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

April 19, 2016

Video Study

NTSB Case Number:
CEN14FA193

A. ACCIDENT

Location: Albuquerque, New Mexico
Date: April 9, 2014
Time: 1743 MDT
Airplane: Airbus Helicopter AS350 B3e

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On April 9, 2014, about 1743 mountain daylight time, an Airbus (Eurocopter) AS350 B3e helicopter, N395P, impacted the hospital rooftop following a departure from the University of New Mexico Hospital helipad, Albuquerque, New Mexico. The helicopter was registered to PHI, Inc., Lafayette, Louisiana, and operated by PHI Air Medical, LLC, under the provisions of Title 14 Code of Federal Regulations Part 91. The commercial pilot and two paramedics received minor injuries and the helicopter was substantially damaged. Visual meteorological conditions prevailed and a company flight plan was filed for the local repositioning flight that was originating at the time of the accident.

D. DETAILS OF INVESTIGATION

The crashing helicopter was captured in a video acquired by a camera mounted on a rooftop structure. The resolution of the video was 352x240. The frame rate was 30 fps, however, the camera was motion-activated. This resulted in a video with gaps of up to two seconds between sections where the rate was 30 fps.

Trajectory and speed estimation of the helicopter was based on a mathematical model of the camera. The model was used to project reference points onto frames from the video and interactively align the projected points with their images in the frames. This approach was used first for calibrating the camera model and then for estimating helicopter trajectory and speed, as described next.

Camera Calibration

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). The camera X and Y coordinates were measurable in Google Earth. The other five parameters had to be estimated.

The estimation was based on 20 reference points on the rooftop helipad that were located based on images from Google Earth. These points included helipad edge and identification markings that were visible in the video. A computer program was used to project these reference points onto a frame from the video in an iterative process in which the five 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 five parameters were their optimal estimates. At that point, the mathematical model of the camera was calibrated.

Helicopter Trajectory and Speed Estimation

Helicopter location and orientation in hospital roof coordinates was estimated by projecting reference points located on it onto frames from the video using the calibrated camera model. Thirteen reference points on the helicopter were used. They included points on the nose, the horizontal and vertical stabilizers, the skid landing gear and the main rotor hub. The relative locations of these points were measured on schematic drawings of the helicopter in a coordinate system with origin at the nose of the helicopter.

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

Six video frames were analyzed. In the first frame, the helicopter was still on the ground. In the last frame, it was near the maximum elevation it reached before it began to descend. Analysis of each frame consisted of iterative movement (X, Y and Z) and rotation (yaw, pitch and roll angles) of the set of thirteen 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 helicopter location and orientation in roof coordinates.

