

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

November 17, 2017

## Video Study

**NTSB Case Number:  
WPR17FA171**

**A. ACCIDENT**

|           |                           |
|-----------|---------------------------|
| Location: | Big Bear City, California |
| Date:     | July 29, 2017             |
| Time:     | 1420 PDT                  |
| Aircraft: | Cessna 172N               |

**B. AUTHOR**

Dan T. Horak  
NTSB

**C. ACCIDENT SUMMARY**

On July 29, 2017, about 1420 Pacific daylight time, a Cessna 172N, N5381J, was substantially damaged after it collided with mountainous terrain shortly after takeoff. The commercial pilot and passenger were fatally injured. The personal flight was operated under the provisions of *14 Code of Federal Regulations Part 91*. Visual meteorological conditions prevailed and a flight plan was not filed for the flight that departed Big Bear City Airport (L35), Big Bear City, California about 1410 PDT and was destined for Apple Valley Airport (APV), Apple Valley, California.

**D. DETAILS OF INVESTIGATION**

The goal of this study was estimating the speed, altitude, rate of climb and pitch angle of the airplane during takeoff roll and then in flight above the runway. The airport has a Exacq Technologies video surveillance system with several cameras. Three cameras, Camera 1, Camera 2 and East Camera, that recorded the airplane as it was taking off, were used in this study. Camera 1 recorded it from takeoff roll until shortly after rotation. When it exited the field of view of Camera 1 and was already airborne, it entered the field of view of Camera 2 and the camera recorded it. The fields of view of

Camera 2 and East Camera have a small overlap so that when the airplane exited the field of view of Camera 2, East Camera was already recording it.

The three cameras provided coverage for about 42 seconds. The cameras were motion-activated which resulted in irregular sampling intervals and a seven seconds long coverage gap from a time before rotation to a time when the airplane was already airborne. Additionally, even when the cameras were apparently activating at each intended time as specified by the requested frame rate, the time intervals were not equal and showed up to 10% variations. It could have been caused by communication delays between the cameras and the surveillance system server that was recording the videos.



**Figure 1. Aerial View of the Airport with Marked Accident-Related Locations**

Each recorded video frame was time-stamped by the server and although the time stamps indicated non-uniform timing, airplane motion analysis described below did not reveal significant speed non-uniformity. This led to the conclusion that while the frame timing was not constant, the time stamps were accurate.

It is not known whether the server time was exactly the local PDT time at Big Bear City airport. However, since the analysis in this study covers only 42 seconds, a possible time offset is irrelevant. Therefore, all times mentioned in the analysis below are the server times as time-stamped on the video frames. The first video frame analyzed in this

study, recorded by Camera 1, was time stamped as 02:03:00.695 PM. The last analyzed video frame, recorded by East Camera was time stamped 02:03:41.895 PM. The analyzed time period in this Video Study was from 02:03:00.00 PM to 02:03:42.00 PM.

Figure 1 shows an aerial map of the airport area. The blue markers are the locations of the three cameras. They were mounted on light poles, with Camera 1 and Camera 2 mounted on the same pole. The red marker is at the crash site, located about 0.75 miles south of the runway. The yellow markers indicated airplane locations that will be explained below. The airplane was moving from left to right (west to east) during takeoff.



