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

February 11, 2014

Video Study

NTSB Case Number:
WPR13FA370

A. ACCIDENT

Location:	Paradise, California
Date:	August 13, 2013
Time:	11:30 AM
Airplane:	Champion 7GCAA, N9607S

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On August 13, 2013 about 1130 Pacific daylight time, a Champion 7GCAA, N9607S, collided with the ground while maneuvering near Paradise, California. The airplane was registered to the pilot and operated by AA Aerial Surveillance, LLC. under the provisions of Title 14 Code of Federal Regulations Part 91 as an aerial observation flight. The commercial pilot and passenger were fatally injured and the airplane was substantially damaged. Visual meteorological conditions prevailed and a flight plan was not filed. The cross-country flight originated from the Nut Tree Airport (VCB), Vacaville, California about 0850 with a destination of Chico Municipal Airport (CIC), Chico, California.

D. DETAILS OF INVESTIGATION

The airplane had a Contour+2 camera mounted on it. The camera was pointed forward and was pitched down relative to the horizontal plane. It recorded continuous video with resolution of 1280x720 and frame rate of 30 frames per second. The camera used a wide-angle lens that severely distorted the images. Figure 1 shows a typical frame from the video that illustrates the distortion.

Figure 1 Distorted Frame from Video

Figure 2 Corrected Frame from Video

Figure 3 Aerial Image from Google Earth with Five Marked Reference Points

Figure 4 Video Frame Showing the Five Reference Points Seen in Figure 3

The distortion was corrected mathematically to generate a video that had only small residual distortion. Figure 2 shows a corrected version of the distorted video frame from Figure 1. The black areas in the corrected video frame correspond to areas that were outside of the distorted frame. The distortion correction is most accurate near the center of the frame. It is least accurate near the corners of the image where it did not matter because the analysis described below did not rely on information near the corners.

The goal of this study was to estimate the motion of the airplane based on the corrected video. This was done in a process that estimated the location and orientation of the airplane by aligning reference points on the ground with their images in the video.

The first step toward location and orientation estimation was identification of reference points on the ground in Google Earth and correlating them with their images in the video. Google Earth imagery at the accident location was acquired in May of 2013, less than five months before the accident. Consequently, the images of bushes and trees in the video and in Google Earth were similar and the use of bushes and trees as reference points was feasible. Figure 3 shows five reference points marked on an aerial image from Google Earth. Figure 4 shows these points as seen in a video frame.

The second step in the process was the derivation of a mathematical model of the camera optics that was capable of mapping the reference points onto a synthesized video frame when given the location and orientation of the camera with respect to ground. Since the camera was rigidly attached to the airplane, locating and orienting the camera also determined the location and orientation of the airplane.

The third step was an iterative process in which a user moved and rotated the simulated camera until synthesized reference points mapped onto a video frame were aligned with the images of these reference points in the frame. Figure 5 shows a video frame with six reference points marked on it (squares) and six mapped synthesized points (circles) after alignment.

Multiple reference points mapped onto a video frame can coincide with their images in the frame only if the location and orientation of the simulated camera is the same as that of the real camera when the video frame was acquired. Therefore, once alignment is achieved, the location and the orientation of the airplane has been estimated. The square markers and the circles in Figure 5 are very close. The maximum misalignment between a square and the corresponding circle is 5 feet. Since the distance from the camera to the reference points was over 300 feet, this error is considered very small. Therefore, the accuracy of airplane location estimates was high.

