

Presentation of HVE Validation Studies

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ABSTRACT

HVE users are regularly required to provide explanation as to how the various HVE simulation programs operate and how they have been validated. This paper presents a method by which HVE validation studies may be visually depicted so that a viewer may gain a rapid understanding of what the HVE programs do and the methods by which they have been validated.

In this method, EDSMAC4 validation simulations are used to create movie files with viewpoints and effective frame rates similar to those of the cameras used to document full-scale dynamic vehicle tests. The viewer is provided with a visual comparison of the motion of the simulated vehicles played adjacent to the films of the full-scale crash tests. It is contended that this technique provides a more concise and understandable explanation of the program's operation and validation than would a verbal description alone.

INTRODUCTION

The physics modules within the HVE simulation environment have been used "to study a variety of design and safety issues related to passenger and commercial motor vehicles, such as dynamic handling behaviors, effects of road conditions, systems failures or driver reactions, and real-world crashes including underrides and rollovers, or involving occupants or pedestrians." [1] In many cases, users of the HVE software suite are asked to explain how the software functions and how it has been validated.

Methods by which an HVE user can convey this information might include verbal description, static diagrams or imagery, and/or motion picture imagery. The first two of these methods are included within a series of technical papers by the developers of the HVE software modules which detail the operation and validation of the programs [2-8]. The authors of this paper have also relied upon flowchart-style diagrams, as

depicted in Figure 1, to provide an overview of how the software functions. Most recently, the authors of this paper have developed a series of HVE movies which allow for use of the third method.

VALIDATION STUDIES

The physics modules within the HVE simulation environment have been validated against full-scale vehicle tests. [2-8],[9]

One such group of tests against which HVE modules have been validated is the RICSAC test series. With the title of "Research Input for Computer Simulation of Automobile Collisions", these twelve tests were performed by Calspan Corporation in the late 1970's under the auspices of the National Highway Traffic Safety Administration (NHTSA). The object of these tests was to "develop a library of experimental data which could be used to validate accident reconstruction techniques such as SMAC and CRASH" [10].

The numerical comparison of the validation of the HVE modules against the measured parameters of the RICSAC tests has been discussed in full elsewhere in the literature [2-8]. Here, the authors present the visual output of simulation runs of a selection of the RICSAC tests made via the HVE physics module EDSMAC4.

METHOD

The authors were provided by Engineering Dynamics Corporation (EDC) with a digital version of a selection of RICSAC crash test films contained within EDC's reference library. These were films which documented RICSAC Tests 3, 6, 7, 8 and 11. These films contained footage collected with film-based motion picture cameras shot from a variety of angles and at varying film speeds. The RICSAC test reports contain information regarding the location of many of the cameras as well as technical specifications such as frame rates and lens focal lengths.

