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

June 8, 2018

Video Study

NTSB Case Number:
ERA18MA099

A. ACCIDENT

Location: New York, NY
Date: March 11, 2018
Time: 1908 EDT
Aircraft: American Eurocopter A350 B2 helicopter

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On March 11, 2018, about 1908 eastern daylight time, an American Eurocopter Corp. (Airbus Helicopters) AS350 B2, N350LH, was substantially damaged when it impacted the East River and subsequently rolled inverted after the pilot reported a loss of engine power near New York, New York. The pilot egressed from the helicopter and sustained minor injuries. The five passengers did not egress and were fatally injured. The scheduled 30-minute, doors-off aerial photography flight was operated by Liberty Helicopters, Inc., on behalf of FlyNYON under the provisions of Title 14 Code of Federal Regulations (CFR) Part 91. Visual meteorological conditions prevailed and no flight plan was filed for the flight which originated from Helo Kearny Heliport (65NJ), Kearny, New Jersey about 1850.

D. DETAILS OF INVESTIGATION

The purpose of this study was estimating the trajectory, ground speed and descent rate of the helicopter as it impacted the East River. The helicopter was captured on videos from two cameras. The first video was from an iPhone 7 Plus that was hand-held by its owner who was standing on Bobby Wagner Walk south of Gracie Mansion. The video was recorded via Snapchat, had 320x568 resolution and frame rate of 30 fps. The iPhone owner was moving and rotating the phone to keep the helicopter in the field of view and was changing the zoom while recording.

The second video was from an iPhone 7 that was hand-held by its owner who was in a high-rise building west of FDR Drive. The video had 960x540 resolution and frame rate of 30 fps. The iPhone owner was moving and rotating the phone to keep the helicopter in the field of view and was changing the zoom while recording.

Estimating Water Impact Location

Figure 1 shows an aerial view of the accident area with the locations of the two cameras marked. Figure 2 shows the top 320x360 segment of a frame from the Camera 1 video taken approximately at the time of water impact. Figure 3 shows the top half of a frame from the Camera 2 video taken approximately at the time of water impact.

Figure 1. Aerial View of the Accident Area

Having images of the helicopter taken by both cameras at approximately the time of water impact made it possible to estimate the location of water impact. Figure 1 shows lines of sight from both cameras that pass through the helicopter at the time of water impact and through reference points on land. The intersection of the lines of sight is the estimated water impact location.

Figure 2. Top 320x360 Segment of a Frame from the Video Recorded by Camera 1

<u>Camera Calibration</u>

The analysis of this accident required a calibrated mathematical model of Camera 1 optics. 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). The approximate X, Y and Z coordinates of the camera were known. However, the accurate camera location was required for analysis. Therefore, all seven parameters had to be estimated.

The estimation was based on references that were visible both in aerial images and in video frames. The references used for calibration were baseball field light poles seen on the right in Figure 2, the four large bright soccer field lights seen left of the center, bridge columns seen left of the center, and points along the coastline.

A computer program that simulates camera optics was then 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.

Figure 3. Top Half of a Frame from the Video Recorded by Camera 2

Estimating Helicopter Trajectory and Speed

The owner of the Camera 1 iPhone was moving and rotating the phone to keep the helicopter in its field of view and was also changing the zoom setting while recording. Consequently, analysis of each frame required calibrated camera parameters specific to that frame. Since six video frames were analyzed, the calibration process was performed six times.

Figure 1 shows in red the ground track of the helicopter as it was approaching the water impact location. The heading indicated by the broken red line was not known and had to be estimated. It was assumed that the helicopter heading was aligned with its longitudinal axis of symmetry. The calibrated camera optics model corresponding to the video frame shown in Figure 2 was then used to superimpose a wireframe model of the A350 B2 helicopter onto the video frame at the estimated water impact location. The model was then rotated in the yaw direction until its nose and tail matched the nose and the tail in the video frame. The yaw angle that generated optimal match was 186º, which is the heading angle of the ground track line in Figure 1.

The 186º heading estimate was then validated using the Camera 2 video. It was accomplished without a seven-parameter calibrated camera optics model. The HFOV of Camera 2 was first estimated using land-based references. Then, considering the line of sight shown in Figure 1, the heading that generated helicopter nose-to-tail distance as seen by the camera that matched the distance in the video frame was estimated. The estimated heading matched the 186º heading estimated based on the Camera 1 video.

