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VIDEO STUDY

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TABLE OF CONTENTS

A. ACCIDENT	3
B. SUMMARY	3
B.1. The accident	3
B.2. Objective and scope of the Video Study	3
C. DETAILS OF THE INVESTIGATION	3
C.1. Engine speed estimation	4
D. CONCLUSIONS	5
FIGURES	6

A. ACCIDENT

Location: Clearwater, Florida
Date: February 1, 2024
Time: 1907 eastern standard time
Aircraft: Beech V35B

B. SUMMARY

B.1. The accident

On February 1, 2024, about 1907 eastern standard time, a Beech V35B, N6659L, was destroyed when it impacted two residences and the ground near Clearwater, Florida. The commercial pilot was fatally injured. Additionally, two occupants of one residence were fatally injured, and one occupant of a second residence sustained minor injuries. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

B.2. Objective and scope of the Video Study

The objective of this Video Study was the estimation of the speed of the airplane engine shortly before ground impact. Analysis was based on the visual and sound information in a video recorded with a camera mounted on a commercial building.

C. DETAILS OF THE INVESTIGATION

Two videos that recorded both the image of the airplane and the sound it emitted were available. They were recorded by cameras that were located about 180 feet apart. Because of the proximity of the cameras to each other, analysis of the information in them generated almost identical engine speed estimates. This report describes in detail engine speed estimation based on the camera that was mounted on the INFINITI of Clearwater car dealership building.

The video had 1920x1080 resolution and frame rate of 30 fps (frames per second). The video lasted about 26.7 seconds and recorded sound at the rate of 48,000 samples/second. The airplane is first seen in the video at video time 9.133 seconds. The last moving image of the airborne airplane is seen at video time 10.233 seconds. At video time 11.2 seconds, the post-crash fire can be seen in the video. Based on these times, the estimated ground impact video time is about 10.6 seconds. Figure 1 is a segment of a video frame recorded at video time 9.267 seconds.

Figure 2 is an aerial view of the accident area. It shows the location of the camera, the location of ground impact, and 24 airplane ground locations that were

available from ADS-B data. The time when the airplane was at five ADS-B locations is shown in the figure.

C.1. Engine speed estimation

The video included a sound stream that recorded the sound emitted by the airplane. The spectrum of the sound was computed with the FFT (Fast Fourier Transform) algorithm. The algorithm used 65,536 point windows, resulting in windows that were 1.3653 seconds wide and in frequency resolution of 40 cpm (cycles per minute).

Figure 3 shows twelve spectra computed in processing windows with window starting times from 0 seconds to 11 seconds. Some peaks are marked on the spectra. Spectral peaks N and M are noise due to sources that are not the accident airplane. They are present at time zero, before the sound emitted by the airplane reached a non-negligible level. Peak N is present even after time 11 seconds, past the time of ground impact.

The first processing window that clearly shows peaks due to the airplane starts at video time 5 seconds. The last processing window that clearly shows peaks due to the airplane starts at video time 9 seconds. The spectral peaks due to the sound emitted by the airplane with the highest intensity are in the window starting at time 7 seconds. This spectrum was used for analysis. The spectral peaks B, B2 and B3 were at frequencies 7207 cpm, 14458 cpm and 21709 cpm. These peaks are the BPF (blade passage frequency) of the three-bladed propeller and its second and third harmonics.

Since the propeller has three blades, the recorded propeller frequency and its harmonics were $7207/3=2402$ cpm, $14458/3=4819$ cpm and $21709/3=7236$ cpm. Figure 3 shows that these frequencies stayed unchanged from the window starting at time 5 seconds through the window starting at time 9 seconds and ending at time 10.3653 seconds, i.e., for more than five seconds.

As can be seen in Figure 2, the airplane had a velocity component toward the camera, causing the recorded frequencies to be higher than the frequencies emitted by the airplane due to the Doppler effect. To account for the Doppler effect, the Doppler-affected frequencies estimated based on the video had to be adjusted based on the airplane speed toward the camera estimated from ADS-B data. The video time and the ADS-B time had to be synchronized to make this possible, as described next.

