

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

January 27, 2016

Video Study

NTSB Case Number:
CEN15FA311

A. ACCIDENT

Location: Oshkosh, Wisconsin
Date: July 22, 2015
Time: 7:44 AM CDT
Airplane: Piper PA-46-310P

B. AUTHOR

Dan T. Horak
NTSB

C. ACCIDENT SUMMARY

On July 22, 2015, at about 7:44 AM central daylight time, a Piper PA-46-310P single-engine airplane, N4BP, sustained substantial damage when it impacted runway 27 (6,179 ft by 150 ft, concrete) while landing at the Wittman Regional Airport (OSH), Oshkosh, Wisconsin. The pilot and two passengers sustained serious injuries and two passengers sustained minor injuries. The airplane was registered to DLM Holding Group LLC and operated by the pilot under the provisions of the 14 Code of Federal Regulations Part 91 as a personal flight. Visual meteorological conditions prevailed at the time of the accident and no flight plan was filed. The flight departed the Southwest Michigan Regional Airport (BEH), Benton Harbor, Michigan, at about 7:30 AM eastern daylight time.

D. DETAILS OF INVESTIGATION

The goals of this study were estimating the ground track, ground speed and altitude of the crashing airplane ('accident airplane') and the location of another moving airplane ('second airplane') that was visible in the video. The accident airplane was captured in a video for approximately eighteen seconds before it impacted ground on runway 27. The video was recorded by a Kodak SP360 camera mounted inside the cockpit of a parked airplane that was not involved in this accident. The camera had a 360° panoramic field of view, the captured video was in polar coordinates, had

resolution of 1440x1440 and frame rate of 30 fps. The video was unfolded from polar to rectangular coordinates, resulting in 1280x720 resolution and 30 fps frame rate. The accident airplane was approximately 1500 ft from the camera and, because of the distance, its image in the video was only approximately 10 pixels long. Figure 1 is a detail from the video frame at time 17 seconds in which the accident airplane is visible shortly before it impacted ground.



Figure 1 Detail from a Video Frame Showing the Accident Airplane

Trajectory of the Accident Airplane

Trajectory estimation explored the 360° field of view of the camera. It made possible direct measurement of the yaw angle from the camera to the image of the accident airplane in frames from the video. The measurements were performed on the unfolded rectangular frames. These frames had 1280 horizontal pixels, resulting in angular scale of $360^\circ/1280=0.28125^\circ/\text{pixel}$.

The camera-to-airplane yaw angles were measured in eighteen frames spaced by one second. The approximate location of the camera was known from an aerial photograph and from statement of the pilot of the camera airplane. More accurate camera location was estimated using the images of three airport buildings visible in the video. These buildings and the location of the crash, also visible in the video, were then used for aligning the yaw of the 360° panoramic camera view with north. Figure 2 shows eighteen lines, originating at the camera location, that point to the airplane image at the eighteen analyzed times. The time corresponding to each line is shown in the figure. Time was set to zero at the first analyzed point which was time 4:53 in the video recording.



Figure 2 Accident Airplane Ground Track and Eighteen Analyzed Trajectory Points

The estimated locations of the airplane in X-Y coordinates are at the intersection of the eighteen lines with the ground track of the airplane, which is shown in magenta in Figure 2. The ground track past time 7 seconds was estimated based on statement of the accident airplane pilot and on statements of witnesses on the ground. Between time 0 seconds and 7 seconds, ground track was estimated based on pilot's statement that he was flying at approximately 90 kts in west to east direction before turning south. The airplane speed at time 7 seconds was estimated based on the video as described below. The trajectory between time 0 seconds and time 7 seconds had to be smooth and the speed had to start at 90 kts and end at the video-based estimated speed at time

7 seconds. This resulted in the trajectory shown in Figure 2. The square markers in Figure 2 are the estimated ground track locations of the accident airplane at the eighteen analyzed times.