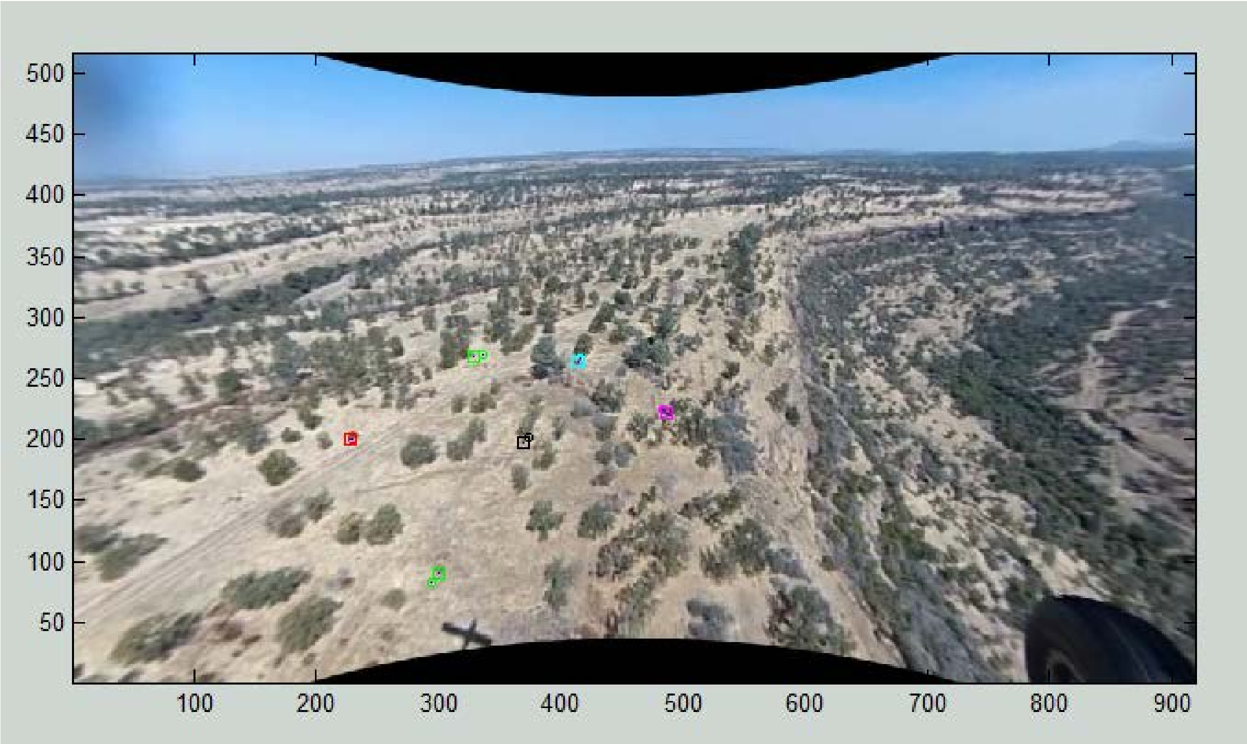

Figure 5 Reference Points (squares) and Mapped Reference Points (circles)

With airplane location estimated at several times that corresponded to frames from the video, it became possible to estimate the ground speed. The speed estimate computed over a 3.2 seconds long period that ended just before there were any indications of problems was 61 mph (53 kts). The airplane hit the ground approximately 18 seconds after the end of this period. The AGL altitude during this period was approximately 215 feet. Ground speed estimated over 17 seconds that ended 74 seconds before ground impact was 62 mph (54 kts).

During a two-second period that ended 18 seconds before ground impact, the airplane pitch (nose up) increased by approximately 8º. There is no information in the video on the cause of this pitch increase. It could have been commanded by the pilot or it could have been an indication of developing problems.

When the pitch angle increase ended, the airplane started developing a right-wing-down roll angle. Over approximately 10 seconds, the roll angle increased from 0º to 15º. This slowly-increasing roll angle could have been commanded by the pilot or it could have been an indication of developing problems.

Over the next 2.7 seconds, the roll angle increased form 15º to 180º, corresponding to an average roll rate of 61 degrees/second. When the roll angle was 180º and the airplane was flying upside down, the roll rate was approximately 105 degrees/second. The airplane continued rolling at a high angular rate and hit the ground approximately 8 seconds after the high roll rate started.

It was concluded that approximately 8 second before ground impact, the airplane started a high roll rate maneuver from which it did not recover. It is possible that the increase in pitch angle and the slow roll angle increase that started approximately 20 seconds before ground impact were early indications of the major problem that became evident 8 seconds before ground impact.

The roll angle and the roll rate are shown in Figures 6 and 7, respectively. Time zero seconds in these figures is set at 20 seconds before ground impact. Roll rate was computed by differentiating the roll angle signal. Differentiation is sensitive to measurement noise and when the raw roll angle estimate was differentiated, the raw roll rate signal was noisy. Therefore, a polynomial was fitted to the raw roll angle signal and differentiated analytically to get a noise-free roll rate signal estimate. Figures 6 and 7 show both the raw and the fitted signals. The fitted curve in Figure 7 is a better estimate of the roll rate than the raw roll rate curve.