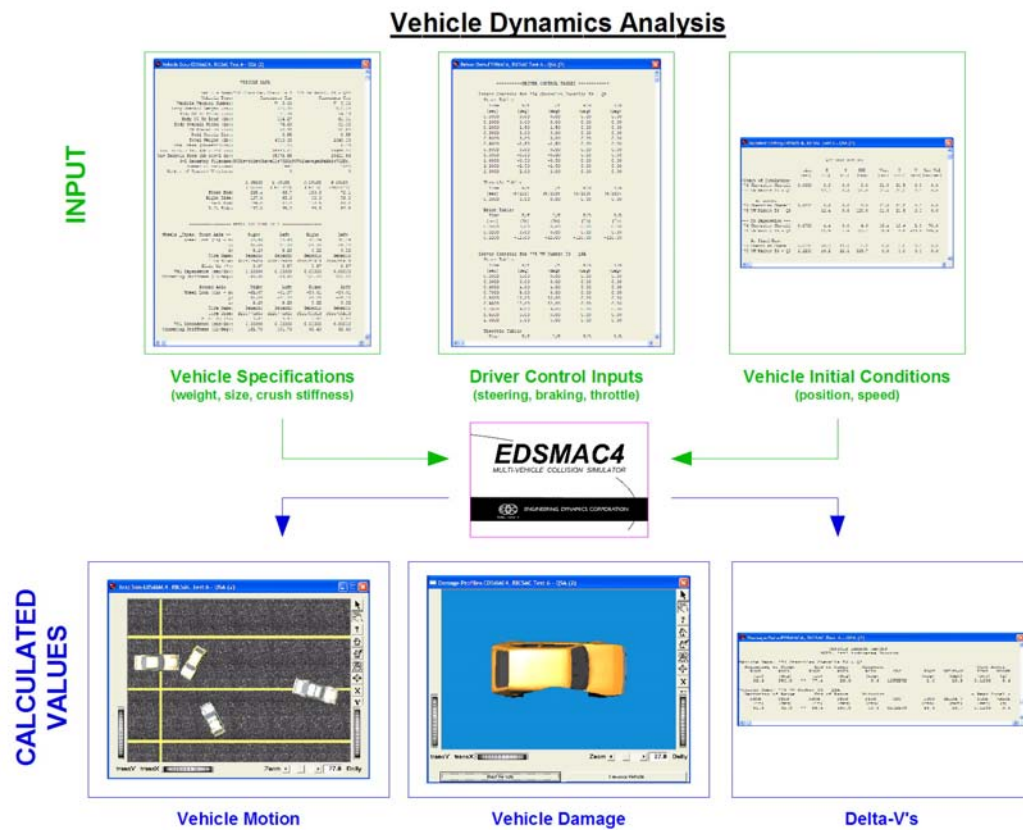


Figure 1 – Flowchart depicting program function

EDC also provided the authors with the PC-formatted input files for the EDSMAC4 physics module which had been created by EDC during prior validation studies. These files were originally developed by EDC for the purpose of comparing the output of simulation runs made using recent software modules such as EDSMAC4 against the output of the original SMAC runs created by the RICSAC researchers. The authors of this paper have subsequently re-examined the EDC EDSMAC4 input files and have made minor modifications to them in the interest of matching the EDSMAC4 output to measured test data, such as vehicle post-impact motion and points of rest. These modifications consisted primarily of refinements in vehicle positions and driver inputs. These changes to the EDC RICSAC runs and the resulting detailed numerical and graphical output is intended to be the subject of a future technical paper.

By studying the crash test films and referring to the camera information contained within the RICSAC test reports, the authors created movie files for each of the five selected tests using the refined EDSMAC4 simulation files. These movies were created by first placing the HVE virtual camera at a location close to that indicated in the test report and with a perspective similar to that observed in the test films. As an example of the camera data provided by the RICSAC researchers,

Figure 2 is a schematic diagram of the test configuration and camera locations for RICSAC Test #6.

Such a schematic identified the location of all cameras for each of the tests analyzed. The authors used the “Tower close” or the “Tower wide” camera positions for all of the tests discussed in this paper. The positions identified in the RICSAC test reports for these cameras were used as a starting point for the placement of the virtual HVE cameras.

Once the approximate camera placement was determined, a movie file was created from the HVE simulation run. Two static images from the actual films were then imported as backgrounds in the HVE playback editor. One image was selected at the point of impact. The second image was selected at a later time such that the vehicles had moved sufficiently to provide a second reference point. Using these two reference points, the HVE camera position, angle and focal length were adjusted for the purpose of matching the view of the camera which captured the test film. Figure 3 depicts a frame from the movie file for RICSAC Test 6 showing its overlay onto the original test film.

