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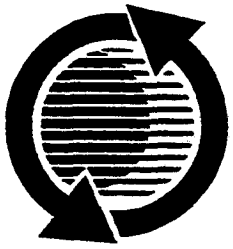

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ABSTRACT

HVE is a product of Engineering Dynamics Corp. designed to do scientific simulations and visualizations of vehicle accidents. It is a computer environment which combines a relational database and 3D graphics with physics programs. This paper is directed to readers who are users of HVE or are familiar with it and are considering becoming users. The purpose of this paper is to describe and discuss the types of available images and the methods for importing them into HVE. It will discuss the special considerations the authors have found necessary for the various types of images and for their incorporation into the HVE environment.

INTRODUCTION

HVE is a product of Engineering Dynamics Corporation.[1] designed to do scientific simulations and visualizations of vehicle accidents. It is a computer environment which combines a relational database and 3D graphics with physics programs such as SMAC,[2,3] SVS,[4] VTS,[5] HIS[6] and HVOSM.[7,8,9] Versions of these programs that run in HVE are called EDSMAC, EDSVS, EDVTS, EDHIS, and EDVSM. They are familiar to the users of the EDVAP series of programs available from Engineering Dynamics Corp. HVE runs on a Silicon Graphics Incorporated (SGI) workstation in Unix. To do its work, HVE requires 3D computer images of accident scenes, vehicles, and people. Some of the necessary images are available in the vehicle and human databases and the 3D editor can be used to produce environments for use in the simulations. HVE was designed to accept objects and images produced or already available in other 3D imaging environments including AutoCAD,[10] 3D Studio,[11] and Wavefront[12] and to accept scanned images in the RGB format. The use of imported images and objects in HVE can significantly reduce the time required to make a realistic visualization of an event and can vastly extend the range of possible simulations.

This paper is directed to readers who are users of HVE or are familiar with it and are considering becoming users. The purpose of this paper is to describe and discuss the types of available images and the methods for importing them into HVE. It will discuss the special considerations the authors have found necessary for the various types of images and for their incorporation into the HVE environment.

HVE WINDOWS

The images in HVE appear in several windows. These include the EVENT WINDOW where the analysis takes place, the PREVIEW WINDOW which plays a completed event after analysis and the PLAYBACK WINDOW where one or more PREVIEW WINDOWS can be shown simultaneously. This last feature makes it possible to combine several events into one for the final presentation.

THE ENVIRONMENT

There are many possible environments which can be used in HVE. The environment can be built with the 3D editor, can be an imported mesh (3D image), can be a flat transparent surface with an aerial photo or a drawing or the scene in the background or can be a 3D terrain used in conjunction with a photo.

SCANNED HORIZONTAL IMAGES – The simplest environment is the flat transparent surface which takes on the color of the sky. It is useful when the event being studied is viewed from above and no details such as streets, lane markings or road edges are necessary. A drawing of the accident scene or an aerial photo can be imported as illustrated in Figures 1 and 2 to represent the important aspects of the accident scene. The vehicles still operate on the flat transparent surface which is the default terrain of HVE but the event appears to occur on the drawing or the aerial photo which is positioned behind the transparent surface.

The diagram or photo must first be digitized and turned into what is called a bitmap. This can be done with any one of a variety of scanners available for use on the SGI computer. They can also be scanned into a personal computer (PC) and then transferred to the SGI. A bitmap file (scanned image) can be imported into the SGI in the form of a TIFF, GIF, PCD or JPEG. These can be converted into an RGB file using the

