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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C

GROUP CHAIRMAN'S
REPORT OF INVESTIGATION
SOUND SPECTRUM STUDY

American Airlines Flight 587
DCA02MA001

Belle Harbor, NY
November 12, 2001

(15 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C. 20594

September 12, 2002

Group Chairman's Sound Spectrum Study

Cockpit Voice Recorder

DCA-02-MA-001

A. ACCIDENT

Location: Belle Harbor, New York

Date: November 12, 2001

Time: 0917 Eastern Standard Time

Airplane: American Airlines Airbus A-300-600R N14053

B. GROUP

Chairman: James R. Cash
Electronics Engineer
National Transportation Safety Board

Member: Captain Rudy Canto
Director, Flight Operations Technical
Airbus Industries

Member: Mr. Phillippe Plantin de Hugues
Safety Investigator
Bureau Enquetes-Accidents (BEA)

Member: Captain Ray Hayes
A-300 Check Airman
American Airlines

Member: Jim Wilson
Manager of Flight Safety
Allied Pilots Association (APA)

C. SUMMARY

A recording recovered from a Fairchild model A-100A cockpit voice recorder (CVR) s/n unknown that was installed on the accident aircraft was examined to document any unknown or abnormal sounds during the airborne portion of the recording.

D. DETAILS OF INVESTIGATION

The good to excellent quality CVR recording consisted of four channels of audio information. One CVR channel contained audio information from the cockpit area microphone (CAM) that is mounted in the cockpit overhead panel of the airplane. The second and third CVR channels contained audio information obtained form the Captain's and the First Officer's audio selector panels in the cockpit. The fourth CVR channel contained a loud squeal noise and was unusable as a source for any audio information. It appeared from the recording that both the Captain and the First Officer were wearing a headsets and "hot" boom microphone. This additional audio information was recorded on their respective individual audio channel of the CVR.

The audio information recovered from the individual channels was examined to document any sounds or disturbances recorded on the CVR. The recording was examined on a spectrum analyzer that gives a visual presentation of the frequency content of the signals. This computer program permits detailed analysis of the analog waveform, presents graphically the frequency content of the signals as well as provides detailed timing information.

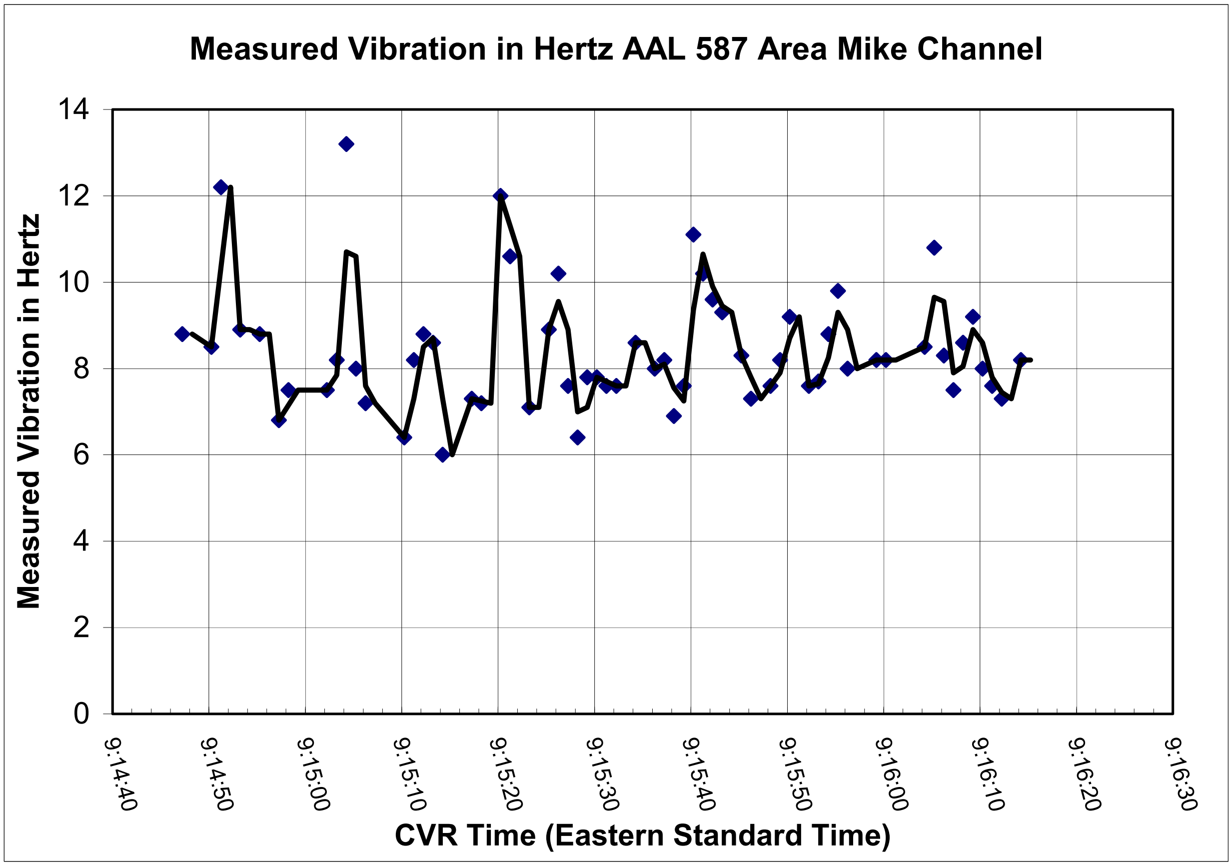
Airframe Vibration of Flutter Examination

