PSI PRECISION SIMULATIONS

DOCUMENT, ANALYZE, VISUALIZE; TURN JURORS INTO WITNESSES

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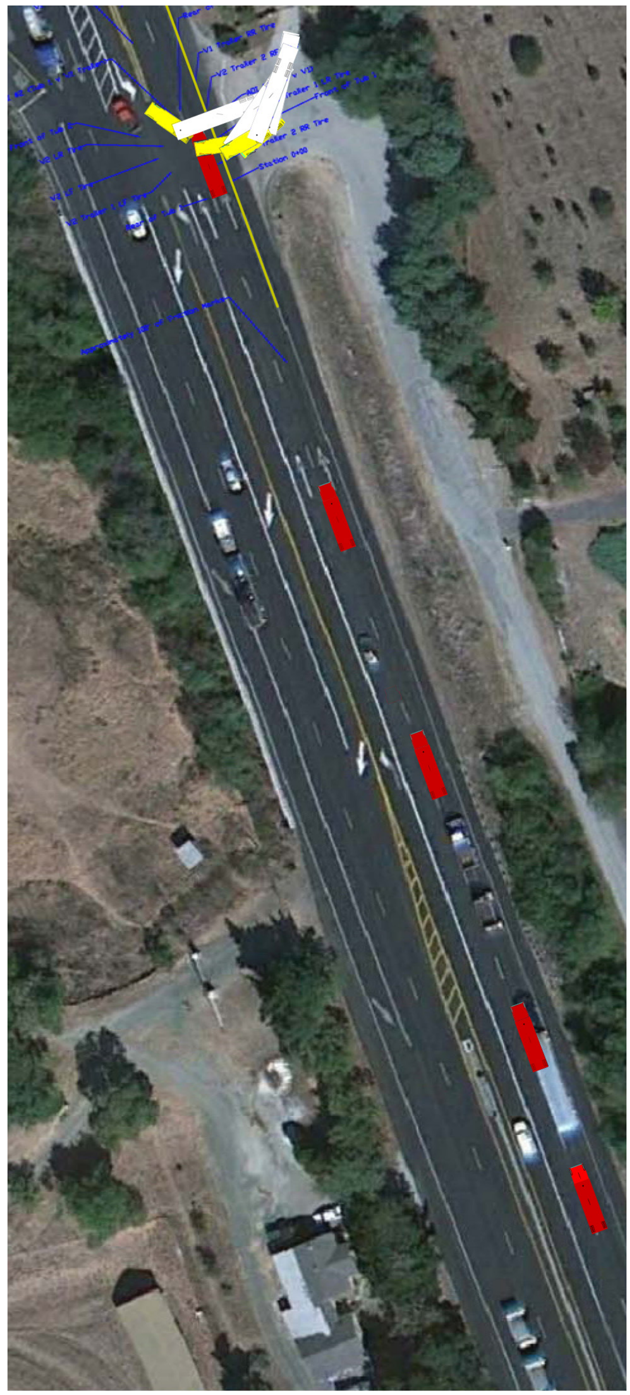
Nighttime Accident Reconstruction

The Challenge

A nighttime collision between two tractor-trailers leaves both drivers with debilitating injuries and closes the lanes of a major California highway for hours. Upon investigation, it becomes clear that one of the drivers was entering the highway from a side road and encroached into the lane in which the second tractor-trailer was traveling. Given the straight nature of the road, the question arises: Did the oncoming tractor trailer have enough time to perceive the encroaching vehicle and avoid the collision?



PSI was asked to visualize the accident from the oncoming drivers view, providing the attorney and potential jury with a view from the driver's perspective as he approached the point of impact with the encroaching vehicle. Given that the accident occurred on a major highway, reconstructing the event and filming it on site was not an available option. Adding to the complexity was the nighttime lighting conditions – in order to create a valid driver's-eye view, it would be necessary to duplicate the lighting conditions present at the time of the accident.

The Solution

PSI's engineers developed a method to film the approach from within the cab of the approaching vehicle, capturing the background under similar ambient illumination as the date of the accident. This would provide the background for the visualization, with a second, animated vehicle composited over the background video.

