NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, DC 20594

September 11, 2020

Sound Spectrum Study

Specialist's Factual Report
By Kyle Garner

1. Event Summary

Location:	Lake City, Florida
Date:	January 25, 2020
Vehicle:	Piper PA-32-260
Registration:	N55455
Operator:	Private
NTSB Number:	ERA20FA085

On January 25, 2020, at 0930 eastern standard time, a Piper PA32-260, N55455, was destroyed when it impacted terrain and a house after takeoff from Cannon Creek Airpark (15FL), Lake City, Florida. The private pilot was fatally injured. The airplane was registered to and operated by the pilot under the provisions of Title 14 Code of Federal Regulations Part 91 as a personal flight. Day visual meteorological conditions prevailed, and no flight plan was filed for the cross-country flight destined for Walk-Air Airport (38XA), Tyler Texas.

2. Sound Spectrum Study Group

A sound spectrum study group was not convened.

3. Details of Investigation

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received a video file from a witness who was recording an unrelated personal video near the airpark, which contained audio only of the event aircraft flying overhead.

3.1. Event Description

A separate witness at the airpark watched the event aircraft depart from runway 36 at 15FL and noticed that the event aircraft "turned hard left" after it cleared the trees, which the witness described as earlier than normal[i].

Figure 1 is a Google Earth overlay showing the location of 15FL, the direction of the travel for the event flight, the approximate location of the witness camera, and the wreckage location. Weather and atmospheric conditions in the overlay are not representative of conditions at the time of the flight.

[i]For more information, see the Memorandum for Record – Telephone Interview, Witness report located in the docket for this event.