The airborne portion of the CVR recording was examined in an attempt to document any airframe vibration or flutter signals that might have been recorded. During normal flight due to the aircraft’s motion through the air, the airframe will normally vibrate at some resonant frequent. In addition to this resonate frequency the airframe may vibrate at harmonic multiples of the resonate frequency. Typically a large commercial aircraft will have a natural resonate frequency somewhere between 5 and 15 hertz depending on the aircraft’s speed and atmospheric conditions. This frequency range is well below the expected frequency response range of the CVR. The specification for a tape based CVR, similar to the unit installed on the accident, aircraft has a designed frequency response from 200 hertz at the low frequency range to over 5,000 hertz at the upper range. While this is the designed frequency response of the CVR, it will record sounds that are outside of the range, if they are loud enough. Additionally fundamental sounds are usually accompanied by harmonics found at even multiples of the fundamental frequency. For example, a fundamental sound at 15 hertz may have harmonics found at 30 hertz (2^{nd} harmonic) or at 45hz, 60hz, 75hz (3^{rd} 4^{th}, 5^{th} …etc harmonics). Even though the CVR might not record the fundamental frequency, one of the upper harmonics might have a high enough frequency or enough energy to be recorded by the CVR.

It is sometimes possible to examine other characteristics of flying aircraft to derive some of the information that is of interest. For example, when an aircraft is flying through the air, there is a considerable amount of air or wind noise generated. This air-generated noise, when recorded on the CVR, exhibits characteristics classified as classic “white” noise. The definition of white noise is noise that has an equal distribution of energy throughout all frequencies. In other words, white noise has the same loudness at both lower and upper frequencies. If there is an airframe vibration associated with the aircraft, this vibration might change or modulate the normal steady background air noise as recorded on the CVR. The resulting modulation of the amplitude of the background wind noise would be directly proportional to airframe vibration.

The background noise from the airborne portion of the CVR recording was examined to document if there was any modulation present. Only the portion of the airborne recording after the aircraft was “cleaned up” (landing gear and flaps/slats up) was examined. The resulting information is found in chart 1. This chart was generated by examining the changes found in the intensity of the background noise, above about 2000 Hz, as recorded on the cockpit area microphone channel of the CVR,. This frequency range was used to avoid any contamination to the measurements caused by voice and cockpit sounds.

CHART 1



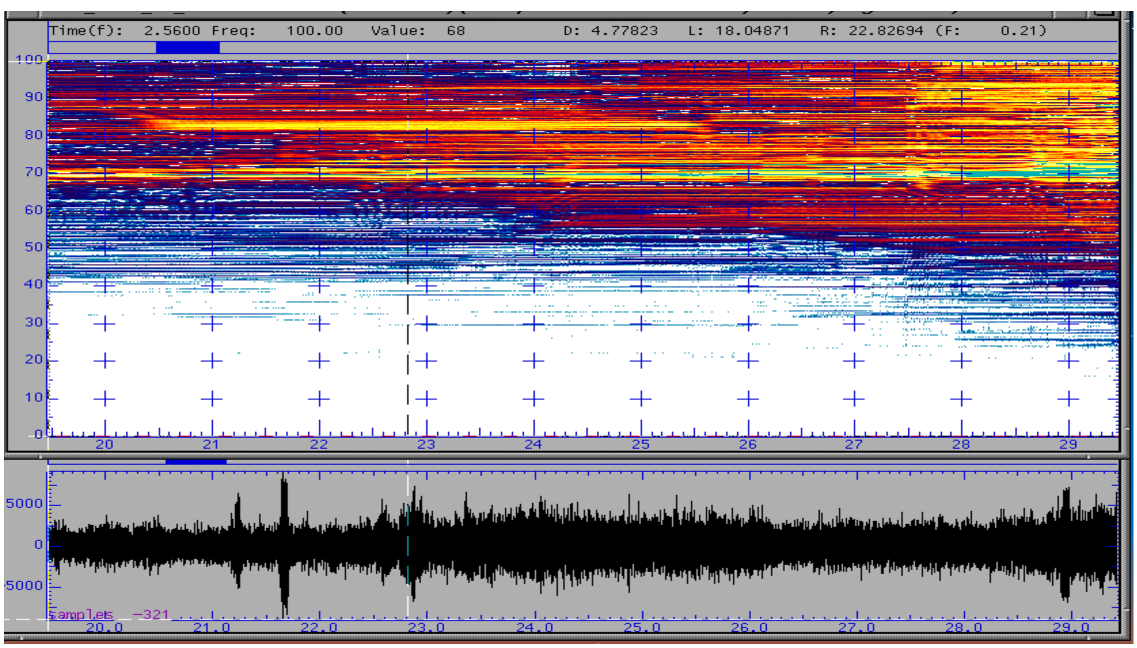
The black trend line shown on the chart is a 2nd order smoothing of the original data points. It can be seen from Chart 1 that there is a general 6-12 hertz vibration measured during the accident flight. This background vibration remains relatively constant throughout the flight from after the landing gear and flaps/slats were retracted to the end of the recording.

It was suggested to the Safety Board that another examination technique be used to document any airframe vibration during the short flight. Specifically, it was suggested that a low pass filter be applied to the CVR recording below 100 Hz.[1] This low pass signal was then passed through a signal processor, which calculated the frequency content of the signal. A spectrogram[2] was chosen as a means of displaying the resulting signals.

Spectrogram charts 2-7 show the low frequency sounds that were found on the cockpit area microphone of the accident recording during various portions of the short flight. These charts show the frequency spectrum plot on the top and the corresponding analog waveform along the bottom. The time depicted at the bottom of the charts is time in seconds starting at an arbitrary zero point.

