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

February 8, 2000

Cockpit Voice Recorder

Sound Spectrum Study

Specialist's Report
By Anna W. Cushman

A. ACCIDENT

Location:	Aberdeen, South Dakota
Date:	October 25, 1999
Time:	About 1713 universal coordinated time (UTC)*
Aircraft:	Learjet 35, N47BA
NTSB Number:	DCA00MA005

B. GROUP

Chairman:	Anna W. Cushman Aerospace Engineer (CVR) National Transportation Safety Board
Member:	Dave Chapel Senior Product Safety Specialist AlliedSignal Engines
Declined participation:	FAA, Bombardier-Learjet, Sunjet Aviation

C. SUMMARY

On October 25, 1999 a Learjet 35, N47BA, departed Orlando, Florida on an IFR flight plan to Dallas, Texas. After departure from Orlando, N47BA was in radio communication with controllers from the Jacksonville air traffic control (ATC). Shortly after 1327 the controller at Jacksonville lost communication with the accident aircraft. N47BA's last communication with ATC was an acknowledgement to climb and maintain

* All times are expressed in universal coordinated time (UTC), unless otherwise noted.

39,000 feet. The aircraft continued on its course until approximately 1713 UTC, at which time it crashed near Aberdeen, South Dakota.

A Universal CVR 30 digital cockpit voice recorder (CVR), serial number 6509, was sent to the audio laboratory of the National Transportation Safety Board on October 28, 1999. A sound spectrum group convened on November 1, 1999 to examine the CVR recording for engine sounds and cockpit aural warnings contained in the last 30 minutes of the accident aircraft's flight.

D. DETAILS OF STUDY

A sound spectrum study was completed on the 30-minute recording of the cockpit area microphone (CAM) channel of the CVR. The CAM channel recording was examined on an audio spectrum analyzer to identify any background sound signatures that could be associated with engine noise and aural cockpit warning tones. Specifically, there were two events studied that had been identified in the CVR transcript within the CVR Group Chairman's Factual Report: the sound similar to N1 drone* ceasing and the sound similar to the cabin altitude warning ceasing. These events occurred within the last two minutes of the recording.

For the first event, regarding the N1 drone, the sound spectrum (see the voiceprint** in Figure 1) showed two signatures: a signal at 340 Hz and another whose signal frequency and strength decreased with time from the 340 Hz signature. At 98.6% N1, the low-pressure turbine spool within the AlliedSignal TFE731-2-2B engine could produce a 340 Hz signature. Furthermore, the signature that was seen weakening with time at 1710:41 indicated that the source producing it had decelerated. If the engines produced the 340 Hz signal that was evident throughout the recording, then at 1710:41 one engine continued to produce the signature, while the other engine spooled down. Notably, the 340 Hz signature that continued remained consistent in

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* *N1 drone*, as referenced within the CVR transcript, can be described as a periodic increase and decrease in engine sound (i.e. the sound of beating due to a phase shift between two superposed sound sources).

** Color on the voiceprint plot represents a relative magnitude of frequency strength – specifically, from low strength to high strength: white, blue, red, orange, yellow and teal. The universal coordinated time (UTC) shown is correlated to the time shown in the CVR transcript in the CVR Group Chairman's Factual Report.

strength, but became obscured in the background noise approximately 40 seconds later (Figure 2).

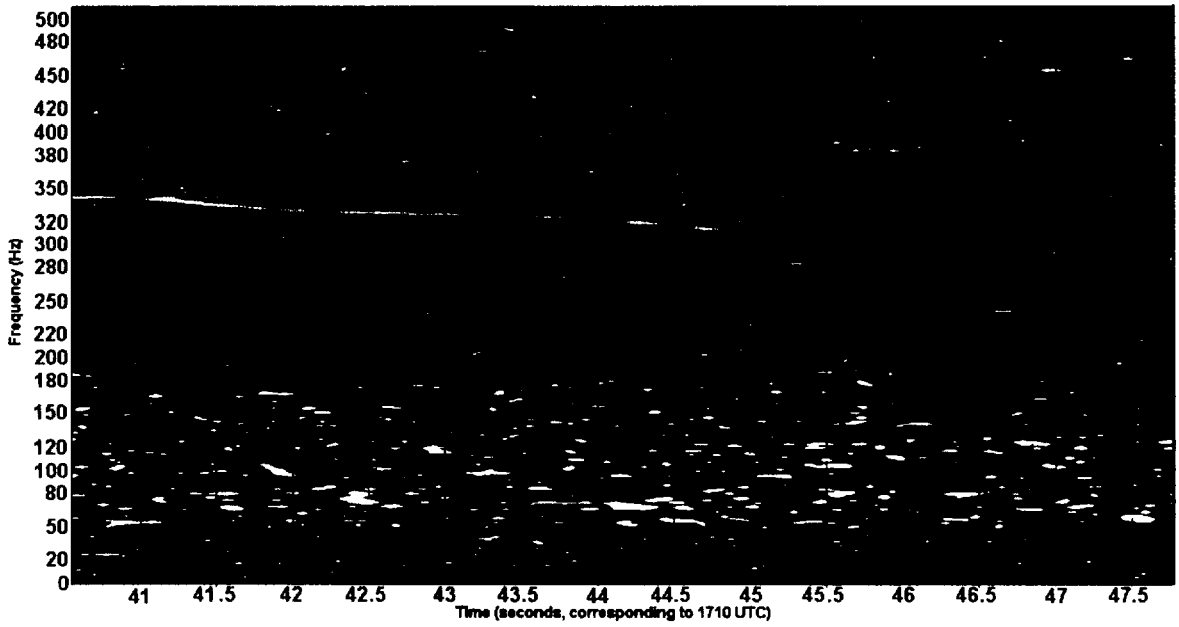

Figure 1: Voiceprint of 340 Hz signature and signal drop-off.

