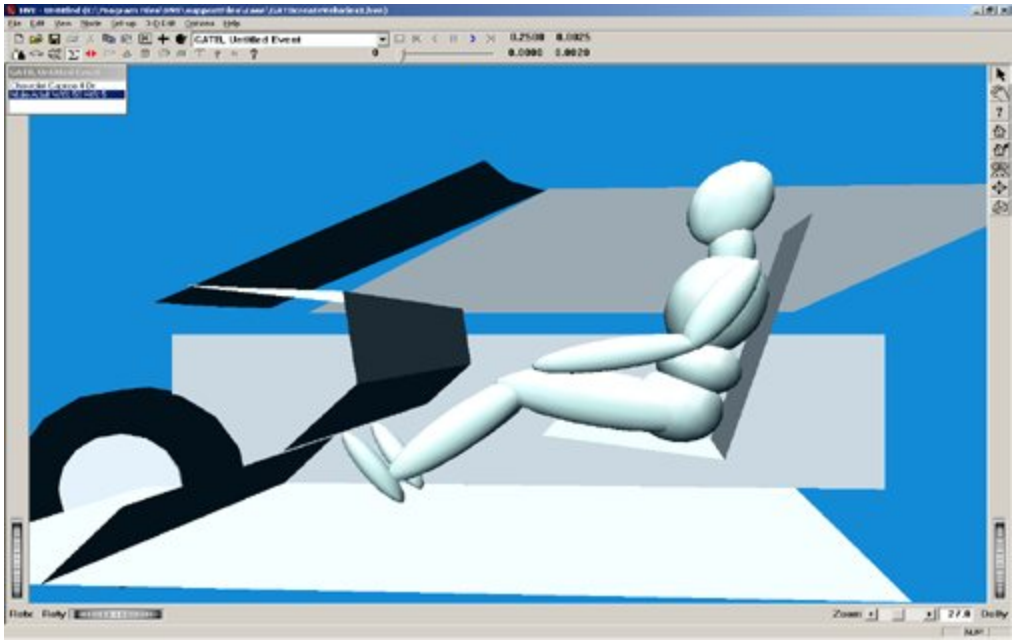


Figure 5-23: View of occupant from specified camera position.

Choose Simulation Controls from the Options menu and change:

- Output Interval Time (sec) = 0.002
- Maximum Time (sec) = 0.25

GATB requires that some information be entered in the Collision Pulse dialog box in order for the simulation to run properly. We will initialize this event with a zero collision pulse in order to examine the interaction between the stationary human and the vehicle contact panels.

- Select Chevrolet Caprice 4-Dr from the Event Humans & Vehicles list.
- Choose Collision Pulse from the Set-up menu.
- Select Acceleration as the Pulse Type.
- Ensure that in the table there is only one time entry for time 0.000 and that all of the column data is set to 0.000.

Once this has been completed, the occupant is close to equilibrium. We can now execute the simulation and examine how the occupant limbs move and adjust with the interacting forces from the contact panels.

> **NOTE:** Details of establishing an initial equilibrium for the occupant are beyond the scope of this simple tutorial.
>
> **NOTE:** In general, the linear and angular accelerations of every mass segment should be as small as possible in comparison to the acceleration pulse that will be used.
>
> **NOTE:** In low speed collisions, it is absolutely critical that the linear and angular accelerations be as close to zero as possible.

Establishing initial equilibrium

The basic equilibrium requirement is that any motion caused by being slightly out of equilibrium is negligible compared to the motion caused by the crash.

As a practical matter, the user will never be able to produce exact equilibrium (i.e., all linear and angular accelerations equal to zero).

Every analysis is different and there are no strict guidelines that define when the human position is close enough to equilibrium. In general, compare the linear acceleration for all the human segments to the linear acceleration of the crash pulse and ensure the human accelerations are much smaller.

In addition, the linear acceleration of all segments should be at least under 0.5 g's, with the possible exception of the feet, which should be at least under 1.0 g's.

> **NOTE:** On humans with small abdomens, it may not be possible to achieve 0.5 g's. In this case make it as low as possible, but certainly under 1.0 g's.

The basic procedure for establishing equilibrium is:

- Position the vehicle so that the roll, pitch, yaw and acceleration pulses are all zero.
- Set the initial velocity of the vehicle to zero.
- Click the Execute button on the tool bar to execute the program for one or two time steps.

> **NOTE:** The exact termination time is not critical.

- Go to the Playback Editor by clicking the Playback Editor button on the tool bar.
- Click on the (+) sign on the tool bar to add a report window.

The Report Window dialog will then appear with the active events shown.

> **NOTE:** If you have not run the EDSMAC4 simulation, the active events list will not include EDSMAC4.

- Highlight GATB, RF Passenger event (Figure 5-24).



Figure 5-24: Setting up a Report Window.

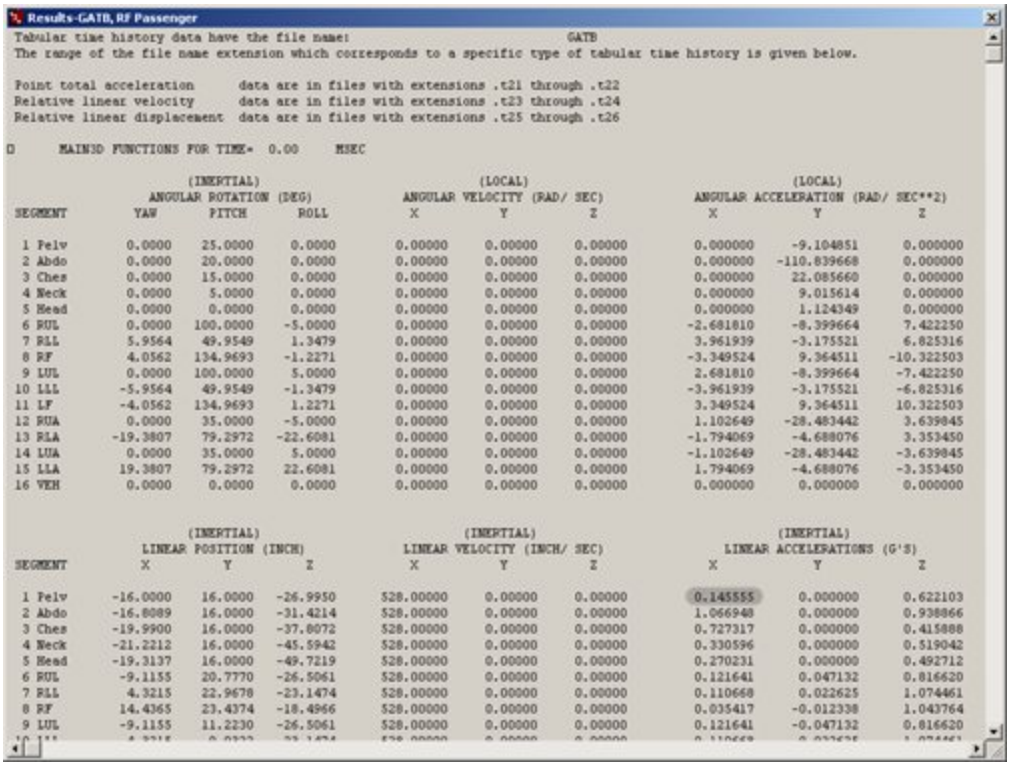
Once the GATB event is highlighted, the available output reports are listed by clicking on the button next to the selected output. For this tutorial, we want to generate a Results Output Report.

- Click on the list of possible output reports and select Results.
- Click OK.

The Results Output Window is displayed (Figure 5-25).

In this example, our initial human position has the pelvis accelerating downward in the positive Z direction at approximately 0.62 g's. In order to position the occupant where this downward acceleration is smaller, we want to move the pelvis downward a small amount.

- Return to the Event Editor by clicking the Event Editor button on the tool bar.
- Click on the pelvis and change the Z position from z = -4.6 to z = -4.5.
- Click the Reset button on the tool bar to clear the event data.
- Click the Execute button on the tool bar to execute the event for one or two timesteps.
- Return to the Playback Editor by clicking on the Playback Editor button on the tool bar and view the Results window again (Figure 5-26).



Results-GATB, RF Passenger

Tabular time history data have the file name: GATB
The range of the file name extension which corresponds to a specific type of tabular time history is given below.

Point total acceleration data are in files with extensions .t21 through .t22
Relative linear velocity data are in files with extensions .t23 through .t24
Relative linear displacement data are in files with extensions .t25 through .t26

0 MAIN3D FUNCTIONS FOR TIME= 0.00 MSEC

SEGMENT	(INERTIAL) ANGULAR ROTATION (DEG) YAW	PITCH	ROLL	(LOCAL) ANGULAR VELOCITY (RAD/ SEC) X	Y	Z	(LOCAL) ANGULAR ACCELERATION (RAD/ SEC**2) X	Y	Z
1 Pelv	0.0000	25.0000	0.0000	0.00000	0.00000	0.00000	0.000000	-9.104851	0.000000
2 Abdo	0.0000	20.0000	0.0000	0.00000	0.00000	0.00000	0.000000	-110.839668	0.000000
3 Ches	0.0000	15.0000	0.0000	0.00000	0.00000	0.00000	0.000000	22.085660	0.000000
4 Neck	0.0000	5.0000	0.0000	0.00000	0.00000	0.00000	0.000000	9.015614	0.000000
5 Head	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000	1.124349	0.000000
6 RUL	0.0000	100.0000	-5.0000	0.00000	0.00000	0.00000	-2.681810	-8.399664	7.422250
7 RLL	5.9564	49.9549	1.3479	0.00000	0.00000	0.00000	3.961939	-3.175521	6.825316
8 RF	4.0562	134.9693	-1.2271	0.00000	0.00000	0.00000	-3.349524	9.364511	-10.322503
9 LUL	0.0000	100.0000	5.0000	0.00000	0.00000	0.00000	2.681810	-8.399664	-7.422250
10 LLL	-5.9564	49.9549	-1.3479	0.00000	0.00000	0.00000	-3.961939	-3.175521	-6.825316
11 LF	-4.0562	134.9693	1.2271	0.00000	0.00000	0.00000	3.349524	9.364511	10.322503
12 RUA	0.0000	35.0000	-5.0000	0.00000	0.00000	0.00000	1.102649	-28.483442	3.639845
13 RLA	-19.3807	79.2972	-22.6081	0.00000	0.00000	0.00000	-1.794069	-4.688076	3.353450
14 LUA	0.0000	35.0000	5.0000	0.00000	0.00000	0.00000	-1.102649	-28.483442	-3.639845
15 LLA	19.3807	79.2972	22.6081	0.00000	0.00000	0.00000	1.794069	-4.688076	-3.353450
16 VEH	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000	0.000000	0.000000

SEGMENT	(INERTIAL) LINEAR POSITION (INCH) X	Y	Z	(INERTIAL) LINEAR VELOCITY (INCH/ SEC) X	Y	Z	(INERTIAL) LINEAR ACCELERATIONS (G'S) X	Y	Z
1 Pelv	-16.0000	16.0000	-26.9950	528.00000	0.00000	0.00000	0.145555	0.000000	0.622103
2 Abdo	-16.8089	16.0000	-31.4214	528.00000	0.00000	0.00000	1.066948	0.000000	0.938866
3 Ches	-19.9900	16.0000	-37.8072	528.00000	0.00000	0.00000	0.727317	0.000000	0.415888
4 Neck	-21.2212	16.0000	-45.5942	528.00000	0.00000	0.00000	0.330596	0.000000	0.519042
5 Head	-19.3137	16.0000	-49.7219	528.00000	0.00000	0.00000	0.270231	0.000000	0.492712
6 RUL	-9.1155	20.7770	-26.5061	528.00000	0.00000	0.00000	0.121641	0.047132	0.816620
7 RLL	4.3215	22.9678	-23.1474	528.00000	0.00000	0.00000	0.110668	0.022625	1.074461
8 RF	14.4365	23.4374	-18.4966	528.00000	0.00000	0.00000	0.035417	-0.012338	1.043764
9 LUL	-9.1155	11.2230	-26.5061	528.00000	0.00000	0.00000	0.121641	-0.047132	0.816620

Figure 5-25: Results Output Report in the Playback Editor.