**Figure 2. Frame from Camera 2 Video Showing the Airborne Airplane**

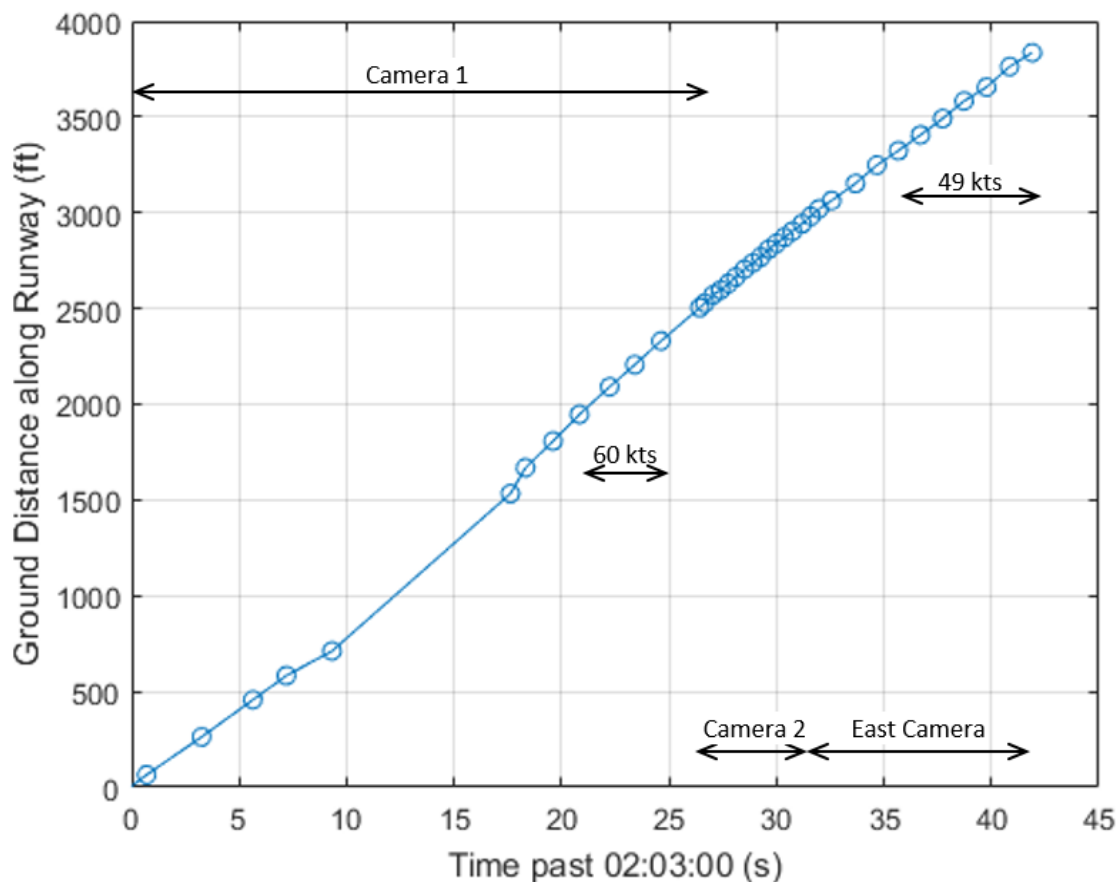
Airplane locations were estimated with a mathematical model of camera optics that was used to map reference points in the 3D field of view of a camera onto a video frame recorded by that camera. The reference points included runway and taxiway markings and signs, building edges and light poles. They were all visible both in the video frames and in aerial images of the airport. A calibrated camera model is one that accurately

maps reference points seen in an aerial image onto the images of these points in a video frame. Calibration of a camera optics model is described next.

### Camera Model Calibration

A model of camera optics uses seven parameters. Three are the camera (x, y, z) location coordinates. Three are the camera orientation angles (yaw, pitch, roll) and the seventh parameter is the camera horizontal field of view angle (HFOV). The (x, y) location coordinates of the three cameras were known because the locations of the light poles were visible in aerial images of the airport. The remaining five parameters of each camera, z, yaw, pitch, roll and HFOV, had to be estimated.

Camera calibration consisted of iteratively varying the five unknown parameters until the reference points were mapped optimally onto their images in the video frames. At that time, the values of the five parameters were their optimal estimates. This calibration process was performed for each of the three cameras.



**Figure 3. Estimated Airplane Distance along Ground Track vs. Time**

## Airplane Location and Speed Estimation

A calibrated camera optics model made it possible to estimate the airplane locations on the runway during takeoff roll, and points on the ground track when the airplane was airborne and above the runway. Figure 2 is an example of a video frame that was used in analysis. It was recorded by Camera 2 and shows the airborne airplane at time 02:03:30.00. This frame and all other analyzed frames were used to estimate and plot the ground track distances of the airplane vs. time that are shown in Figure 3. The distance was set to zero at time 02:03:00.00.

