

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

July 10, 2018

Video Study

**NTSB Case Number:
CEN18FA063**

A. ACCIDENT

Location: Punta Islita, Costa Rica
Date: December 31, 2017
Time: 1756 UTC
Airplane: Cessna 208B

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On December 31, 2017, about 1756 hours coordinated universal time (UTC), a Cessna 208B airplane, Costa Rica registration TI-BEI, impacted terrain shortly after takeoff from the Islita Airport (MRJA), Punta Islita, Costa Rica. The two pilots and 10 passengers received fatal injuries. The intended destination was the Juan Santamaria International Airport (MROC), San Jose, Costa Rica.

D. DETAILS OF INVESTIGATION

The purpose of this study was estimating the trajectory and speed of the airplane. The airplane was captured on a video acquired by a camera that was mounted on a structure at the airport. The airborne airplane was visible in the video for about 25 seconds. The video had 704x480 resolution and frame rate of 15 fps. Because of the distance from the camera to the airplane and the relatively low video resolution, the image of the airplane in the video frames was small. The wingspan and the fuselage length in the video frames were only 8 pixels long or shorter. Consequently, only 13.4 of the 25 seconds could be used for estimating airplane trajectory with reasonable accuracy. At the beginning of the 13.4 second period, the airplane was flying north and climbing. At

the end of this period, it was flying west and descending, its roll angle was very high, and ground impact was imminent. Because of vegetation and the large white time stamps superimposed on the video frames, the airplane was not visible in the video past the last analyzed location.

The analysis of the video consisted of three stages. First, a model of the camera optics was developed and calibrated. Then, the locations and orientation angles of the airplane were estimated based on eight video frames with an analysis program that used the camera optics model. Finally, speed of the airplane was estimated based on the estimated locations and the frame rate of the video. The three stages are described next.

Camera Calibration

Figure 1 shows an aerial view of the accident area, including the runway, the taxiway between the end of the runway and the airport building, the camera, and the crash site. Figure 2 shows a video frame acquired by the camera shown in Figure 1. The frame shows the northern end of the runway and the taxiway. These details are also seen in Figure 1. A mountain peak P is marked on the video frame in Figure 2. It is not seen in Figure 1 because its location is north of the area shown in the figure.

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 (HFOV). None of the seven parameters were known or measured. Therefore, all had to be estimated.

The estimation was based on references that were visible both in aerial images and in video frames. These references were primarily the runway and the taxiway. The mountain peak P marked in Figure 2 was also used as a reference. It was not visible in aerial images and its location was determined based on elevation data extracted from Google Earth.

A computer program that simulates camera optics was used to project the references onto a frame from the video in an iterative process in which the seven 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 seven parameters were their optimal estimates. At that point, the model of the camera optics was calibrated.

Airplane Trajectory and Speed Estimation

Airplane locations and orientation angles in ground coordinates were estimated by projecting reference points on it onto frames from the video using the calibrated camera optics model. Because of the long distance from the camera and the low video resolution, only four reference points on the airplane could be accurately identified in the video frames. They were the nose, the tail and the two wing tips.

