

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

September 24, 2018

Sound Spectrum Study

**Specialist's Study Report
by Christopher Babcock**

1. EVENT

Location: Reno, Nevada
Date: September 11, 2016
Aircraft: Piper PA-28R-201T
Registration: N821ET
Operator: Private
NTSB Number: WPR16FA178

On September 11, 2016, at 1813 Pacific daylight time, a Piper PA-28R-201T, registration N821ET, collided with vehicles in an airport parking lot after takeoff from Reno/Tahoe International Airport, Reno, Nevada. The airplane was registered to RCS3 LLC, and operated by the pilot under the provisions of 14 *Code of Federal Regulations* Part 91. The private pilot and two passengers were fatally injured, and the airplane sustained substantial damage. The cross-country flight was destined for San Carlos Airport, San Carlos, California. Visual meteorological conditions prevailed, and an instrument flight rules flight plan had been filed.

2. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received files containing air traffic control recordings of transmissions to and from the accident aircraft.

2.1. Audio Description

Audio from the Reno Ground and Reno Tower control positions was provided to the NTSB. The mono track containing the transmissions was sampled at 8000 kHz. The file from the Reno Ground control contained 12 transmissions from the accident aircraft and the file from the Reno Tower control position contained 5 transmissions from the accident aircraft. Table 1 shows the contents of those transmissions.

Table 1. Transmissions from the accident aircraft.

Elapsed Time in File (mm:ss)	Source File	Transmission Contents
2:13	Ground	Reno Ground november eight two one echo tango. we finally figured out the routing and uh we're at uh Atlantic ready for taxi. which runway would you like us on?
2:32	Ground	affirmative three four right. ready for taxi.
2:41	Ground	uh via charlie. hold short uh runway two five. one echo tango.
2:48	Ground	yes we have information zulu. one echo tango.
3:40	Ground	that would be— with these winds? yeah two five would be great for one echo tango.
4:04	Ground	okay we'll climb via the SID maintain one zero thousand and then we'll do the Reno nine departure as it's depicted off of runway two five that'd be a three four zero heading for one echo tango.
4:20	Ground	your welcome. three four— uh one echo tango.
4:27	Ground	uh two five via taxi charlie lima. one echo tango.
5:26	Ground	uh yes sir. run up at the end will be a very quick run up.
5:32	Ground	thank you sir. will do so.
9:05	Ground	yeah Reno Ground november eight two one echo tango. we're done with the— with the run up and ready for release.
9:15	Ground	okay will do so. one echo tango.
7:51	Tower	alright Reno Tower november eight two one echo tango holding short uh runway two five ready for IFR release.
8:09	Tower	standing by. what is the departure frequency for one echo tango?
8:14	Tower	one two six point three. thank you.
8:30	Tower	uh one two— two five. cleared for takeoff uh one echo tango's rollin'. thank you sir have a great day.
10:18	Tower	negative. we got a— we got a problem.

2.2. Spectrum Study

A spectrogram was generated for the final two transmissions showing the frequency content of the sound and how it changed over time. 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 y-axis was limited to 4000 Hz due to the 8000 Hz sampling rate of the original audio. The spectrogram was examined to identify frequencies associated with the engine, propeller, turbocharger, and stall warning horn.

The aircraft was equipped with a turbocharged Continental TSIO-360-FB engine with a two-bladed propeller. At the maximum rated engine speed of 2575 rpm, the propeller blade passage frequency was 86 Hz. The turbocharger compressor contained seven blades and the turbine contained 11 blades. According to the manufacturer's best estimate, the turbocharger shaft speed was approximately 76900 rpm during the accident takeoff conditions which equate to a fundamental shaft frequency of 1282 Hz. The blade

passage frequencies of the turbine and compressor are both above the upper limit of the spectrogram and would not be visible. The manufacturer also provided an estimate for the stall warning horn of 700-800 Hz.

Figures 1-2 show the spectrograms corresponding to the final two transmissions from the accident aircraft.

