National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594

RRD22MR010

VIDEO STUDY

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A. ACCIDENT

Location: Mendon, Missouri
Date: June 27, 2022
Time: 12:42 Central Daylight Time (CDT)
Train: Amtrak Train No. 4
Truck: 2007 Kenworth W900B Dump Truck

B. SUMMARY

B.1. Objective and scope of the Video Study

The objective of this Video Study was estimating the speed of the truck.

B.2. Summary of results

The truck was moving at the estimated speed of 30.5±1.5 mph up to 16 seconds before it collided with the train. It then slowed down and was moving at the estimated speed of 6±1 mph when it was at the grade crossing.

C. DETAILS OF THE INVESTIGATION

C.1. Introduction

The analysis was based on a video that was recorded by a camera mounted on the windshield of the leading locomotive of the train. The video had 704x480 resolution and frame rate of 15 frames per second. The video recorded the dump truck as it was approaching the rail crossing up to the time when the truck was hit by the locomotive. The speed of the truck was estimated with a method that used a model of the camera optics, as described below.

C.2. Camera calibration

The use of a model of camera optics for estimation of the speed of the dump truck seen in the video required a set of calibrated model parameters. The mathematical model of camera optics requires seven parameters. Three are the X, Y and Z camera location coordinates. Three are the yaw, pitch and roll camera orientation angles, and the seventh parameter is the camera horizontal field of view angle (HFOV).

The X and Y coordinates of the camera were changing from video frame to video frame because the camera was mounted on a moving locomotive. The Z coordinate of the camera, its height above the ground, was fixed. The yaw, pitch and roll camera orientation angles were also fixed because the train was moving along a straight track during the time period that was analyzed. Consequently, the camera Z, yaw, pitch, roll and HFOV parameters had to estimated only once and the X and Y camera locations had to be estimated for each analyzed video frame.

The estimation of camera model parameters is based on references that are visible both in aerial images and in video frames. The references must be man-made objects that can be identified in aerial images. In this case, the only useful calibration references were the rails and three power line poles. Figure 1 is an aerial view of the accident area. It shows the grade crossing where the train and the truck collided, the direction of train motion, the direction of truck motion, and the three power line poles, P1, P2 and P3, that were used for camera calibration.

Figure 2 is a frame from the video that was analyzed. It shows the images of the three power line poles, P1, P2 and P3, that were used for camera calibration and are also marked in the aerial view in Figure 1. The location of the truck is also marked in Figure 2. The rear end of the truck is at the location of the leading edge of the cloud of dust created by the passing truck.

In this case, the camera was mounted on a moving locomotive so that each video frame, such as the one in Figure 2, was recorded from a different location. The X-Y locations of the camera that corresponded to the analyzed video frames were estimated by integrating the train speed back in time starting at the grade crossing, using the train speed that was superimposed on the video. Figure 1 shows the location of the camera corresponding to the first analyzed video frame. Once the camera locations were estimated, it was possible to estimate the five fixed camera parameters, Z, yaw, pitch and roll and HFOV, as explained next.

A computer program that simulates camera optics was used to project the calibration references onto a frame from the video in an iterative process in which the five unknown parameters were varied so as to align the projected references with their images. When the projected references were aligned optimally with their images in the frame, values of the five parameters were their optimal estimates. At that point, the model of the camera optics was calibrated.

C.3. Estimation of dump truck speed

The estimation of the dump truck speed required the estimation of the truck locations along the road on which it was moving. These locations were estimated by placing in an analysis program that was similar to the one used for camera calibration markers spaced by 20 meters along the road on which the truck was moving. The last marker was at the grade crossing. These markers were superimposed on the analyzed video frames and the location of the truck along the road was measured in the video frames relative to the markers. A total of 19 truck locations were estimated, each from a different camera location. The time when the truck was at these locations was known because the video frame rate was known. Analysis time was set to zero when the camera was at the camera location marked in Figure 1. The last analysis time was 38 seconds, when the train and truck collided.

Figure 3 shows the total distance traveled by the dump truck during the analyzed 38 seconds. The travel distance was set to zero at time zero. The figure shows that during the first 22 seconds, the truck was traveling at the constant speed of 30.5 mph. When uncertainty tolerances are added to this nominal estimate, the estimated speed can be expressed as 30.5±1.5 mph. Figure 3 shows that the truck started slowing past time 22 seconds. During the last six seconds, between time 32 seconds and time 38 seconds, a time period that includes the time when the truck was on the grade crossing, the estimated speed was 6±1 mph.

D. CONCLUSIONS

The speed of a truck that collided with a train was estimated based on a video recorded by a camera mounted on the leading locomotive of the train. The truck was moving at the estimated speed of 30.5±1.5 mph up to 16 seconds before it collided with the train. It then slowed down and was moving at the estimated speed of 6±1 mph when it was at the grade crossing.

