NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

September 26, 2019

Sound Spectrum Study

1. EVENT SUMMARY

Location:	Zaleski, Ohio
Date:	January 29, 2019
Helicopter:	Bell 407
Registration:	N191SF
Operator:	Viking Aviation, LLC.
NTSB Number:	CEN19FA072

On January 29, 2019, at 0650 Eastern standard time, a single-engine, turbine-powered, Bell 407 helicopter, N191SF, collided with forested, rising terrain about 4 miles northeast of Zaleski, Ohio. The helicopter was registered to and operated by Viking Aviation, LLC, doing business as Survival Flight, Inc., as a visual flight rules helicopter air ambulance flight under the provisions of *14 Code of Federal Regulations* Part 135 when the accident occurred. The certificated commercial pilot, flight nurse, and flight paramedic were fatally injured, and the helicopter was destroyed. Visual meteorological conditions existed at the departure location, and company flight following procedures were in effect. The flight departed Mt. Carmel Hospital, Grove City, Ohio at 0628, destined for Holzer Meigs Hospital, Pomeroy, Ohio, about 69 miles southeast.

2. GROUP

A flight data group was convened on June 12, 2019, at the Vehicle Recorder Division Laboratory at the National Transportation Safety Board (NTSB) headquarters in Washington, DC. The group members who participated are listed below:

Chairman:	Sean Payne Mechanical Engineer National Transportation Safety Board (NTSB)
Member:	Royce Snider Fmr. S.M.E. Acoustics - Principal Engineer Certification and ODE Administrator Bell Helicopters

3. DETAILS OF INVESTIGATION

The NTSB Vehicle Recorder Division received the following global positioning system (GPS) device:

Device Manufacturer/Model:	Outerlink IRIS Data Comm Processor
Serial Number:	00254
Device Manufacturer/Model:	Outerlink IRIS Data Comm Dialer
Serial Number:	DCP00251

3.1. Flight Data Monitoring (FDM) Device Carriage Requirements

Per federal regulation 14 CFR 135.607, helicopters in air ambulance operations must be equipped with an approved flight data monitoring system capable of recording flight performance data. The system must receive electrical power from the bus that provides the maximum reliability for operation without jeopardizing service to essential or emergency loads and be operated from the application of electrical power before takeoff until the removal of electrical power after termination of flight.

This rule went into effect on April 23, 2018. The rule does not include the helicopter air ambulance operators perform periodic reviews of the flight data to ensure the data is valid, or use the flight data in any kind of flight operations quality assurance (FOQA) program. Additionally, there is no requirement that the FDM devices be certified to any crashworthiness standard.

3.2. Outerlink IRIS Description

The Outerlink IRIS is a lightweight flight data monitoring, recording and satellite communications device. The system consists of two main components, a control head (known as the dialer unit) that is installed in the helicopter’s instrument panel as well as a second processing device (processor) which is installed in the helicopter’s avionics bay. The system provides instantaneous two-way communication between the helicopter’s flight crew and any equipped ground operator (internet or telephone) via a global satellite network.

In addition to communications features, the device provides flight data monitoring features and the ability to record these functions. The unit contains an internal Attitude Heading Reference System (AHRS) as well as components that facilitate the input of ARINC avionic data streams. A typical configuration will record native AHRS data as well as a variety of ARINC labeled messages that could potentially record engine information.

The system can also record voice and video data. In a typical configuration, the helicopter’s intercom system (ICS) is configured to interface with the IRIS device. The pilot’s headset hot mic and ear cups are recorded to the IRIS through the ICS system.

Additionally, a lipstick style video camera interfaces with the system and is set to record a view over the pilot's shoulder of the helicopter's cockpit, including the pilot's control stick inputs as well as portions of the instrument panel and windscreen.

Data is recorded in three places on the IRIS system, an SD card and two solid-state disks (SSD) in both the dialer and the processor unit. The pedestal mounted control head contains a removable SD card which records only flight data. In an abrupt power loss situation, such as an accident, the SD card is not likely to contain the latest information.

Inside the control head and the processor unit, a SSD is configured to record flight data, audio and video data. Data recorded by the unit reaches the SSD first and is then dispatched to the SD card (applicable data only). The SSD can be accessed through a hardwire ethernet connection on the back of each device or the unit can be disassembled and the SSD can be read independently. The IRIS system runs on a version of the Linux operating system.