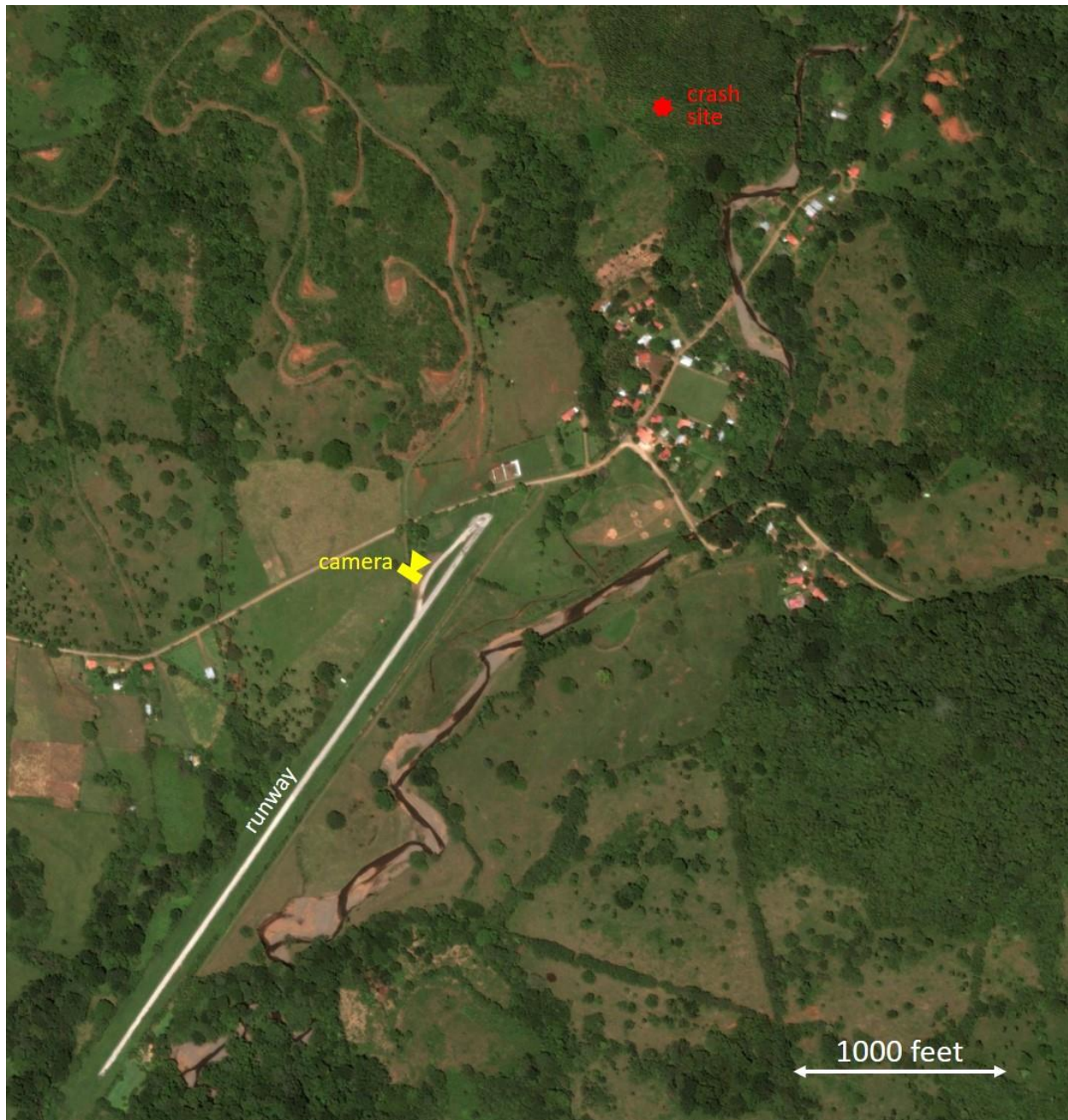


Figure 1. Aerial View of the Accident Area

A computer program similar to the one used for camera calibration was used for estimating location and orientation of the airplane. The seven camera model parameters were fixed at their estimated values. The program was capable of moving the set of the four airplane reference points in the X, Y and Z directions, and orienting the set according to Euler yaw-pitch-roll sequence of rotations.



Figure 2. Video Frame Used for Camera Calibration

Analysis of each frame consisted of iterative movement (X, Y and Z) and rotation (yaw, pitch and roll angles) of the set of the four reference points until they optimally coincided with their images in the video frames. At that time, the X, Y, Z, yaw, pitch and roll were the optimal estimates of the airplane location and orientation.

Figure 3 shows a frame from the video that was used for airplane trajectory estimation. It shows the four reference points superimposed on the image of the airplane. The green reference point closest to the top margin of the video frame is the right wing tip. This video frame corresponds to trajectory point No. 5 marked in the plots below.

Airplane location and orientation were estimated at eight times, corresponding to eight frames from the video. The time of the first analyzed frame was set to zero. The time of the last analyzed frame was 13.4 seconds. Figure 4 shows the estimated ground track of the airplane. A fourth order polynomial was fitted to the first five raw data points and is shown in red. It provides continuous estimates of the trajectory during the first 11.3 seconds of analysis (up to point No. 5).