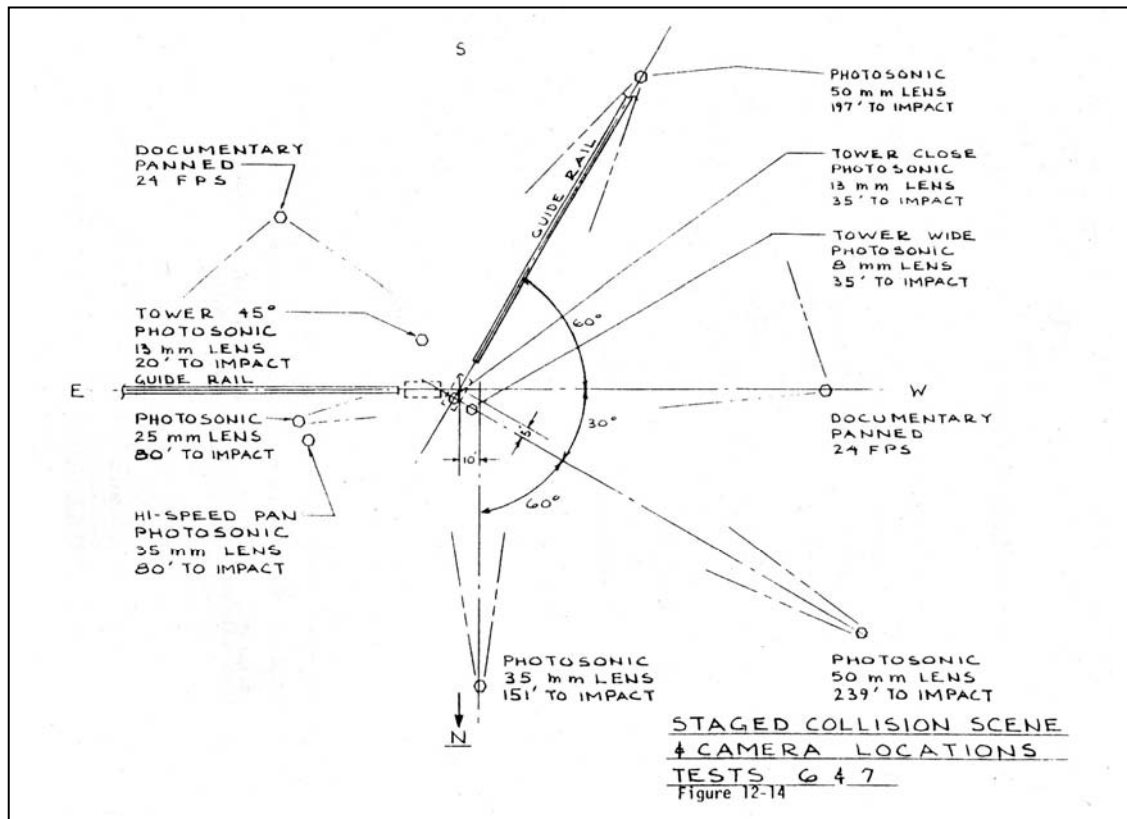


Figure 2 – Diagram of camera locations for RICSAC Test #6



Figure 3 – Overlay of HVE movie onto frame of test film

Note that the RICSAC film cameras were of a 16 mm high speed format [10], whereas the HVE virtual cameras model a 35 mm camera playing in real time [11]. Thus, in order to play the HVE movie files next to the crash test films at the same effective frame rate, the speed of the HVE movies had to be adjusted so that the motion depicted in the HVE movies matched that documented in the crash test films.

Because the output of the simulation run, including post-impact vehicle motion and vehicle points of rest correlate closely with the measured RICSAC test data, the authors could use the features within the video editing software package "Combustion 3.0" [12] to adjust the speed at which the HVE movie file was depicted until the motion of the vehicles in the movie matched the motion of the vehicles shown in the test films.

Once the motion of the imagery in the HVE movie had been matched to the test films, the video editing software was used to create a split screen video so that a viewer is able to easily make a comparison between the vehicle motion as depicted in the simulation movie and the crash test film.

RESULTS

Figures 4 through 8 depict still frames from each of the completed comparison videos. As can be observed, the positions of the simulated vehicles at coincident points in time closely match the positions of the test vehicles in terms of location, heading, and perspective.