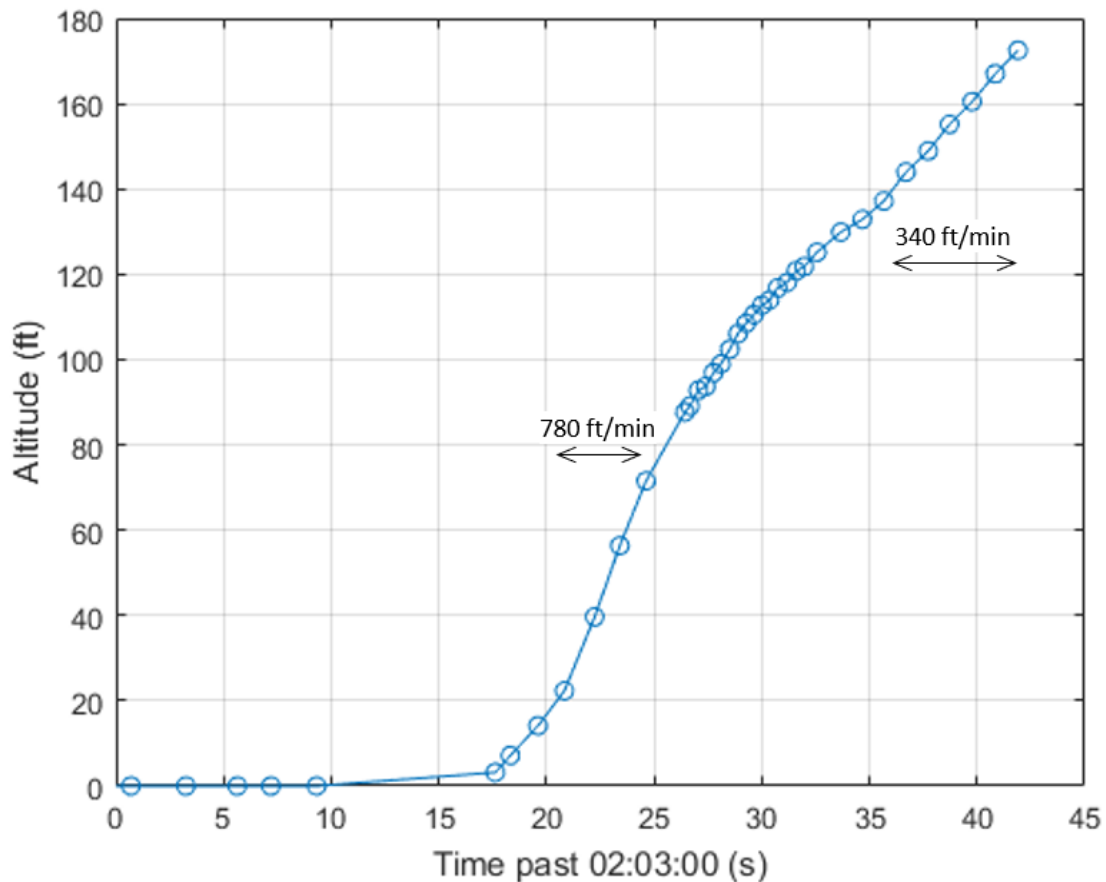
Figure 3 also shows the time segments that correspond to the cameras that were used for ground track estimation. Note the gap from  $T=10$  s to  $T=17$  s where Camera 1 was not motion-activated. The first Camera 1 recorded video frame after this gap was at time 02:03:17.6. This is the first available frame after rotation. The airplane ground track location at the time this frame was recorded is marked in yellow in Figure 1. The second yellow marker in Figure 1, at time 02:03:31.6, corresponds to the last Camera 2 frame that recorded the full image of the airborne airplane. The nose of the airplane was out of the field of view of Camera 2 in the next frame. The third yellow ground track marker in Figure 1, recorded at time 02:03:41.9, corresponds to the last East Camera video frame that captured the airplane.

Two ground speed estimates are shown in the Figure 3. The first was estimated over 4 seconds shortly after rotation and is 60 kts. The airplane pitch angle in this time interval was estimated as  $8.5^\circ$ . The second ground speed was estimated during the last 6 seconds of data and is 49 kts. The airplane pitch angle in this time interval was estimated as  $5^\circ$ .

Since the ground speed was much higher than the vertical speed, the contribution of the vertical speed to the total speed (the vector sum of ground speed and vertical speed) was less than 0.5 knots. The accuracy of the ground speed estimates is  $\pm 2$  kts, much more than the contribution of the vertical speed to the total speed. Therefore, the speed estimates shown in Figure 3 can be viewed as both ground speed and total speed.

Figure 4 shows the estimated airplane altitude above runway vs. time. Two rates of climb estimates are shown in the figure. The rate estimate between times  $T=21$  s and  $T=24$  s is 780 ft/min. The rate estimate between times  $T=36$  s and  $T=41$  s is 340 ft/min. The tolerances of the rates of climb estimates are  $\pm 5\%$ , resulting in  $780 \pm 40$  ft/min and  $340 \pm 20$  ft/min, respectively.

The information in Figures 3 and 4 shows that the airplane had reasonable speed, rate of climb and pitch angle shortly after takeoff and that about 10 seconds later, the speed, the rate of climb and the pitch angle were too low. The values started declining when the airplane altitude was about 90 feet above the runway.



**Figure 4. Estimated Airplane Altitude above Runway vs. Time**

## **E. CONCLUSIONS**

Videos recorded by three surveillance cameras at an airport were used to estimate speed, altitude, rate of climb and pitch angle of an airplane that impacted ground shortly after takeoff. Shortly after rotation, the airplane had estimated air speed of  $60 \pm 2$  knots, rate of climb of  $780 \pm 40$  ft/min, and pitch angle of  $8.5^\circ$ .

These values started declining when the airplane was about 90 feet above the runway. After about 10 seconds, air speed estimate was down to  $49 \pm 2$  knots, rate of climb was down to  $340 \pm 20$  ft/min, and pitch angle was down to  $5^\circ$ .