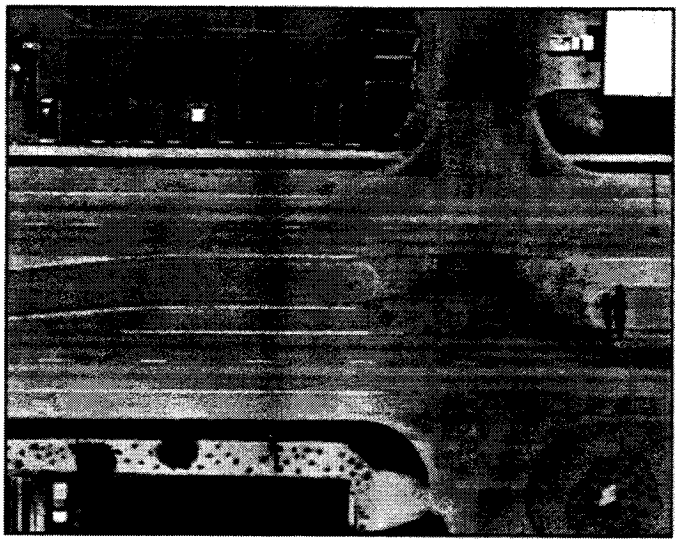

Figure 1

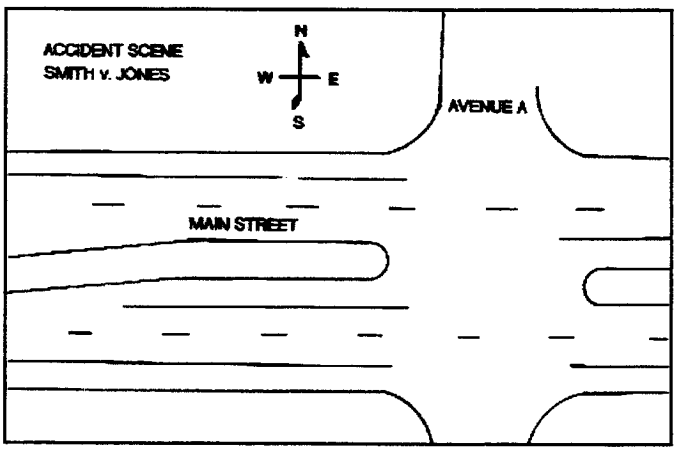

Figure 2

IMAGE VIEW or IMAGE WORKS utilities on the SGI computer. The JPEG file is a compressed image file which can be transferred on a floppy disk. The JPEG can also be converted to an RGB file using the IMAGE WORKS utility on the SGI. Table 1 lists the file formats which can be converted to RGB on the SGI computer.

TABLE 1

SGI image (rgb)
TIFF
GIF
JFIF
JPEG
FIT

File formats which are accepted by the SGI computer.

The scanned image or bitmap must have certain characteristics to be useable in HVE. The image must have sufficient resolution to provide a clear image in the playback window of HVE and on a video monitor and be undistorted. The resolution is affected by the quality of the original image and the number of dots per inch of the scan. On a photo, the smallest individual element of a scanned image is called a dot. In video, the smallest element is called a pixel. If a one inch square photo is scanned at 100 dots per inch, this results in an image of 100 pixels. This is 10 pixels on a side. Generally an image of 1200 by 1600 pixels or more is very satisfactory in HVE. An image this size will have a file size of seven megabytes. A JPEG file of this size will have one megabyte and can be easily transferred on a floppy disk. A discussion of this subject can be found in the Adobe Users Manual.[13]

SCALE – It is necessary to know the scale of the drawing or photo so that the camera distance in HVE can be set so that the vehicles are the same scale as the photo or diagram. This is quite easily done using the target option in the physics programs to set targets at a known distance apart and then adjusting the camera distance from the surface so that they appear the correct distance apart in the photo or diagram. To have the scale of the event properly represented, the camera position must be the same in all three windows.

ORIGIN OR REFERENCE POINT – The zero point in the HVE default terrain is the center of the event window. If a scanned diagram or aerial photo is used, the x = 0, y = 0 point will be the center of the event window. This can be adjusted by changing the "camera position" and the "center of picture position" by the same exact amount.

ASPECT RATIO – The aspect ratio (width to height) must be controlled so that the image is not stretched to fill a window. HVE uses an image which has an aspect ratio of 4 to 3. That is 4 units wide by 3 units high. If the aspect ratio of the image is different than this, it will be stretched to fill the window causing distortion. The image can be adjusted by cropping in IMAGE WORKS before importing into HVE. In order for the events to appear in exactly the same position in the event, preview and playback windows the aspect ratio of these windows must have the same 4 x 3 ratio. It is not necessary that they be the same size but they must have the same aspect ratio.