The device is designed to close recorded files every 100 milliseconds, reducing the potential for lost data in abrupt power loss scenario. The manufacturer reports that the device is not crashworthy (as defined by ED155 or ED112), however, the manufacturer has a crash hardened memory that is available for purchase. As of August 2019, the manufacturer reported that the crash hardened memory option has not been purchased by any customer.

3.3. Data Recovery

For a detailed description of how audio and data was recovered from the device please refer to Flight Data Monitoring (FDM) Device – Data – Group Chairman's Factual Report, which can be found in the public docket for this investigation.

3.4. Audio Recording Description

For additional description of recorded audio recovered from the device, as well as a transcript of audio information, please refer to Flight Data Monitoring (FDM) Device – Audio – Group Chairman's Factual Report, which can be found in the public docket for this investigation.

3.5. Timing and Correlation

Timing of the figures in the sound spectrum study use audio taken from the last 60 seconds of the recording. The recording ends at 06:49:08.9 EST. As such, the time interval of the studied audio information is between approximately 06:48:08.9 and 06:49:09.8 EST. This portion of audio information was recorded during a time in which the data portion of the FDM recorder failed to record. For more information of the data recovered from the FDM device refer to Flight Data Monitoring (FDM) Device – Data – Group Chairman's Factual Report, which can be found in the public docket for this investigation.

3.6. Sound Spectrum Discussion and Figures.

Figure 1 is an audio spectrogram for the last 60 seconds of the recording. Frequency is shown in the y-axis and time is given in the x-axis. A pattern frequency excitation consistent with main rotor blade slap occurred approximately 30 seconds prior to the end of recording, which was around 6:48:38 EST. The main rotor blade slap has a modulating amplitude, with a dynamic component. This is consistent with the main rotor four per revolution (four bladed rotor system).

A new and unknown sound was recorded at 06:48:59, around 10 seconds from the end of the recording.

According to the audio transcript group, this sound was described as “A whining sound, potentially aerodynamic in nature.”

Figure 2 is an audio spectrogram for the last 15 seconds of the recording. The new and unknown sound was recorded around 10 seconds from the end of the recording, which was around 06:48:59. The sound had a frequency of around 180 Hz with a strong harmonic at approximately 356 Hz. The frequency information does not correlate with known engineering data for any rotating mechanical parts. The frequency is distinctly different from any parts associated with the rotorcrafts drivetrain, rotor system or transmission.

Figure 3 is a Fast Fourier Transform (FFT) averaged for the time interval between approximately 06:48:35 and 06:48:45 EST. In this FFT, frequency information was associated with the following equipment and their associated harmonic frequencies:

- Main Rotor – 4 per revolution (4 bladed main rotor system)
- Tail Rotor – 2 per revolution (2 bladed tail rotor system)
- Tail Rotor Driveshaft
- Main Rotor System Blade Slap
- Transmission Gear Mesh (annotated “XMSN Gearmesh”)

The recorded frequency information shows the components operating within their expected ranges.

Figure 4 is a FFT averaged for the time interval between approximately 06:48:50 and 06:49:00 EST. This period of time is just prior to the introduction of the new and unknown sound. In this FFT, frequency information was associated with the following equipment and their associated harmonic frequencies:

- Main Rotor – 4 per revolution (4 bladed main rotor system)
- Tail Rotor – 2 per revolution (2 bladed tail rotor system)
- Tail Rotor Driveshaft

- Main Rotor System Blade Slap
- Transmission Gear Mesh (annotated “XMSN Gearmesh”)

The recorded frequency information shows the components operating within their expected ranges. The amplitudes of these data may have varied, however, the frequency remained unchanged.

Figure 5 is a FFT averaged for the time interval between approximately 06:48:49 and the end of the recording at 06:49:08.9 EST. This period of time is during the time the new and unknown sound was recorded. In this FFT, frequency information was associated with the following equipment and their associated harmonic frequencies:

- Main Rotor – 4 per revolution (4 bladed main rotor system)
- Tail Rotor – 2 per revolution (2 bladed tail rotor system)
- Tail Rotor Driveshaft
- Main Rotor System Blade Slap
- Transmission Gear Mesh (annotated “XMSN Gearmesh”)

The recorded frequency information shows the components operating within their expected ranges. The amplitudes of these data may have varied, however, the frequency remains unchanged, this would indicate the components continued to operate normally.

