

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

September 10, 2018

Video Study

NTSB Case Number:
CEN18FA023

A. ACCIDENT

Location: Alva, Oklahoma
Date: November 4, 2017
Time: 1728 CDT
Airplane: Beech V35B

B. AUTHOR

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NTSB

C. ACCIDENT SUMMARY

On November 4, 2017, at 1728 central daylight time, a Beech V35B airplane, N777PH, impacted terrain during approach to the Alva Regional Airport (AVK), Alva, Oklahoma. The airplane was destroyed and the flight instructor and pilot were fatally injured. The airplane was registered to and operated by the pilot under the provisions of 14 Code of Federal Regulations Part 91 as an instructional flight. Day visual meteorological conditions prevailed for the local flight, which departed without a flight plan at about 1710.

D. DETAILS OF INVESTIGATION

The goal of this study was estimating the trajectory and speed of the airplane as it was approaching the airport runway based on videos from security cameras. Several security cameras were installed on a house in an Alva residential neighborhood. Videos from three of them were used in this study.

The three cameras were Lorex LBV2521 and the security system DVR was Lorex LHV2000. The videos had 1920x1080 resolution and frame rate of 13 fps. The security

system owner named the cameras 'Driveway', 'Carport' and 'West-Front' based on their locations and azimuth orientations. Figure 1 shows an aerial view of Alva, Oklahoma with superimposed geometric information relevant to the analysis.