The ADS-B ground track data and airplane altitude data were affected by measurement noise, resulting in a ground track that was not smooth and in an altitude vs. time plot that was not smooth. For maximum accuracy, the raw ADS-B data was

smoothed via 3rd order polynomial fits to the raw data. Figure 4 shows the estimated smoothed ground speed and the smoothed 3D speed of the airplane. The plotted 3D speed is the vector sum of the ground speed and the vertical descent speed. The speed plots in the figure end at ADS-B time 19:06:55.774, the time of the last ground track location in Figure 2. At that time, the ground speed was 117 knots and the 3D speed was 136 knots.

Figure 2 shows that the distance that the airplane traveled during the 3.484 seconds between ADS-B times 19:06:52.290 and 19:06:55.774 is about the same as the distance from the 19:06:55.774 location to the crash location. This indicates that the airplane impacted the ground about three seconds past 19:06:55.774.

The engine speed was estimated above based on the video time segment between 7 seconds and 8.3653 seconds. Ground impact time was estimated above as video time 10.6 seconds. This places the FFT window between video time 7 seconds and 8.3653 seconds at about 3 seconds before ground impact. This time approximately corresponds to the ADS-B time 19:06:55.774 that is the last ADS-B time marked in Figure 2. This indicates that the Doppler effect in the video time window between 7 seconds and 8.3653 seconds (see Figure 3) should be evaluated based on the airplane velocity vector at ADS-B time 19:06:55.774 (see Figure 2).

The Doppler effect depends on the component of the 3D speed along the line from the airplane to the camera. At time 19:06:55.774, that speed component was 160 feet/second. Doppler multiplier, defined as the number by which a frequency emitted by the airplane is multiplied when it reaches the camera, was 1.17 at that time. Consequently, the estimated engine speed after correcting for the Doppler effect is $2402/1.17=2053$ rpm.

D. CONCLUSIONS

A video recorded with a camera installed on a commercial building was used to estimate the engine speed of an airplane that crashed. The estimated engine speed during the last five seconds before ground impact was 2053 rpm.