EXAMPLES – Figures 3 and 4 are examples of accident reconstructions on aerial photos. Figure 3 is a city street. Figure 4 shows an accident situation in a railroad switch yard. The background photos and all the vehicle and train images were imported.

SCANNED NON HORIZONTAL IMAGES – Scanned images such as photos taken at ground level or from an airplane or helicopter have been used in HVE in conjunction with 3D terrain models. In HVE, there is an option in the 3D

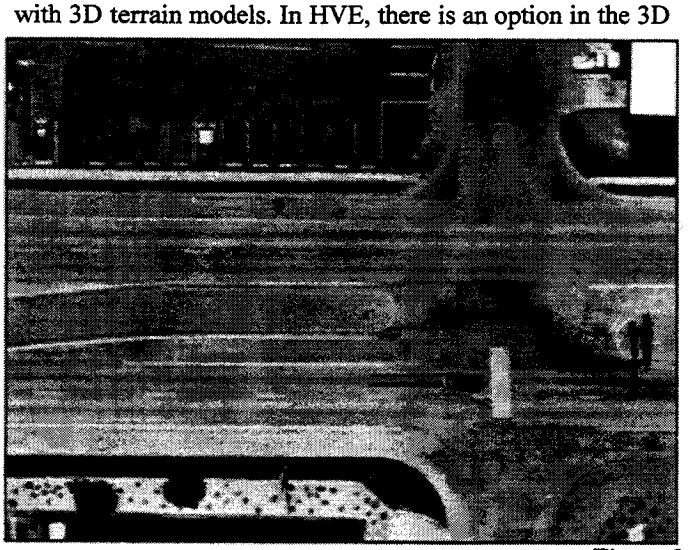

Figure 3

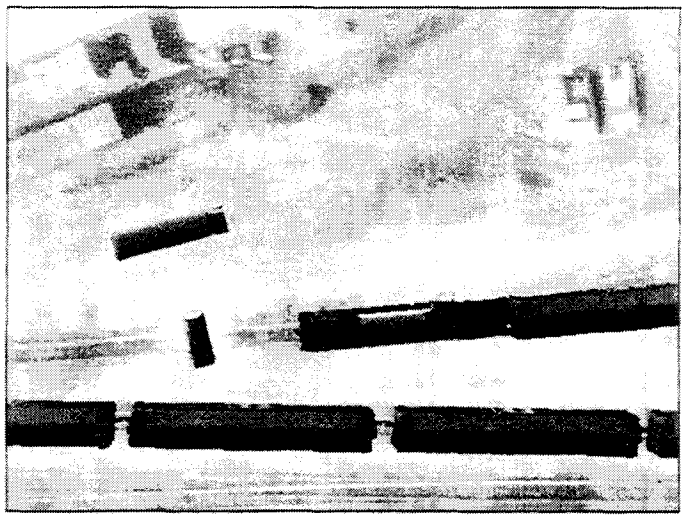

Figure 4

editor to put objects in a terrain on layers. In the view option, it is possible to select each of the layers to be shown or to be hidden. With this facility it is possible to match the photo with the terrain and then show the event as though it occurs in the photo. For this purpose, it is desirable to have reference marks or details on the terrain and the photo which can be matched. An example of this technique is shown in Figures 5 and 6. The vehicle operates on the 3 dimensional terrain and appears to be operating on the same terrain shown in the photo.