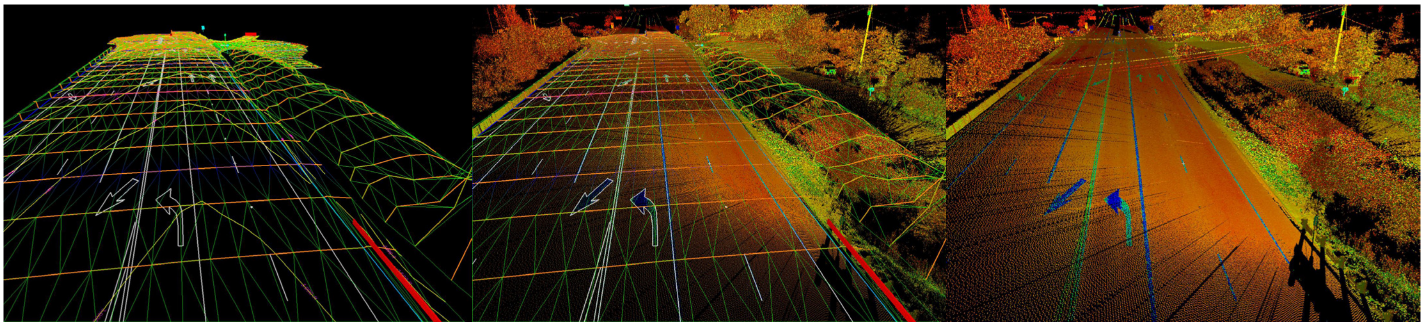
As the encroaching vehicle could not be filmed on site on the highway and was in the process of making a complex maneuver at the time of impact, it was necessary to create a 3D animation of this portion for the project. Using an adjacent parking lot, the tractor-trailer was positioned at the appropriate distances and relative locations to the exemplar approaching vehicle, and was filmed from the stationary exemplar approaching vehicle at 5 points along its travel. These still images, along with photometric readings of the vehicles reflectance, provided a foundational reference against which the 3D animation would be matched.

To complete the visual, a 3D model was created of the encroaching vehicle and was matched in location, position and relative brightness to each of the 5 controlled locations, providing a foundation for its inclusion as an animated object over the background video. The lighting on the encroaching tractor trailer provided the majority of the conspicuity and was painstakingly re-created on the 3D model. The 3D model was viewed from the driver's eye position and the results were composited over the background video from the same vantage point to create a very realistic, accurate and real-time view of the event from the drivers eye as he approached the point of impact.

The combination of 3D animation, 3D laser scanning and ultra-high definition video showed that the approaching driver could see the encroaching vehicle was entering the roadway many seconds before the physical evidence of pre-impact braking began, and furthermore, that had the driver been paying attention, he could have braked in time to avoid the accident altogether.

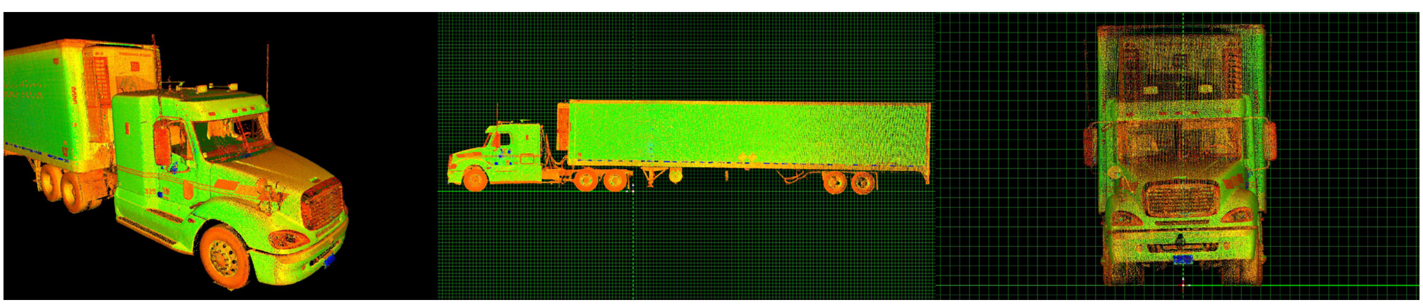
3D Laser Scanning

The environment in which the accident occurred included a number of features that added to the challenges in reconstruction and increased the complexity of the human factors issues involved. The highway in this location had large changes in vertical topography, with the point of impact being in a trough between two rolling hills – not a single portion of the area was flat. The side of the highway from where the encroaching vehicle appeared included both large topographic features covered in trees and shrubbery as well as man-made objects that caused obstructions to each driver's line of sight to the other.



3D laser scanning was a critical element in preserving this rich set of features with enough accuracy and detail to ensure that the line of sight and vehicle dynamics maintain fidelity to the conditions of the accident. Laser scanning the scene also provided the necessary link between the portions of the final visual that were filmed directly at the scene and the computer-generated elements that were overlaid later.