Notice the small differences between the two results windows (Figures 5-25 and 5-26). The linear acceleration for the pelvis in the Z direction has lowered. However, in examining the linear acceleration in the X direction for the pelvis, the value has increased from 0.145555 g's to 0.161370 g's.

There are other small changes with all of the mass segments, but you can see the effect that moving the pelvis downward slightly affects not only the linear acceleration of the pelvis in the Z direction, but affects the other mass segments in other directions as well.

To further confirm this, click on the Event Editor button on the toolbar.

- Select the pelvis with the pointer mouse icon.
- Change the position of the pelvis to z = -4.0.
- Clear the event data by clicking the Reset button on the tool bar.
- Execute the event for one or two timesteps.

Return to the Playback Editor and view the Output Results window. It should look like Figure 5-27.

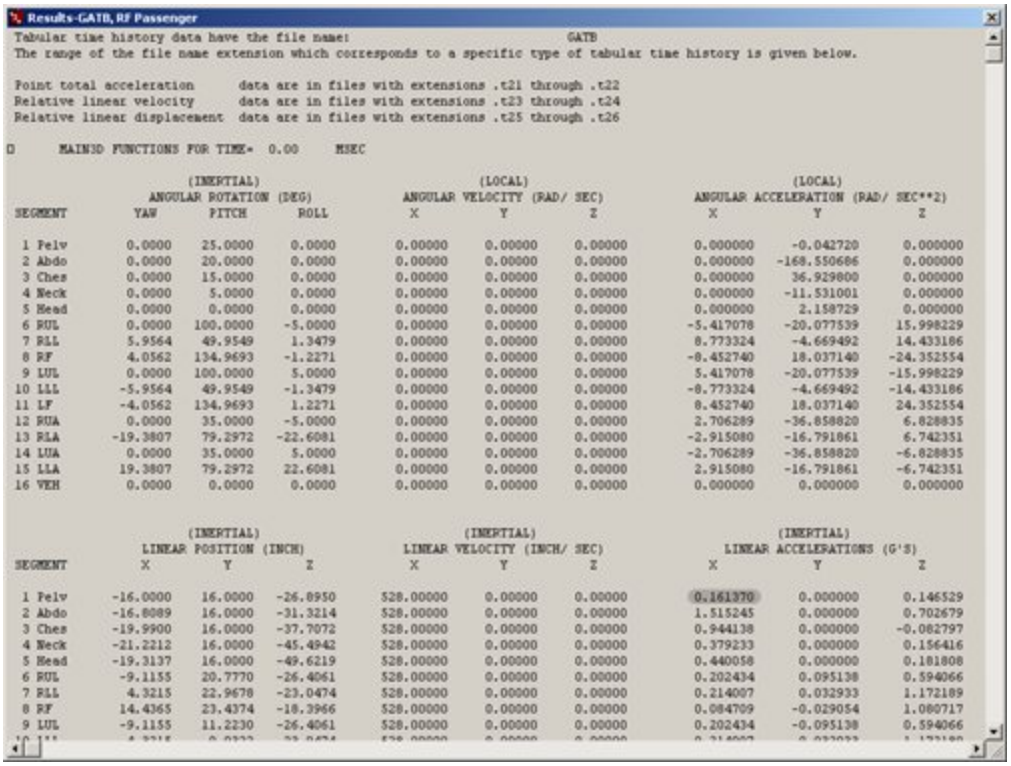
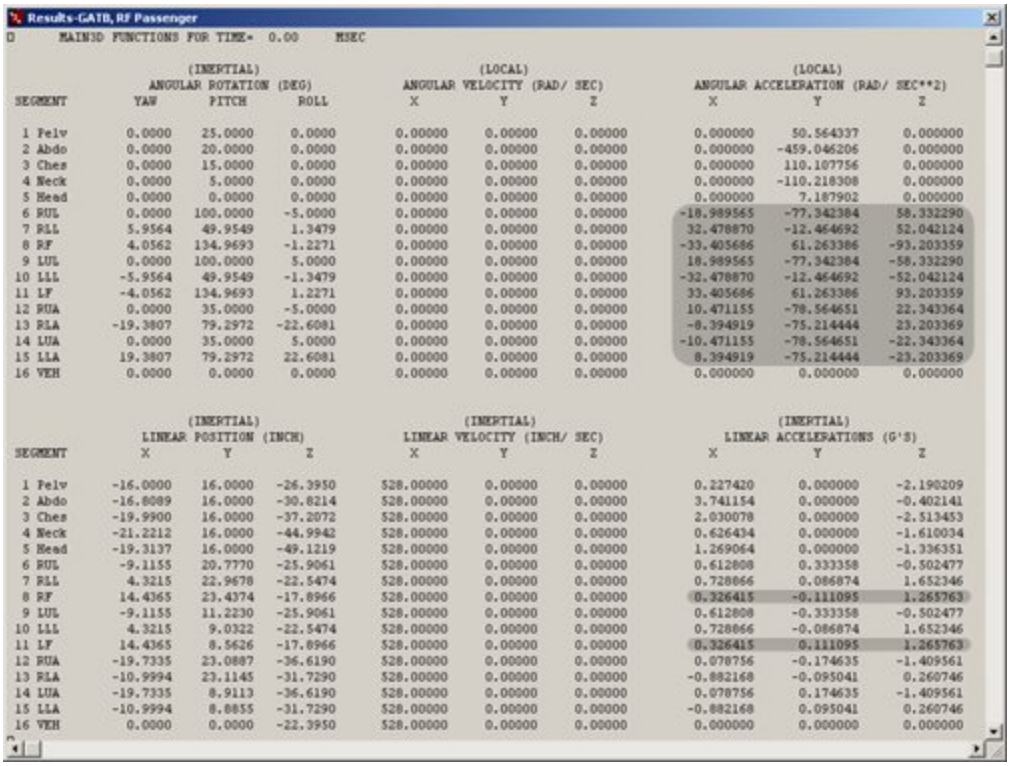


Figure 5-26: Results report, after changes to Human Position.

By reviewing this figure compared to the previous two figures, you can see the angular accelerations for the legs and feet have become quite large, and the linear accelerations particularly for the feet have become very large. Effectively, what we have done by moving the pelvis downward is position the feet into the floor so the floor will push back very hard.

> **NOTE:** When you move the pelvis on a human, all of the other segments move also because they are all linked in a hierarchy where the pelvis is the dominating mass.

- Return to the Event Editor by clicking the Event Editor button on the tool bar and change the Z position of the pelvis back to -4.6.
- Clear the event data by clicking the Reset button on the tool bar.
- Execute the event for two timesteps by clicking the Execute button on the tool bar.
- Confirm that the Output Results window appears the same as Figure 5-25.



Results-GATB, RF Passenger

0 MAIN3D FUNCTIONS FOR TIME= 0.00 MSEC

SEGMENT	(INERTIAL) ANGULAR ROTATION (DEG) YAW	PITCH	ROLL	(LOCAL) ANGULAR VELOCITY (RAD/ SEC) X	Y	Z	(LOCAL) ANGULAR ACCELERATION (RAD/ SEC**2) X	Y	Z
1 Pelv	0.0000	25.0000	0.0000	0.00000	0.00000	0.00000	0.000000	50.564337	0.000000
2 Abdo	0.0000	20.0000	0.0000	0.00000	0.00000	0.00000	0.000000	-459.046206	0.000000
3 Ches	0.0000	15.0000	0.0000	0.00000	0.00000	0.00000	0.000000	110.107756	0.000000
4 Neck	0.0000	5.0000	0.0000	0.00000	0.00000	0.00000	0.000000	-110.218308	0.000000
5 Head	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000	7.187902	0.000000
6 RUL	0.0000	100.0000	-5.0000	0.00000	0.00000	0.00000	-18.989565	-77.342384	58.332290
7 RLL	5.9564	49.9549	1.3479	0.00000	0.00000	0.00000	32.478870	-12.464692	52.042124
8 RF	4.0562	134.9693	-1.2271	0.00000	0.00000	0.00000	-33.405686	61.263386	-93.203359
9 LUL	0.0000	100.0000	5.0000	0.00000	0.00000	0.00000	18.989565	-77.342384	-58.332290
10 LLL	-5.9564	49.9549	-1.3479	0.00000	0.00000	0.00000	-32.478870	-12.464692	-52.042124
11 LF	-4.0562	134.9693	1.2271	0.00000	0.00000	0.00000	33.405686	61.263386	93.203359
12 RUA	0.0000	35.0000	-5.0000	0.00000	0.00000	0.00000	10.471155	-78.564651	22.343364
13 RLA	-19.3807	79.2972	-22.6081	0.00000	0.00000	0.00000	-8.394919	-75.214444	23.203369
14 LUA	0.0000	35.0000	5.0000	0.00000	0.00000	0.00000	-10.471155	-78.564651	-22.343364
15 LLA	19.3807	79.2972	22.6081	0.00000	0.00000	0.00000	8.394919	-75.214444	-23.203369
16 VEH	0.0000	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000	0.000000	0.000000

SEGMENT	(INERTIAL) LINEAR POSITION (INCH) X	Y	Z	(INERTIAL) LINEAR VELOCITY (INCH/ SEC) X	Y	Z	(INERTIAL) LINEAR ACCELERATIONS (G'S) X	Y	Z
1 Pelv	-16.0000	16.0000	-26.3950	528.00000	0.00000	0.00000	0.227420	0.000000	-2.190209
2 Abdo	-16.8089	16.0000	-30.8214	528.00000	0.00000	0.00000	3.741154	0.000000	-0.402141
3 Ches	-19.9900	16.0000	-37.2072	528.00000	0.00000	0.00000	2.030078	0.000000	-2.513453
4 Neck	-21.2212	16.0000	-44.9942	528.00000	0.00000	0.00000	0.626434	0.000000	-1.610034
5 Head	-19.3137	16.0000	-49.1219	528.00000	0.00000	0.00000	1.269064	0.000000	-1.336351
6 RUL	-9.1155	20.7770	-25.9061	528.00000	0.00000	0.00000	0.612808	0.333358	-0.502477
7 RLL	4.3215	22.9678	-22.5474	528.00000	0.00000	0.00000	0.728866	0.086874	1.652346
8 RF	14.4365	23.4374	-17.8966	528.00000	0.00000	0.00000	0.326415	-0.111095	1.265763
9 LUL	-9.1155	11.2230	-25.9061	528.00000	0.00000	0.00000	0.612808	-0.333358	-0.502477
10 LLL	4.3215	9.0322	-22.5474	528.00000	0.00000	0.00000	0.728866	-0.086874	1.652346
11 LF	14.4365	8.5626	-17.8966	528.00000	0.00000	0.00000	0.326415	0.111095	1.265763
12 RUA	-19.7335	23.0887	-36.6190	528.00000	0.00000	0.00000	0.078756	-0.174635	-1.409561
13 RLA	-10.9994	23.1145	-31.7290	528.00000	0.00000	0.00000	-0.882168	-0.095041	0.260746
14 LUA	-19.7335	8.9113	-36.6190	528.00000	0.00000	0.00000	0.078756	0.174635	-1.409561
15 LLA	-10.9994	8.8855	-31.7290	528.00000	0.00000	0.00000	-0.882168	0.095041	0.260746
16 VEH	0.0000	0.0000	-22.3950	528.00000	0.00000	0.00000	0.000000	0.000000	0.000000

Figure 5-27: Results report, after additional changes.

For this example, we will not spend any additional effort in attempting to produce smaller linear accelerations.

