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

February 21, 2018

Video Study

NTSB Case Number:
ERA16FA288

A. ACCIDENT

Location:	Fredericksburg, Virginia (Shannon airport)
Date:	August 12, 2016
Time:	1222 EDT
Aircraft:	Beech 95-B55

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On August 12, 2016, at 1222 eastern daylight time, a Beech 95-B55, N128VB, was substantially damaged when it collided with trees and terrain during an aborted landing attempt at Shannon Airport (EZF), Fredericksburg, Virginia. The private pilot/owner, commercial pilot, and four passengers were fatally injured. The airplane was registered to Ross and Company PLL and operated under the provisions of 14 Code of Federal Regulations Part 91 as a personal flight. Visual meteorological conditions prevailed near the accident site at the time of the accident, and no flight plan was filed for the flight, which originated from Shelbyville Municipal Airport (GEX), Shelbyville, Indiana, at about 1015.

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 an airport building. The airplane entered the field of view of the camera when it was approximately 1400 feet from the beginning of the 3000-foot-long runway and stayed in the field of view until it crashed. The video had 1920x1080 resolution and frame rate of 0.75 fps. This frame rate is that of a video file downloaded from an airport security system and its rate accuracy has not been verified. The video shows 18 frames from the time the airplane first appeared in the video and the time when it was already on the ground after crashing. In the first 15 frames, the roll and pitch angles were within reasonable limits. In frames 16 and 17, the roll and pitch angle were large and the airplane was no longer in stable flight. In frame 18, the airplane was already past the time of ground impact.

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 the 18 frames with an analysis program that used the camera 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

The mathematical model of the 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 reference points that were visible both in Google Earth and in the video frames. These points included pavement markings, points along the runway, building corners, and poles near the aviation fuel tanks. A computer program that simulates camera optics was used to project these reference points onto a frame from the video in an iterative process in which the seven parameters were varied so as to align the projected points with their images. When the projected points 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 located on it onto frames from the video using the calibrated camera model. The camera was looking at the airplane as it was moving along the runway and away from it. The distance from the camera to the airplane was more than 600 ft. when it first appeared in the field of view and more than 2600 ft. when it impacted the ground. Because of the distance and the viewing angle, only three reference points on the airplane could be accurately identified in the frames. They were the two wing tips and the top of the rudder. Therefore, the airplane model used in the analysis consisted of only these three points, with longitudinal, lateral and vertical distances between them set to the actual dimensions of a Beech 95-B55.

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 three airplane reference points in the X, Y and Z directions, and orienting the set according to Euler yaw-pitch-roll sequence of rotations.

Analysis of each frame consisted of iterative movement (X, Y and Z) and rotation (yaw, pitch and roll angles) of the set of the three 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 1 shows a subset of Frame 3 with the three airplane reference points, marked by red circles, in optimal alignment. This alignment process was performed on the first 15 video frames. Figure 2 shows the ground track of the airplane. The numbered markers correspond to the numbers of the analyzed frames.

Figure 1. Video Frame No. 3 with Marked Airplane Reference Points (red circles)

The horizontal coordinate in Figure 2 was set so that the 3000 ft. runway ended at 3000 and the distance increased along the runway. The vertical coordinate of the camera was set to zero in the figure.

Figure 3 shows the speed of the airplane, computed as the magnitude of the vector sum of ground speed and vertical speed. It was computed over time intervals between adjacent video frames and posted at the end time of each interval. Since there are 15 analyzed frames, there are 14 estimated speeds and the first speed estimate is at point 2 (because the time interval starts at frame 1 and ends at frame 2). The time in Figure 3 starts at zero seconds at point 1, which corresponds to the first analyzed video frame. The point numbering in Figures 1 and 2 is consistent, which allows correlation between distance in Figure 1 and time in Figure 2.