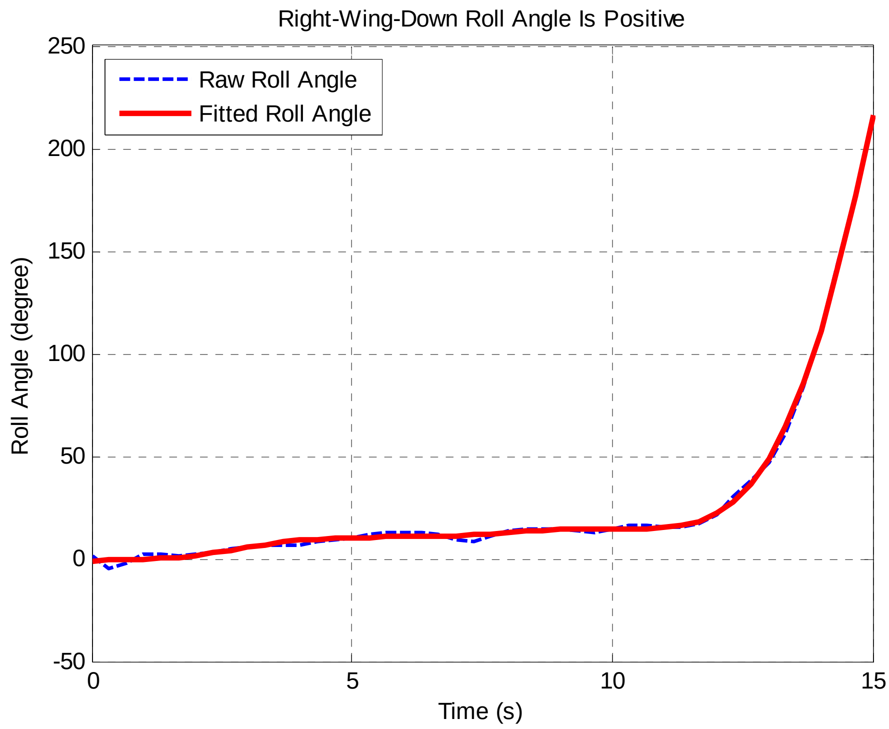

Figure 6 Roll Rate Estimate (airplane hit ground at time 20 s)

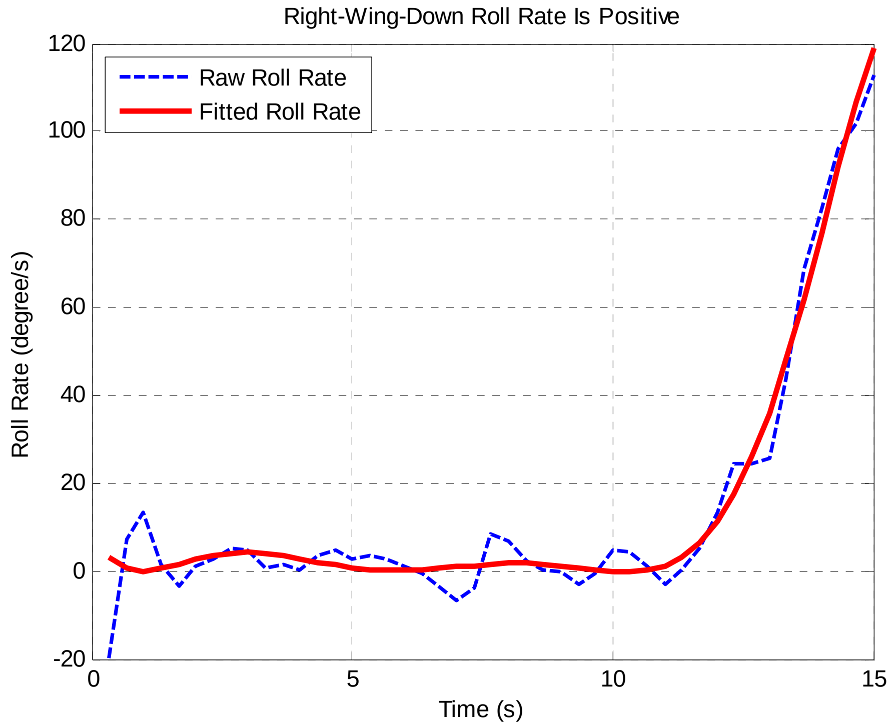

Figure 7 Roll Rate Estimate (airplane hit ground at time 20 s)

Propeller blades were in the field of view of the camera and are seen in the video. However, the blade passage frequency was about three times the camera frame rate of 30 fps so that only every 3rd blade passage was clearly recorded. Furthermore, the CMOS camera used a rolling shutter and acquired each frame one row of pixels at a time so that the bottom of a frame was acquired later than the top of a frame. This resulted in rotor blades in some video frames seen spaced by less than 180º as it should be in a rotor with two blades. Consequently, engine RPM could not be easily estimated from the video. However, it could be determined that engine RPM did not change until 3 seconds before ground impact.

E. CONCLUSIONS

1. Engine RPM was constant until 3 seconds before ground impact.
2. Ground speed before problems became evident was approximately 61 mph (10 mph above the specified stall speed of 51 mph).
3. Ground speed 74 seconds before ground impact was approximately 62 mph.
4. Pitch angle increased by 8º over a two-seconds period that ended approximately 18 seconds before ground impact.
5. Slow increase of roll angle started approximately 18 second before ground impact.
6. Fast increase of roll angle started approximately 8 seconds before ground impact. The airplane did not recover from it.
7. There is no information in the video on the cause of the fast increase of roll angle.
8. Shadow of the airplane seen in the video less than one second before ground impact does not show damage to wings, fuselage or tail assembly.