SUMMARY AND CONCLUSION

- EDSMAC4 simulation runs were made of RICSAC Tests 3, 6, 7, 8 and 11.
- Virtual camera locations were created within HVE to approximate the locations of the film cameras used to document the RICSAC tests
- The resulting HVE movie files were overlaid onto frames of the crash tests films and the HVE virtual camera positions were refined
- The resulting HVE movie files were composited with the original test films in a split-screen view
- The simulated motions of the vehicles match the motions of the test vehicles in terms of position, heading, and perspective
- Based on the HVE movie files, a viewer can easily gain a basic understanding of how the HVE modules function to simulate vehicle motion, and the viewer can also readily evaluate the fidelity by which the HVE results duplicate the full-scale test results

- It is believed that the methods discussed in this paper provide useful techniques for researchers interested in comparing the results of computer-simulated vehicle motions against full-scale crash tests, and that the comparison videos created in this particular study can be relied upon by other HVE users when describing the validation of HVE software modules against full-scale vehicle tests

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Engineering Dynamics Corporation for providing digital versions of the RICSAC test films as well as the HVE input files which formed the basis of the simulations of the RICSAC tests.

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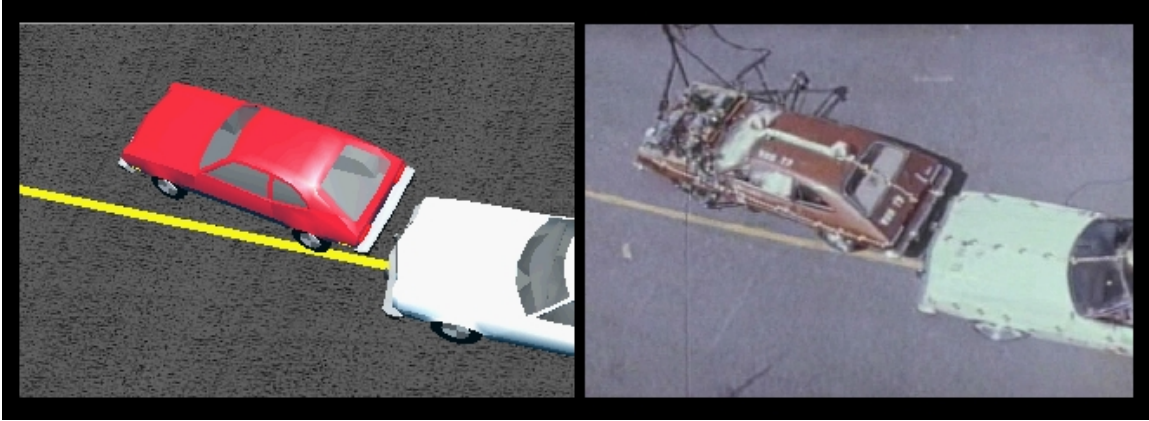
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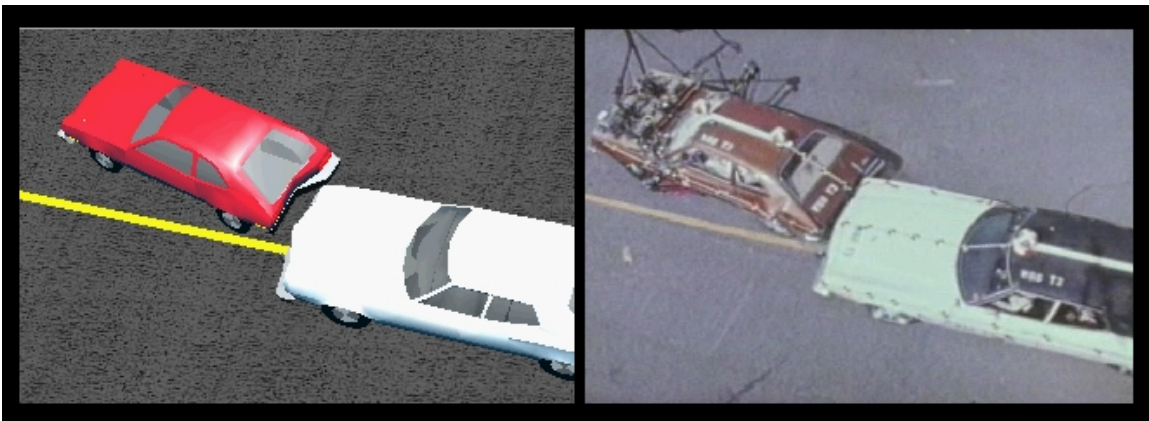
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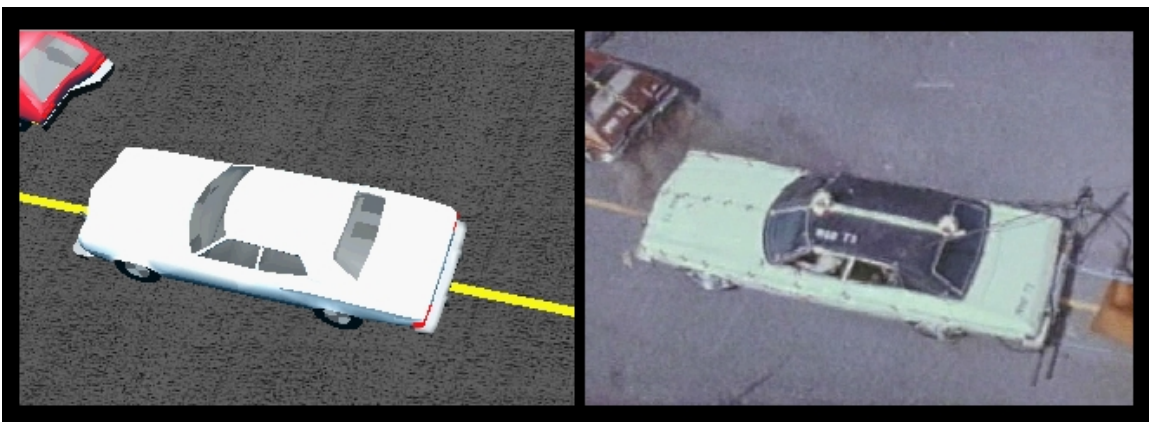
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$t = 0$ seconds