Once the initial equilibrium has been established, the vehicle can then be positioned to the appropriate place in the environment with the appropriate orientation to match the event being modeled.

> **NOTE:** Recall that we changed the initial angles — roll, pitch, and yaw values — to zero degrees, the velocity to zero, and the crash pulse to zero, in order to help us obtain the initial equilibrium of this human.

Applying the crash pulse

The next step is to apply a crash pulse to the vehicle. This involves two parts.

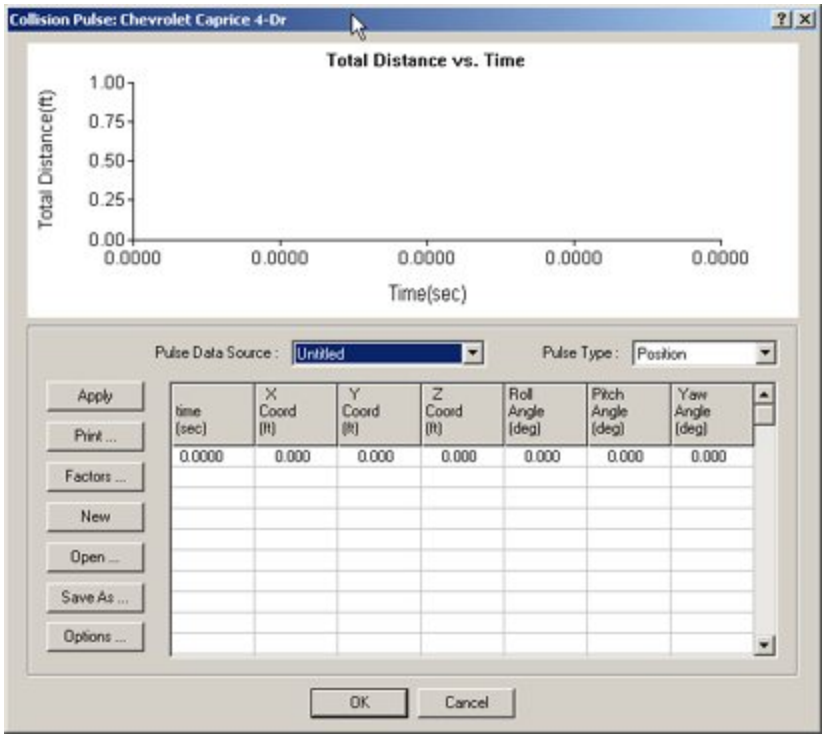


Figure 5-28: Collision Pulse dialog, without a pulse.

The first part is to set up the initial speed of the vehicle to match that of the crash being simulated. In this example, recall from the EDSMAC4 run that the initial speed is 30 mph.

- Go to the Event Editor by clicking on the Event Editor button on the tool bar.
- Choose the Chevrolet Caprice 4-Dr from the vehicles list.
- Select Set-up from the menu bar.
- Select Position/Velocity and click Initial.
- Assign the Velocity to 30 mph.
- Choose Set-up from the menu bar and select Collision Pulse.

The Collision Pulse dialog will appear like Figure 5-28.

- Select Acceleration as the Pulse Type.
- Select the collision pulse, EDSMAC4, Frontal Impact, from the Pulse Data Source drop-down menu. The window should look like Figure 5-29.

> If you do not have EDSMAC4 or were not able to execute the EDSMAC event, click Open in the Collision Pulse window and select the file `GATBTutorialPulse1`.
>
> If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateGATBpassenger` in the `/HVE/supportFiles/case` directory contains all necessary information up to this point.

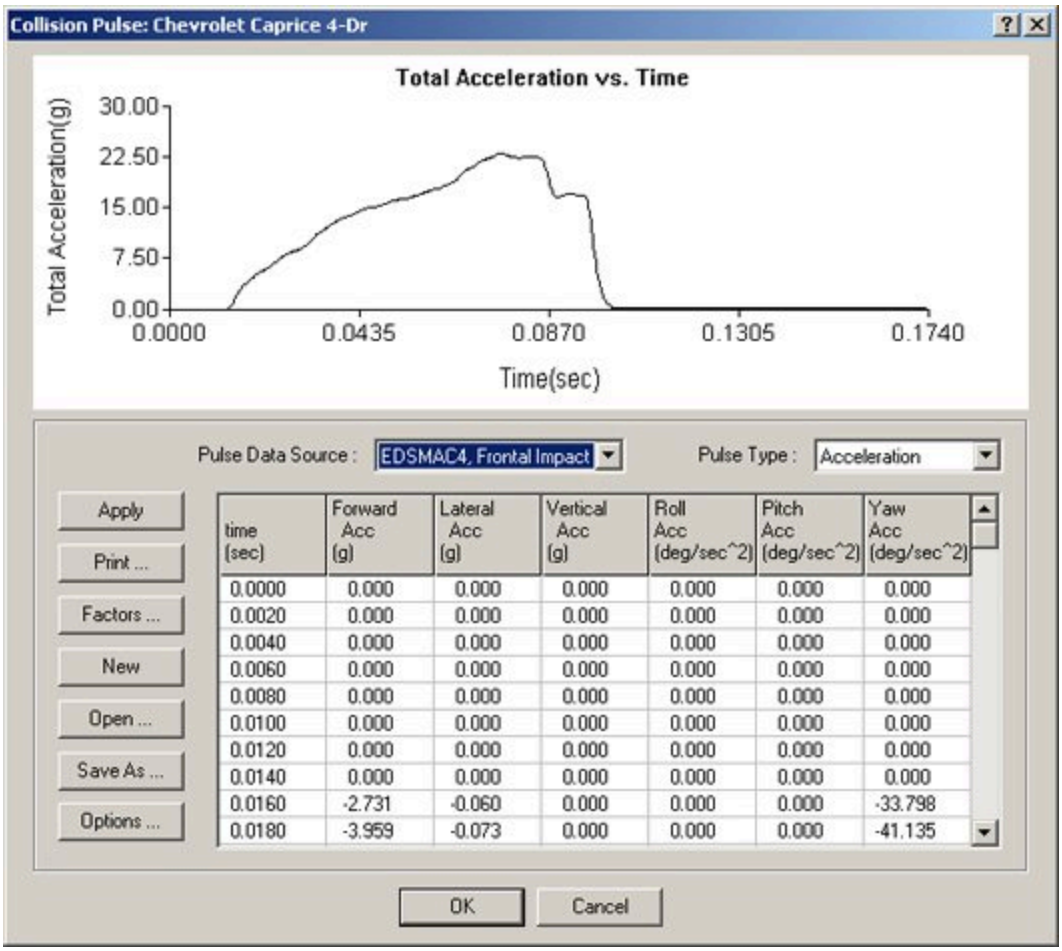


Figure 5-29: Collision Pulse dialog, with EDSMAC4 pulse.

At this point, you may be prompted that warnings exist. If you choose to look at those warnings, they may indicate that the yaw acceleration is higher than normal. Accept these as possible warnings, and when HVE asks you to see them again, just click Cancel. You will return to the Event Editor where you can now execute the event, which demonstrates occupant motion in a frontal car crash.

A side view from the left side of the vehicle helps you to visualize the forward motion. The camera setup for the left side view has the camera attached to the Chevrolet Caprice with the following camera coordinates:

- Camera Coordinates: x = -1, y = -10, z = -1
- Picture Center: x = 0, y = 0, z = -1
- Depth of Field: near = 2.0, far = 5000
- Focal Length: 50 mm

Another view that is helpful to demonstrate the side motion which occurs is positioned with the camera attached to the Chevrolet Caprice as follows:

- Camera Coordinates: x = -5, y = 2, z = -10
- Picture Center: x = 0, y = 2, z = -1
- Depth of Field: near = 2.0, far = 5000
- Focal Length: 50 mm

Changing the principal direction of force

To explain how the principal direction of force affects occupant motion, return to the EDSMAC4 event in the Event Editor.

- Select the Buick Skylark 4-Dr from the Event Humans & Vehicles list.
- Choose Set-up from the menu bar.
- Select Position/Velocity and select Initial.

Change the following values:

- x (ft) = 23
- y (ft) = 3.5
- yaw (deg) = 270
- Click Apply.
- Clear the calculation by pressing the Reset button on the tool bar.
- Execute the EDSMAC4 event.
- Return to the GATB event.
- Clear the calculation by pressing the Reset button on the tool bar.
- Execute the GATB event with the new EDSMAC4 collision pulse data by clicking the Execute button on the tool bar.

> If you do not have EDSMAC4 or were not able to execute the EDSMAC event, click Open in the Collision Pulse window and select the file `GATBTutorialPulse2`.

Notice that the occupant moves forward and to the right in this new collision configuration, as opposed to the purely frontal impact previously modeled.

This completes the examples of the occupant simulation.

You may wish to modify the crash pulse by rerunning the EDSMAC4 event and changing the direction of the crash pulse, and then importing it as previously described. You can also change the camera positions and explore other aspects of the occupant motion.

Pedestrian Simulation Tutorial

Using GATB to simulate a pedestrian impact is very similar to the previous occupant simulation.

- Select File from the menu bar and save any previous work you would like to keep.

To create the human pedestrian in this example, perform the following steps:

- If the HVE Human Editor is not the current editor, choose Human Mode by clicking the Human Mode button on the tool bar.
- Click the (+) sign on the tool bar to add a human. The Human Information dialog is displayed. The Human Information dialog includes option buttons allowing the user to select a seat position within the vehicle

(alternatively, Pedestrian could be selected), and assign the human's attributes according to Sex, Age, Weight Percentile and Height Percentile.

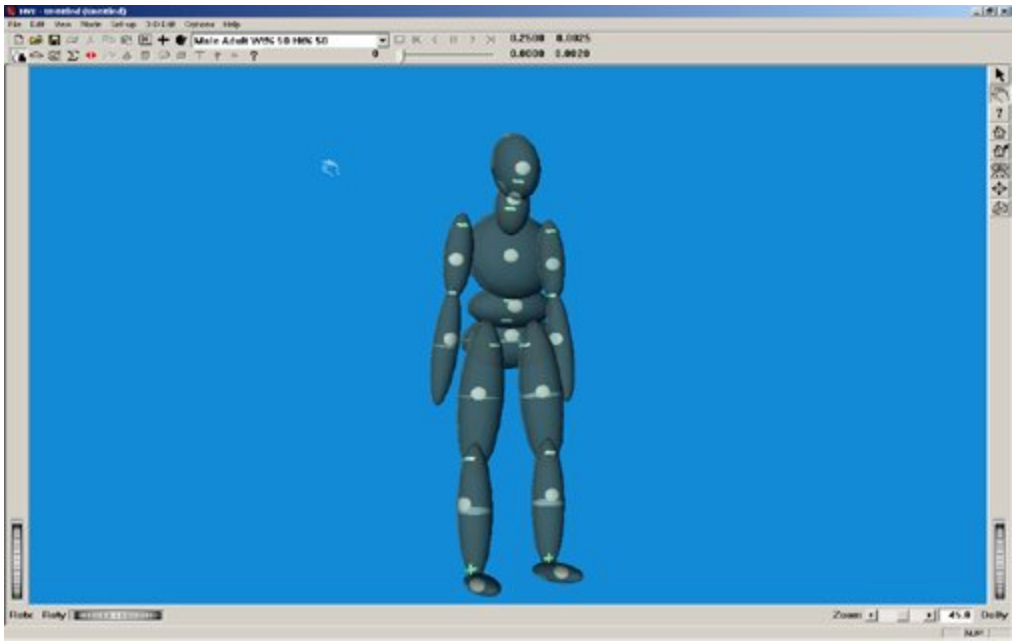


Figure 5-30: Pedestrian Human in the Human Editor.