Chart 2 displays time at the start of the takeoff roll. The aircraft starts moving down the runway at about 25 seconds chart time.

Chart 2



[1] A low pass filter will pass sound energy below the specified filter frequency thus a 100 Hz low pass filter will only pass sound energy below 100 Hz and remove everything above 100 Hz.
[2] A spectrogram or "voiceprint" depicts time in seconds along the bottom axis of the chart. Frequency in hertz is presented along the vertical axis. Energy is presented by the different colors associated with the signals. The colors range from the darker blue-green colors that represent low energy signals to the lighter reds and yellows that represent higher energy signals.

Charts 3-8 depict the last 50 seconds of the cockpit area microphone channel of the accident CVR recording. This is about same time frame as the data presented in Chart 1. It can be seen that there is little if any audio energy below about 30 Hz. From chart time 145 seconds until the end of the recording, this examination technique is not usable because the sound spectrum analysis cannot compensate for the loud noises that are found on the cockpit area microphone channel of the CVR.

Chart 3

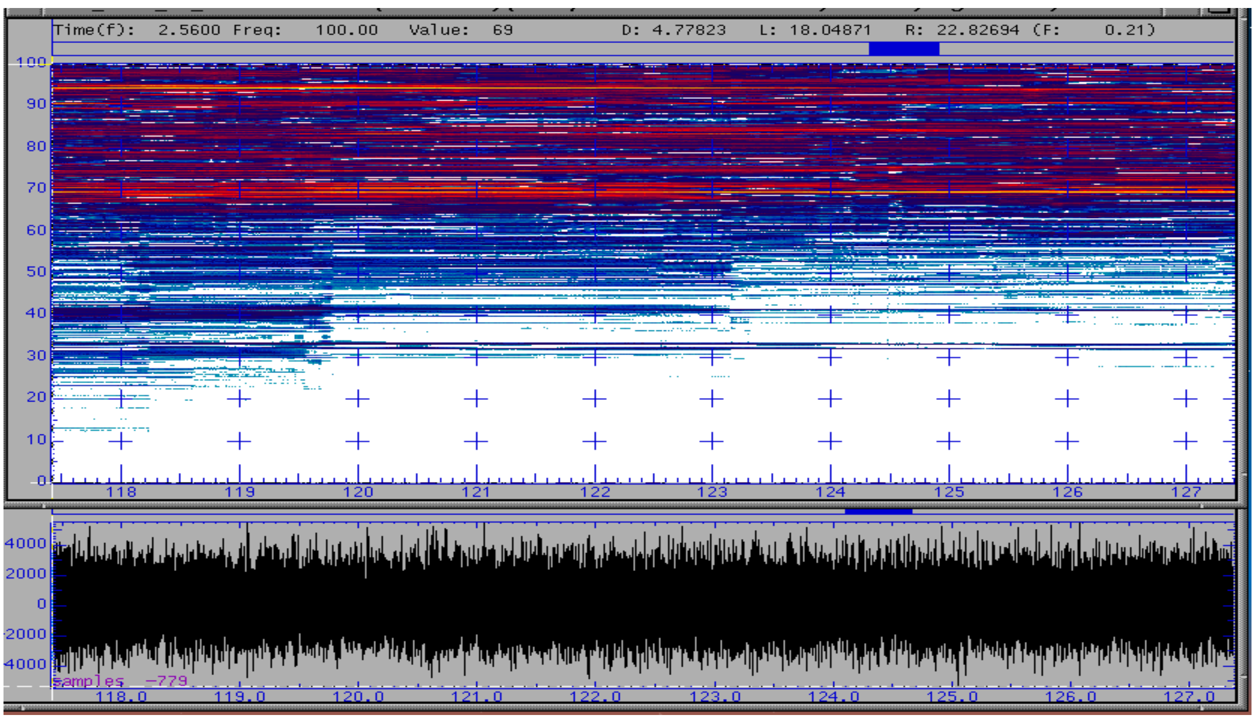


Chart 4

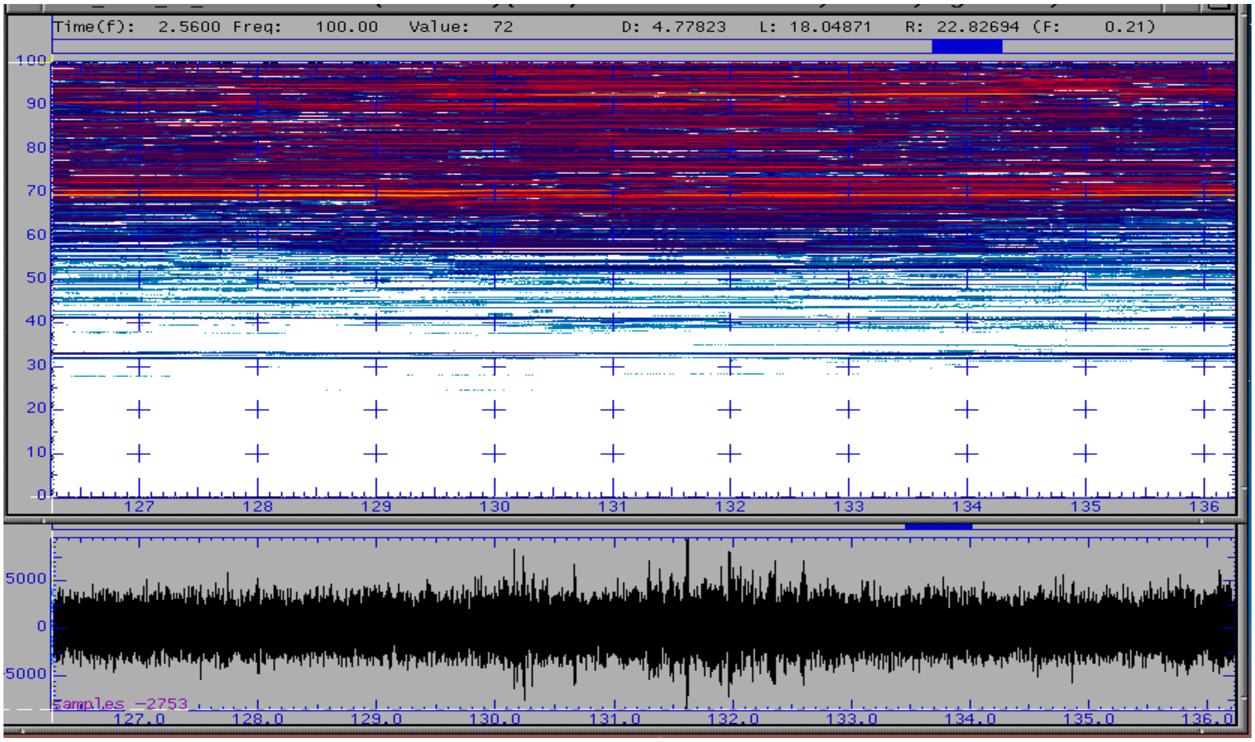


Chart 5

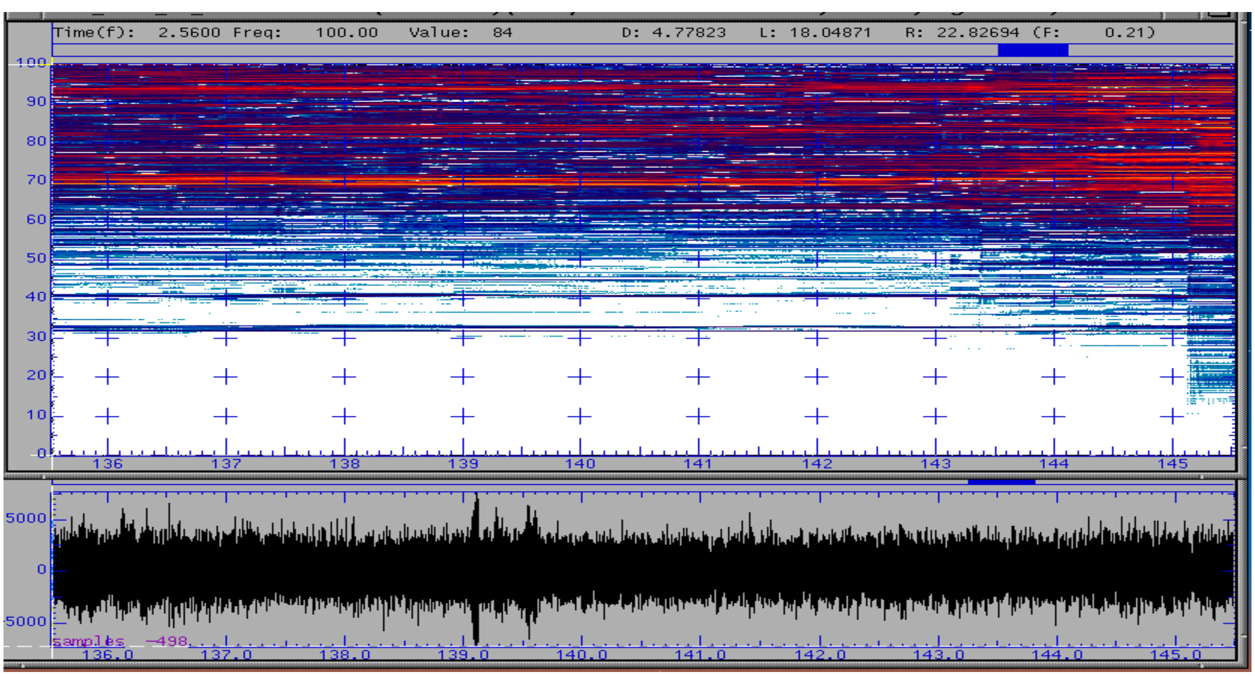


Chart 6

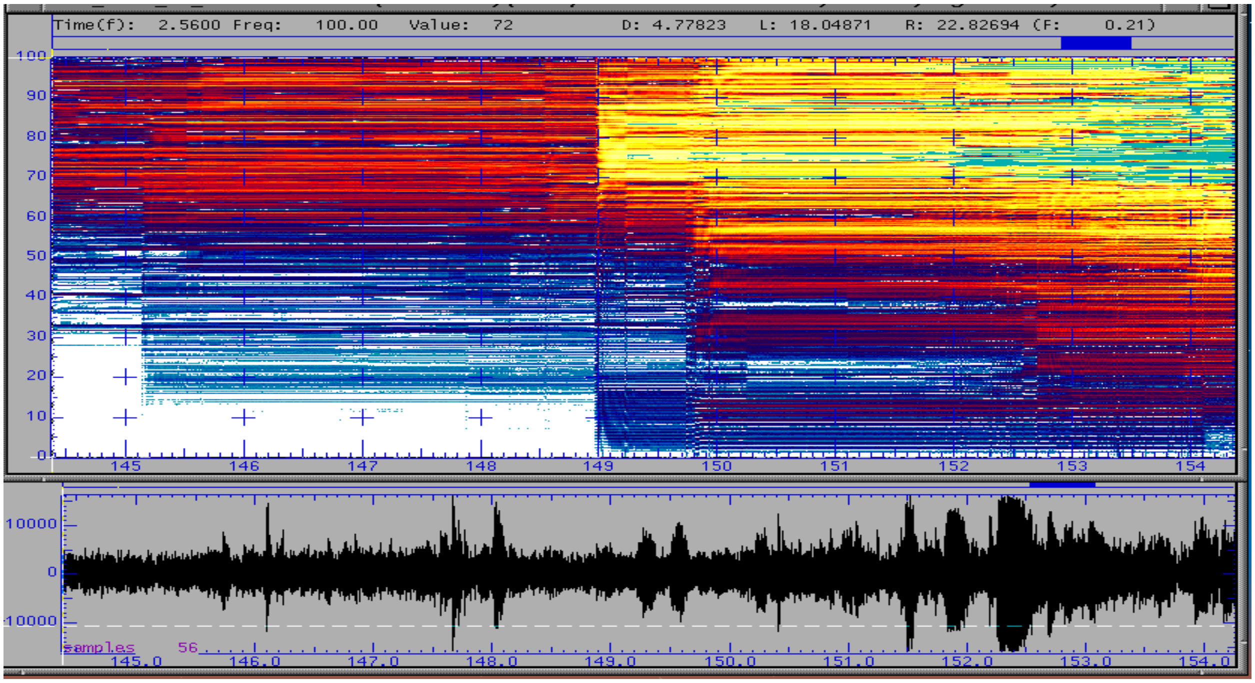


Chart 7

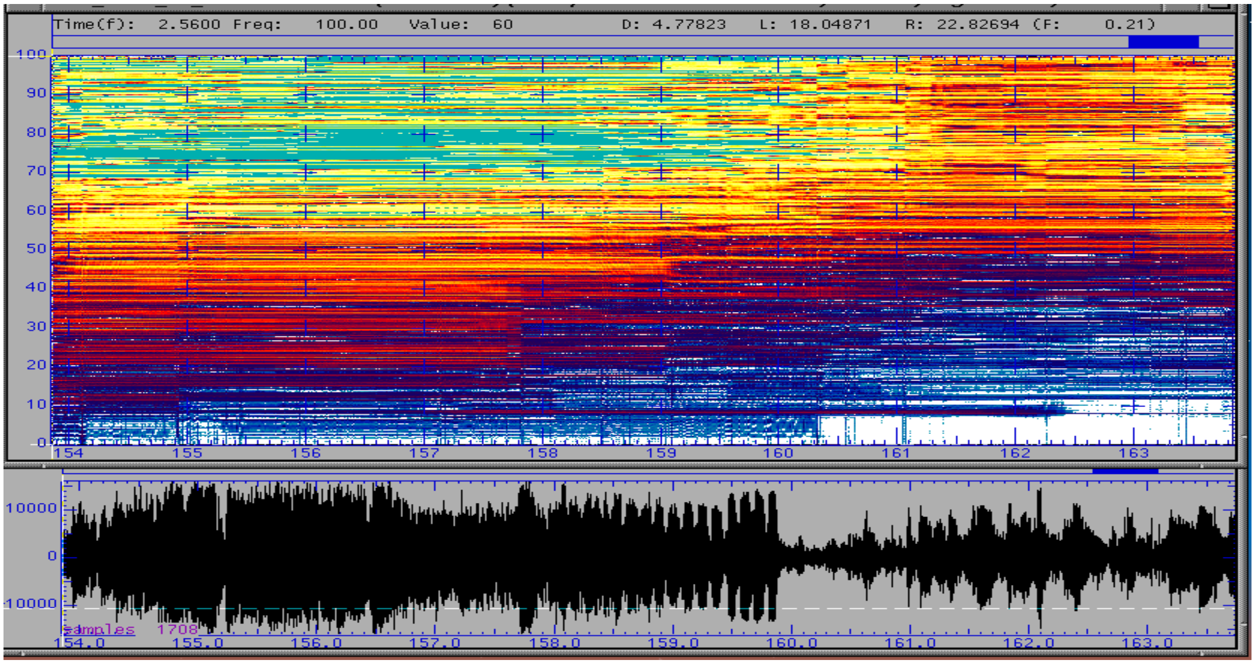
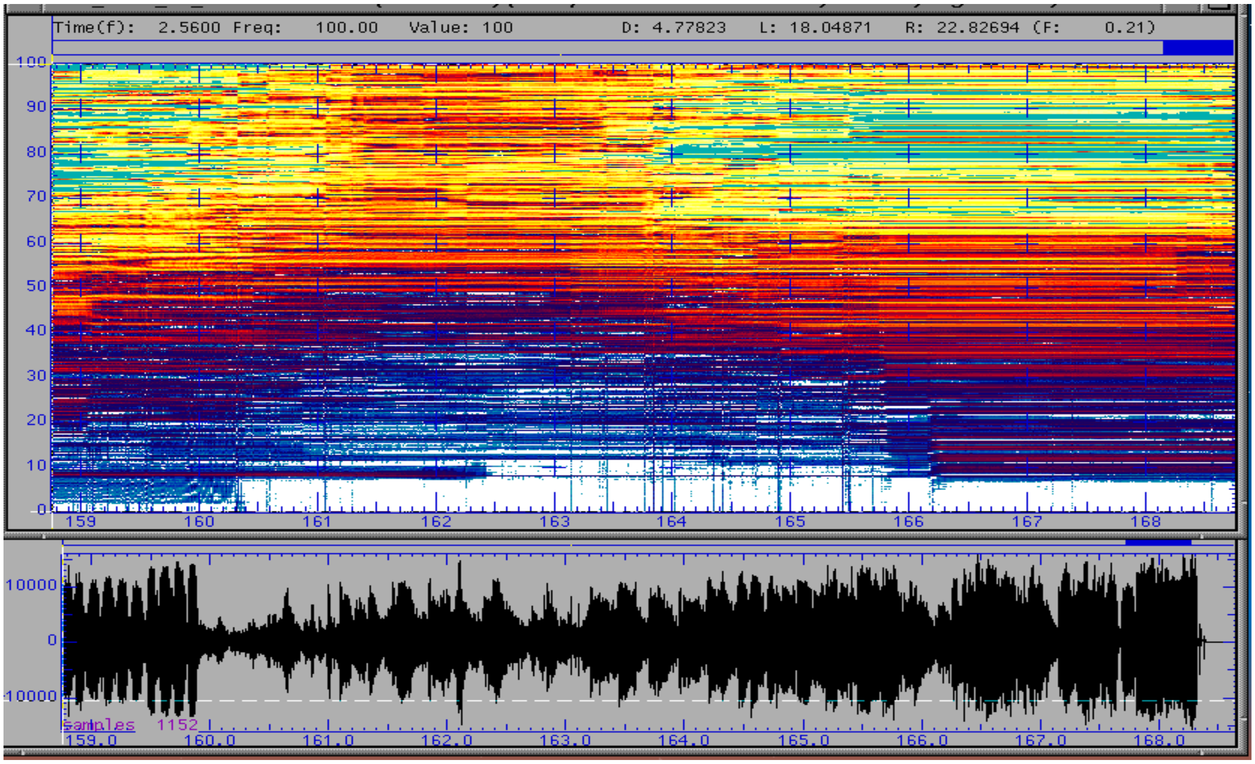