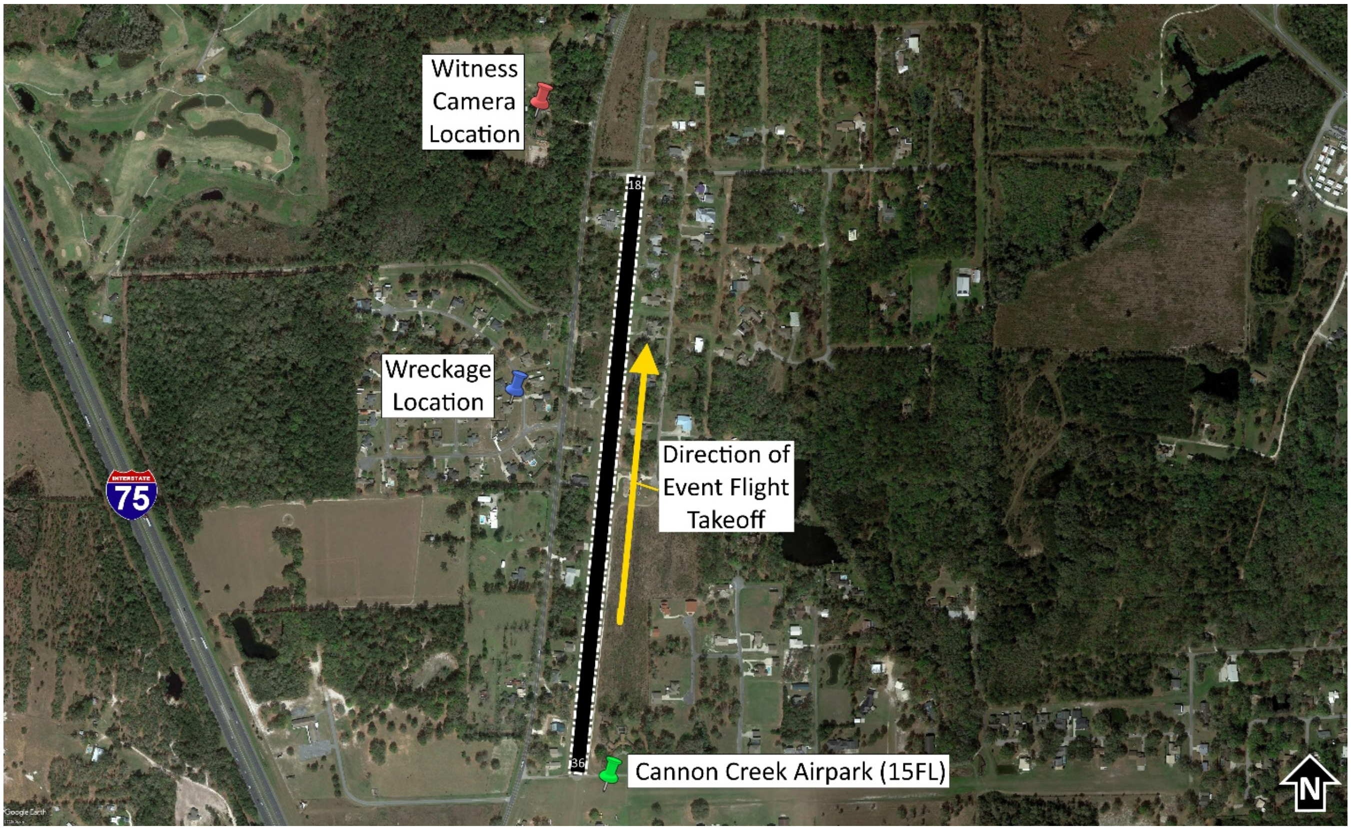

Figure 1. Google Earth overlay of the airpark, the direction of travel of the event flight, the location of the witness camera, and the wreckage location.

3.2. Witness Video Description

The witness video was 10 minutes and 22 seconds in duration and was recorded at a resolution of 1920 x 1080 pixels and a frame rate of 30 frames per second. A stereo audio track was included in the video and was sampled at a rate of 44,100Hz. The type and manufacturer of the camera was unknown.

The event aircraft was never visible on the recording. The ground track and speed of the aircraft were also unknown.

3.2.1. Witness Video Timing

The video contained no external time reference, thus, for the remainder of this report the video time is referenced as total elapsed seconds from the beginning of the recording.

3.2.2. Witness Video Summary

An aircraft was first heard flying overhead beginning at 296s on the video recording, however, per the Investigator-in-Charge (IIC) this was later determined to be another aircraft that took off immediately before the event aircraft.

Another aircraft was heard beginning at 357s and the sound persisted until approximately 420s. Per the IIC, this was determined to be the event aircraft.

3.2.3. Sound Spectrum Study

One channel of the stereo audio portion of the video recording was evaluated to determine the operating speed of the engine before the event aircraft impacted the ground.

The aircraft was equipped with a Lycoming O-540-E series 260 horsepower, six-cylinder, direct-drive engine with a two-bladed propeller. According to the aircraft and engine Type Certificate Data Sheets (TCDS), the engine was rated and limited to a speed of 2700 revolutions per minute (rpm).

The principal source of piston engine noise is the regular firing of the cylinders. The fundamental frequency, *F*, in Hertz (Hz) of this noise is given by the following expression for a four-stroke engine:

$$F = \frac{NR}{120} \qquad (1)$$ [ii]

where *N* is the number of cylinders and *R* is the rpm. Using (1), for the event aircraft's engine configuration the fundamental frequency at the maximum rated power of 2700rpm was 135Hz or 8100 cycles per minute (cpm).

A spectrogram was generated, as shown in Figure 2, showing the frequency content of the audio channel from 392s to 401s, or the period in which the event aircraft's engine noise had the highest intensity. The x-axis represents time in elapsed seconds and the y-axis represents sound frequency in Hz. The color represents sound intensity, with blue being the lowest intensity sound and dark red being the highest intensity.

[ii] G. Jerry and P. Lilly, "Engine Exhaust Noise Control," JGL Acoustics, 2008.