The sound spectrum group offered the following possibilities as descriptors of the new and unknown sound:

- Air being rammed into a plenum
- A horn sound, such as air across the top of a bottle. A “blue note.”
- Possibility of air blowing into a window opening

3.7. Summary

A FFT was taken across two intervals prior and one interval during the recording of the new and unknown sound. During these intervals, frequency information showed that the introduction of the new and unknown sound was not tied to known frequency information for any rotating part. Main rotor, tail rotor, tail rotor driveshaft and transmission frequencies remained unchanged throughout the examined intervals.

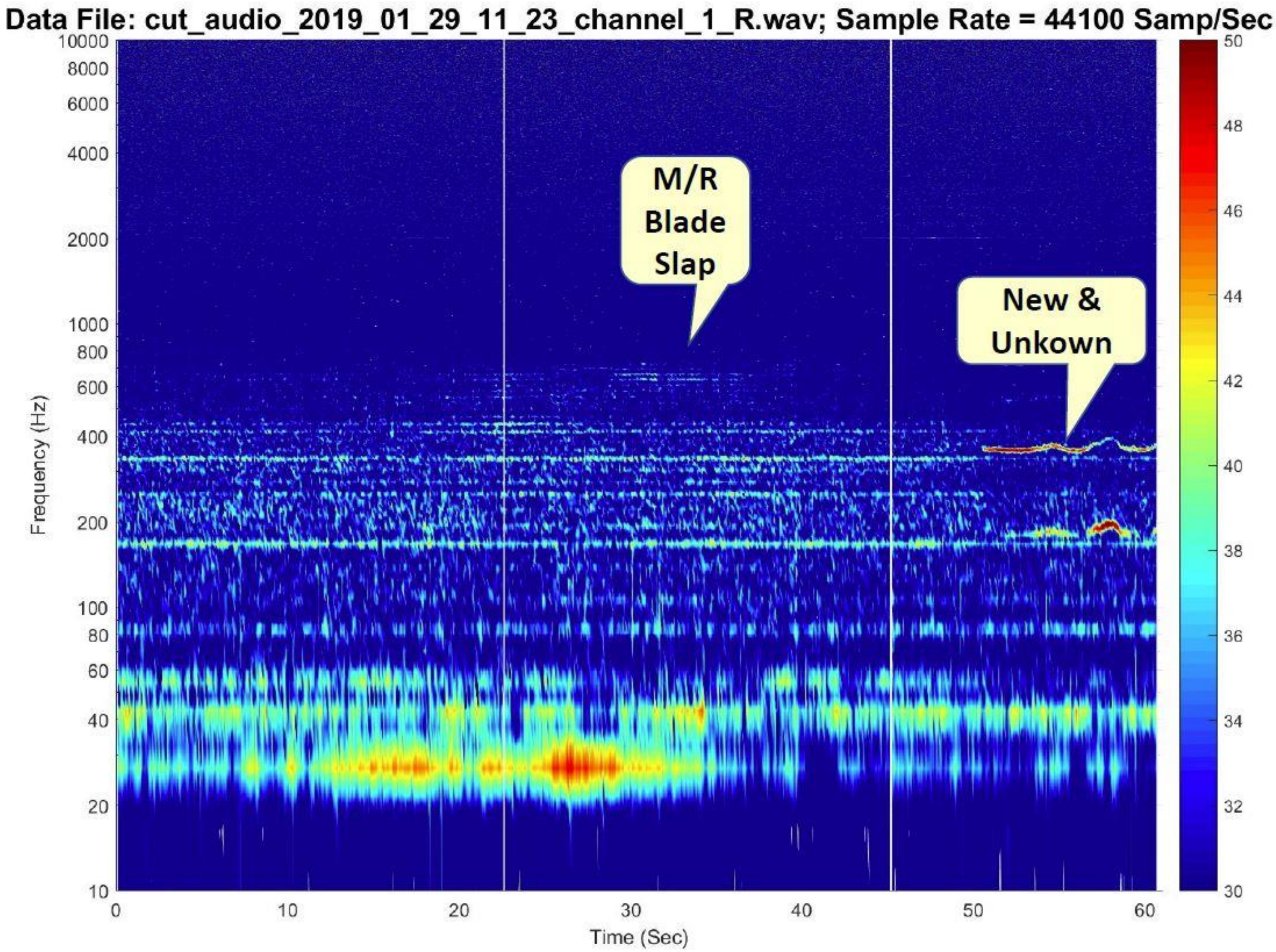

Figure 1. an audio spectrogram for the last 60 seconds of the recording.

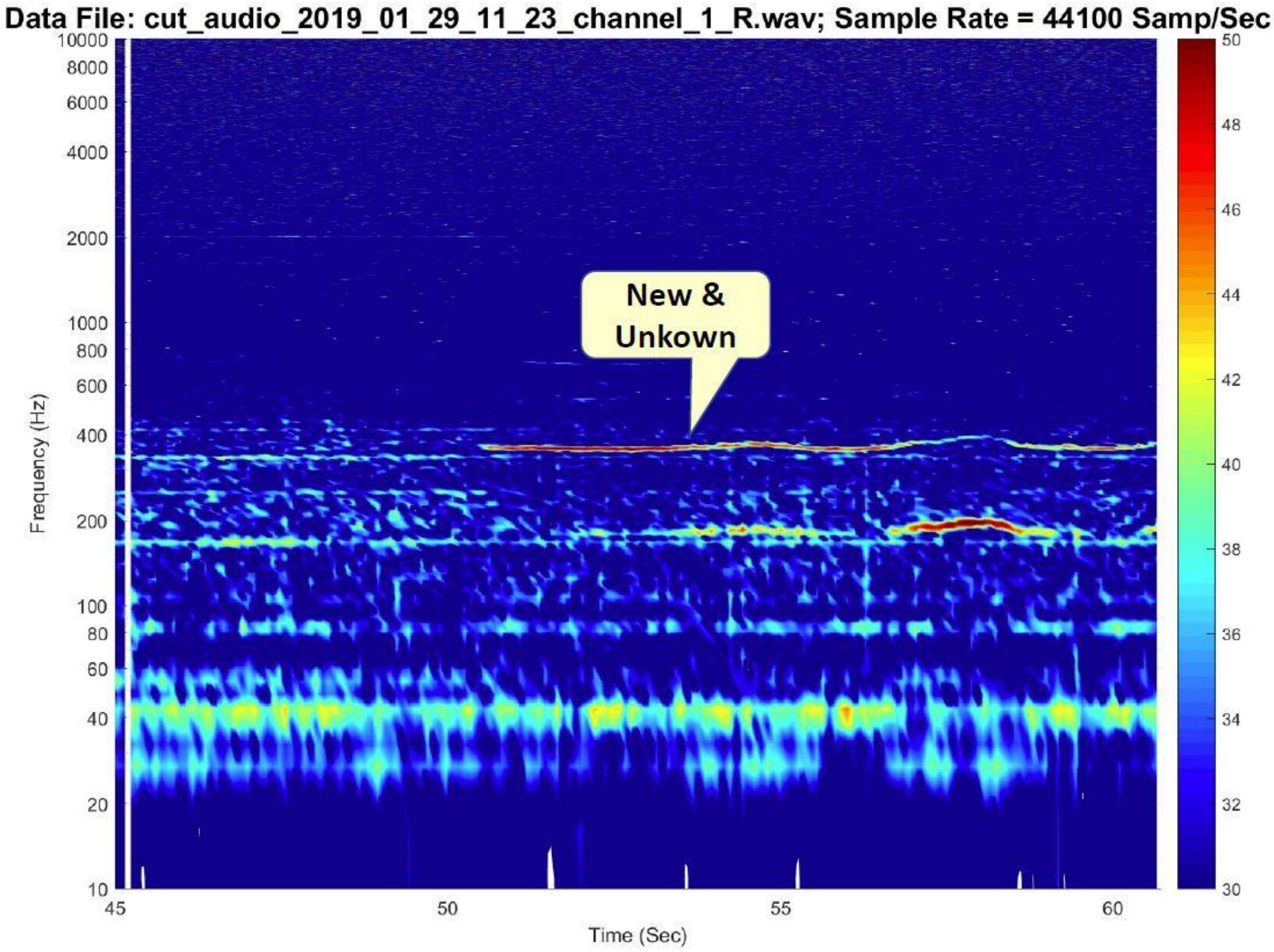

Figure 2. Audio spectrogram for the last 15 seconds of the recording.