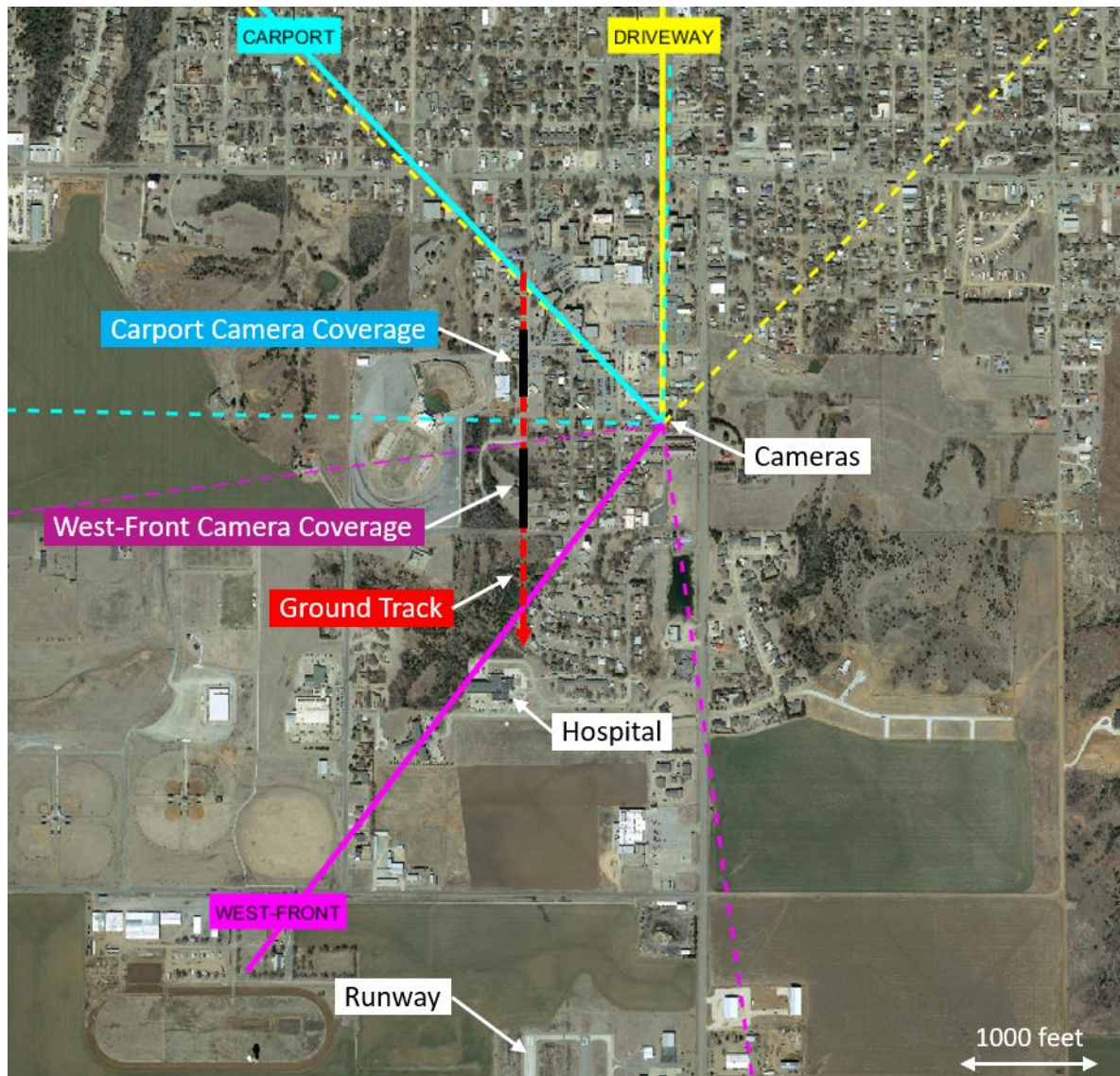


Figure 1. Aerial View of Alva, Oklahoma

The location of the cameras is marked in the figure. The fields of view of the three cameras are color coded. The solid lines originating at the location of the cameras are their azimuth orientations. The broken lines indicate the fields of view of the cameras. The Driveway camera, color coded yellow, was pointed north. Its main use was calibrating the horizontal field of view (HFOV) of the cameras. The Carport camera was color coded cyan and was pointed in the northwest direction. It recorded the airplane as it was approaching the airport. The West-Front camera was color coded magenta and

was pointed in the southwest direction. It recorded the airplane as it was approaching the airport and after it exited the field of view of the Carport camera.

The airplane crashed north of the hospital, at the location of the arrowhead of the ground track marked in red in Figure 1. This assumed ground track passes about 1000 feet west of the cameras. Because of the long distance from the cameras to the airplane, image analysis of the video frames from the Carport and West-Front videos could not determine whether the ground track was a straight line leading south to the crash location or if there were small deviations from a straight line. Therefore, a straight ground track was assumed and is shown in Figure 1.

The black segments on the ground track mark the portion of the ground track where airplane trajectory and speed were estimated based on the Carport and West-Front camera videos. The West-Front camera segment represents the entire period when the airplane was visible in that video. The Carport segment corresponds to the time before the airplane exited the camera field of view. The airplane was visible in the video before that time, but its image was too small to allow accurate analysis. Note that there is a gap in coverage of about 390 feet between the segments that corresponds to about 3.2 seconds of flight. Figure 2 shows the upper left quarter of a frame from the Carport camera video with the image of the airplane marked and Figure 3 shows the upper right quarter of a frame from the West-Front camera video with the image of the airplane marked.



Figure 2. Upper Left Quarter of a Frame from the Carport Camera Video



Figure 3. Upper Right Quarter of a Frame from the West-Front Camera Video

Camera Calibration

The airplane trajectory and speed were estimated with a model of camera optics. Such a model requires seven parameters. Three parameters are the camera x, y and z location coordinates. Three are the yaw, pitch and roll orientation angles in an earth-fixed coordinate system. The seventh parameter is the horizontal field of view (HFOV) angle of the camera.

The cameras had wide field of view that resulted in barrel distortion of the video frames. Barrel distortion is most significant near the corners and edges of an image, where the airplane happened to be in the West-Front camera video. Therefore, distortion correction was important. It was corrected mathematically based on frames from all three cameras because no single camera video had enough straight references on which to base the distortion correction. Using all three cameras was possible because they were identical and had the same distortion characteristics. The subsequent analysis steps were based on the corrected video frames.

The camera HFOV and orientation angles were calibrated using reference points located on structures near the house on which the cameras were mounted. These structures, seen in Figures 1 and 2, were visible both in the videos and in Google Earth aerial images. The camera owner provided approximate locations of the cameras on the house, but exact locations were required for accurate HFOV and orientation angle

estimation. Consequently, all seven camera parameters had to be estimated during the calibration process.