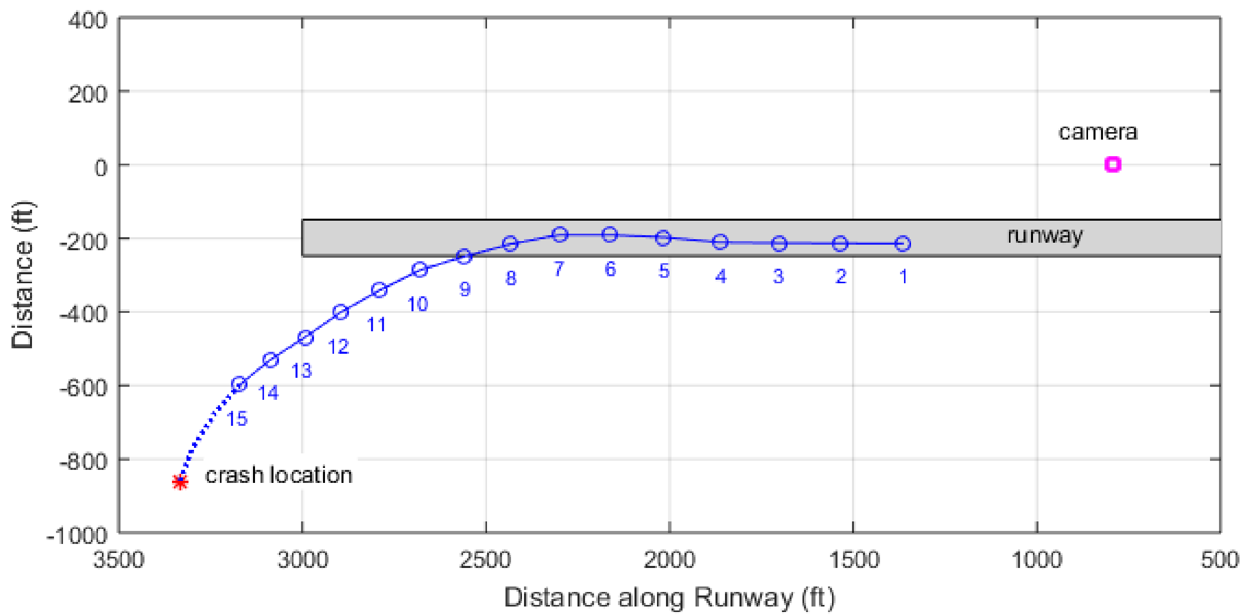

Figure 2. Estimated Ground Track of Accident Airplane

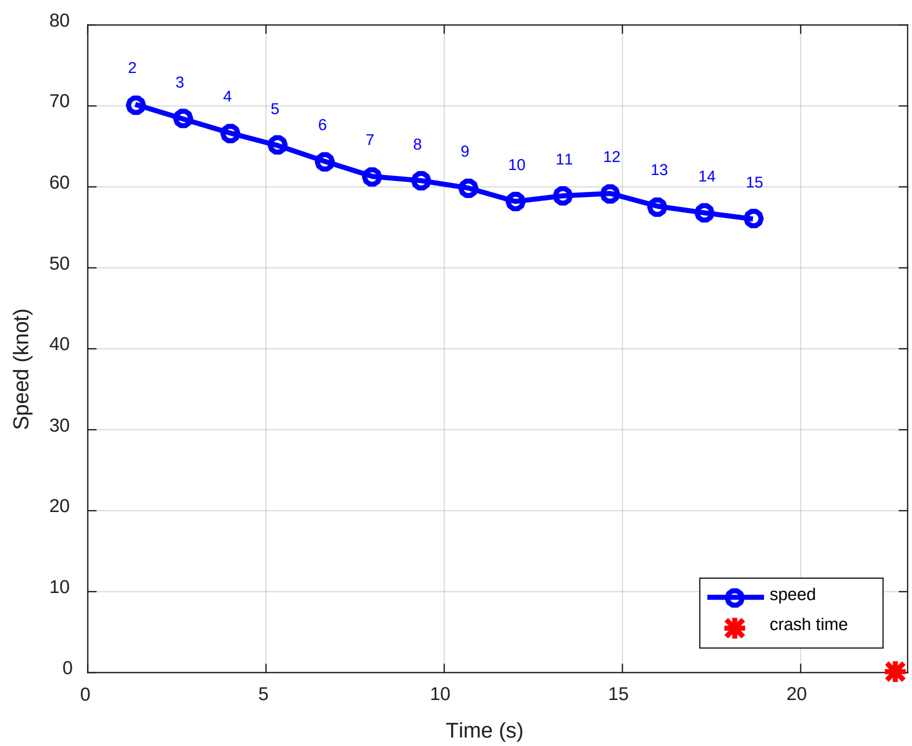

Figure 3. Estimated Speed of the Airplane

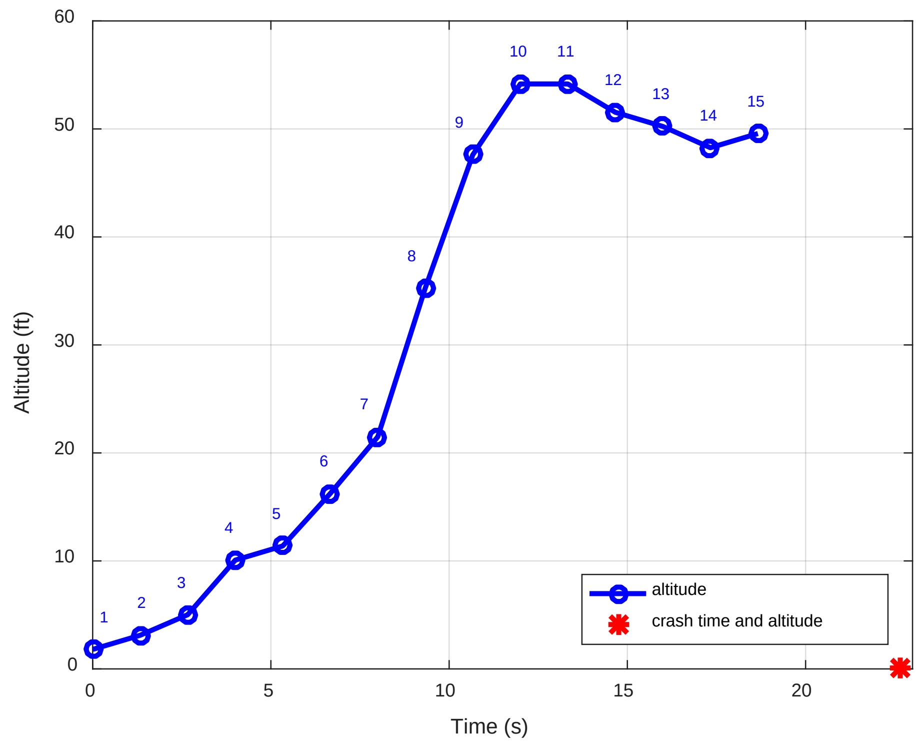

Figure 4. Estimated AGL Altitude of the Airplane

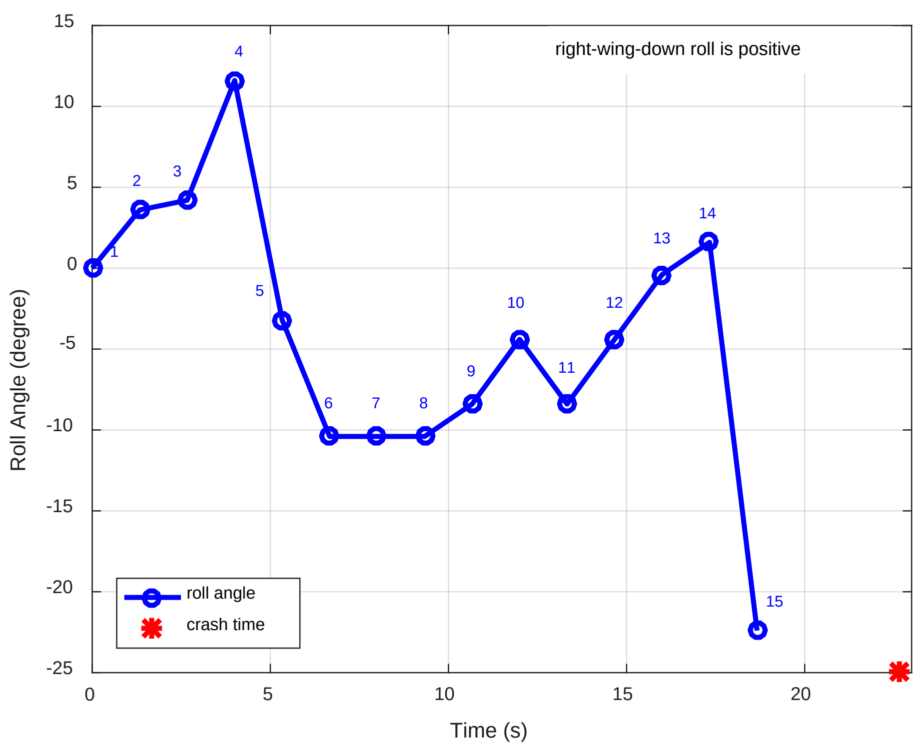

Figure 5. Estimated Roll Angle of the Airplane

Figure 4 shows the estimated AGL altitude and Figure 5 shows the estimated roll angle of the airplane. Figure 5 shows a large roll angle magnitude increase from point 14 to point 15. That increase continued even more rapidly past point 15 and at the time frame 16 was acquired, the roll angle magnitude was above 60º, and the airplane was less than three seconds from ground impact.

E. <u>CONCLUSIONS</u>

Video captured by a camera mounted on an airport building was used for estimating trajectory and speed of a crashing airplane. It was estimated that the airplane entered the field of view of the camera when it was moving along the runway at 70 kt. It then became airborne and its speed started decreasing as it was climbing. When it was at altitude 50 feet at point 13, its speed was down to 58 kt. and decreasing. One second later, the magnitude of the airplane left-wing-down roll angle started rapidly increasing and approximately five seconds thereafter the airplane impacted the ground.