Using these option buttons, click each one to choose the following human attributes:

- Location = Pedestrian
- Sex = Male
- Age = Adult
- Weight Percentile = 50
- Height Percentile = 50

> **NOTE:** Make sure the moment of inertia data for the right and left upper legs are: - Ixx (lb-sec²-inch) = 1.3599 - Jyy (lb-sec²-inch) = 1.4348 - Kzz (lb-sec²-inch) = 0.3769
>
> **NOTE:** If you are having difficulty completing this portion of the tutorial, the `GATBcreatePedestrian` file in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Creating the Vehicle

- Choose Vehicle Mode by clicking the Vehicle Mode button on the tool bar. The Vehicle Editor is displayed.
- Click the (+) sign on the toolbar to add a vehicle. 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.

Using the Option buttons, click each one to choose the following vehicle from the database:

- Type = Pickup
- Make = Dodge
- Model = Dakota

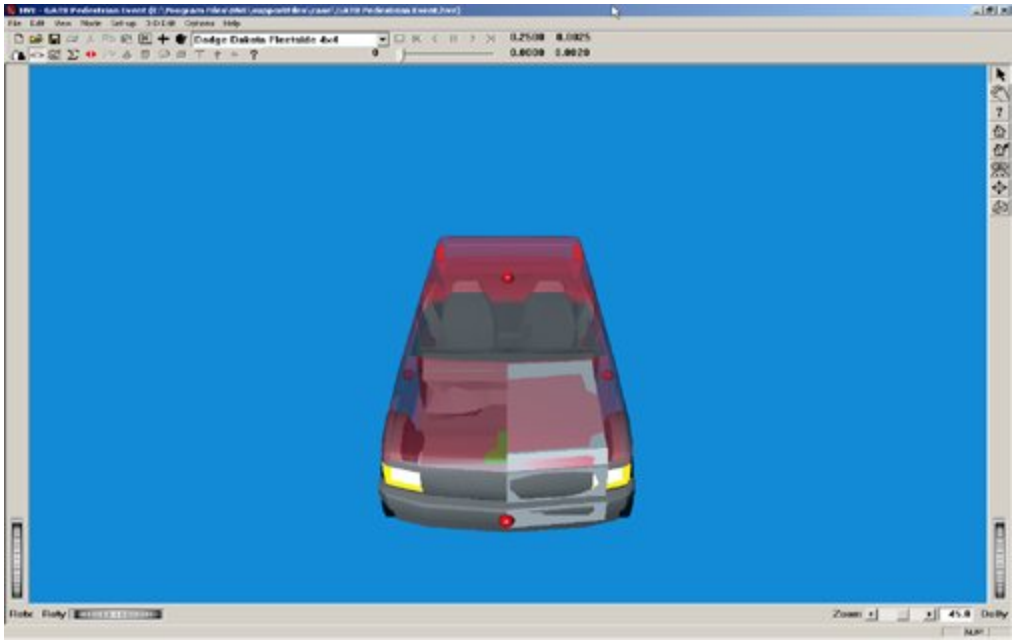
- Year = 1987-1996
- Body Style = Fleetside 4x4
- Click OK to add Dodge Dakota 4x4 to the active vehicles list.
- Create the exterior contact panels using the data from Table 5-2.

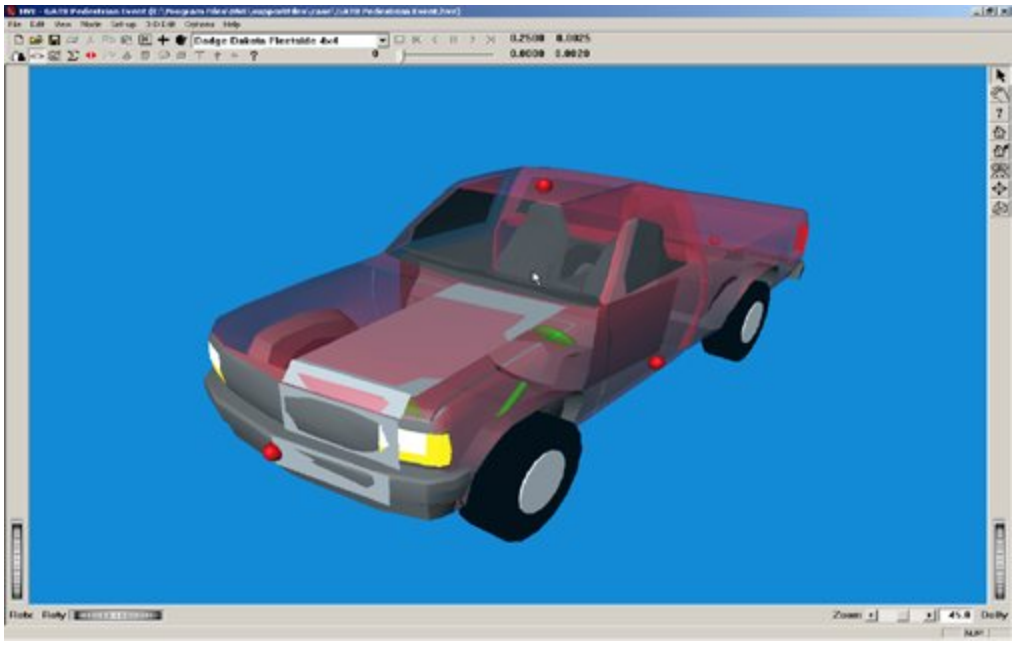
> **NOTE:** Make sure to select Location: Exterior when creating your contact surfaces, or your pedestrian simulation will generate an error.
>
> If you are having difficulty in completing this portion of the tutorial, the file `GATBcreateDodgeContacts` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

Table 5-2: Contact Surfaces to use in Pedestrian impact example

Name	Coord	First	Middle	Third	Material
Bumper-Front	X	80.5	80.5	77.0	Default Vehicle
	Y	0.0	0.0	-25.0	
	Z	-4.0	3.0	3.0	
Grill	X	77.7	77.7	74.5	Default Vehicle
	Y	0.0	0.0	-25.0	
	Z	-15.0	-2.0	-2.0	

The completed contact panels are shown in Figures 5-31 and 5-32.





Figures 5-31 and 5-32: Contact Surfaces on pickup.

Creating the Event

- Select the Event Editor by clicking the Event Editor button on the tool bar.
- Click the (+) sign on the tool bar to add an event. The Information Dialog is displayed (Figure 5-33).
- Choose the Dodge Dakota 4x4 and the Male Adult, 50% Wt., 50% Ht. from the Active Vehicles list and Active Humans list, respectively.
- Select GATB from the Calculation Methods options list.
- Edit the Event name: `Pickup/Pedestrian Impact`.
- Press OK to display the event editor.

Select Options from the menu bar and then Simulation Controls from the drop-down menu. Change the following options:

- Simulation Output Time Interval (sec) = 0.002
- Simulation Maximum Time (sec) = 1.0



Figure 5-33: Creating the Pedestrian impact event in the HVE Event Editor.

Using the Event Editor dialog, select the Dodge Dakota 4x4 from the Event Humans & Vehicles list, then select Edit from the menu bar, choose Position/Velocity and click Initial. The vehicle is displayed at the earth-fixed origin.

Now, let's set up and execute the pedestrian simulation event using GATB.

Enter the following values in the appropriate boxes of the Position/Velocity, Initial dialog (Figure 5-34):

- x (ft) = 15.0
- y (ft) = -5.0
- z (ft) = -2.094
- Roll (deg) = 0.0
- Pitch (deg) = 0.0
- Yaw (deg) = 0.0
- Assigned Velocity (mph) = 15.0

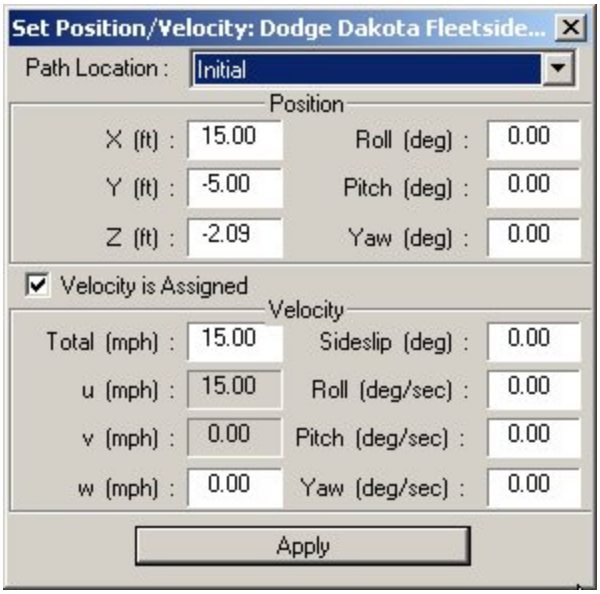


Figure 5-34: Setting Initial Position / Velocity of Dodge Pickup.

- Using the Event Editor dialog, select the Human from the Event Humans & Vehicles list, then select Set-up from the menu bar, choose Position/Velocity and click Initial. The human is displayed at the vehicle's origin (notice the human is half-buried in the vehicle geometry; this occurs because AutoPosition does not apply to humans). See Figure 5-35.

Enter the following data in the appropriate fields in the Position/Velocity, Initial dialog:

- x (ft) = 7.15
- y (ft) = -1.5
- z (ft) = -1.0
- Roll (deg) = 0.0
- Pitch (deg) = 0.0
- Yaw (deg) = 120.0

- Assigned Velocity (mph) = 1.0

The effects of these changes are displayed in Figure 5-36.

- Choose Set-up from the menu bar and select Collision Pulse.
- Select Acceleration as the Pulse Type.
- Ensure that in the table there is only one time entry for time 0.000 and that all of the column data is set to 0.000.
- Click OK to close the Collision Pulse window.

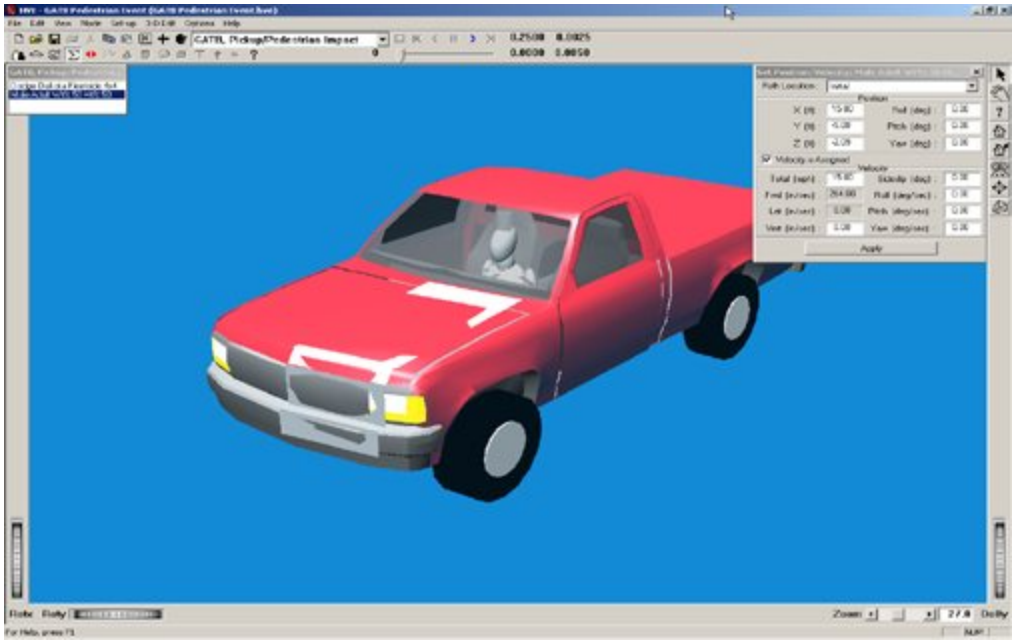


Figure 5-35: Setting up pedestrian position.