The 0.28125°/pixel scale of the video frames applied to both the horizontal and the vertical axes. From the analysis illustrated in Figure 2, it was also possible to estimate the altitude of the accident airplane. The crash location was visible in the video. The vertical pixel level at which the crash location was visible in the video was set to correspond to zero AGL altitude. The vertical pixel level at which the airplane appeared in the eighteen analyzed frames prior to the crash were then measured. The pitch angle θ from the camera to the airplane, relative to the crash location at zero AGL, was then estimated using the video frames and the camera angular scale of 0.28125°/pixel. Since the distance d from the camera to the ground track at each analyzed time was already estimated as illustrated in Figure 2, the airplane AGL altitude a could be estimated as $a = d \times \tan(\theta)$. The estimated AGL altitude is shown in Figure 3. The airplane impacted ground at approximately time 19 seconds.

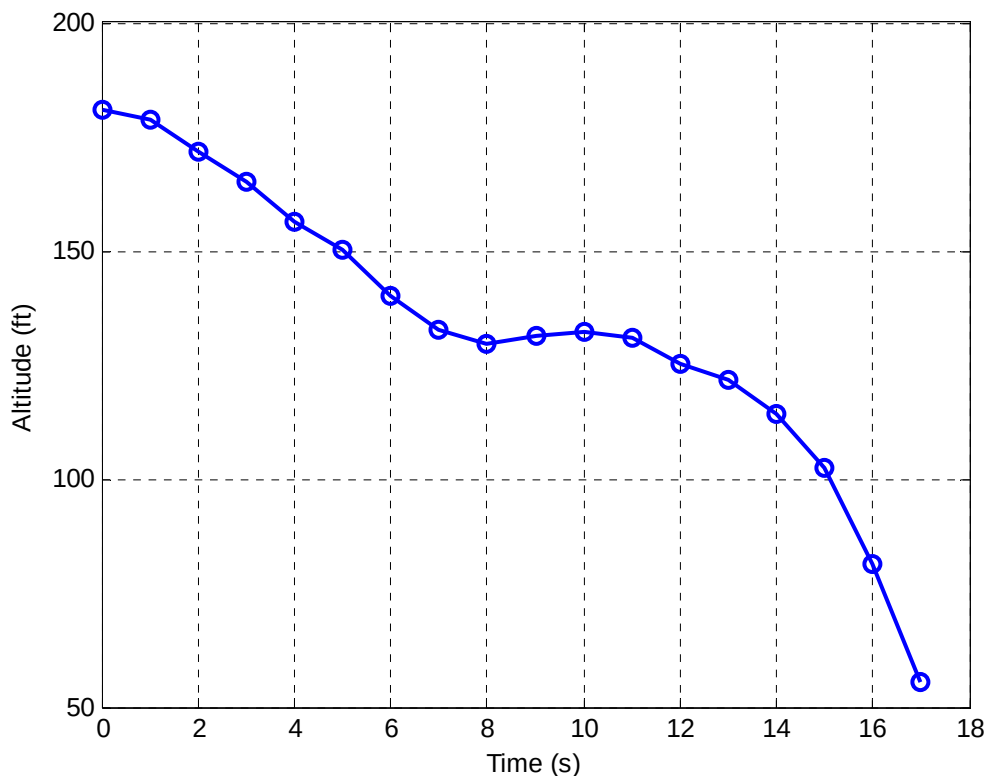


Figure 3 Estimated Accident Airplane AGL Altitude

At this stage, estimates of the X, Y and Z locations of the airplane were available at the eighteen analyzed times. Speed of the airplane was then estimated by dividing the 3D distances between adjacent locations by the time difference between them, which resulted in seventeen speed estimates. These speed estimates are the total inertial speeds, i.e., the vector sums of the ground speeds and the vertical speeds.

Since the vertical speed was very small compared to the ground speed, the total inertial speed was only marginally higher than the ground speed. The estimated total inertial speed is shown in Figure 4. The speed was below 70 kts during the last eight seconds of flight.