The estimated airplane ground speed during the 11.3 seconds long time period corresponding to the polynomial fit was 68 ± 3 knots. It was computed along the fitted continuous ground track. The estimated speed during the last two seconds of analyzed flight, when the airplane was descending, was 82 ± 4 knots.



Figure 3. Video Frame Showing Superimposed Airplane Reference Points

Figure 5 shows the estimated altitude of the airplane above the crash site. The crash site elevation is about 140 feet higher than the elevation at the northern end of the runway. Therefore, estimated airplane altitude above the runway is about 140 feet higher than the altitude shown in Figure 6. Figure 6 shows a climb rate of approximately 715 feet/minute during the first 7 seconds and a descent rate of approximately 1510 feet/minute during the last two analyzed seconds.

Figure 6 shows the estimated roll angle of the airplane. The red line is a second order polynomial fit to the raw data. The relatively large deviations of the raw data points from the polynomial fit are indicative of the relatively large roll angle estimation errors caused by the small image of the airplane in the video frames (see Figure 3). The polynomial fit filters out these errors and is a continuous and relatively accurate roll angle estimate.

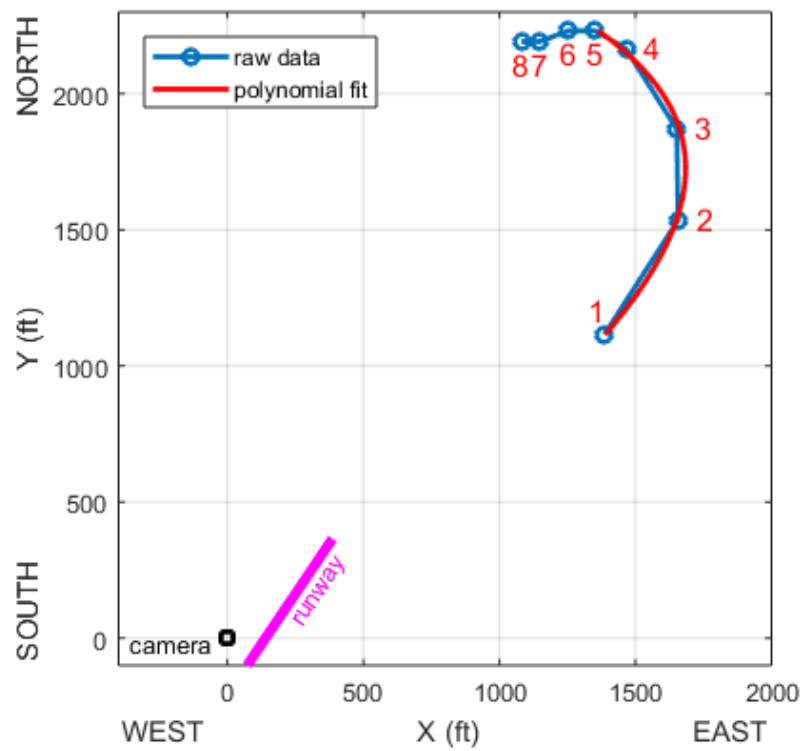


Figure 4. Estimated Ground Track of the Airplane

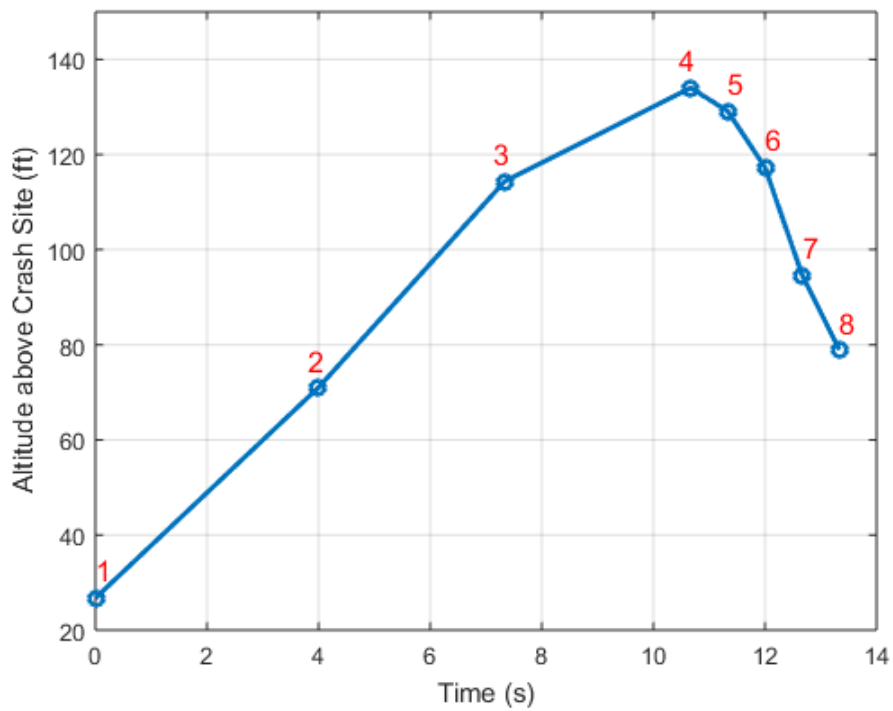


Figure 5. Estimated Airplane Altitude above the Crash Site

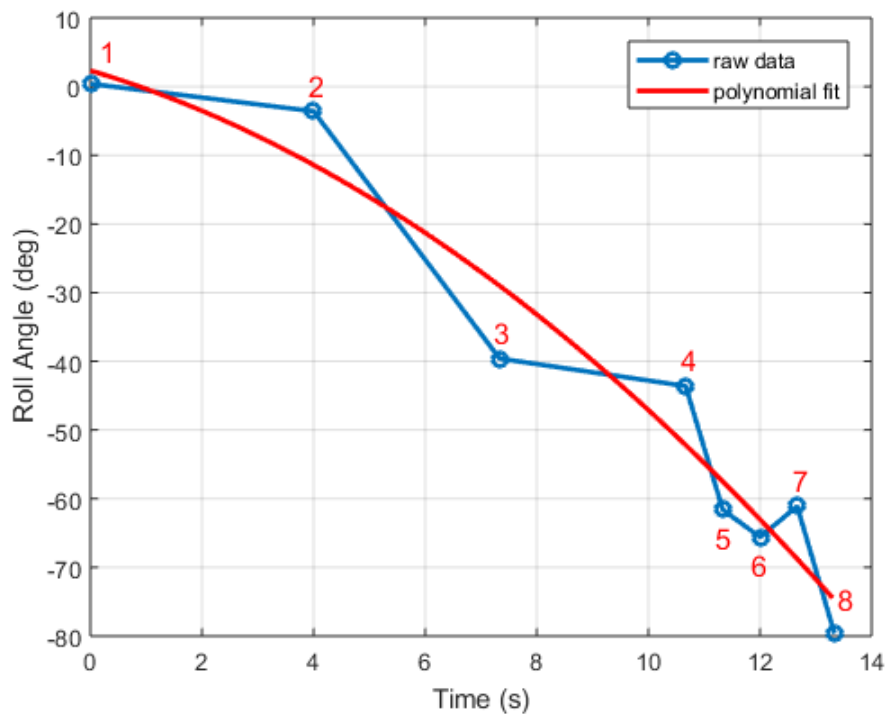


Figure 6. Estimated Roll Angle of the Airplane (negative is right wing up)

E. CONCLUSIONS

Video captured by a camera mounted on an airport structure was used for estimating trajectory and speed of an airplane that crashed shortly after takeoff. It was estimated that the airplane ground speed was 68 ± 3 knots shortly after takeoff and it was climbing at approximately 715 feet/minute. Several seconds later, it was descending at the rate of approximately 1510 feet/minute and its ground speed was 82 ± 4 knots. Its roll angle reached up to 75° right-wing-up at that time. The airplane impacted the ground shortly thereafter.