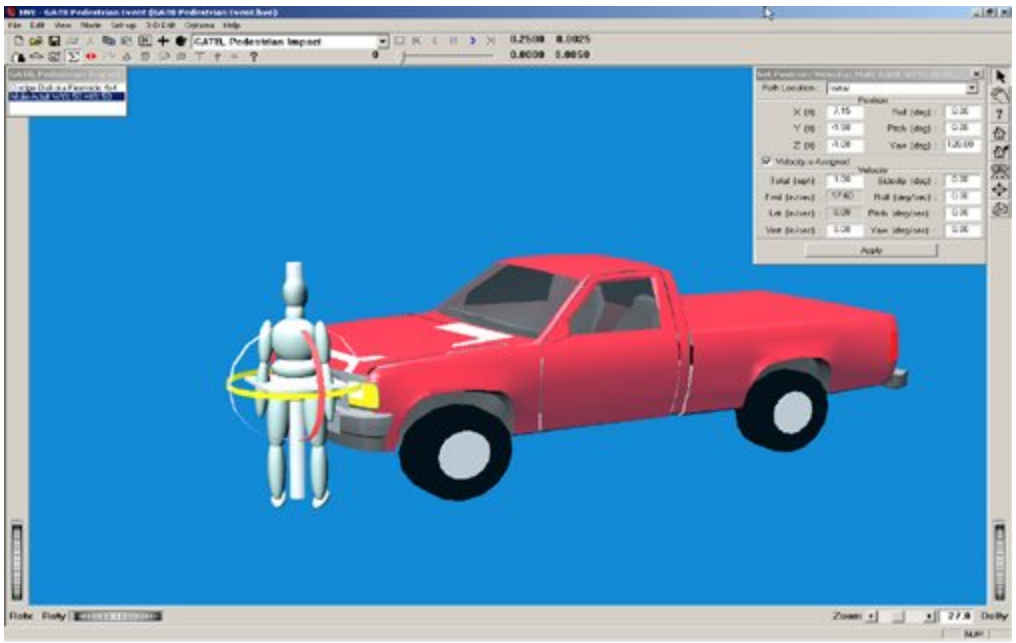


Figure 5-36: Positioning the human in front of pickup.

- Choose Set-up from the menu bar and select Contacts. The Contact Interactions dialog box will be shown (Figure 5-37).
- Choose Dodge Dakota Fleetside 4x4 from the object menu in the upper right-hand corner of the window.
- Click on the Select All button underneath the Human Source Object list to allow all human ellipsoids to interact with all of the contact surfaces attached to the Dodge Dakota pickup.
- Click OK to return to the Event Editor.

> **NOTE:** In order to reduce processing time for GATB events, it may be helpful to only designate contact interactions between specific contact surfaces. For example, if we were only examining the ground-feet interaction, we would only need to specify the left and right foot ellipsoids of the human and the GROUND object attached to the Dodge Dakota pickup truck.

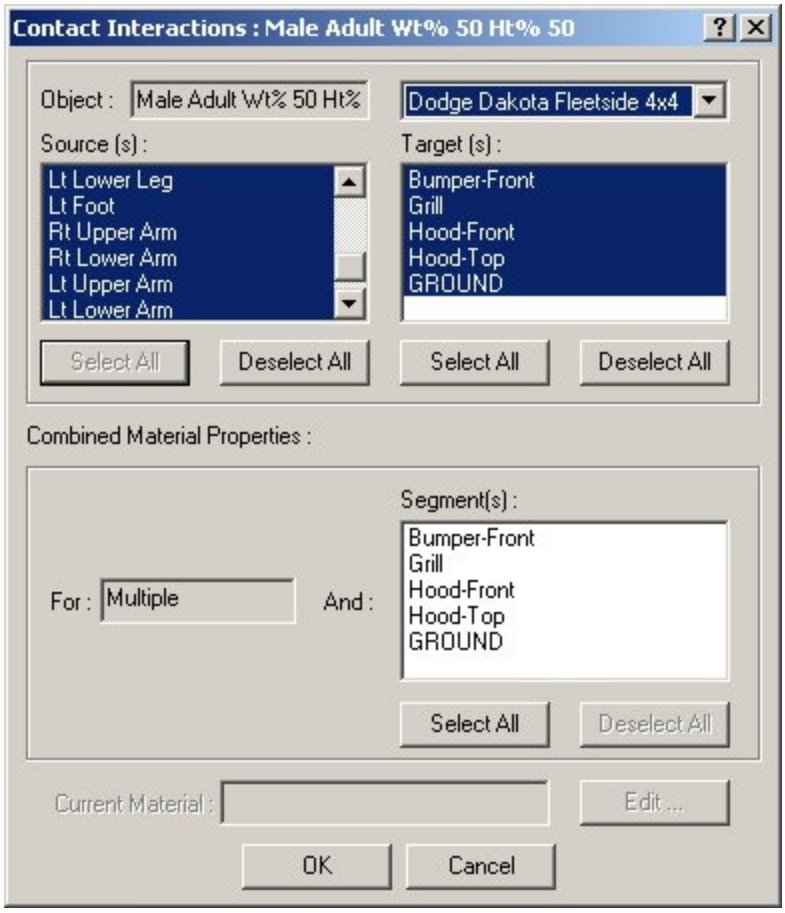


Figure 5-37: Contact Interactions dialog box.

In order to examine the interaction between the pedestrian and the GROUND contact panel, we need to set up the Key Results window to show the total force on each of the pedestrian's feet ellipsoids.

- In the Key Results window for the pedestrian, click on the Select Variable button.

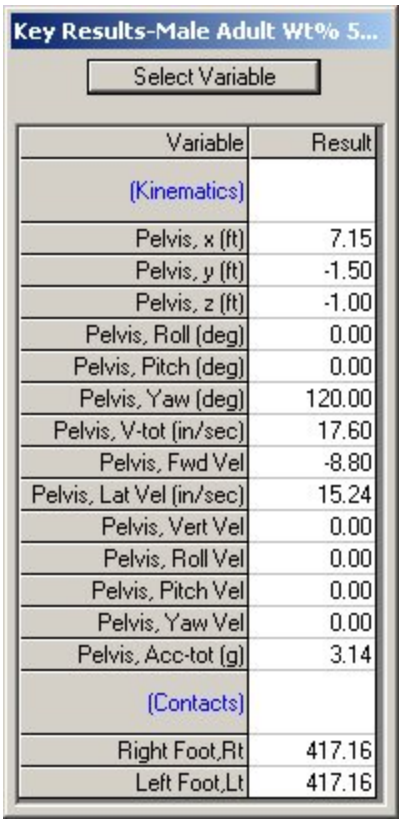
In the Output Groups listing, choose the following variables:

- `Contacts:Rt Foot:Rt Foot:Dodge Dakota Fleetside 4x4:GROUND:Cont F tot`
- `Contacts:Lt Foot:Lt Foot:Dodge Dakota Fleetside 4x4:GROUND:Cont F tot`

Your Key Results Window should look like Figure 5-38.

- Execute 1 timestep, rewind to time 0.0 sec, and examine the foot-ground interaction.

> **NOTE:** Total weight of the pedestrian (173.5 lbs in this example) should be approximately equal to total force of both feet interacting with the ground.



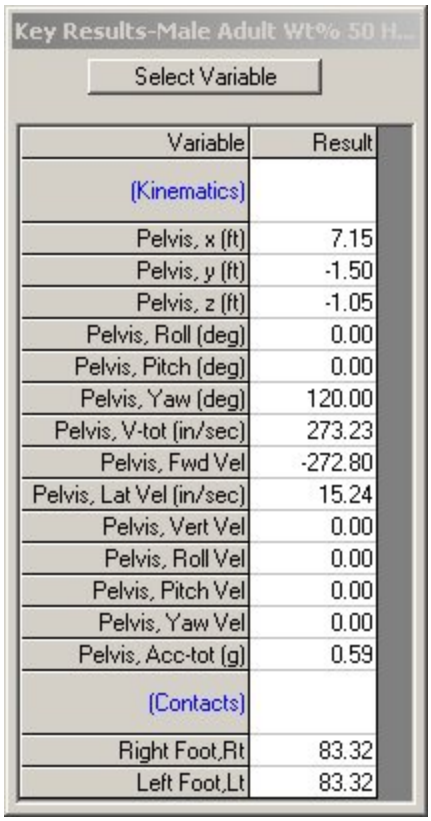
Variable	Result
(Kinematics)	
Pelvis, x (ft)	7.15
Pelvis, y (ft)	-1.50
Pelvis, z (ft)	-1.00
Pelvis, Roll (deg)	0.00
Pelvis, Pitch (deg)	0.00
Pelvis, Yaw (deg)	120.00
Pelvis, V-tot (in/sec)	17.60
Pelvis, Fwd Vel	-8.80
Pelvis, Lat Vel (in/sec)	15.24
Pelvis, Vert Vel	0.00
Pelvis, Roll Vel	0.00
Pelvis, Pitch Vel	0.00
Pelvis, Yaw Vel	0.00
Pelvis, Acc-tot (g)	3.14
(Contacts)	
Right Foot,Rt	417.16
Left Foot,Lt	417.16

Figure 5-38: Key Results window.

Figure 5-38 shows total force from feet-ground contacts to be approximately 834 lbs. We must move the pedestrian up slightly.

- Change the Z position of the pedestrian to -1.053 feet. Results of this change are shown in Figure 5-39.

> **NOTE:** You may find it helpful to edit the `language.rsc` in the `/HVE/supportFiles/sys` directory in order to show 3 decimal digits.



Variable	Result
(Kinematics)	
Pelvis, x (ft)	7.15
Pelvis, y (ft)	-1.50
Pelvis, z (ft)	-1.05
Pelvis, Roll (deg)	0.00
Pelvis, Pitch (deg)	0.00
Pelvis, Yaw (deg)	120.00
Pelvis, V-tot (in/sec)	273.23
Pelvis, Fwd Vel	-272.80
Pelvis, Lat Vel (in/sec)	15.24
Pelvis, Vert Vel	0.00
Pelvis, Roll Vel	0.00
Pelvis, Pitch Vel	0.00
Pelvis, Yaw Vel	0.00
Pelvis, Acc-tot (g)	0.59
(Contacts)	
Right Foot,Rt	83.32
Left Foot,Lt	83.32

Figure 5-39: Key Results window.

We will use the collision pulse to approximate the vehicle braking.

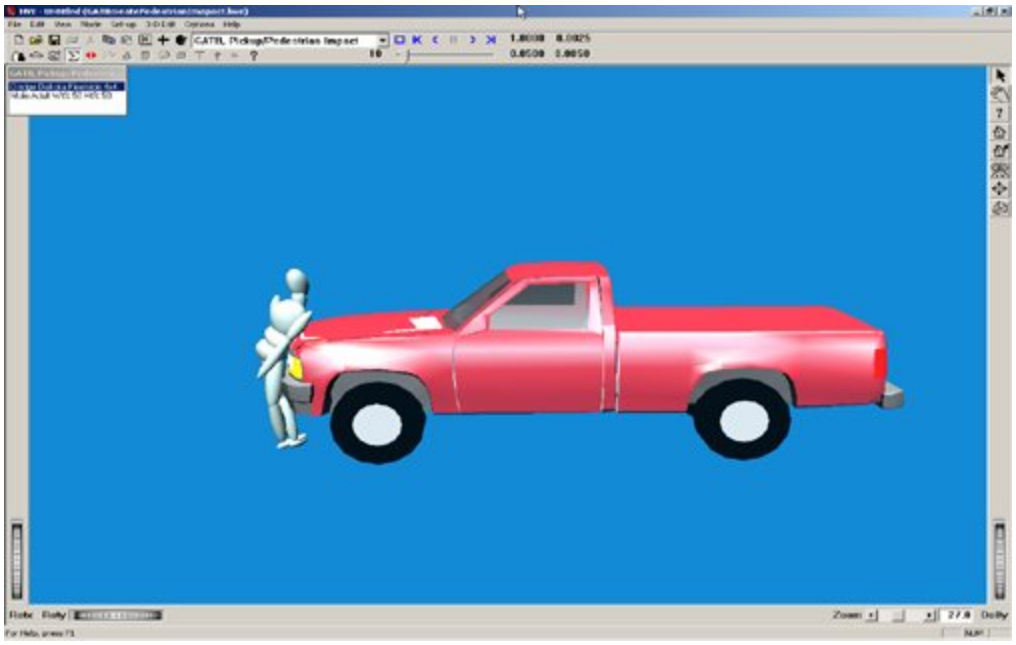
- Enter the following collision pulse for the Dodge Dakota 4x4 (Table 5-3).