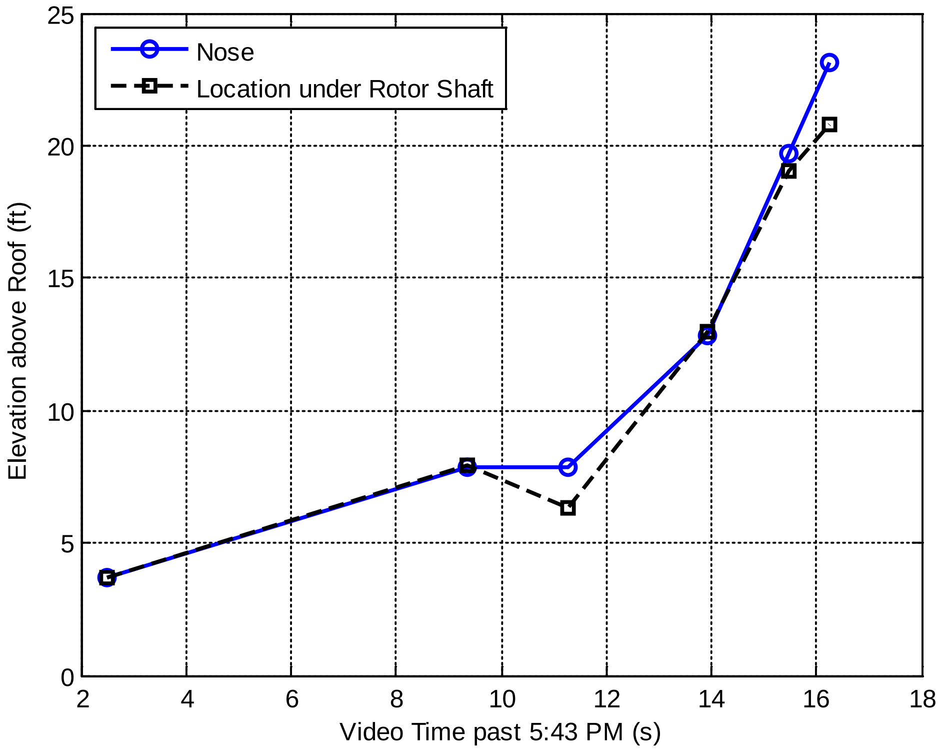

Figure 1 Estimated Helicopter Elevation above Roof

Figure 1 shows the helicopter elevation (the z coordinate) above the roof. The solid blue line shows the elevation of the nose. The broken black line shows the elevation of a point at the same height above the landing skids as the nose, but at the longitudinal location of the rotor shaft, i.e., near the longitudinal center of gravity. These elevations differ because the helicopter was pitching during flight.

The data shown in Figure 1 can be used for estimating the vertical speed (i.e., climb rate, positive up) of the helicopter. When estimated via least squares over the last four data points, both curves yield 3±0.3 ft/s. When estimated over the last three data points in Figure 1, the climb rate of the nose is 4.5±0.4 ft/s and the climb rate of the point at the longitudinal location of the shaft is 3.5±0.4 ft/s.

It was possible to estimate the yaw angle of the helicopter in a process much less time-consuming that estimating all three coordinates and all three angles. Yaw was estimated based on fifteen frames and the estimated angles are shown in Figure 2. Note that the helicopter completed several yaw rotations during its short flight.

The last eleven data points in Figure 2 can be accurately matched by a second order polynomial curve. Because the yaw angle behaves as a second order polynomial, the yaw rate (derivative of the yaw angle) is linearly increasing. Its estimate is shown in Figure 3.