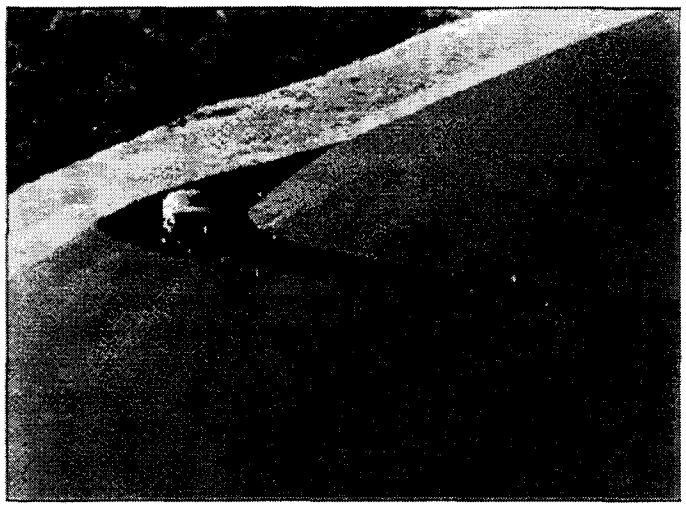

Figure 5

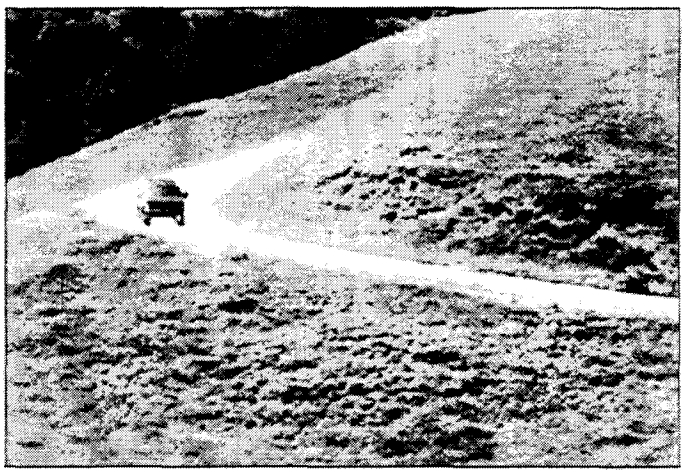

Figure 6

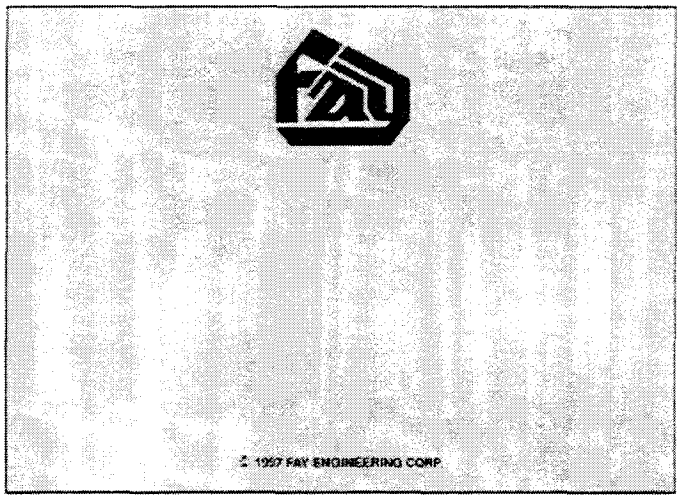

Figure 7

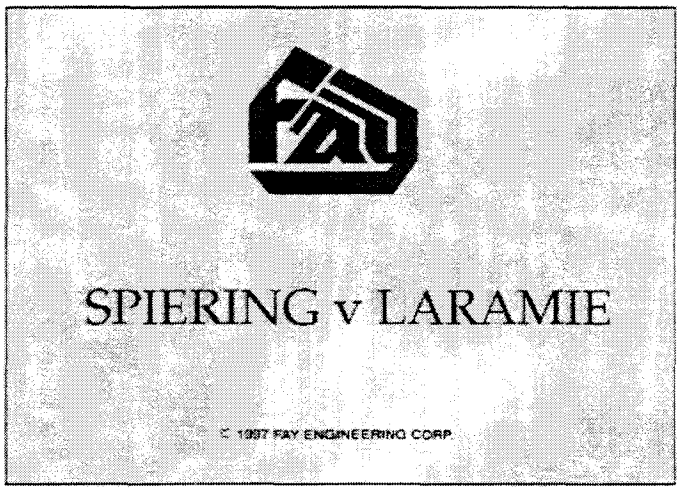

Figure 8

TITLES

A scanned image of the company logo or other information can form the basic background for titles to be used on the presentations of the simulations or visualizations. Figure 7 is an example of the use of a scanned image for the background with the project specific text added in the 3D editor in HVE. The camera position can be changed to adjust the size of the letters and they can be moved around on the background with the "hand" in the environment window. The image can be exported out by making it into an event or by using the VIDEO OUT feature of the SGI computer. Figure 8 shows the combination of the text with the scanned background.