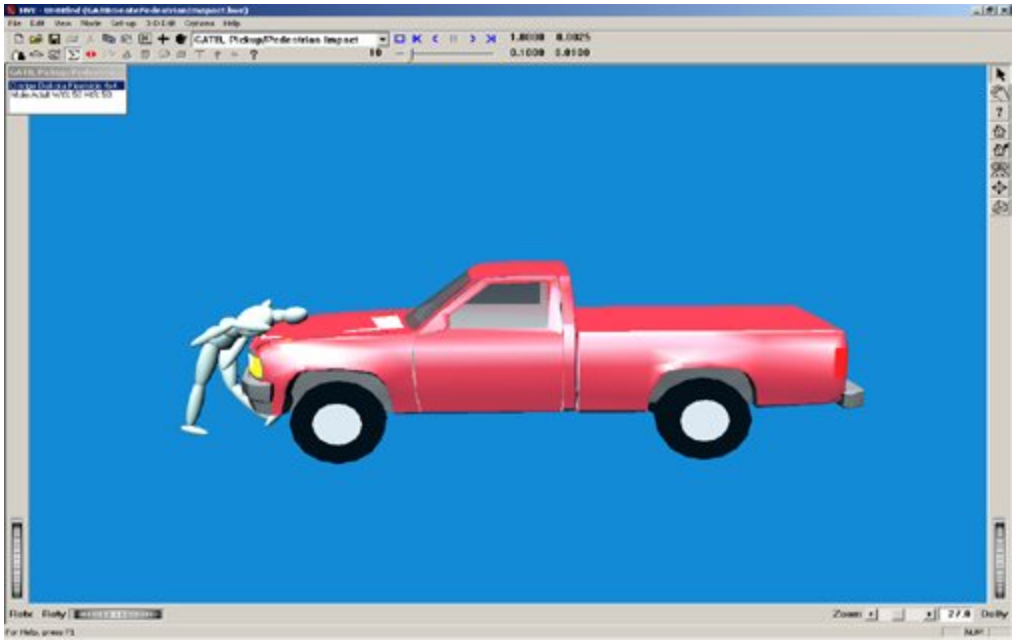
> **NOTE:** This crash pulse is available in the file `GATBTutorialPulse3`. Execute the run to analyze pedestrian behavior in this type of crash. The speeds of the vehicle and pedestrian can be modified, as well as braking effort on the pickup. Results of this run are shown in the following figures.
>
> If you are having difficulty in completing this portion of the tutorial, the file `GATBcreatePedestrianImpact` in your `/HVE/supportFiles/case` directory contains all necessary information up to this point.

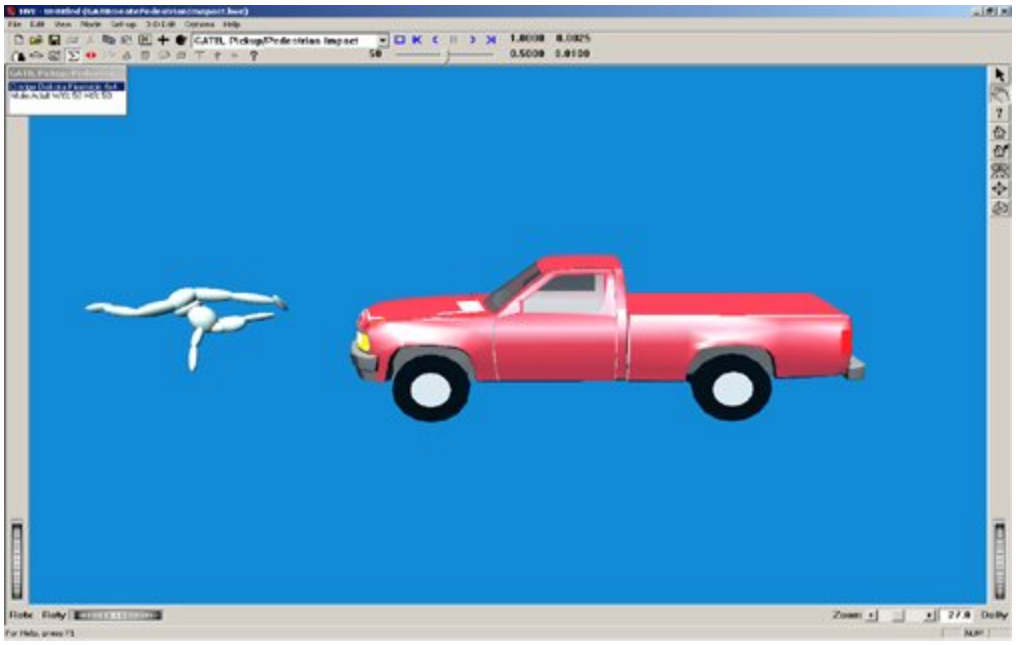
Table 5-3: Collision pulse to approximate hard braking by pickup

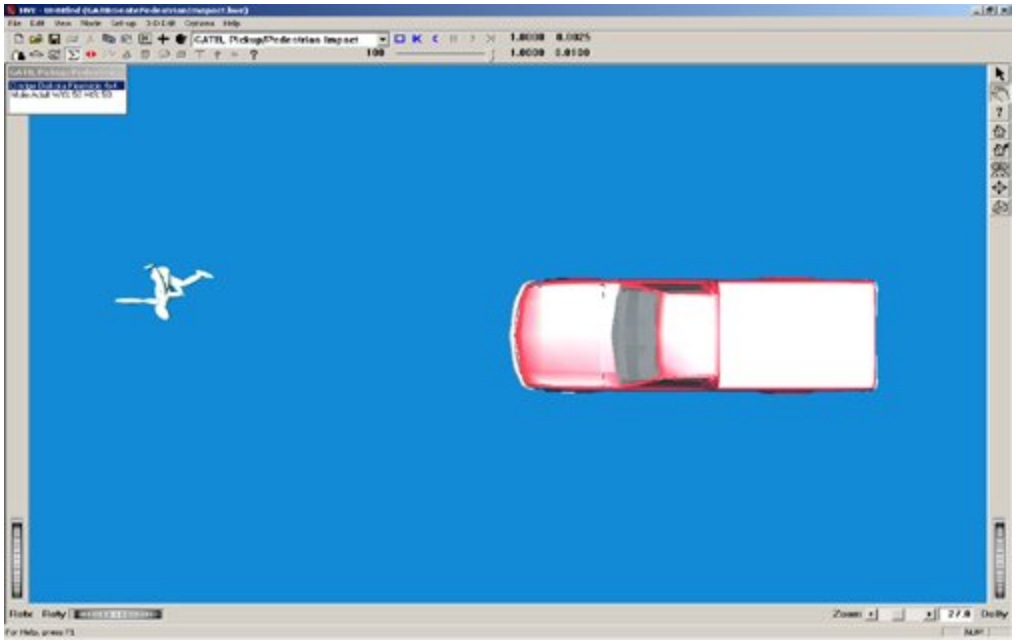
Time (s)	Forward Acceleration (g's)
0.0	-0.75
0.2	-0.75
0.4	-0.75
0.6	-0.75

Examine Figures 5-40 through 5-43 for views of the pedestrian interaction with the pickup truck. Try several different scenarios, increasing and decreasing the speed of the pickup. Also try changing the initial velocity of the pedestrian to study how the motion across the vehicle changes.









Figures 5-40 through 5-43: Pedestrian interaction at Time = 0.05, 0.10, 0.50 and 1.00 sec.

This completes the examples of the pedestrian simulation.

Chapter 6 — Messages

(This chapter was marked "to be added" in the printed Fifth Edition manual. The catalog below lists only the messages that a GATB event can raise, with the message code and the text as HVE displays it. The message catalog is shared across the HVE simulation models, so a given installation may show additional codes that do not apply to GATB.)

GATB reports problems in two ways:

- **Event Termination / Fatal Errors** — the simulation cannot continue and stops. These are shown as a dialog and are also written to the **Message** output report (see Chapter 3, Program Output).
- **Warnings** — a possible inconsistency was detected but the run continues. You may inspect these and choose to accept them.

The verbosity of the Message report is governed by the diagnostic level set in the HVE user options (Fatal Errors only; Fatal Errors + Diagnostics; Fatal Errors + Diagnostics + Informative).

GATB event set-up and termination messages

These are the codes GATB can report while setting up or running an event, together with the message text displayed for each.

Code	Type	Message text
-6800	Fatal	Event Termination: No Vehicle Position(s) Assigned!
-6810	Fatal	Event Termination: No Vehicle Velocity(ies) Assigned!
-6820	Fatal	Event Termination: No Human Position(s) Assigned!
-6830	Fatal	Event Termination: No Human Velocity(ies) Assigned!
-6530	Fatal	Event Termination: Bad Human vs Vehicle Contact Force
-6500	Fatal	Event Termination: Excessive Joint Articulation Angle
-6510	Fatal	Event Termination: Too Many Human Ellipsoids
-6520	Fatal	Event Termination: Too Many Vehicle Contact Surfaces
-6700	Fatal	Event Termination: Error in Derivative Calculations (excessive force). Try reducing integration timestep.
-6710	Fatal	Event Termination: Singular Matrix (Bad News!)
-6182	Fatal	Event Termination: Entered initial position is illegal

Notes on the common GATB messages:

- **No Human Position / No Human Velocity** — Every human in the event must have an initial position and (if the Velocity is Assigned box is checked) a velocity. Return to Set-up → Position/Velocity for each human. See the Tutorial for the correct procedure.
- **No Vehicle Position / No Vehicle Velocity** — Same requirement for each vehicle carrying the collision pulse.
- **Bad Human vs Vehicle Contact Force** — Usually indicates a human ellipsoid that starts deeply embedded in a contact panel (for example, feet driven into the floor), producing a very large restoring force. Re-establish an initial

equilibrium (Tutorial, "Establishing initial equilibrium") so that all segment accelerations are small before applying the crash pulse.

- **Excessive Joint Articulation Angle** — A joint has been driven past its allowable range of motion. Check the initial limb angles and the joint stop/torque data.
- **Too Many Human Ellipsoids / Too Many Vehicle Contact Surfaces** — The number of active contact ellipsoids or contact surfaces has exceeded the ATB model's internal limits. Reduce the number of designated contact interactions (Set-up → Contacts): specify only the ellipsoid-vs-surface pairs that are physically relevant rather than Select All. (Recall each human has 15 segments with up to 3 contact ellipsoids per segment — see Chapter 2.)
- **Error in Derivative Calculations / Singular Matrix** — Numerical instability, typically from excessive forces or too large a time step. Reduce the integration time step or correct the offending contact/joint data.

Vehicle-model warnings that can appear during a GATB event

Because a GATB event carries a vehicle (for the collision pulse and contact geometry), the shared vehicle-model messages may also appear. Those most relevant to GATB users:

Code	Type	Message text
-6000	Info	Done.
-6010	Info	Simulation Interrupted By User
-6030	Info	Maximum Simulation Time Reached
-6600	Fatal	Event Termination: Excessive Inter-vehicle Articulation Angle
-6870	Warning	Warning: The output interval is rather large for a collision simulation. Important collision pulse data may be missing. See Messages output report.

> **NOTE:** As illustrated in the Tutorial, GATB may warn that an angular (e.g. yaw) acceleration is higher than normal when a collision pulse derived from EDSMAC4 is applied. These are informational and may be accepted.