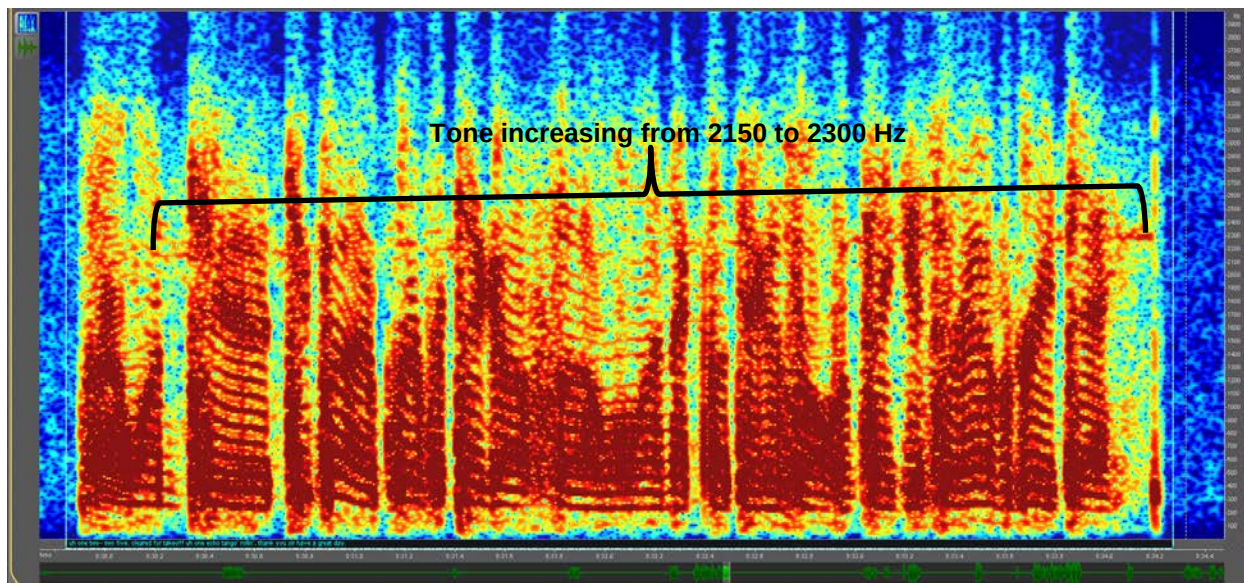


Figure 1. Spectrogram of takeoff clearance readback (color adjusted to emphasize increasing tone).

Figure 1 shows a faint tone increasing from about 2150 Hz to about 2300 Hz at the end of the transmission. This is a potential match for the turbocharger shaft second harmonic nearing takeoff power as the throttle was increased. This corresponds to turbocharger shaft speeds of 64500 rpm increasing to 69000 rpm. Sounds of the engine and propeller were not visible, likely because of the combination of audio processing effects between the microphone, radio system, and ATC recording system causing a rolloff below approximately 150 Hz.