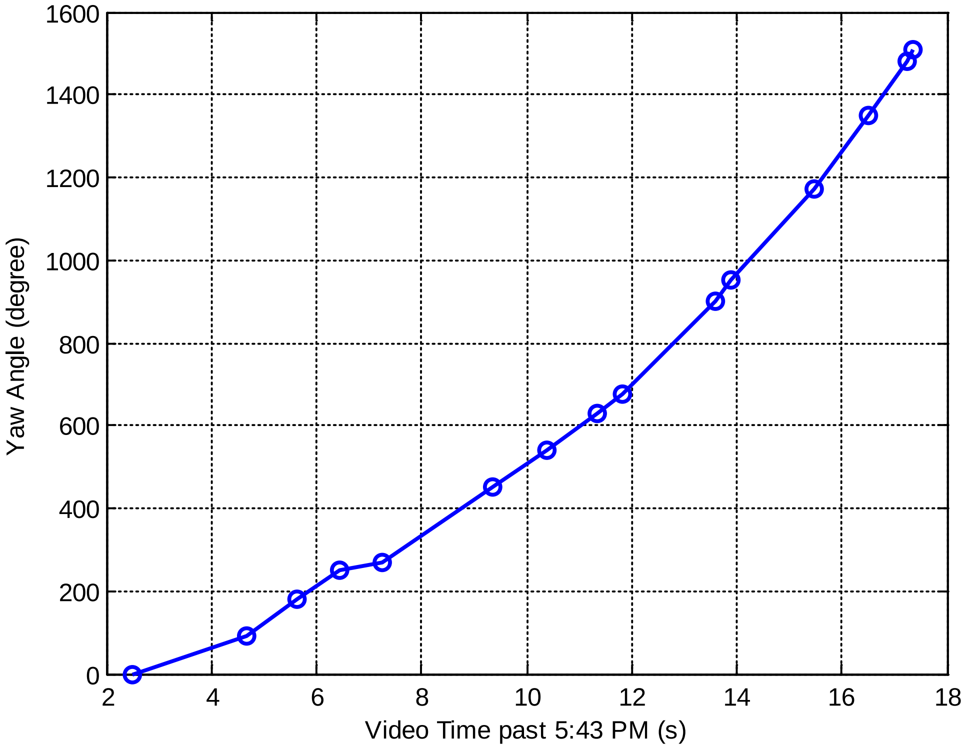

Figure 2 Estimated Helicopter Yaw Angle

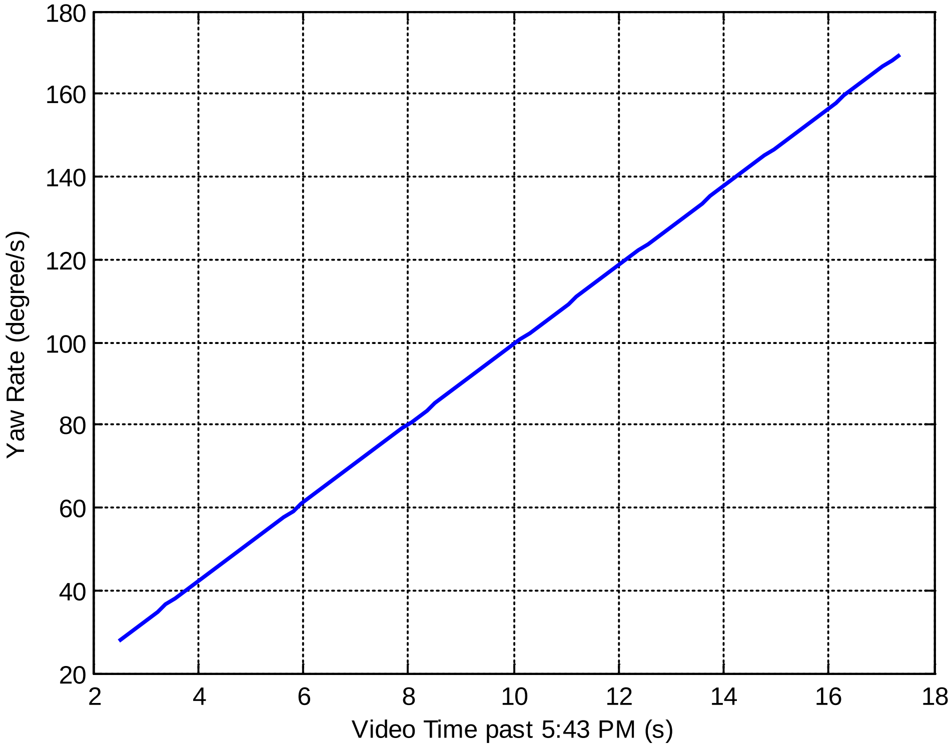

Figure 3 Estimated Helicopter Yaw Rate

Comparison of Albuquerque and Frisco Helicopter Accidents

Both the Albuquerque (CEN14FA193) and the Frisco (CEN15MA290) accidents involved Airbus AS350 B3e helicopters that started yawing counterclockwise after taking off and crashed seconds later. Table 1 summarizes the main characteristics of the flights of the accident helicopters during the first several seconds after taking off. Detailed characteristics of these flights and descriptions of how they were estimated are in this report and in the Frisco (CEN15MA290) Video Study report. Note that the tabulated Frisco maximum values correspond to time when the helicopter exited the field of view of the camera. It could have reached higher values later. The Albuquerque values are the maximum values reached during the flight because the helicopter stayed in the field of view of the camera.

Table 1 Characteristics of Albuquerque and Frisco Helicopter Flights

	Albuquerque	Frisco
Maximum Climb Rate (ft/s)	4.5	6.1
Maximum Yaw Rate (degree/s)	170	45
Time after Takeoff when Maximum Values Reached (s)	15	12

E. CONCLUSIONS

Video captured by a camera mounted on a rooftop structure was used to estimate trajectory and speed of a crashing helicopter. It was estimated that the helicopter reached climb rate of up to 4.5±0.4 ft/s.

It was further estimated that the yaw rate of the helicopter peaked at approximately 170 degrees per second when it reached its maximum altitude above the roof.