For the complete HVE physics message catalog (all codes and their text), see the HVE Operations Manual, Appendix II (Messages).

Chapter 7 — Technical References

References

1. Obergefell, L.A., Gardner, T.R., and Kaleps, I., "Articulated Total Body Enhancements — Volume 2: User's Guide", AAMRL-TR-88-043, January 1988 (NTIS No. A203 566).

2. Fleck, J.T., Butler, F.E., and Vogel, S.L., "An Improved Three Dimensional Computer Simulation of Crash Victims", NHTSA Report Nos. DOT-HS-801-507 through 510, April 1975, Volumes 1-4.

3. Fleck, J.T., Butler, F.E., "Development of an Improved Computer Model of the Human Body and Extremity Dynamics", Report No. AMRL-TR-75-14, July 1975 (NTIS No. AD-A014 816).

4. Fleck, J.T., Butler, F.E., and DeLeys, N.J., "Validation of the Crash Victim Simulator", Calspan Report Nos. ZS-5881-V-1 through 4, DOT-HS-806-279 through 282, 1982, Volumes 1-4 (NTIS No. PC E99, PB86-212420).

5. ATB Version V.1 obtained from Wright-Patterson Air Force Base, Dayton, OH.

6. Cheng, H., Obergefell, L.A., Rizer, A.L., "Generator of Body (GEBOD) Manual", Report No. AL/CF-TR-1994-0051, Armstrong Laboratory, Dayton, Ohio.

GEBOD Data Pages

*(These pages reproduce the Generator of Body Data — GEBOD — anthropometry tables printed at the back of the GATB manual. They list the **selected/computed body dimensions** produced by the GEBOD regression equations for the standard humans that GATB/HVE can create. In the current release these same standard subjects are generated through the GEBOD-based Human Information dialog — Subject Type Child/Female/Male/User, with Basis Age/Weight/Height/All — documented under Humans dialog reference. Values are computed body dimensions in the units shown; the child tables also list a Weight Correction Factor. Reference 6 in Chapter 7 is the GEBOD manual.)*

All linear dimensions are in inches (in); weight is in pounds (lb).

Child Subjects (Age 2-19 years)

Standard children are defined by age. The four tabulated ages are 3, 6, 9 and 12 years.

#	Dimension	3 yr	6 yr	9 yr	12 yr
0	WEIGHT (lb)	23.08	46.93	70.78	94.63
1	STANDING HEIGHT (in)	38.94	45.26	51.58	57.91
2	SHOULDER HEIGHT (in)	30.25	35.72	41.18	46.65
3	ARMPIT HEIGHT (in)	27.81	33.09	38.37	43.65
4	WAIST HEIGHT (in)	22.01	26.28	30.55	34.82
5	SEATED HEIGHT (in)	21.98	24.79	27.60	30.41
6	HEAD LENGTH (in)	7.012	7.143	7.274	7.405
7	HEAD BREADTH (in)	5.351	5.482	5.613	5.744
8	HEAD TO CHIN HEIGHT (in)	6.906	7.229	7.553	7.876
9	NECK CIRCUMFERENCE (in)	9.242	10.06	10.88	11.71
10	SHOULDER BREADTH (in)	8.824	10.12	11.41	12.71
11	CHEST DEPTH (in)	6.258	7.291	8.325	9.358
12	CHEST BREADTH (in)	6.167	7.138	8.110	9.082
13	WAIST DEPTH (in)	5.486	5.948	6.411	6.873
14	WAIST BREADTH (in)	6.345	7.324	8.302	9.281
15	BUTTOCK DEPTH (in)	5.795	6.778	7.760	8.743
16	HIP BREADTH, STANDING (in)	6.821	8.099	9.378	10.66
17	SHOULDER TO ELBOW LENGTH (in)	7.785	9.201	10.62	12.03
18	FOREARM-HAND LENGTH (in)	10.18	11.95	13.71	15.48
19	BICEPS CIRCUMFERENCE (in)	5.935	6.894	7.853	8.812
20	ELBOW CIRCUMFERENCE (in)	5.968	6.784	7.600	8.416
21	FOREARM CIRCUMFERENCE (in)	5.968	6.784	7.600	8.416
22	WRIST CIRCUMFERENCE (in)	4.383	4.795	5.208	5.620
23	KNEE HEIGHT, SEATED (in)	11.71	13.84	15.97	18.10
24	THIGH CIRCUMFERENCE (in)	11.49	13.68	15.86	18.05
25	UPPER LEG CIRCUMFERENCE (in)	9.728	11.46	13.19	14.92
26	KNEE CIRCUMFERENCE (in)	9.728	11.46	13.19	14.92
27	CALF CIRCUMFERENCE (in)	7.961	9.237	10.51	11.79
28	ANKLE CIRCUMFERENCE (in)	5.753	6.390	7.028	7.665
29	ANKLE HEIGHT, OUTSIDE (in)	1.565	1.811	2.057	2.304
30	FOOT BREADTH (in)	2.508	2.822	3.137	3.452
31	FOOT LENGTH (in)	6.261	7.138	8.015	8.892

#	Dimension	3 yr	6 yr	9 yr	12 yr
—	Weight Correction Factor	0.747	1.028	1.088	1.054

Adult Human Female

Standard adult females are defined by weight percentile (2.5, 50, 97.5) and standing-height percentile (2.5, 5, 50, 95, 97.5).

Adult — Weight 2.5%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	94.76	94.76	94.76	94.76	94.76
1	STANDING HEIGHT (in)	59.19	59.94	63.82	67.70	68.45
2	SHOULDER HEIGHT (in)	47.75	48.38	51.67	54.96	55.59
3	ARMPIT HEIGHT (in)	43.52	44.15	47.47	50.79	51.43
4	WAIST HEIGHT (in)	36.31	36.82	39.48	42.14	42.65
5	SEATED HEIGHT (in)	31.66	31.96	33.51	35.07	35.37
6	HEAD LENGTH (in)	7.035	7.053	7.149	7.245	7.264
7	HEAD BREADTH (in)	5.581	5.581	5.581	5.581	5.581
8	HEAD TO CHIN HEIGHT (in)	8.263	8.306	8.526	8.746	8.788
9	NECK CIRCUMFERENCE (in)	12.53	12.53	12.53	12.53	12.53
10	SHOULDER BREADTH (in)	13.33	13.38	13.67	13.95	14.01
11	CHEST DEPTH (in)	8.363	8.306	8.011	7.716	7.659
12	CHEST BREADTH (in)	10.08	10.05	9.882	9.718	9.686
13	WAIST DEPTH (in)	5.916	5.858	5.557	5.255	5.198
14	WAIST BREADTH (in)	8.430	8.403	8.263	8.124	8.097
15	BUTTOCK DEPTH (in)	7.387	7.328	7.020	6.712	6.653
16	HIP BREADTH, STANDING (in)	12.52	12.50	12.37	12.25	12.22
17	SHOULDER TO ELBOW LENGTH (in)	11.25	11.39	12.11	12.83	12.97
18	FOREARM-HAND LENGTH (in)	15.25	15.43	16.35	17.27	17.44
19	BICEPS CIRCUMFERENCE (in)	8.989	8.876	8.283	7.690	7.576
20	ELBOW CIRCUMFERENCE (in)	9.738	9.771	9.942	10.11	10.15
21	FOREARM CIRCUMFERENCE (in)	8.467	8.438	8.287	8.136	8.107
22	WRIST CIRCUMFERENCE (in)	5.497	5.511	5.581	5.651	5.665
23	KNEE HEIGHT, SEATED (in)	17.16	17.39	18.59	19.80	20.03
24	THIGH CIRCUMFERENCE (in)	19.48	19.35	18.66	17.97	17.84
25	UPPER LEG CIRCUMFERENCE (in)	16.20	16.12	15.73	15.33	15.25
26	KNEE CIRCUMFERENCE (in)	12.92	12.90	12.80	12.70	12.68
27	CALF CIRCUMFERENCE (in)	12.26	12.21	12.00	11.79	11.75
28	ANKLE CIRCUMFERENCE (in)	7.688	7.696	7.742	7.788	7.796
29	ANKLE HEIGHT, OUTSIDE (in)	2.474	2.505	2.667	2.828	2.859
30	FOOT BREADTH (in)	3.304	3.317	3.383	3.449	3.461

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	8.794	8.876	9.303	9.731	9.813

Adult — Weight 50%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	127.2	127.2	127.2	127.2	127.2
1	STANDING HEIGHT (in)	59.19	59.94	63.82	67.70	68.45
2	SHOULDER HEIGHT (in)	48.00	48.63	51.91	55.20	55.83
3	ARMPIT HEIGHT (in)	43.31	43.94	47.26	50.58	51.22
4	WAIST HEIGHT (in)	36.31	36.82	39.48	42.14	42.65
5	SEATED HEIGHT (in)	31.85	32.15	33.70	35.26	35.56
6	HEAD LENGTH (in)	7.133	7.151	7.247	7.343	7.362
7	HEAD BREADTH (in)	5.714	5.714	5.714	5.714	5.714
8	HEAD TO CHIN HEIGHT (in)	8.363	8.405	8.625	8.845	8.888
9	NECK CIRCUMFERENCE (in)	13.29	13.29	13.29	13.29	13.29
10	SHOULDER BREADTH (in)	13.77	13.83	14.11	14.40	14.45
11	CHEST DEPTH (in)	9.659	9.602	9.307	9.011	8.955
12	CHEST BREADTH (in)	11.22	11.18	11.02	10.86	10.82
13	WAIST DEPTH (in)	7.056	6.999	6.697	6.396	6.338
14	WAIST BREADTH (in)	9.664	9.638	9.498	9.358	9.331
15	BUTTOCK DEPTH (in)	8.693	8.634	8.326	8.018	7.959
16	HIP BREADTH, STANDING (in)	13.91	13.89	13.77	13.64	13.62
17	SHOULDER TO ELBOW LENGTH (in)	11.35	11.49	12.21	12.93	13.06
18	FOREARM-HAND LENGTH (in)	.	15.53	16.44	17.36	17.54
19	BICEPS CIRCUMFERENCE (in)	10.78	10.67	10.08	9.486	9.372
20	ELBOW CIRCUMFERENCE (in)	10.42	10.45	10.62	10.79	10.82
21	FOREARM CIRCUMFERENCE (in)	9.422	9.393	9.242	9.091	9.062
22	WRIST CIRCUMFERENCE (in)	5.807	5.820	5.891	5.961	5.974
23	KNEE HEIGHT, SEATED (in)	17.37	17.60	18.80	20.01	20.24
24	THIGH CIRCUMFERENCE (in)	22.66	22.53	21.83	21.14	21.01
25	UPPER LEG CIRCUMFERENCE (in)	18.54	18.46	18.06	17.67	17.59
26	KNEE CIRCUMFERENCE (in)	14.41	14.40	14.29	14.19	14.17
27	CALF CIRCUMFERENCE (in)	13.69	13.65	13.44	13.23	13.19
28	ANKLE CIRCUMFERENCE (in)	8.246	8.255	8.301	8.346	8.355
29	ANKLE HEIGHT, OUTSIDE (in)	2.474	2.505	2.667	2.828	2.859
30	FOOT BREADTH (in)	3.413	3.426	3.492	3.558	3.570

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	8.966	9.048	9.475	9.903	9.985