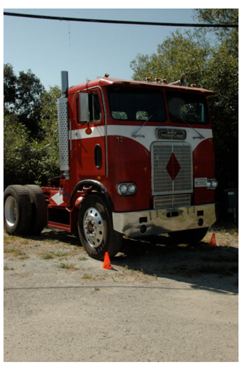
The accident location and the two vehicles involved were also complex and had unique features that affected their dynamics. One of the vehicles was a vintage tractor from 1960 with specific and rare dimensions and handling characteristics.



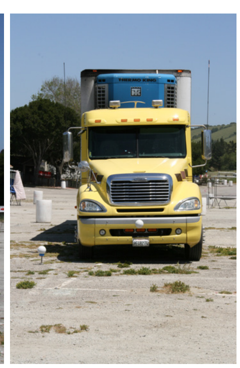
The second tractor-trailer had a trailer with adjustable wheelbase and 5th wheel location, each of which changes the vehicles handling characteristics and must be properly documented to ensure the vehicle dynamics in the simulation matched the real world characteristics. 3D laser scanning the vehicles provided the detail needed to include the critical vehicle characteristics and ensure the final product would stand up under opposition scrutiny.

Site Visit - Off Site Reconstruction

As is often the case, it was not possible to reconstruct the motions of the encroaching vehicle directly on-site, and closing the highway for the reconstruction was not an option. In addition, driving the actual tractor-trailer through the dynamic turning maneuver precisely as dictated by the reconstruction analysis would prove difficult. The solution was to find an off-site location and position the tractor-trailer in 5 discrete positions and use computer animation to interpolate smooth motion between them. The site needed to be close enough to the actual location to ensure similar environmental conditions and large enough to replicate the critical sight distances. Once a site was selected and permission granted by the property owners to use the location, both tractor trailers were driven to the location. The original plan was to position the oncoming vintage tractor at one end of the property and then position the encroaching tractor-trailer at 5 specific locations relative to the first. Using the laser documented dimensions of the vehicles, PSI was able to calculate the distance, lateral offset and angle of both the tractor and the trailer, at each of the five times up to impact. With the tractor-trailer located at each position, ultra-high resolution video was to be taken from within the driver's location from the vintage tractor to document the relative visibility and conspicuity. However, when the math was worked through and the positions were mapped out on the off-site property, it quickly became apparent that there was not enough space for the driver to maneuver the combination rig into each location.






Given the need to film while the moon was still down, time quickly became a concern as there were only a few hours available to perform this portion of the study. Quick thinking resulted in a new plan – to unhook the tractor and trailer and analyze each element separately. The math was reworked for each of the two vehicle sections and in the wee hours of the morning markers were laid for each vehicle section.

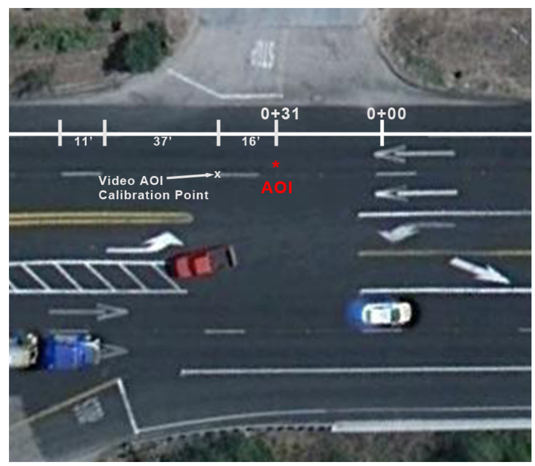
The tractor was placed without the trailer, the film taken and the photometric values documented for the tractors body and its lights. The process was repeated for the trailer alone, capturing the foundational data just in time before civil dawn began and closed the window for the study.

Accurately Replicating Visibility

Traditionally, driver's-eye nighttime visibility cases have been visualized for the jury via film and video. The benefits of this approach are mostly related to the use of the actual vehicles and scene elements, which allows the complex lighting and visibility conditions to be replicated directly. However, this approach also has a number of drawbacks, particularly if both vehicles are in motion.

First, it requires that the vehicles motion can be accurately replicated by a real-world driver – this turns out to be a difficult task, particularly when attempting to synchronize more than one vehicles approach.

If the vehicles in the study are driven in a different manner, the resultant lack of fidelity to the underlying reconstruction becomes fruitful ground for pointed cross-examination and potentially exclusion. Given that both elements are visible in the video, it is not possible to adjust speeds or trajectories of the vehicles independently – any edits to one automatically affect the other.



Second, the filming must either take place at the accident location, which is often not possible, or a secondary location must be located that is sufficiently similar in environmental conditions.