3D TERRAINS

HVE has its own 3D editor. However, users may prefer to build scenes with other editors and then import them into HVE. Accident scenes can be made in AutoCAD, 3D Studio, or Wavefront and imported into HVE. AutoCAD and 3D Studio run on a PC. These programs have advantages over the 3D editor in HVE due to their many features which save time and effort in the development of objects. Wavefront operates on an SGI.

AUTOCAD – This program is familiar to many practitioners in the field of vehicle dynamics and accident reconstruction

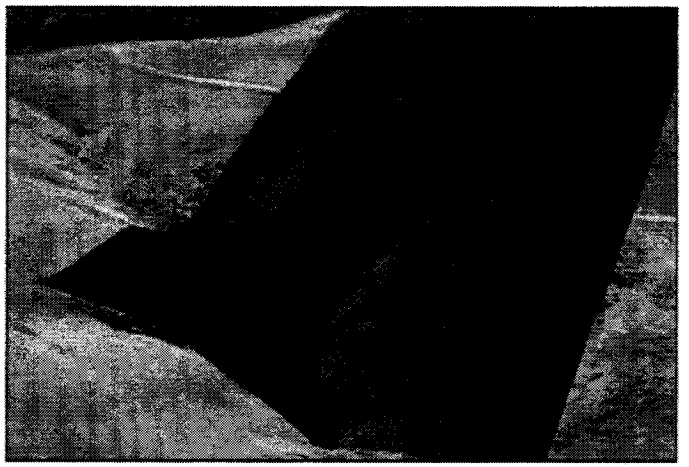

Figure 9

who use it to make accident scene diagrams. The diagrams can be scanned and used as RGB images as described above. 3D AutoCAD meshes can be imported as DXF files and used in HVE. Contour surveys can be digitized in AutoCAD using a digitizing table and formed into a mesh using a program such as Quick Surf.[14] The meshes are put into the 3D Studio format (3DS). A rather complex terrain can be formed with a file of .5 to 1 megabyte. An example of this type of terrain is shown in Figure 9.

3D STUDIO/3D MAX – This is a widely used program by practitioners in the field of vehicle dynamics and accident reconstruction. There are many utilities which work with these programs to help in building terrains and accident scenes. Civil detailer[15] makes highway and structural details. The abilities of the programs to replicate and modify objects speed the work. The facilities for lofting and smoothing are useful. It is possible to scan in photos and use them for patterns for building roadways and structures. An aerial photo, scanned in can aid in making a road or street to scale with all the painted lines in the correct location.

SCALE AND ORIENTATION – AutoCAD and 3D Studio/ 3D Max use a scale for their images denominated in feet. HVE uses a scale in inches because all the physics programs are written in inches. Therefore, all the images scaled in feet must be scaled up by a factor of 12 before they are imported. In HVE, the positive Z direction is down. In AutoCAD and 3D Studio/3D Max, positive Z is up. Therefore, the mesh must be turned upside down before it is imported into HVE.

SPECIAL CONSIDERATIONS – The surfaces on which the vehicles operate can have their friction factors assigned in the 3D editor of HVE. The default friction factor for each object is 1.0. Localized areas of higher or lower friction can be defined by making these separate objects. Objects which do not interact with the vehicle(s) can be defined as "other" causing the physics package to simply ignore them. This is important if the vehicle operates under a bridge or other structure. Special care should be taken to assure that the surfaces that the vehicle is to operate on have only one surface thickness. If there is more than one thickness, the "get surface" routine of the physics package can be difficult to predict and the vehicle may drop through the first surface and find the second one. The objects identified by the 3D editor after being imported will appear in the view editor window and can be selected to appear or not to appear.