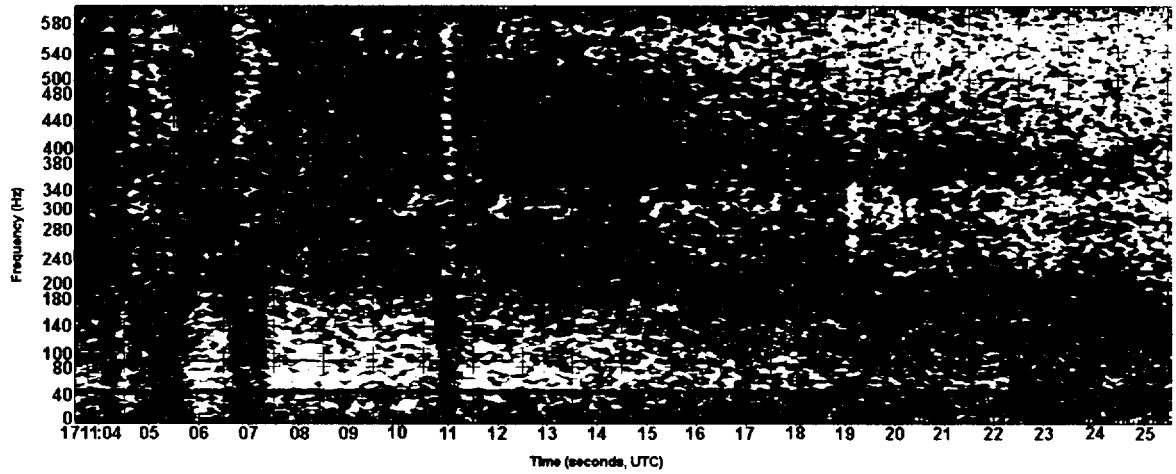

Figure 2: Voiceprint of 340 Hz signal with background noise.

The second event studied was the sound similar to the cabin altitude warning. From the sound spectrum and CVR transcript, the cabin altitude warning was evident from the start of the recording on the CAM channel. Near the end of the recording the

warning ceased. The voiceprint (Figure 3) revealed two signals – the signal with the short cycle was the cabin altitude warning and it ceased at 1712:25.85. The other signal (with the longer cycle) evident in the voiceprint was identified as the overspeed warning, which continued until the end of the recording at 1712:40.00.

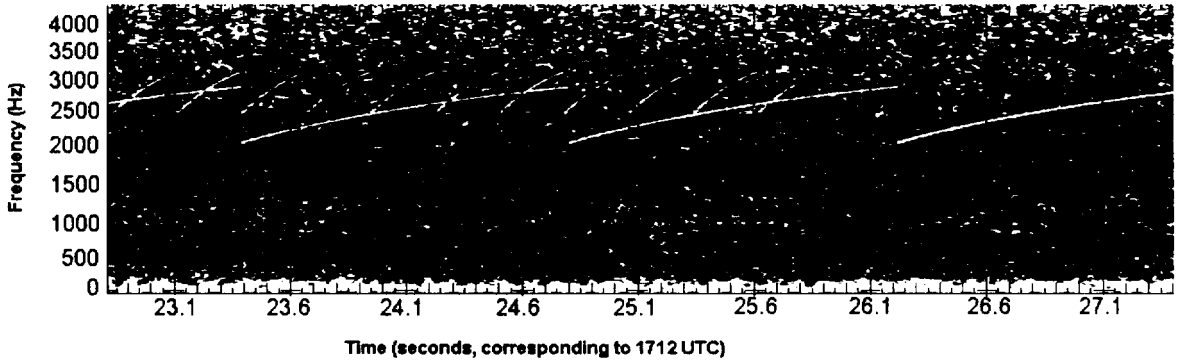

Figure 3: Voiceprint of Cabin Altitude Warning ceasing.

Although the entire 30 minutes of the CAM channel recording was studied, there were two events in particular that were investigated. The first event concerned the apparent spool down of one engine. The sound spectrum of this area of the recording revealed a 340 Hz signature. It also showed a second signal dropping off from the 340 Hz signature. Assuming the engines produced the 340 Hz signature, than the signal drop-off would indicate that one of the engines had spooled down. The other event that was studied was the cabin altitude warning. As evident in the sound spectrum, this warning ceased 14.15 seconds prior to the end of the recording.

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Anna W. Cushman
CVR Sound Spectrum Group Chairman