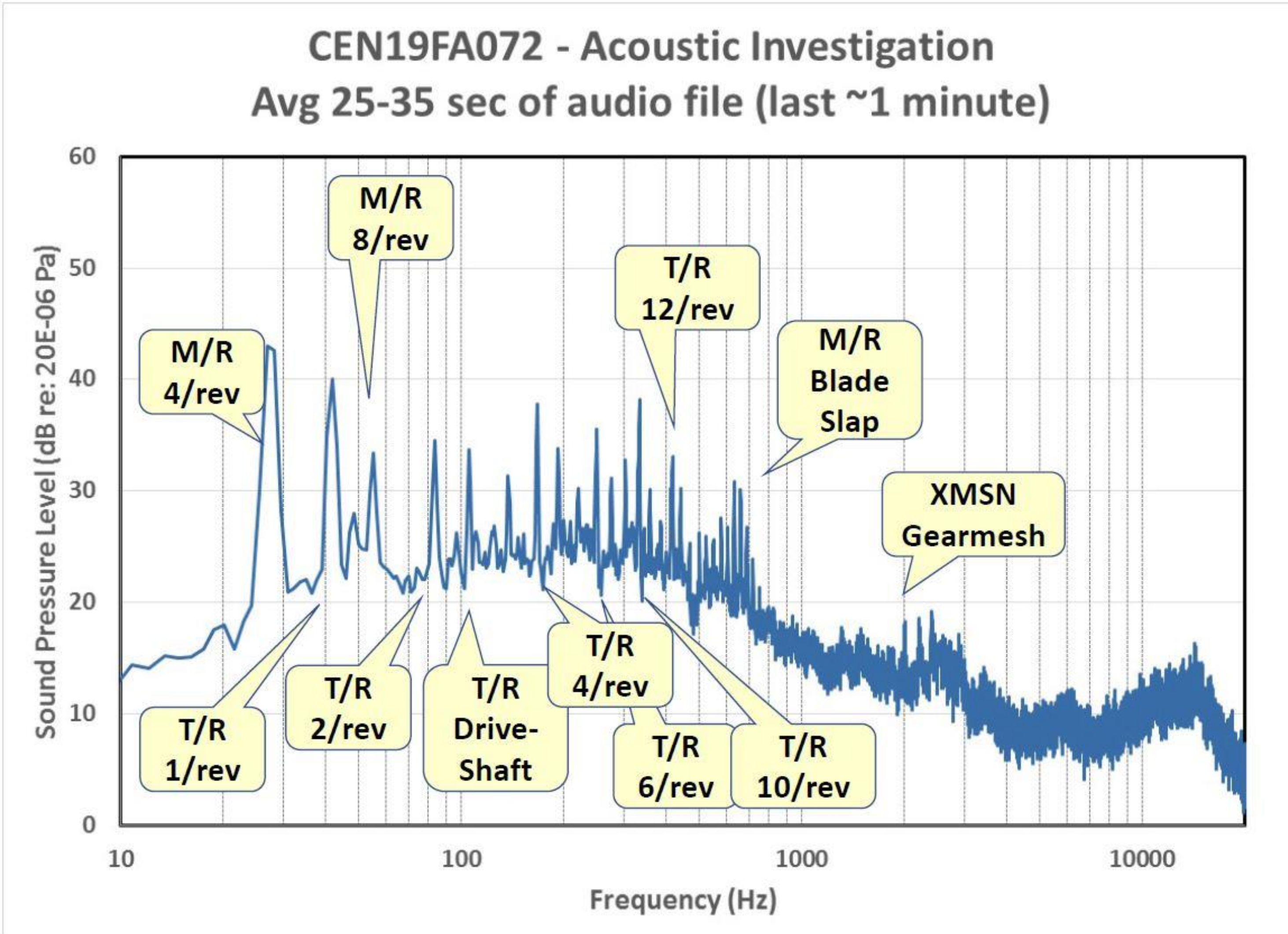

Figure 3. FFT averaged for the time interval between approximately 06:48:35 and 06:48:45 EST