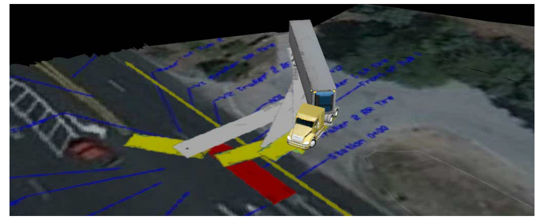
Finally, unless the speeds are very low, it is very difficult to show impact given the obvious dangers involved in replicating the terminal end of the reconstruction.

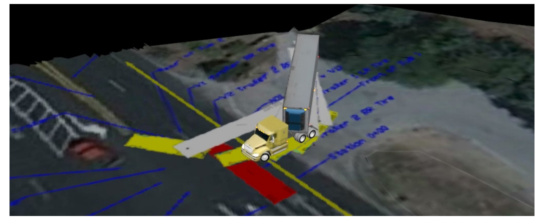
These limitations have been accepted, as it has been the only way to visualize the event. Until recently. With advances in both the fidelity of documentation techniques available with image-photometers and laser scanners and the ever-increasing power of computers and computer software, it has become possible to accurately replicate the surface lighting conditions within the computer.

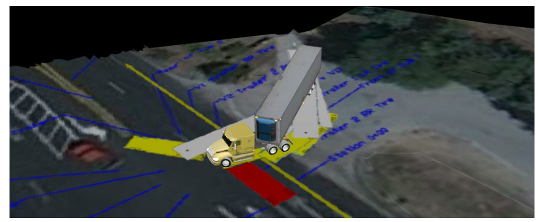
The advantages of this technique are manifold:

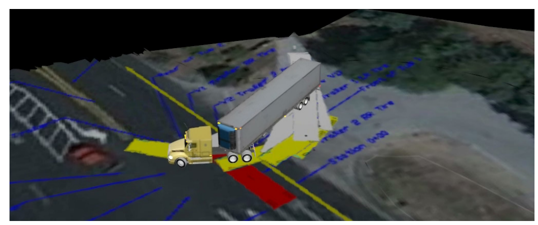
- Computer generated 3D models can have their dynamic motion finely controlled to ensure an exact match to the underlying reconstruction. The final visualization does not suffer from deviations to the physical evidence or witness testimony as is typical when using the film/video method exclusively.
- If edits are required due to further discovery or one wishes to explore rebuttal/"what-if" versions, these changes occur easily in the computer. Using the video/film method, each one of these additional scenarios would require a complete redo of the process.
- Using the computer-generated method, each element can be edited independently; lighting can be edited on one vehicle without effecting the overall scene lighting or the lighting on another vehicle.
- The speed or path of one element can be changed without effecting the others.
- Impact and post-impact can be shown without the inherent danger of attempting it with film or video.
- The portions that require film or video can be generated with these mediums and those that are better created in the computer can be approached in this manner. The process allows complete customization and maximizing the benefits of each technique without carrying the drawbacks of either.

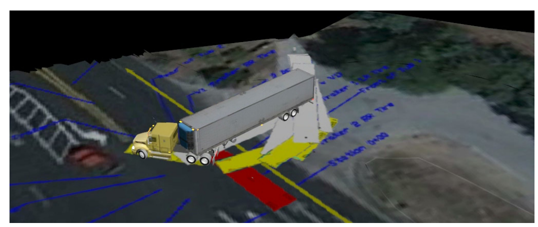
The final result combines the best of both worlds – the accuracy and fidelity of critical environmental elements and lighting conditions from video, along with the precision and control of dynamic elements that only the power of the computer can provide.

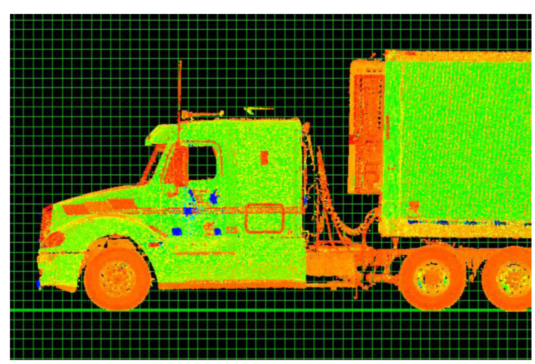












Accurately Replicating Visibility

Even with the numerous challenges presented by this case and the need to perform the calibration and motion studies at different venues, the use of the 3D working model and advanced 3D animation techniques allowed PSI to create accurate and compelling real-time driver's eye visualizations.

In the images below, note the fidelity of the 3D animation/video composite to the real-world control photography. The result is the best of both worlds: the precision and flexibility afforded by the computer reconstruction AND the realism and fidelity to reference photography previously only afforded by video recreation.

3D Animation Over Nighttime Video – Turn Jurors Into Witnesses.