Once the ground track orientation was estimated, it became possible to estimate the 3D locations of the helicopter at the times corresponding to the six analyzed video frames. It was performed with the calibrated Camera 1 optics model in an iterative process where the location of the helicopter wireframe model along the ground track, its altitude above water and its pitch and roll angles were varied until the model optimally matched the helicopter image in the frame. At that point, the location, altitude, pitch angle and roll angle were the optimal estimates of these parameters.

The Camera 1 video allowed analysis over 1.7 seconds that ended at the time of water impact. The first frame was acquired 1.7 seconds before water impact and the last was acquired at the time of water impact. The ground distance traveled during this time was 63 feet. The average speed during the 1.7 seconds was 63/1.7=37 feet/second. Converting to knots and adding a ±10% uncertainty range yields ground speed estimate of 22±2 knots at the time of water impact. Note that the 63-foot long analyzed distance along the ground track is very short compared to the ground track line shown in Figure 1.

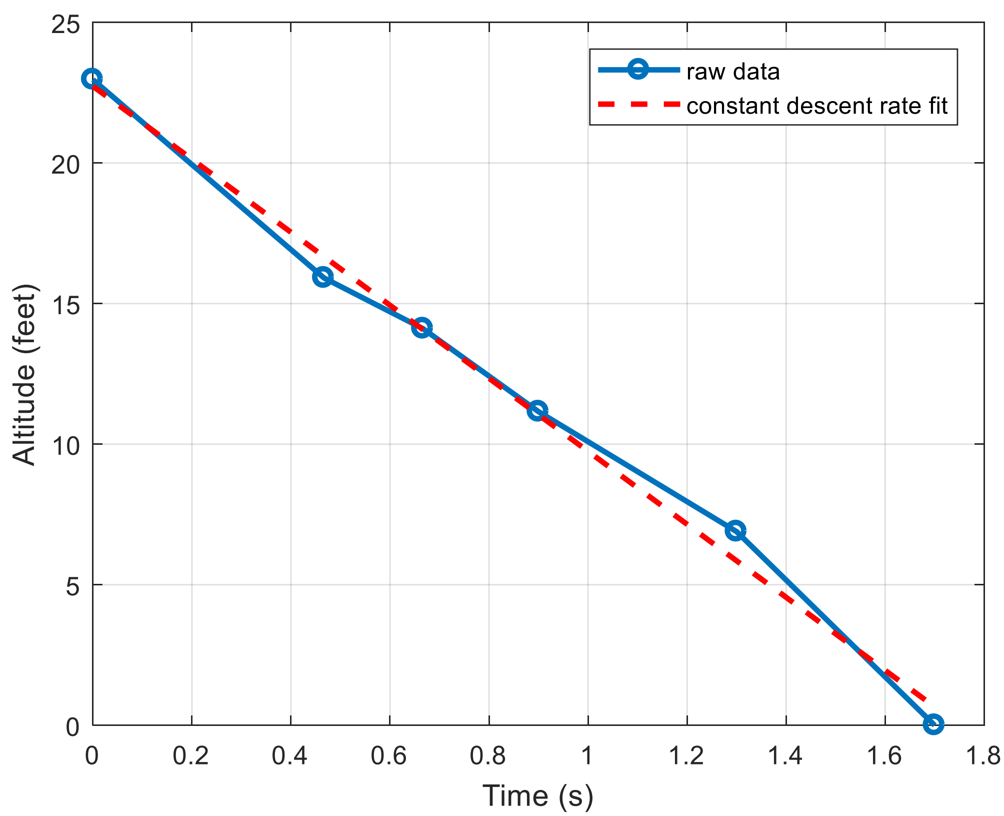

Figure 4. Estimated Helicopter Altitude vs. Time

Figure 4 shows a plot of six altitude estimates. Superimposed on the raw data plot is a constant descent rate fit. The constant descent rate estimate is 13 feet/second. Converting to units of feet/minute and adding a ±10% uncertainty range yields 780±80 feet/minute.

The descent rate can be added vectorially to the ground speed to get the magnitude of the velocity vector at the time of water impact. The velocity vector magnitude estimate is 23±2.5 knots (or 27±3 mph).

E. <u>CONCLUSIONS</u>

Videos captured by two hand-held smartphones were used to estimate the trajectory and speed of a helicopter that crashed into the East River in New York. It was estimated that the airplane ground speed was 22±2 knots at the time of water impact. The estimated descent rate at the time of water impact was 780±80 feet/minute. The estimated magnitude of the velocity vector at the time of water impact was 23±2.5 knots.