FIGURES

Figure 1. Aerial View of the Accident Area

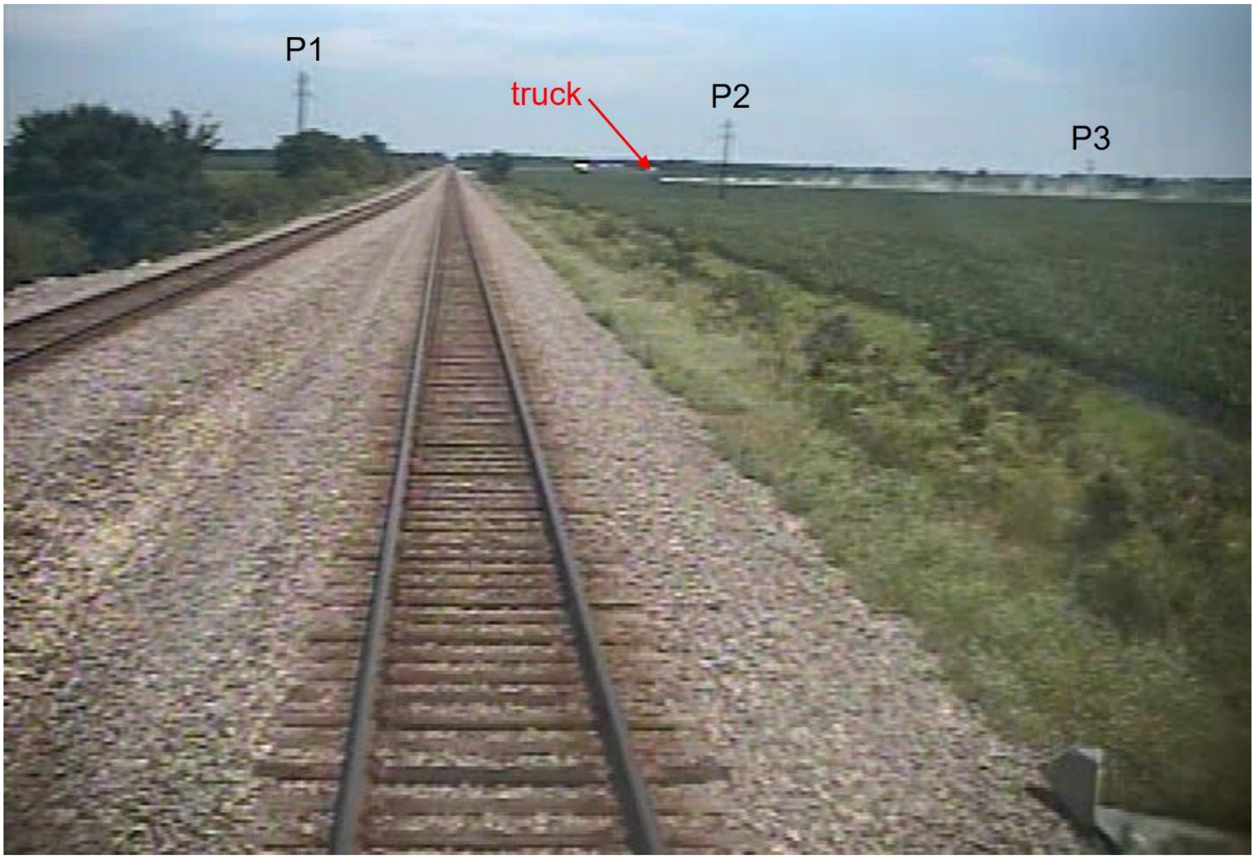

Figure 2. Frame from the Analyzed Video

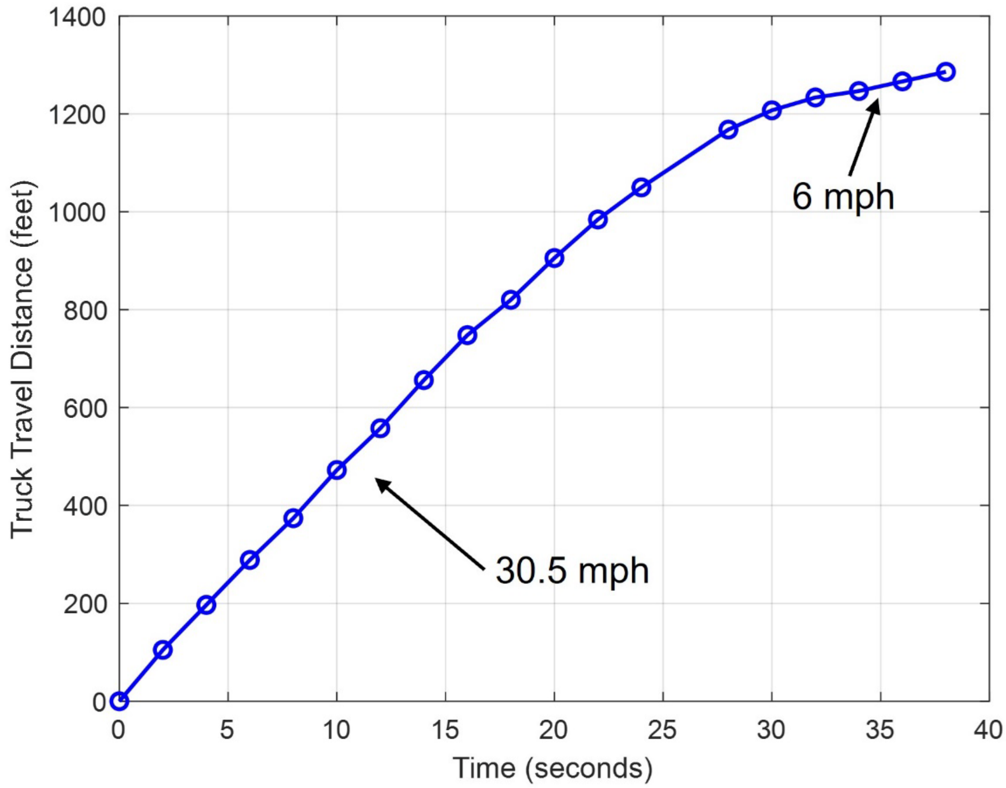

Figure 3. Travel Distance of the Truck