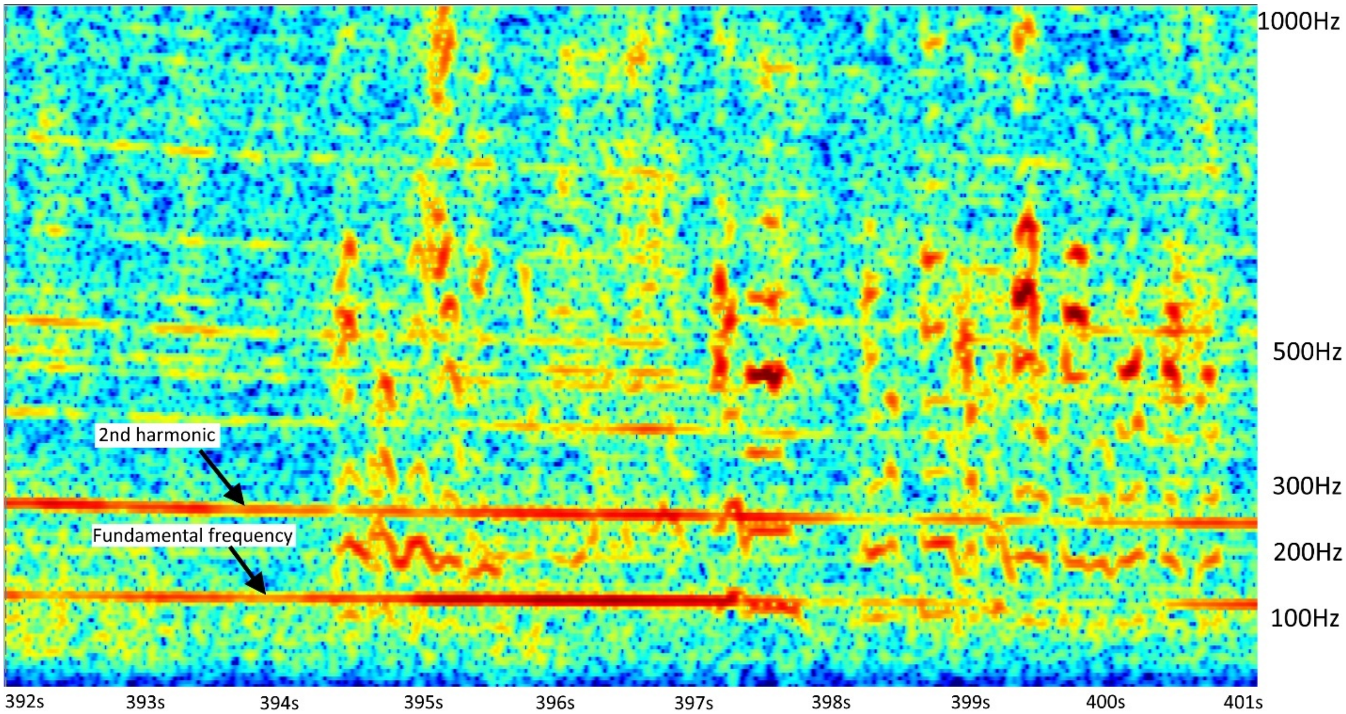

Figure 2. Spectrogram of audio file from 392s to 401s.

Lines identified as the fundamental frequency and the second harmonic are shown in Figure 2. Measured at the area of highest intensity, which occurred at approximately 396s, the fundamental frequency was approximately 129Hz. Using (1), this corresponds to a likely engine speed of about 2580rpm, or slightly below the maximum rated 2700rpm for this engine.

Next, a fast Fourier transform (FFT) was generated to further understand the dominant frequencies in the spectrum. The 44,100 Hz audio signal was analyzed with a 32,768-point FFT algorithm, resulting in a frequency resolution of 1.3458Hz or 80.75cpm. The FFT was analyzed in 0.743-second-long windows (32,768 / 44,100 = 0.743).

Figure 3 is the FFT plot generated for each 0.743-second window from 392s to 401.743s. The x-axis is the frequency measured in cpm and the y-axis is the magnitude of the FFT. The red dashed lines on each plot represent the fundamental frequency of 8100cpm from the engine noise in this engine configuration. The blue dashed lines on each plot represent the second harmonic frequency of 16,200cpm.

The data show that the highest magnitude spectral peak of 7752cpm was at time 396s, as shown in Figure 3. 7752cpm corresponds to an engine speed of approximately 2584rpm, or slightly below the maximum rated 2700rpm.