Chart 8



Neither examination methods identified any unusual vibration or flutter that preceded the event identified on the CVR transcript at time 0915:52.9 EST

Unknown Sounds

All channels of the accident recording were examined to document any unknown or unusual cockpit/aircraft sounds. There were several sounds noted and documented on the CVR group's transcript. The thumps/clicks/squeaks and rattle sounds noted on the transcript at 0915:37.3 EDT and again at 0915:52.9 EDT were identified to be associated with movement of cockpit items in response to the wake encounter of the aircraft. No attempt was made to determine the sources of sounds after the aircraft was believed to have started its uncontrolled descent into the ground. No specific events or noises were identified that could be associated with the departure of the rudder or vertical tail of the aircraft.

Event Documentation

To aid in the documentation of the events heard during the final few minutes of the CVR, the Sound Spectrum Group produced an annotated timeline. Charts 9 thru 16 depict the waveform of the three useful CVR channels (Co-pilots radio/hot microphone channel top trace the cockpit area microphone (CAM) channel, middle trace and the Captains radio/hot microphone channel bottom trace). The selected text annotations found at the bottom of the charts are comments taken from the CVR Group transcript. Time depicted along the bottom horizontal axis of the charts is shown in both arbitrary elapsed seconds and in CVR hours:minutes:seconds EST time. Chart 9 is shown with the channel assignments annotated and with the text and time labeled.

CHART 9 (shown with legend)