FIGURES

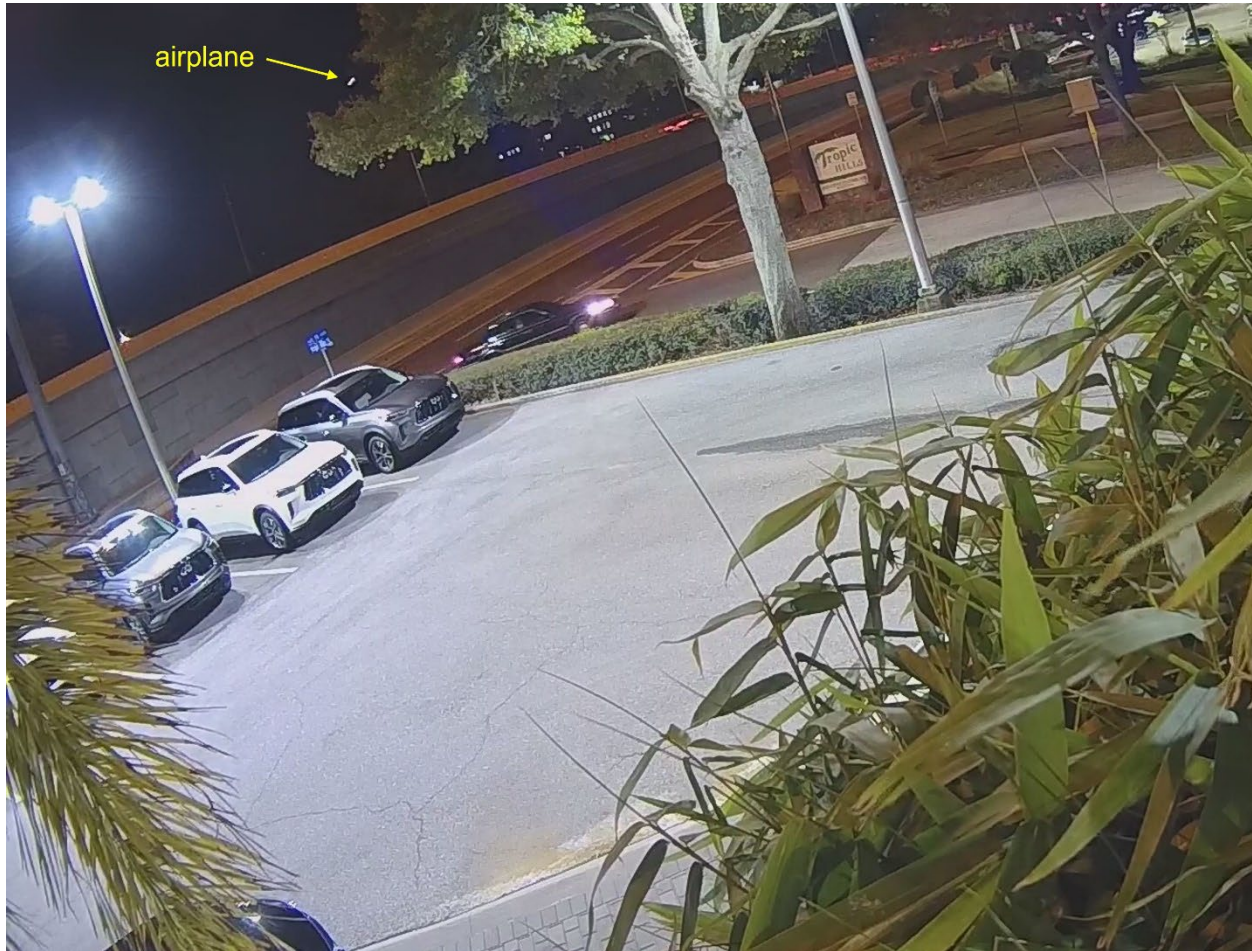


Figure 1. Video frame recorded at video time 9.267 seconds



Figure 2. Aerial view of the accident area