$t = 0.2$ seconds

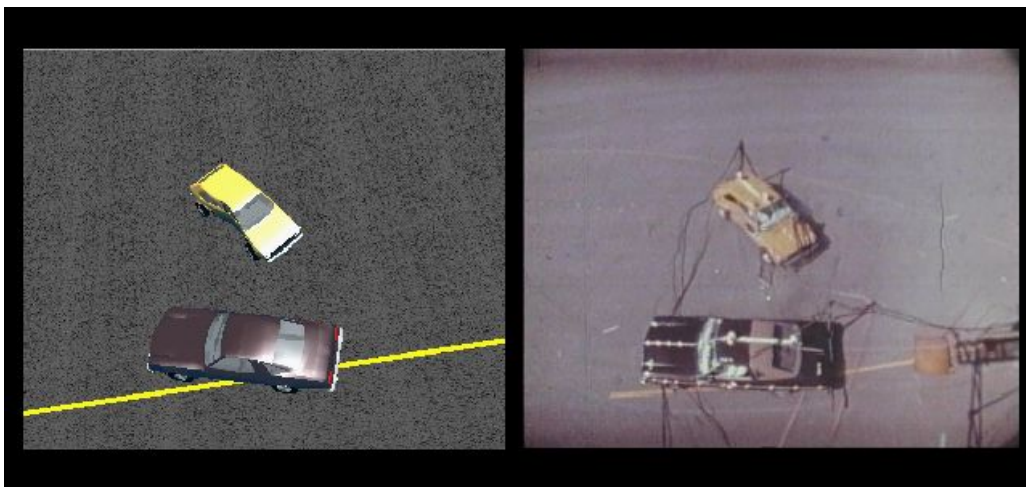


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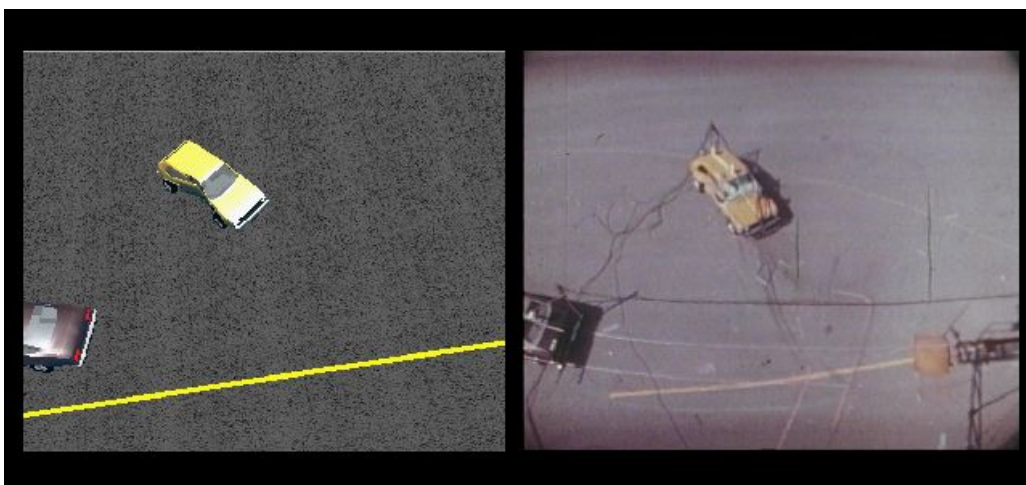
Figure 4 – RICSAC Test #3



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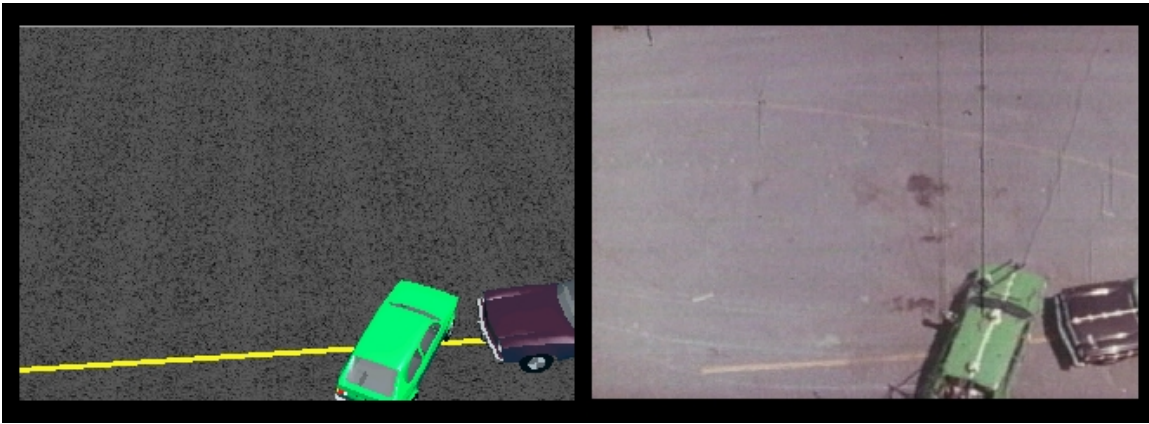