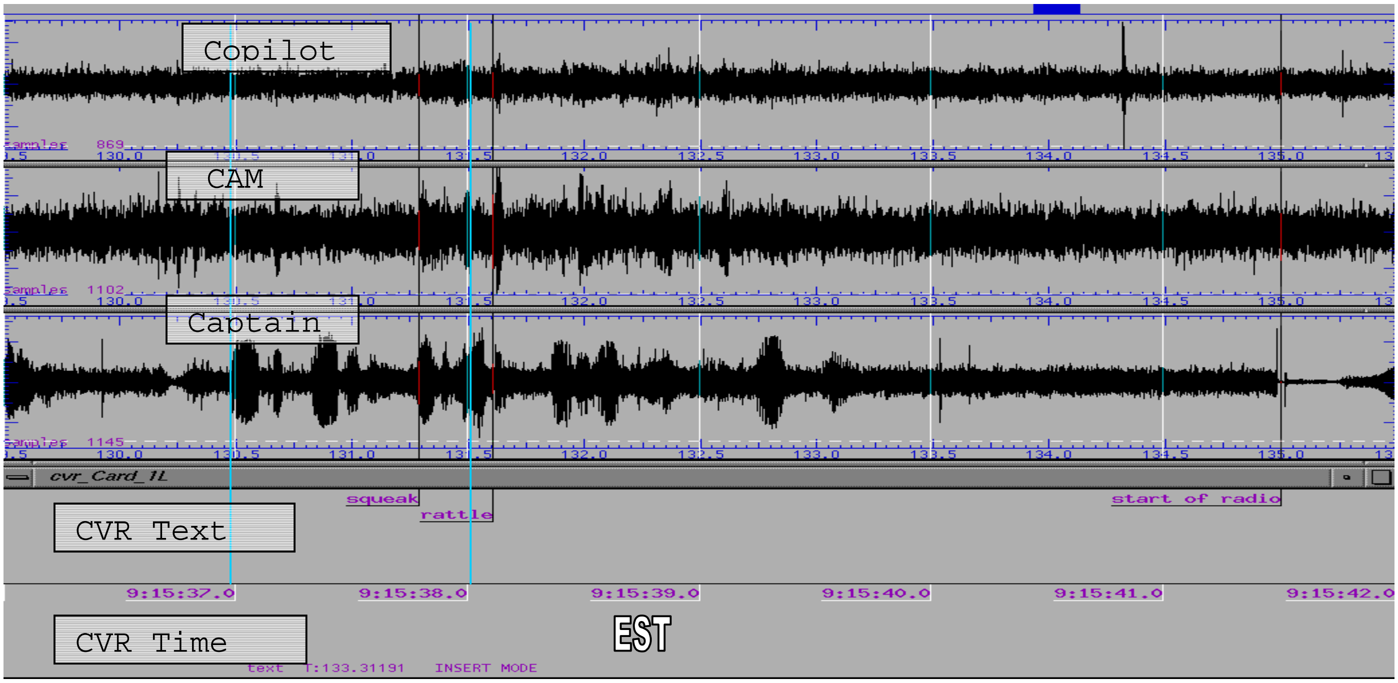


CHART 10

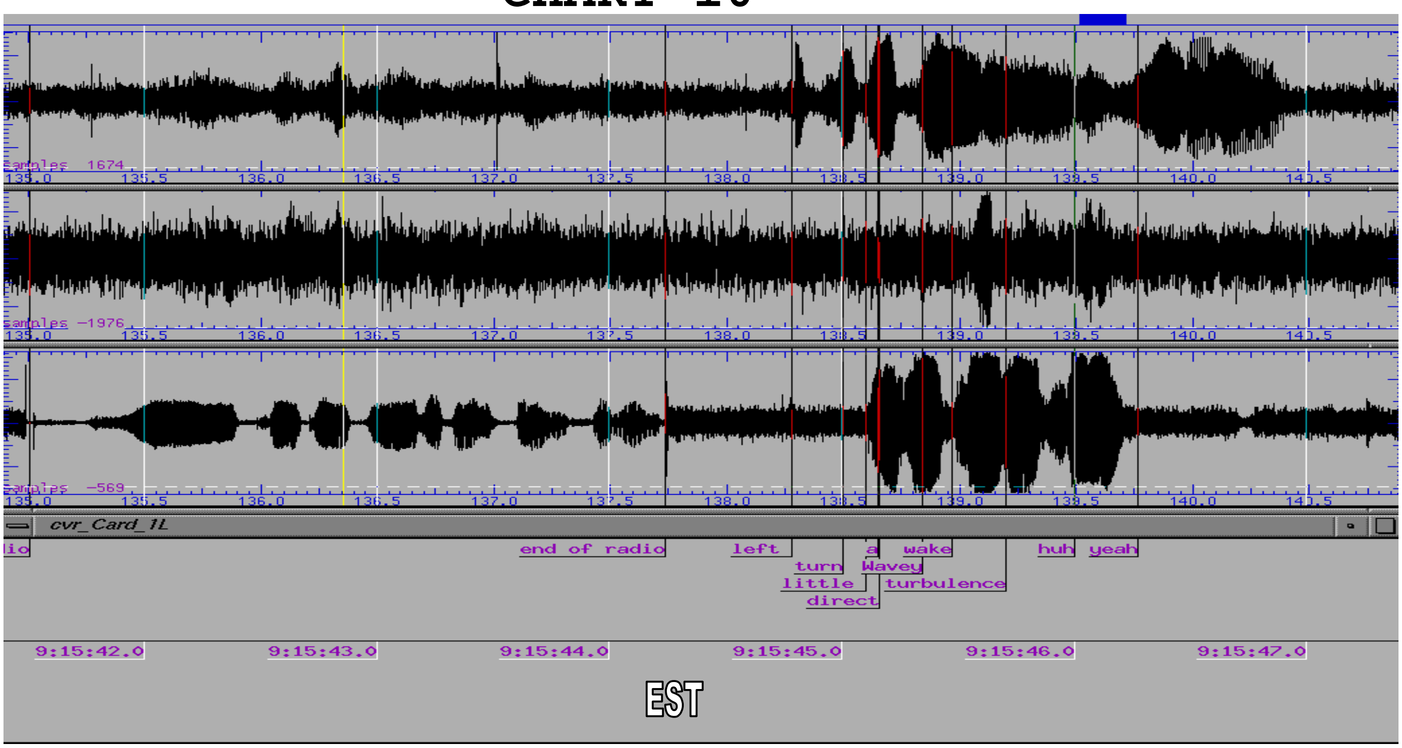


CHART 11