The calibration process consisted of mapping reference points measured in aerial images onto frames from the videos using the camera optics model. The seven camera parameters were then iteratively varied until all reference points were mapped optimally onto their images in the video frames. At that time, the values of the seven parameters were their optimal estimates. Since the three cameras were identical, the optimal HFOV value was one that generated the best match in all the three videos. The Driveway camera video, which was not used for airplane trajectory estimation, was the best reference for camera HFOV estimation.

Airplane Trajectory and Speed Estimation

Airplane location estimation was performed using the camera optics model with its parameters set at the calibrated values. The process was similar to the calibration process. A wireframe model of the airplane was constructed and mapped onto a video frame using the camera optics model. The y and z coordinates and the yaw, pitch and roll orientation angles of the wireframe model were then varied iteratively until the wireframe model was optimally mapped onto the image of the airplane in the video frame.

At that time, the values of these parameters were their optimal estimates. The x coordinate, oriented from west to east, was not varied because it was fixed to place the airplane on the ground track line shown in Figure 1. The z coordinate was the airplane altitude with respect to the altitude of the camera. The x, y and z coordinates defined one point on the trajectory of the airplane, corresponding to the time when the analyzed video frame was acquired.

The time when the airplane was at a location seen in a video frame was known because the frame rate of the video was known. Consequently, it was possible to estimate the ground speed of the airplane by dividing the distance between two trajectory points by the time difference between the corresponding video frames.

Several trajectory points were estimated during a 4.2 seconds-long time period when the airplane was recorded by the Carport camera. The ground speed during this period was estimated as 76 kts. As mentioned above, because of the large distance from the cameras to the airplane, it was not possible to account for small deviations of the actual ground track from the assumed ground track shown in Figure 1. Therefore, the estimated speed was assigned a tolerance of $\pm 5\%$, resulting in 76 ± 4 kts.

After a 3.2 seconds-long gap in coverage, speed was estimated during a 4.6 seconds-long period based on the West-Front camera video. The estimated speed was 71 ± 4 kts. Note that the two speed estimates overlap in the 72 kts to 75 kts interval when their tolerances are taken into account. The time elapsed from the beginning of the Carport camera coverage shown in Figure 1 to the end of the West-Front camera coverage was approximately 12 seconds and the ground distance between these

locations was approximately 1500 feet. During this time, the nominal speed estimates (neglecting the tolerances) indicate a speed decrease of $76-71=5$ kts.

There is no information in the videos on the speed of the airplane during the approximately 850 feet from the last location observed in the West-Front video to the crash location. According to witness statements, during the approach to the airport, the left engine cowling opened. The open cowling can be seen in Figure 2. It was open during the entire 12 seconds analyzed in this report and at least 2 seconds before the analyzed time. The time when the cowling opened could not be determined because at earlier times, the airplane was too far from the Carport camera and its image was too small to show details such as an open engine cowling. The position of the flaps during the analyzed time period could not be determined either because of the distance of the airplane from the cameras.

During the analyzed 12 seconds, the altitude of the airplane above the crash location decreased from approximately 250 feet to approximately 100 feet, resulting in an average descent rate of 750 ft/minute. Toward the end of the time segment when the airplane was recorded by the Carport camera, the rate of descent was decreasing and then coverage was lost for 3.2 seconds. Toward the end of the time segment when the airplane was recorded by the West-Front camera, the descent rate increased to approximately 1000 ft/minute and then coverage ended.

As the airplane flew the remaining ground distance of 850 feet to the crash location, it descended the remaining 100 feet, resulting in an average angle of descent of 6.7° . The speed during this flight segment is unknown because none of the cameras recorded the airplane.

E. CONCLUSIONS

Videos recorded by security cameras installed on a house were used to estimate the trajectory and speed of an airplane that crashed on approach to an airport. The videos were analyzed over a 12 second time segment corresponding to 1500 feet of ground track. The estimated speed was 76 ± 4 kts when the analyzed segment started and 71 ± 4 kts when it ended. Altitude above crash location decreased from approximately 250 feet when analysis started to approximately 100 feet when analysis ended.

According to witness statements, during the approach to the airport, the left engine cowling opened. The open cowling can be seen in the videos starting two seconds before the analyzed 12 second period. The position of the airplane flaps could not be estimated based on the videos because of the distance from the cameras.