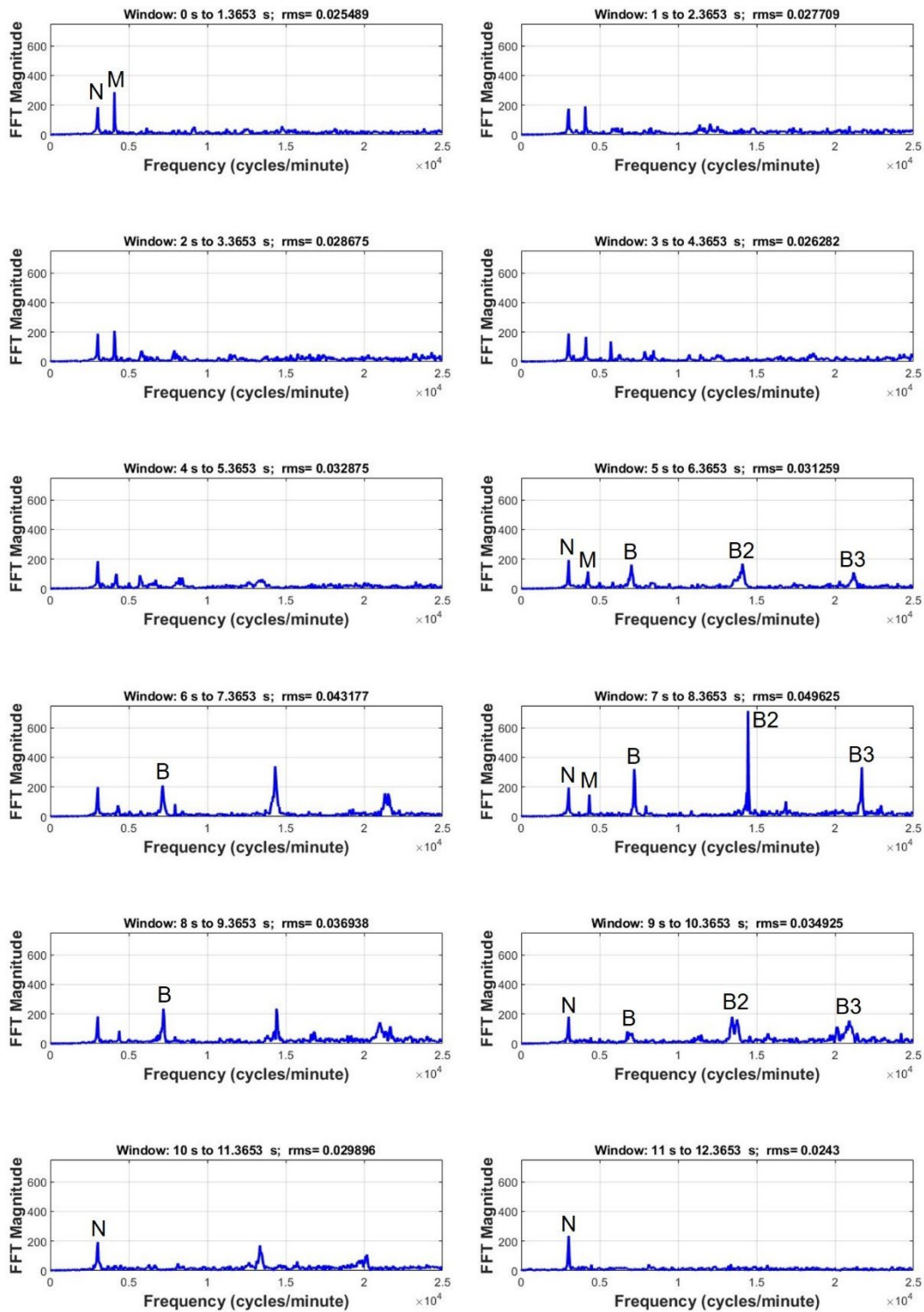


Figure 3. Sound spectrum plots

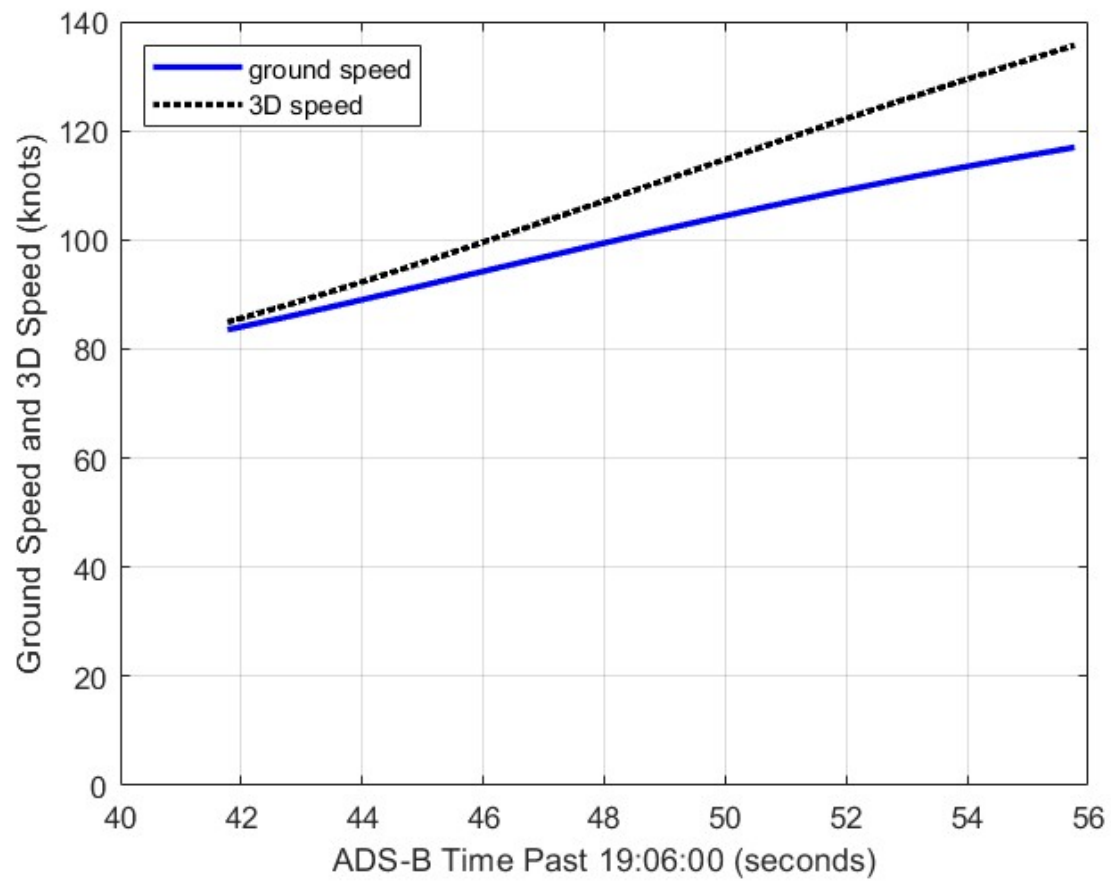


Figure 4. Estimated ground speed and 3D speed of the airplane