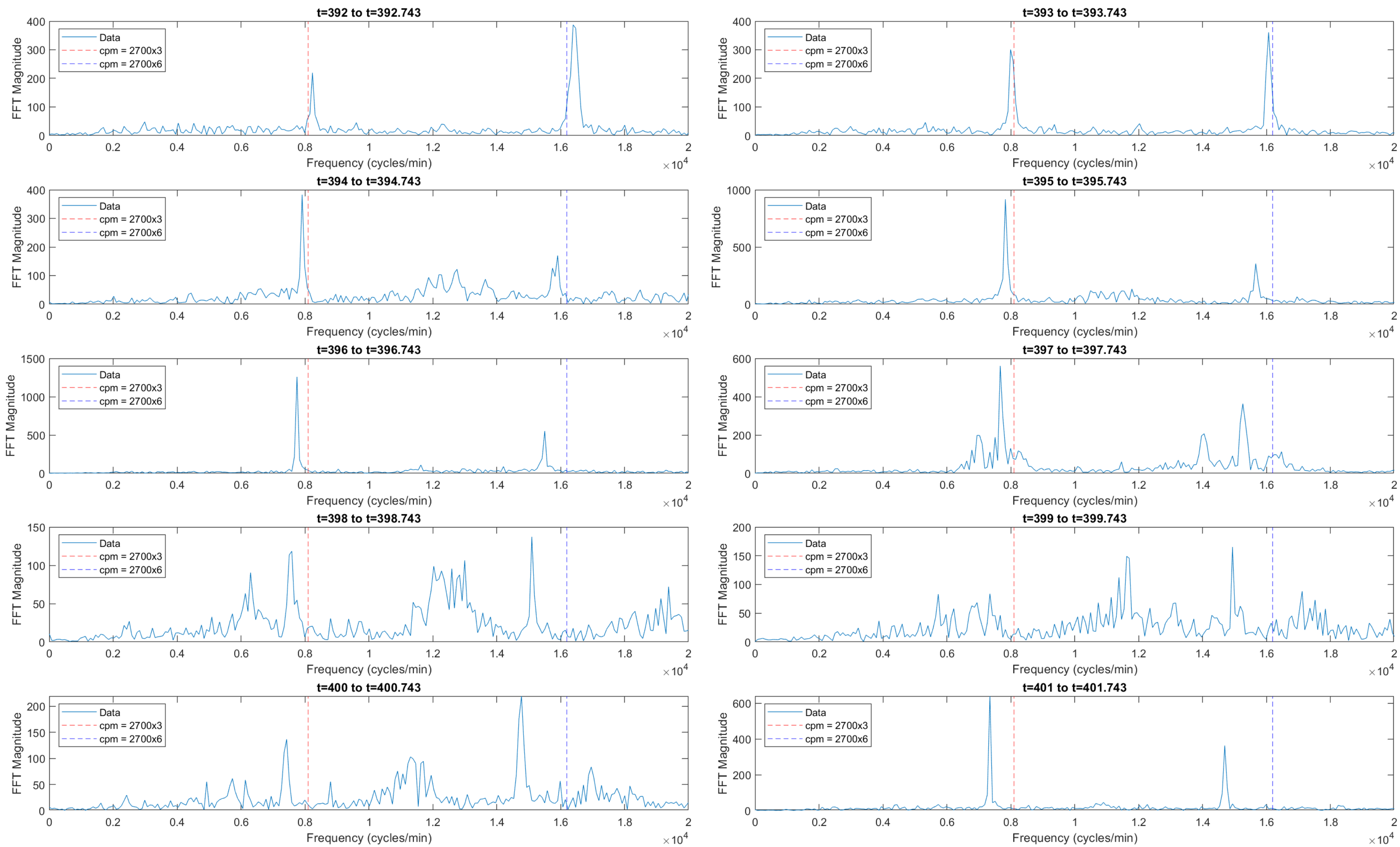

Figure 3. FFT of audio file from 392s to 401.743s.

3.2.4. Doppler Effect

Because the camera was stationary with respect to the moving aircraft, the engine 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. As the object moves away from the observer, the sound frequencies appear lower than the emitted frequency.

As the ground track and speed of the event aircraft are unknown, the influence of the Doppler effect on the fundamental frequency is also unknown. This is also complicated by the fact the event aircraft was never visible on the video recording.

However, as shown in Figure 3, the highest magnitude spectral peak of 7752cpm was at time 396s, which is likely the point at which the event aircraft was closest to the location of the witness camera. The higher frequencies of the spectral peaks before 396s and the lower frequencies of the spectral peaks after 396s could be the result of the Doppler effect.

3.3. Engine RPM Determination

Determination of the engine rpm over time was complicated by the lack of information related to the ground track of the aircraft, the aircraft's speed, and no visible reference to the aircraft on the video recording. If the assumptions about the Doppler effect in Section 3.2.4 are valid, it's likely that the event aircraft was closest to the witness camera at 396s elapsed time in the video, and at that time the engine was likely operating at approximately 2580rpm, slightly below its maximum rated 2700rpm.

A copy of a trimmed portion of audio used to create figures 2 and 3 is provided in .wav format as Attachment 1 to this report.