

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division

Washington, DC 20594

October 17, 2016

Sound Spectrum Study

Specialist's Study Report

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1. EVENT SUMMARY

Location: Westmoreland, New York
Date: April 18, 2016
Aircraft: Cessna 172C
Registration: N1863Y
Operator: Private
NTSB Number: ERA16FA161

On April 18, 2016, at 1910 eastern daylight time (EDT), a Cessna 172C, registration N1863Y, collided with trees and terrain during takeoff from Sophie's Choice airstrip in Westmoreland, New York. The airplane was destroyed by a postcrash fire. The private pilot and one passenger were fatally injured and a second passenger sustained minor injuries. The airplane was registered to a private individual and operated under the provisions of 14 *Code of Federal Regulations* Part 91. Visual meteorological conditions prevailed for the flight, which was originating at the time of the accident.

2. GROUP

A group was not convened.

3. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received a file containing audio and video from an unknown device.

3.1. File Description

The video file was 37 seconds in duration and recorded at a resolution of 1920 by 1080 pixels and a frame rate of 29.97 frames per second. Audio was contained in a single mono channel sampled at 44100 Hz. Figure 1 shows a Google Earth image of the grass airstrip and the approximate location of the camera.

The aircraft began its takeoff approximately 2 seconds after the video began. The aircraft became airborne just after it passed the windsock noted in Figure 1, approximately 20 seconds after the aircraft began its takeoff roll. The windsock was pointing straight at the ground. The aircraft banked to the left and then to the right before the camera shifted toward the ground. Sounds of impact were heard approximately 28 seconds after the start of the takeoff roll. Due to the angle between

the line of sight from the camera to the aircraft and the aircraft's groundpath, it was not possible to determine where the aircraft began its takeoff from the video.

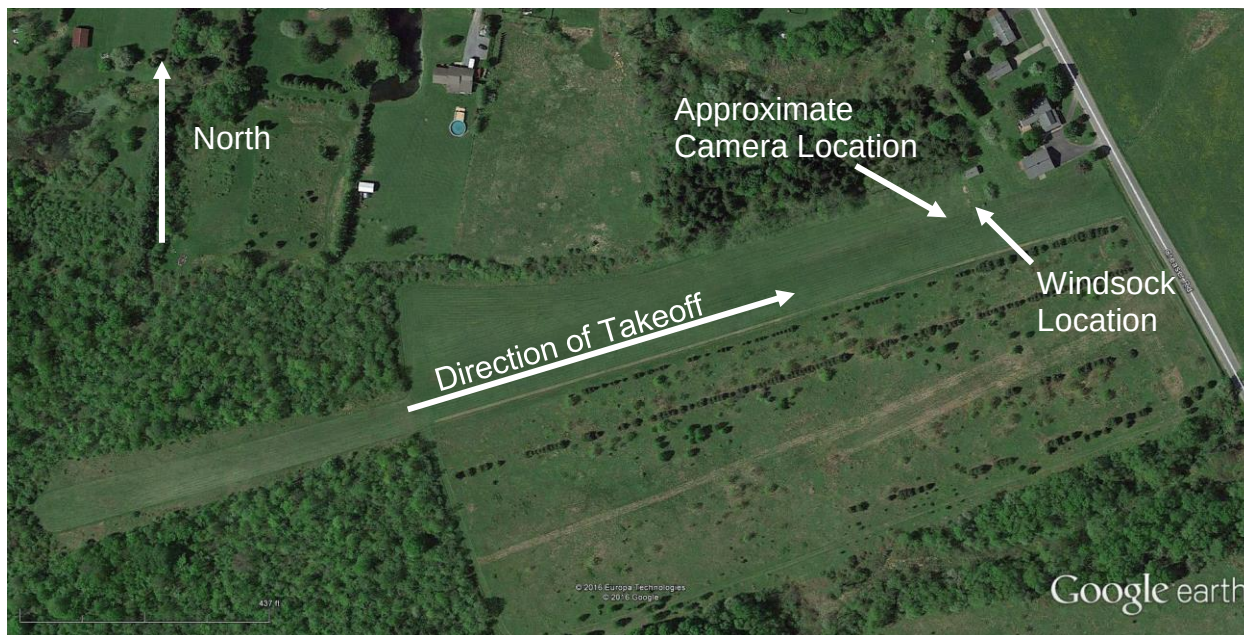


Figure 1. Overview of accident location.

3.2. Sound Spectrum Study

The audio portion of the video was evaluated in an attempt to determine the engine operating speed during the takeoff roll. A spectrogram was generated showing the frequency content of the sound and how it changes over time (Figure 2). The x-axis represents time in elapsed seconds of the video. The y-axis represents sound frequency in Hertz (Hz), and the color represents sound intensity.