VEHICLES AND OTHER OBJECTS

Vehicles can be made in AutoCAD and 3D Studio/3D Max. Frequently it is more efficient to obtain models from the companies which sell images such as Viewpoint Data Labs[16] and REM Infografica.[17] The images can be obtained individually or in groups by paying a certain fee. There is a wide selection of images available in this fashion and these images can be modified in 3D Studio/3D Max to produce other images if desired. Another source of images is the practitioner's own files from previous projects. Frequently a simple modification of a previously used vehicle or object can be made to produce the desired vehicle or object. To do this, the vehicle can be exported from HVE, modified and reimported.

TWO WHEEL VEHICLES AND OTHER OBJECTS – Figure 10 is the image of a motorcycle with a driver. The motorcycle was modified from a mesh obtained from Infografica and the driver was formed in 3D Max using Character Studio[18]. The motorcycle was attached to the fixed barrier in HVE and its motion was defined using EDGEN.[19]

The same technique has been applied to lawn tractors and bicycles with riders. A driver is shown in the car in Figure 11. The driver was put in the car before it was imported into HVE. The driver is part of the vehicle mesh and does not have the properties of the human in EDHIS.

SEMI-TRUCKS – Figure 12 shows a semi-tractor pulling a livestock trailer. The tractor was modified from a Viewpoint