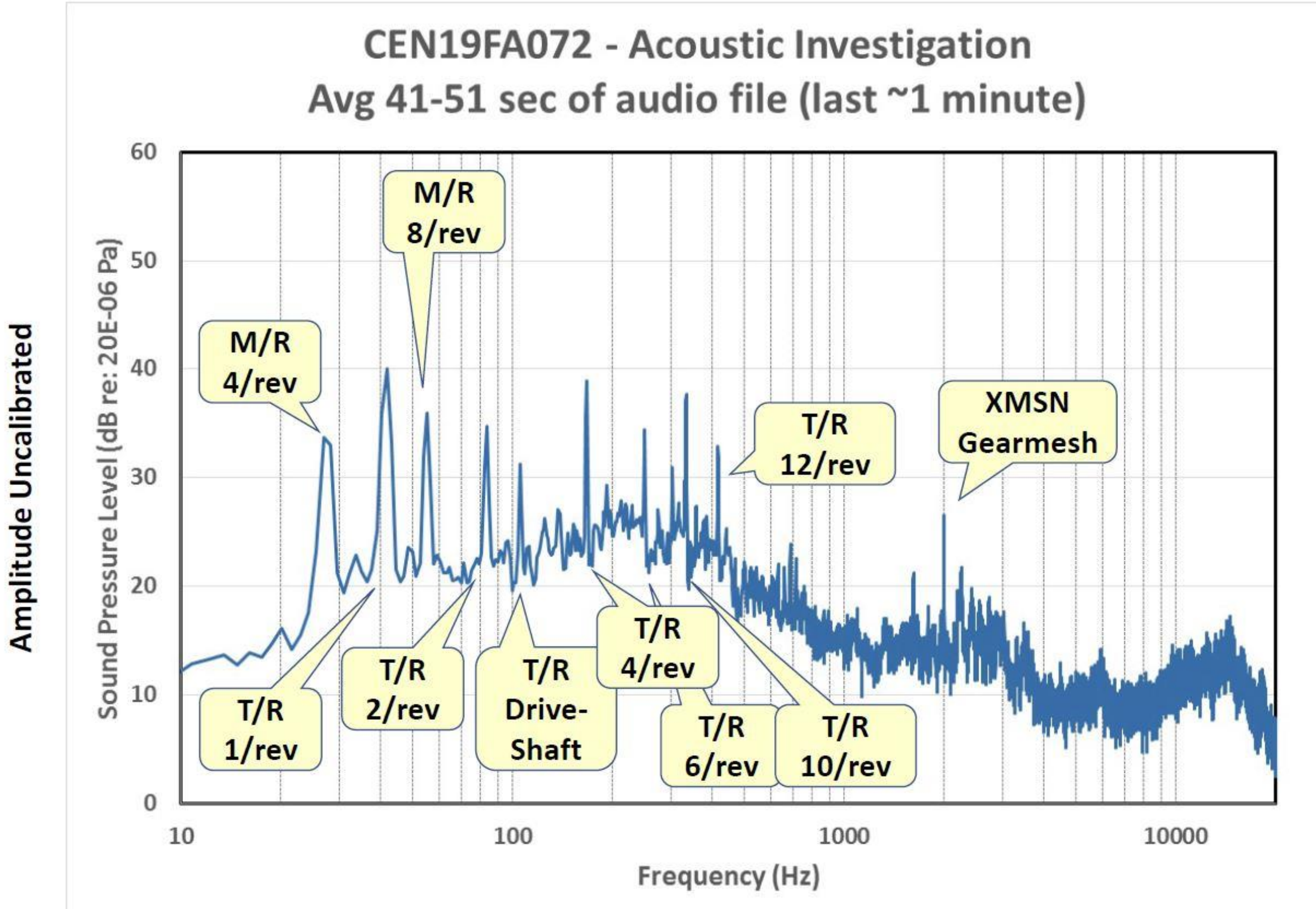

Figure 4. FFT averaged for the time interval between approximately 06:48:50 and 06:49:01 EST.