Adult — Weight 97.5%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	159.7	159.7	159.7	159.7	159.7
1	STANDING HEIGHT (in)	59.19	59.94	63.82	67.70	68.45
2	SHOULDER HEIGHT (in)	48.24	48.87	52.16	55.45	56.08
3	ARMPIT HEIGHT (in)	43.09	43.73	47.05	50.37	51.01
4	WAIST HEIGHT (in)	36.31	36.82	39.48	42.14	42.65
5	SEATED HEIGHT (in)	32.03	32.33	33.89	35.45	35.75
6	HEAD LENGTH (in)	7.231	7.250	7.346	7.441	7.460
7	HEAD BREADTH (in)	5.847	5.847	5.847	5.847	5.847
8	HEAD TO CHIN HEIGHT (in)	8.462	8.504	8.724	8.945	8.987
9	NECK CIRCUMFERENCE (in)	14.04	14.04	14.04	14.04	14.04
10	SHOULDER BREADTH (in)	14.22	14.27	14.56	14.84	14.90
11	CHEST DEPTH (in)	10.95	10.90	10.60	10.31	10.25
12	CHEST BREADTH (in)	12.35	12.32	12.16	11.99	11.96
13	WAIST DEPTH (in)	8.197	8.139	7.838	7.536	7.479
14	WAIST BREADTH (in)	10.90	10.87	10.73	10.59	10.57
15	BUTTOCK DEPTH (in)	9.999	9.940	9.632	9.324	9.265
16	HIP BREADTH, STANDING (in)	15.31	15.29	15.16	15.04	15.01
17	SHOULDER TO ELBOW LENGTH (in)	11.45	11.58	12.30	13.02	13.16
18	FOREARM-HAND LENGTH (in)	15.45	15.62	16.54	17.46	17.64
19	BICEPS CIRCUMFERENCE (in)	12.58	12.47	11.87	11.28	11.17
20	ELBOW CIRCUMFERENCE (in)	11.09	11.13	11.30	11.47	11.50
21	FOREARM CIRCUMFERENCE (in)	10.38	10.35	10.20	10.05	10.02
22	WRIST CIRCUMFERENCE (in)	6.117	6.130	6.200	6.271	6.284
23	KNEE HEIGHT, SEATED (in)	17.58	17.81	19.01	20.22	20.45
24	THIGH CIRCUMFERENCE (in)	25.83	25.70	25.01	24.32	24.18
25	UPPER LEG CIRCUMFERENCE (in)	20.87	20.79	20.40	20.00	19.92
26	KNEE CIRCUMFERENCE (in)	15.91	15.89	15.79	15.69	15.67
27	CALF CIRCUMFERENCE (in)	15.13	15.09	14.88	14.67	14.62
28	ANKLE CIRCUMFERENCE (in)	8.805	8.814	8.859	8.905	8.914
29	ANKLE HEIGHT, OUTSIDE (in)	2.474	2.505	2.667	2.828	2.859
30	FOOT BREADTH (in)	3.522	3.535	3.601	3.666	3.679

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	9.138	9.220	9.647	10.07	10.16

Adult Human Male

Standard adult males are defined by weight percentile (2.5, 50, 97.5) and standing-height percentile (2.5, 5, 50, 95, 97.5).

Adult — Weight 2.5%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	131.5	131.5	131.5	131.5	131.5
1	STANDING HEIGHT (in)	65.04	65.81	69.82	73.83	74.60
2	SHOULDER HEIGHT (in)	52.73	53.38	56.81	60.23	60.88
3	ARMPIT HEIGHT (in)	47.17	47.83	51.27	54.71	55.37
4	WAIST HEIGHT (in)	38.68	39.25	42.19	45.14	45.70
5	SEATED HEIGHT (in)	34.67	34.97	36.52	38.07	38.36
6	HEAD LENGTH (in)	7.650	7.662	7.729	7.796	7.809
7	HEAD BREADTH (in)	6.014	6.014	6.014	6.014	6.014
8	HEAD TO CHIN HEIGHT (in)	8.742	8.778	8.965	9.152	9.188
9	NECK CIRCUMFERENCE (in)	14.21	14.16	13.91	13.66	13.62
10	SHOULDER BREADTH (in)	15.21	15.26	15.51	15.75	15.80
11	CHEST DEPTH (in)	8.715	8.652	8.320	7.988	7.924
12	CHEST BREADTH (in)	11.82	11.77	11.53	11.30	11.25
13	WAIST DEPTH (in)	7.778	7.689	7.222	6.756	6.666
14	WAIST BREADTH (in)	10.80	10.74	10.42	10.09	10.03
15	BUTTOCK DEPTH (in)	8.365	8.292	7.911	7.531	7.458
16	HIP BREADTH, STANDING (in)	12.71	12.71	12.71	12.71	12.71
17	SHOULDER TO ELBOW LENGTH (in)	13.16	13.32	14.16	14.99	15.15
18	FOREARM-HAND LENGTH (in)	18.15	18.35	19.38	20.41	20.61
19	BICEPS CIRCUMFERENCE (in)	11.29	11.19	10.69	10.19	10.10
20	ELBOW CIRCUMFERENCE (in)	11.43	11.45	11.56	11.66	11.68
21	FOREARM CIRCUMFERENCE (in)	10.29	10.26	10.10	9.948	9.919
22	WRIST CIRCUMFERENCE (in)	6.486	6.493	6.530	6.566	6.573
23	KNEE HEIGHT, SEATED (in)	20.15	20.40	21.74	23.07	23.32
24	THIGH CIRCUMFERENCE (in)	20.71	20.54	19.69	18.84	18.68
25	UPPER LEG CIRCUMFERENCE (in)	13.87	13.87	13.87	13.87	13.87
26	KNEE CIRCUMFERENCE (in)	14.07	14.07	14.07	14.07	14.07
27	CALF CIRCUMFERENCE (in)	13.46	13.40	13.08	12.75	12.69
28	ANKLE CIRCUMFERENCE (in)	8.168	8.161	8.123	8.085	8.078
29	ANKLE HEIGHT, OUTSIDE (in)	5.005	5.076	5.446	5.817	5.888
30	FOOT BREADTH (in)	3.622	3.638	3.722	3.807	3.823

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	9.948	10.04	10.50	10.96	11.05

Adult — Weight 50%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	173.5	173.5	173.5	173.5	173.5
1	STANDING HEIGHT (in)	65.04	65.81	69.82	73.83	74.60
2	SHOULDER HEIGHT (in)	53.09	53.75	57.17	60.59	61.24
3	ARMPIT HEIGHT (in)	47.01	47.67	51.11	54.55	55.21
4	WAIST HEIGHT (in)	38.41	38.97	41.92	44.87	45.43
5	SEATED HEIGHT (in)	34.84	35.14	36.69	38.24	38.53
6	HEAD LENGTH (in)	7.743	7.756	7.823	7.890	7.903
7	HEAD BREADTH (in)	6.142	6.142	6.142	6.142	6.142
8	HEAD TO CHIN HEIGHT (in)	8.742	8.778	8.965	9.152	9.188
9	NECK CIRCUMFERENCE (in)	15.39	15.34	15.09	14.84	14.80
10	SHOULDER BREADTH (in)	15.74	15.79	16.03	16.28	16.33
11	CHEST DEPTH (in)	10.05	9.984	9.653	9.321	9.257
12	CHEST BREADTH (in)	13.18	13.14	12.90	12.67	12.62
13	WAIST DEPTH (in)	9.334	9.245	8.778	8.312	8.222
14	WAIST BREADTH (in)	12.57	12.51	12.18	11.86	11.80
15	BUTTOCK DEPTH (in)	9.890	9.817	9.437	9.056	8.983
16	HIP BREADTH, STANDING (in)	13.88	13.88	13.88	13.88	13.88
17	SHOULDER TO ELBOW LENGTH (in)	13.16	13.32	14.16	14.99	15.15
18	FOREARM-HAND LENGTH (in)	18.22	18.42	19.45	20.48	20.68
19	BICEPS CIRCUMFERENCE (in)	12.99	12.90	12.40	11.90	11.80
20	ELBOW CIRCUMFERENCE (in)	12.17	12.19	12.30	12.40	12.42
21	FOREARM CIRCUMFERENCE (in)	11.27	11.24	11.08	10.93	10.90
22	WRIST CIRCUMFERENCE (in)	6.880	6.887	6.924	6.960	6.967
23	KNEE HEIGHT, SEATED (in)	20.37	20.62	21.96	23.29	23.54
24	THIGH CIRCUMFERENCE (in)	24.17	24.00	23.15	22.30	22.14
25	UPPER LEG CIRCUMFERENCE (in)	15.22	15.22	15.22	15.22	15.22
26	KNEE CIRCUMFERENCE (in)	15.47	15.47	15.47	15.47	15.47
27	CALF CIRCUMFERENCE (in)	15.02	14.96	14.64	14.32	14.25
28	ANKLE CIRCUMFERENCE (in)	8.867	8.860	8.822	8.784	8.777
29	ANKLE HEIGHT, OUTSIDE (in)	4.959	5.030	5.401	5.771	5.842
30	FOOT BREADTH (in)	3.744	3.760	3.844	3.929	3.945

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	10.10	10.19	10.65	11.11	11.20

Adult — Weight 97.5%-tile

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
0	WEIGHT (lb)	215.5	215.5	215.5	215.5	215.5
1	STANDING HEIGHT (in)	65.04	65.81	69.82	73.83	74.60
2	SHOULDER HEIGHT (in)	53.45	54.11	57.53	60.95	61.60
3	ARMPIT HEIGHT (in)	46.85	47.51	50.95	54.39	55.05
4	WAIST HEIGHT (in)	38.14	38.70	41.65	44.59	45.16
5	SEATED HEIGHT (in)	35.01	35.31	36.86	38.41	38.70
6	HEAD LENGTH (in)	7.837	7.850	7.917	7.984	7.997
7	HEAD BREADTH (in)	6.271	6.271	6.271	6.271	6.271
8	HEAD TO CHIN HEIGHT (in)	8.742	8.778	8.965	9.152	9.188
9	NECK CIRCUMFERENCE (in)	16.57	16.52	16.27	16.02	15.97
10	SHOULDER BREADTH (in)	16.27	16.31	16.56	16.81	16.85
11	CHEST DEPTH (in)	11.38	11.32	10.99	10.65	10.59
12	CHEST BREADTH (in)	14.55	14.50	14.27	14.03	13.99
13	WAIST DEPTH (in)	10.89	10.80	10.33	9.868	9.779
14	WAIST BREADTH (in)	14.34	14.28	13.95	13.63	13.57
15	BUTTOCK DEPTH (in)	11.41	11.34	10.96	10.58	10.51
16	HIP BREADTH, STANDING (in)	15.06	15.06	15.06	15.06	15.06
17	SHOULDER TO ELBOW LENGTH (in)	13.16	13.32	14.16	14.99	15.15
18	FOREARM-HAND LENGTH (in)	18.29	18.49	19.52	20.55	20.75
19	BICEPS CIRCUMFERENCE (in)	14.70	14.61	14.11	13.61	13.51
20	ELBOW CIRCUMFERENCE (in)	12.92	12.94	13.04	13.14	13.16
21	FOREARM CIRCUMFERENCE (in)	12.25	12.22	12.07	11.91	11.88
22	WRIST CIRCUMFERENCE (in)	7.274	7.281	7.318	7.355	7.362
23	KNEE HEIGHT, SEATED (in)	20.59	20.84	22.18	23.51	23.77
24	THIGH CIRCUMFERENCE (in)	27.63	27.46	26.61	25.76	25.60
25	UPPER LEG CIRCUMFERENCE (in)	16.58	16.58	16.58	16.58	16.58
26	KNEE CIRCUMFERENCE (in)	16.87	16.87	16.87	16.87	16.87
27	CALF CIRCUMFERENCE (in)	16.58	16.52	16.20	15.88	15.82
28	ANKLE CIRCUMFERENCE (in)	9.567	9.559	9.521	9.483	9.476
29	ANKLE HEIGHT, OUTSIDE (in)	4.913	4.984	5.355	5.725	5.796
30	FOOT BREADTH (in)	3.866	3.882	3.966	4.051	4.067

#	Dimension	Ht 2.5%	Ht 5%	Ht 50%	Ht 95%	Ht 97.5%
31	FOOT LENGTH (in)	10.25	10.34	10.80	11.26	11.35