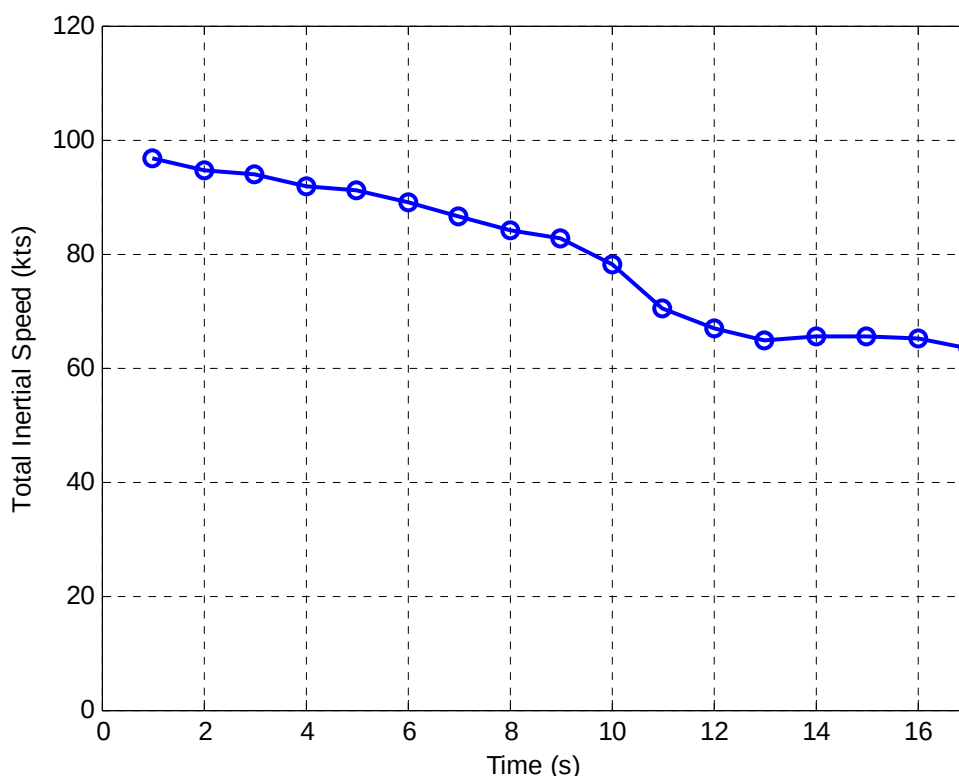


Figure 4 Estimated Total Inertial Speed of the Accident Airplane

Second Airplane Location and Time

At time 5:06 in the video, corresponding to time 13 s in Figure 2, an object is seen moving east to west and is assumed to be a departing airplane on runway 27. It is only seen for a fraction of a second because the camera view is obstructed. Because the second airplane was on the ground and far from the camera, its image in the video is only a barely visible moving dot. Its location was estimated with the method used for analyzing the trajectory of the accident airplane. The location of the second airplane at time 13 s is shown by the red 'X' marker in Figure 2.

Analysis of Runway Separation Distance

The accident airplane was heading south seven seconds before it crashed on Runway 27. It crashed before completing its 90° turn to right to be heading west along the runway. Therefore, the following analysis is hypothetical. Rather than analyzing events that actually happened, it presents a kinematic analysis of what could have happened if the assumptions listed below were all correct.

Assumptions used in the following analysis:

1. At time 13 s (see Figure 2), the airplane started a constant-radius 90° right turn that would bring it to the centerline of Runway 27.
2. The ground speed remained constant during the turn as it was at time 13 s (see Figure 4).
3. Wind speed is not taken into account.
4. Altitude is not taken into account.

The required radius of the turn is $R=655$ ft (see Figure 2). The length of the $\frac{1}{4}$ circle trajectory is $(\pi/2)R=1029$ ft. The estimated speed at time 13 s was 109.7 ft/s. Therefore, the time required to complete the hypothetical $\frac{1}{4}$ circle turn is $1029/109.7=9.4$ seconds.

If the second airplane stayed at the location where it is shown in Figure 2, when the accident airplane completed its turn, the estimated distance between the airplanes would have been $2000-570-655=775$ ft. However, the second airplane was departing and moving west. To keep the separation between the airplanes at 1500 ft when the accident airplane completed the turn, during the 9.4 seconds the second airplane would have to move west at the average speed of $(1500-775)/9.4=77.1$ ft/s=45.7 kts.

E. CONCLUSIONS

Video captured by a camera located in a parked airplane not involved in the accident was used for estimating ground track, altitude and speed of a crashing airplane. It was found that the speed of the airplane was below 70 kts during the last eight seconds of flight. Location of a second airplane that was moving along a runway and was visible in the video for a short time was also estimated.