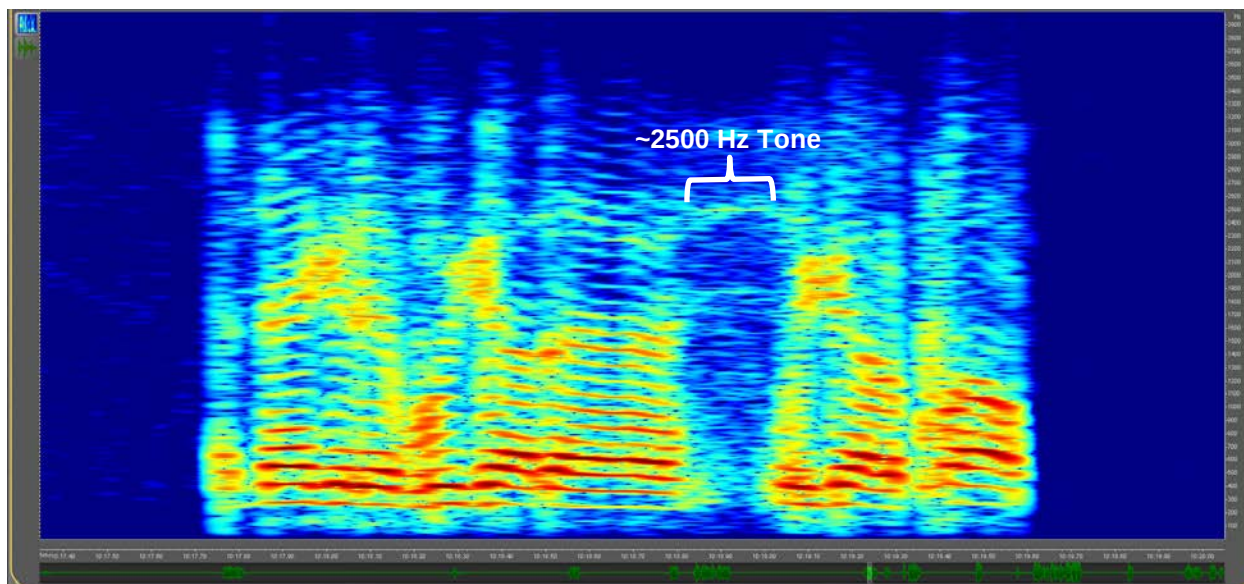


Figure 2. Spectrogram of pilot reporting a problem.

Figure 2 shows a tone at approximately 2500 Hz during a pause in the pilot's speech. This is also a potential match for the turbocharger shaft second harmonic corresponding to a shaft speed of 75000 rpm. Propeller and engine sounds were not visible. There are no tones consistent with a stall warning horn visible in the spectrogram. Figure 3 shows a spectrogram of an in-aircraft recording of an exemplar stall horn.

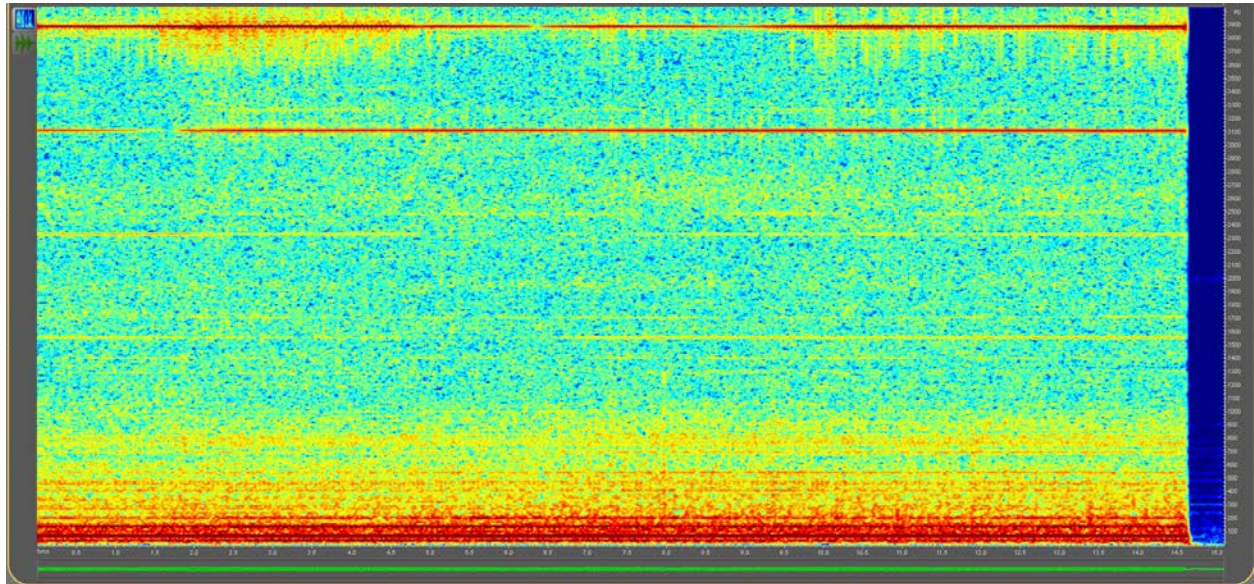


Figure 3. Exemplar in-aircraft recording of PA-28 stall horn