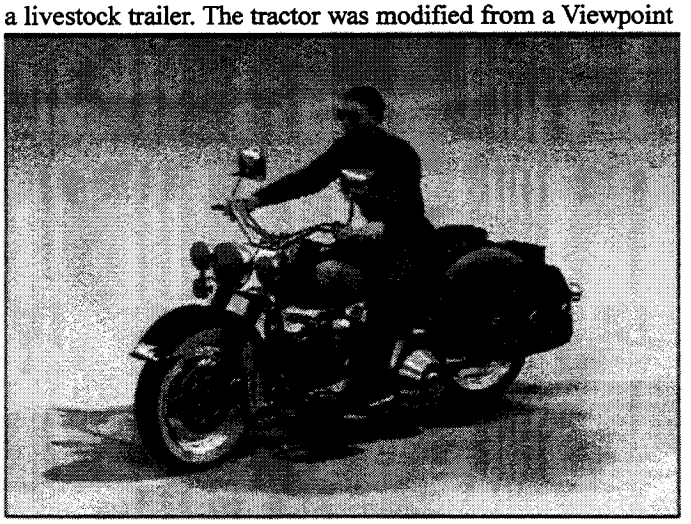

Figure 10

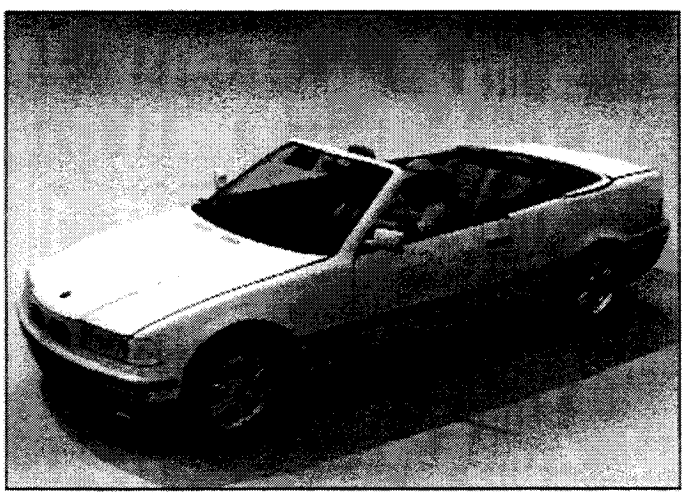

Figure 11

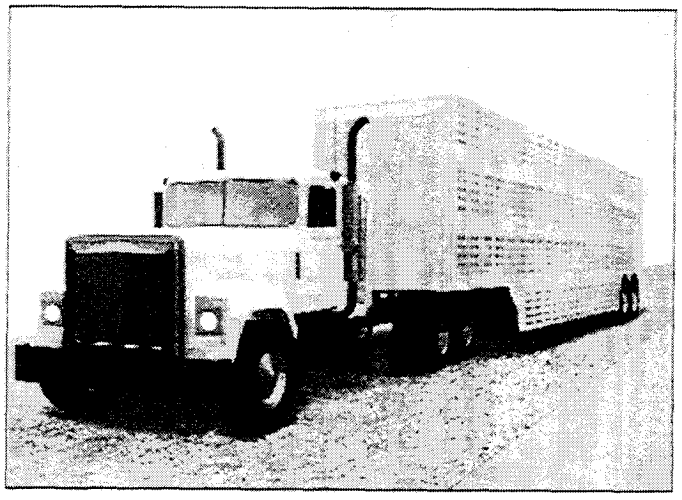

Figure 12

mesh and the trailer was built in 3D Studio on a suspension obtained from a Viewpoint mesh. The truck was used with EDVTS. The tractor and trailer were applied to a generic truck and semi-trailer.

SCALE AND ORIENTATION – As with the terrains, vehicle images must be rescaled and inverted before importing them into HVE. Vehicles must have their wheels removed if they are to be used on HVE vehicles with their wheels showing. This can be done easily in AutoCAD and 3D Studio. The vehicle's origin will probably not be the center of gravity but likely be the center of the object. This will be close enough that adjustments can be made in HVE as will be discussed later.

IMAGE MODIFICATIONS AND ADJUSTMENTS IN HVE

3D EDITOR–In the absence of an additional 3D modeling package like 3D Studio and AutoCAD, an HVE user may import vehicle images and use the HVE 3D Editor to modify these models. The HVE 3D Editor can perform simple modifications to imported objects by providing translations or rotations to individual object groups, as well as delete unneeded portions of the models, i.e. delete the tires, and rotate the entire image. As shown in Figure 13 (before) and 14 (after).

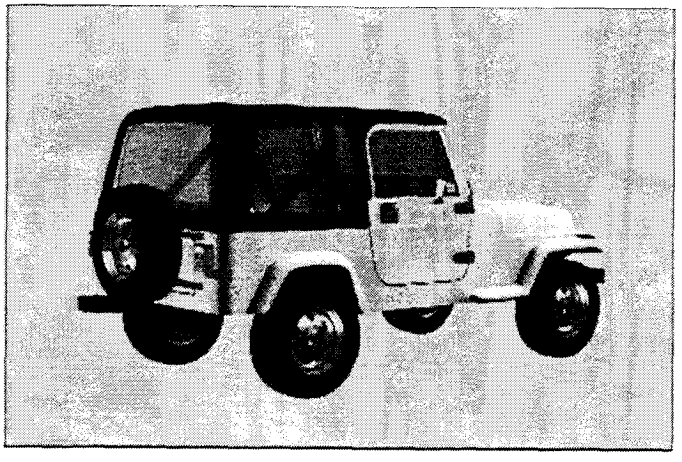

Figure 13

INVENTOR FILES – Images imported into HVE may be translated into the SGI INVENTOR file format, an easily read, well organized ASCII file format. The image is first saved as an HVE image, then its inventor file is opened. The