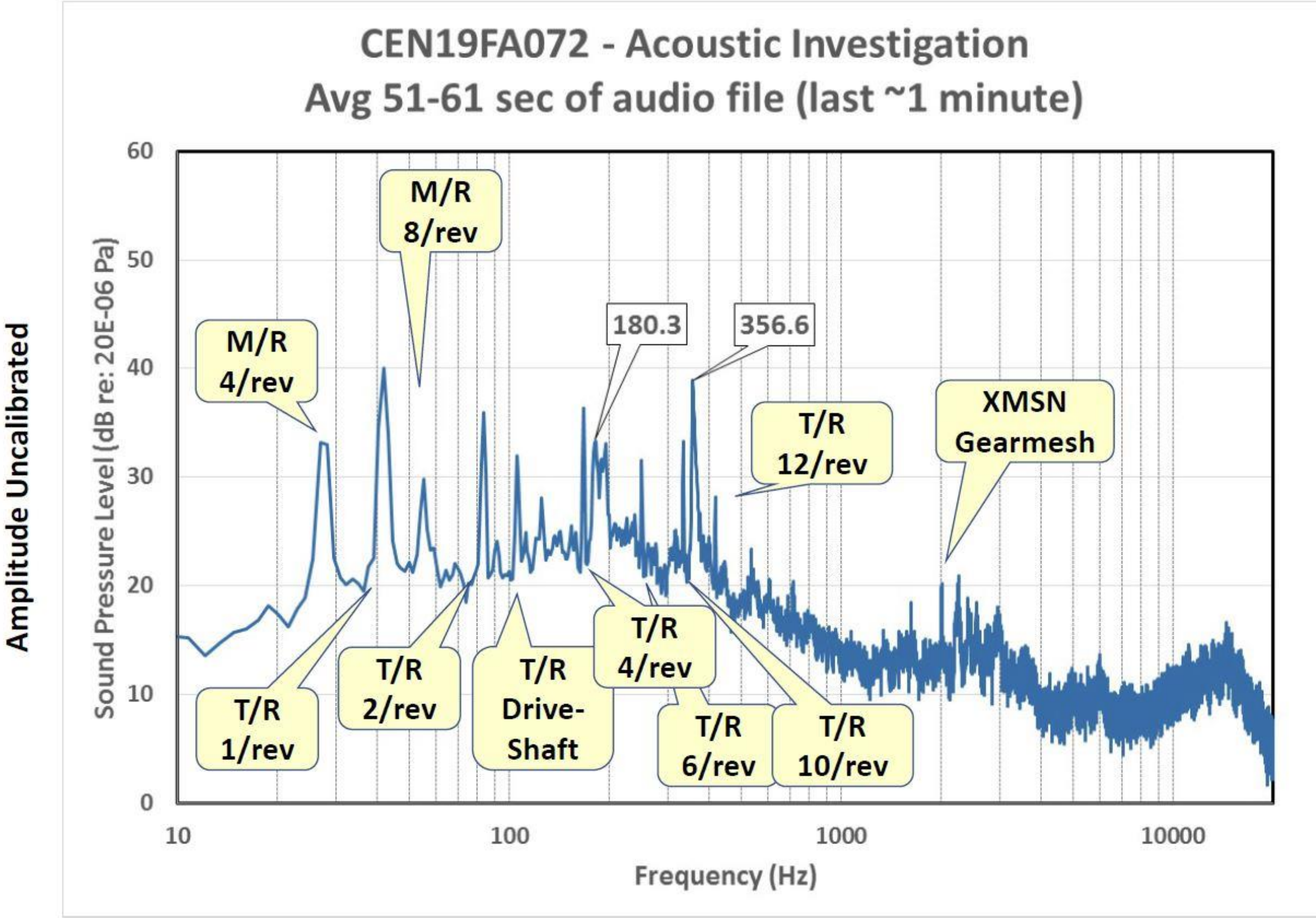

Figure 5. FFT averaged for the time interval between approximately 06:48:49 and the end of the recording at 06:49:08.9 EST.