The accident aircraft was equipped with one Continental O-300-D direct drive piston engine and a two bladed fixed pitch propeller. The noise generated by the propeller for this type of engine configuration is generally the strongest at the fundamental blade passage frequency (BPF) with higher harmonics decaying by 5-10 decibels (dB).¹ According to the aircraft and engine Type Certificate Data Sheets, the engine is rated and limited to 2700 revolutions per minute (rpm) maximum takeoff and maximum continuous operation. The propeller was limited to between 2230 and 2350 static rpm at the maximum permissible throttle setting. For example, at 2700 rpm the propeller noise would be most evident at the blade passage frequency (BPF) of 90 Hz (eq. 1).

$$RPM = BPF \left(\frac{blades}{sec} \right) * \frac{1}{2} \left(\frac{rev}{blades} \right) * 60 \left(\frac{sec}{min} \right) \quad \text{eq. 1}$$

Figure 2 shows the lower frequency sounds generated by the engine and propeller during the video. The impact with terrain occurred at 30 seconds video elapsed time.

¹ Smith, M. (1989). "Aircraft Noise." Cambridge University Press.

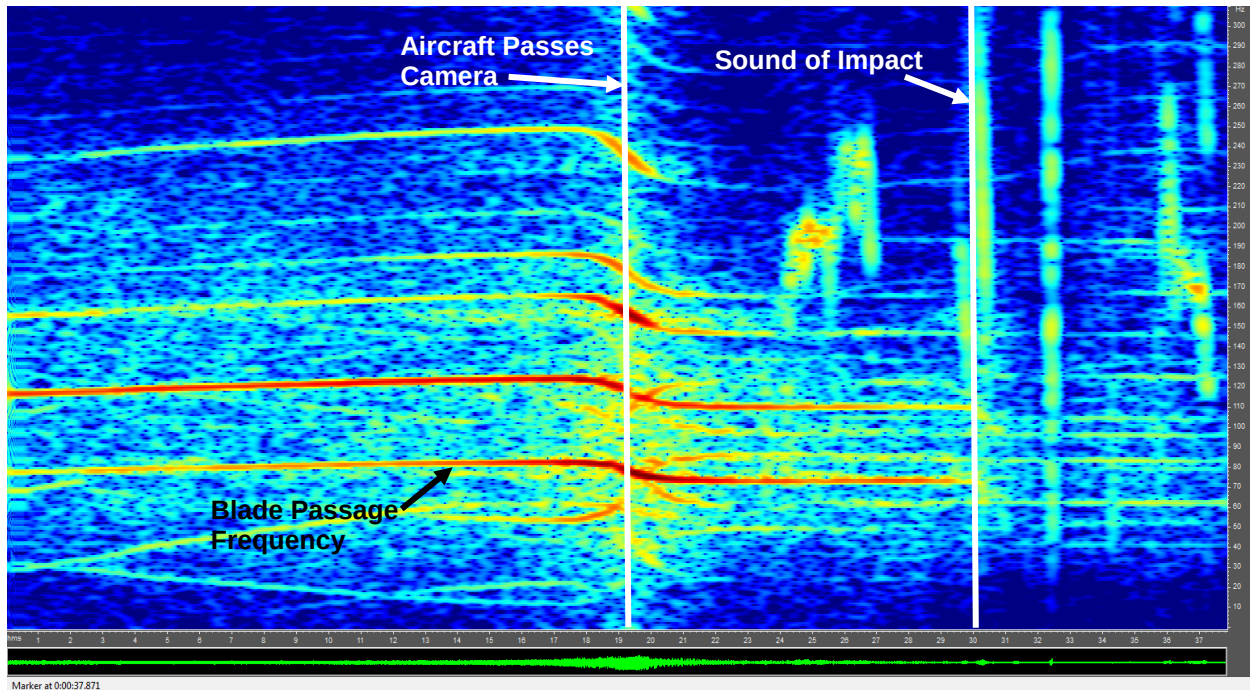


Figure 2. Spectrogram of entire video.

3.2.1. Doppler Effect

Because the camera was stationary with respect to the moving aircraft, the engine and propeller noises recorded by the camera were subject to the Doppler Effect. The Doppler Effect causes sound frequencies emitted from an object to appear higher to a stationary observer if the object is moving toward the observer (eq. 2). As the object moves away from the observer, the sound frequencies appear lower than the emitted frequency. The observed frequency and the emitted frequency are equal as the object passes the observer. In this case, because the aircraft and the observer were relatively close at the point of passage (approximately 40 feet), the sound travel time effect can be ignored.

$$f_s = \frac{c + v_s \cos \theta}{c} f_o \quad \text{eq. 2}$$

In equation 2, c is the speed of sound, f_s is the source frequency, v_s is the source velocity (negative when approaching the observer), θ is the angle between the velocity vector and the line of sight from the source to the observer and f_o is the observed frequency.

3.2.2. Engine RPM Determination

At the time the aircraft passed the camera, the BPF was approximately 78 Hz. Using equation 1, the engine was operating at approximately 2340 rpm. Because the speed of the aircraft is unknown, it is not possible to accurately determine engine rpm throughout the takeoff roll due to the Doppler Effect. Figure 2 also shows the BPF, and hence engine rpm, increasing slightly as the aircraft approached the camera. At takeoff speeds typical for a Cessna 172, the BPF did not change after the aircraft passed the camera.