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t = 3.6 seconds

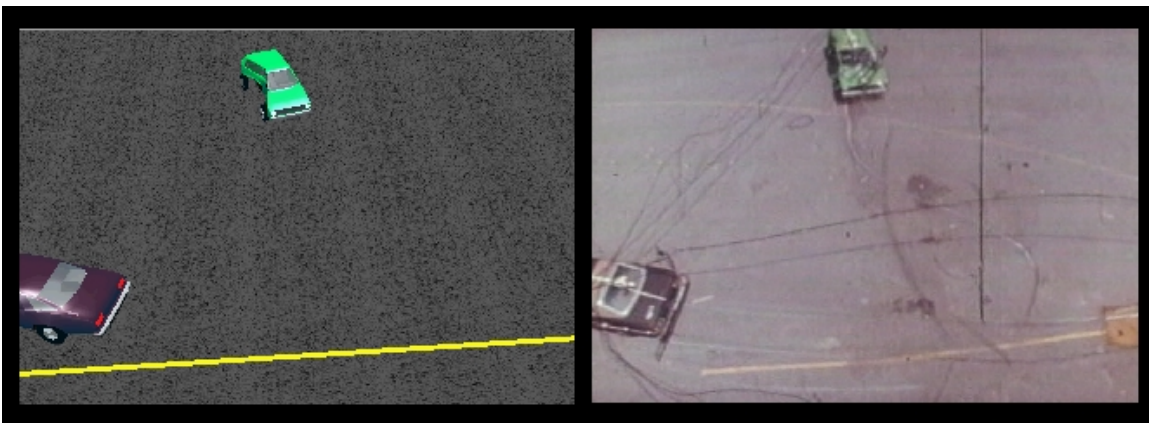
Figure 5 – RICSAC Test #6



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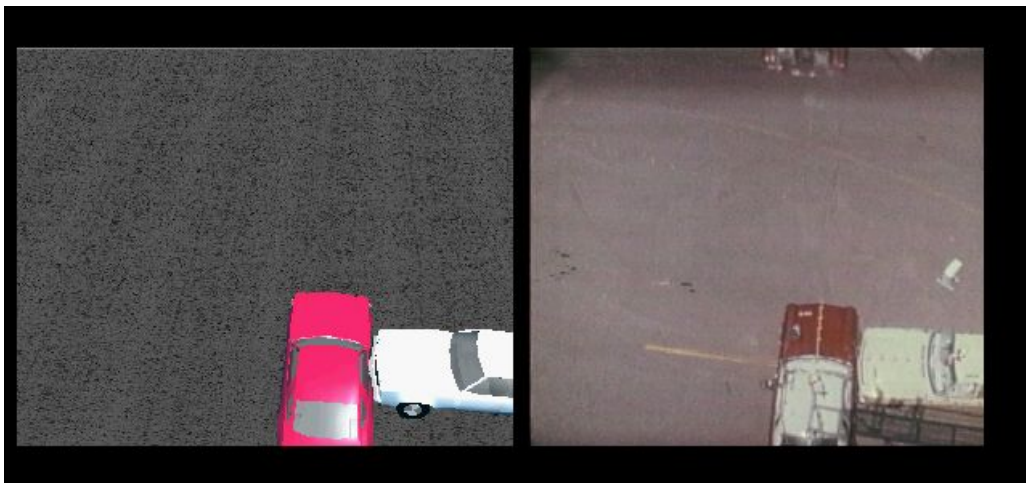


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t = 1.8 seconds

Figure 6 – RICSAC Test #7



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t = 0.2 seconds

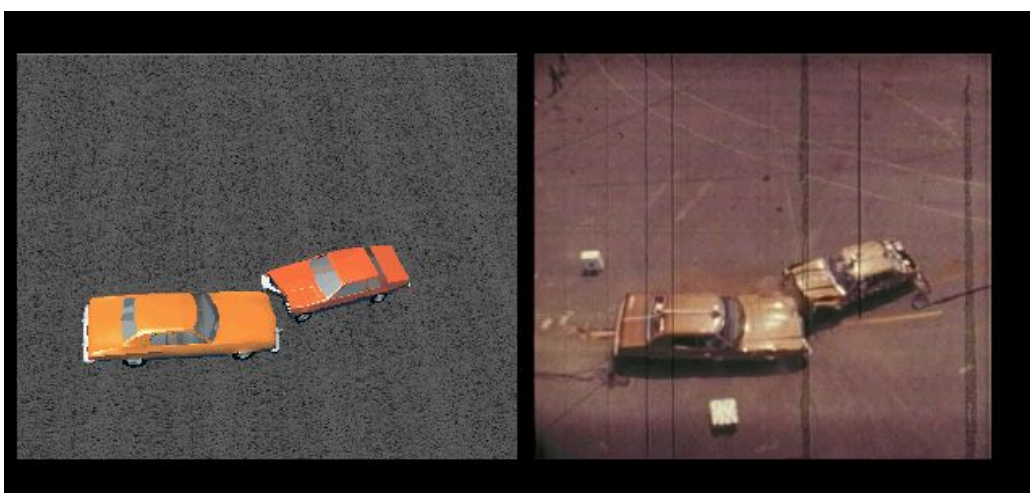


t = 1.7 seconds

Figure 7 – RICSAC Test #8



t = 0 seconds



t = 0.6 seconds



t = 1.2 seconds

Figure 8 – RICSAC Test #11