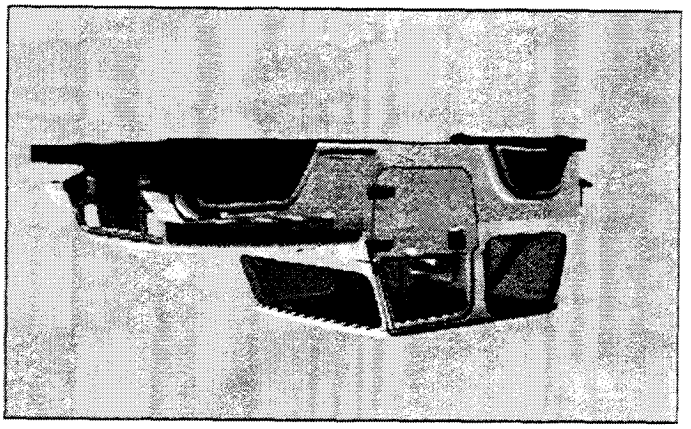

Figure 14

image files may then be easily manipulated with a few simple ASCII codes added at obvious locations within the file. Figures 15 (before) and 16 (after) show an inserted scale multiplier translation and rotation to an entire complex vehicle image.

```
#Inventor v2.0 ascii

Separator  {
        Switch  {
        WhichChild      -1
        DEF Body+0 Material  {
                ambientColor        0.5  0.5  0.5
                diffuseColor        0.156  0.625  0.977
                specularColor       1  1  1
                shininess       0.5
}
```

Figure 15

```
#Inventor v2.0 ascii

Separator  {
        Transform  {
                scaleFactor    12  12  12
                }
        Translation  {
                translation     -6.25  0  -20.25
                }
        RotationXYZ  {
                axis    y
                angle  1.570796
                }
        Switch  {
        WhichChild      -1
        DEF Body+0 Material  {
                ambientColor        0.5  0.5  0.5
                diffuseColor        0.156  0.625  0.977
                specularColor       1  1  1
                shininess       0.5
        }
```

Figure 16

IMPORTING DATA FILES INTO HVE

IMPORTING TO THE SGI COMPUTER – Data files can be imported into the SGI computer in several ways. Many data files can be transferred on a floppy disk. Larger

files can be transferred on a Zip[20] or Jaz[21] drive connected to the SCSI port of the SGI. The SGI computer can be connected to PC's with an Ethernet allowing files to be transferred with the <ftp> protocol.

PLACING IMPORTED FILES INTO HVE – Imported files must be placed in the proper directories in HVE to be accessible. The files can be imported into a Temp file and then transferred into the appropriate environment and vehicle directories for access by HVE using X Windows or Unix commands.

SUMMARY

The application of HVE can be enhanced by using imported objects and images. These range from meshes (images) of humans, vehicles, and environments to scanned images such as photos and diagrams. The file structure of HVE is designed to accept imported files in formats produced by AutoCAD, 3D Studio, Wavefront, and scanned images in the RGB format. This capability of the program makes it possible to import valid and realistic terrains based on measurements and survey data, put dimensionally accurate bodies on vehicles, and to show realistic images of people in vehicles and scenes. With this facility it is possible to extend the range of moving objects which can be realistically presented to include trains, motorcycles, lawn tractors, and other forms of vehicular machinery in HVE events. Accurate images imported into HVE can play an extremely important role in the analysis and the visualization of an event.

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9. Segal, D.J., "Highway-Vehicle-Object Simulation Model - Volume 4, Validation," US DOT, Federal Highway Administration Report No. FHWA-RD-76-165, Calspan Corporation, February, 1976.

10. AutoCAD is a trademark of the Kinetix Division of Auto Desk, 111 McInnis Parkway, San Rafael, California 94903.

11. 3D Studio is a product of the Kinetix Division of Auto Desk, (See Reference No. 10).

12. Wavefront is a product of ALIAS, subsidiary of Silicone Graphics International, 110 Richmond Street, East Toronto, Ontario Canada M5C-1P1.

13. Adobe Photo Shop is a product of Adobe Systems, Inc., 1585 Charleston Road, PO Box 7900, Mountainview, California, 94039-7900.

14. Quick Surf is a product of the Kinetix Division of Auto Desk, (See Reference No. 10).

15. Civil detailer is a product of the Kinetix Division of Auto Desk, (See Reference No. 10).

16. View Point Data Labs 625 South State Street, Orem, Utah 84058.

17. REM Infografica, SA Plaza, Santa Barbara 10, Madrid, Spain 28004.

18. Character Studio is a product of Kinetix Division of Auto Desk, (See Reference No. 10).

19. EDGEN is an integral part of HVE, (See Reference No. 1).

20. ZIP is a product of the IOMEGA Corporation 1821 West Iomega Way, Roy, Utah 84067.

21. JAZ is a product of the IOMEGA Corporation, (See Reference No. 20).