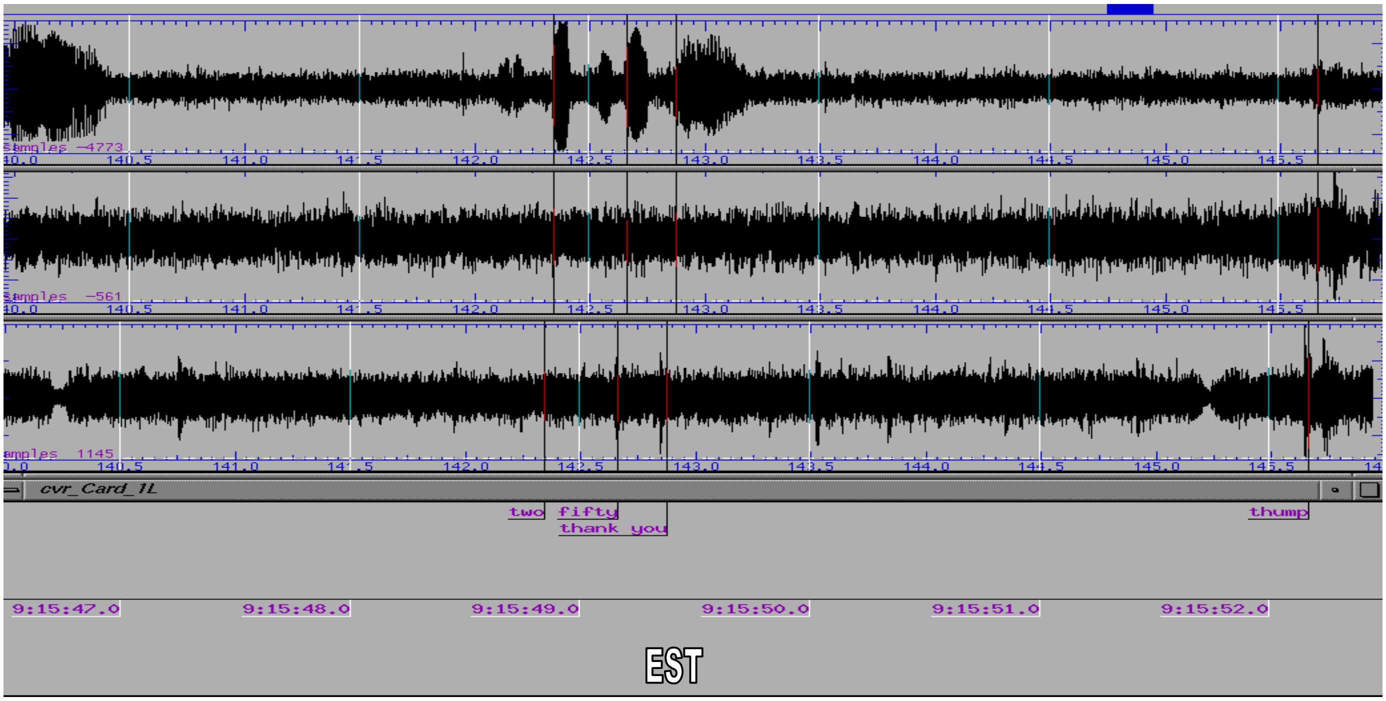


CHART 12

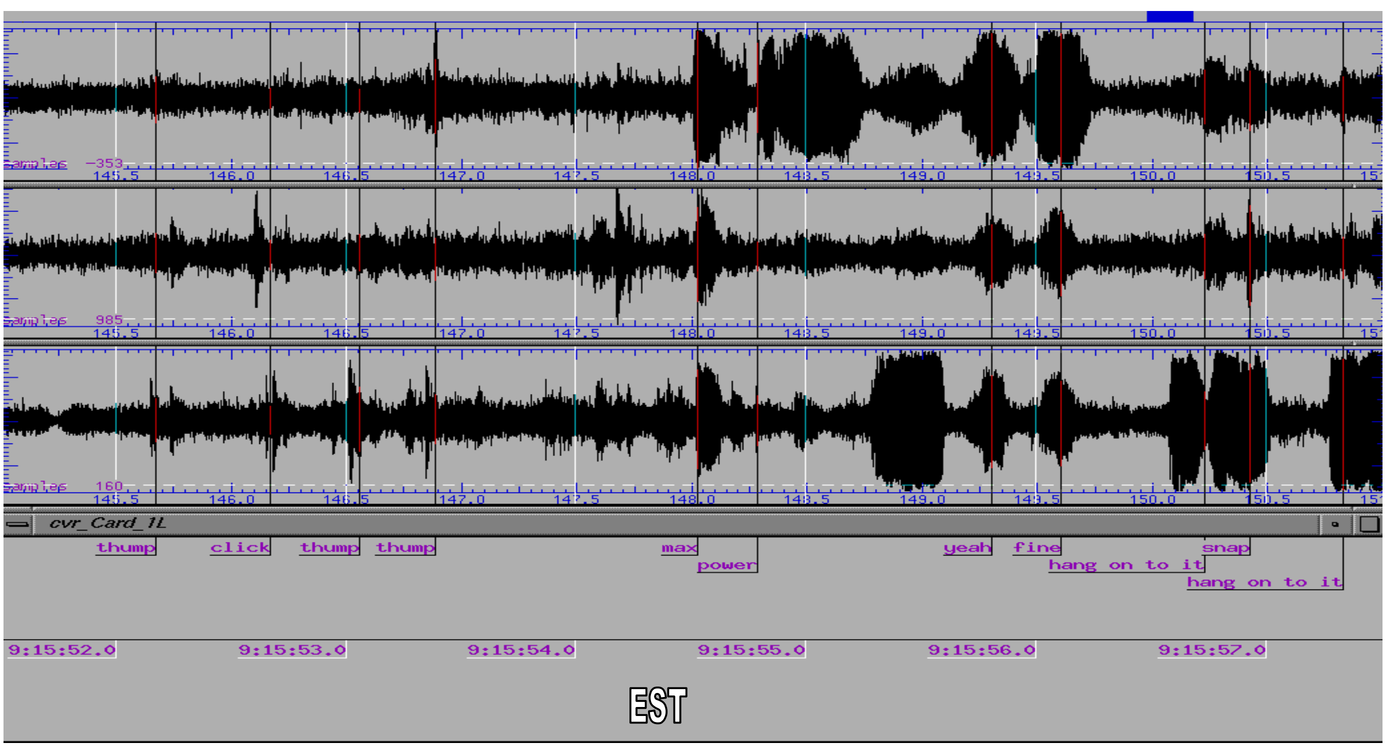


CHART 13

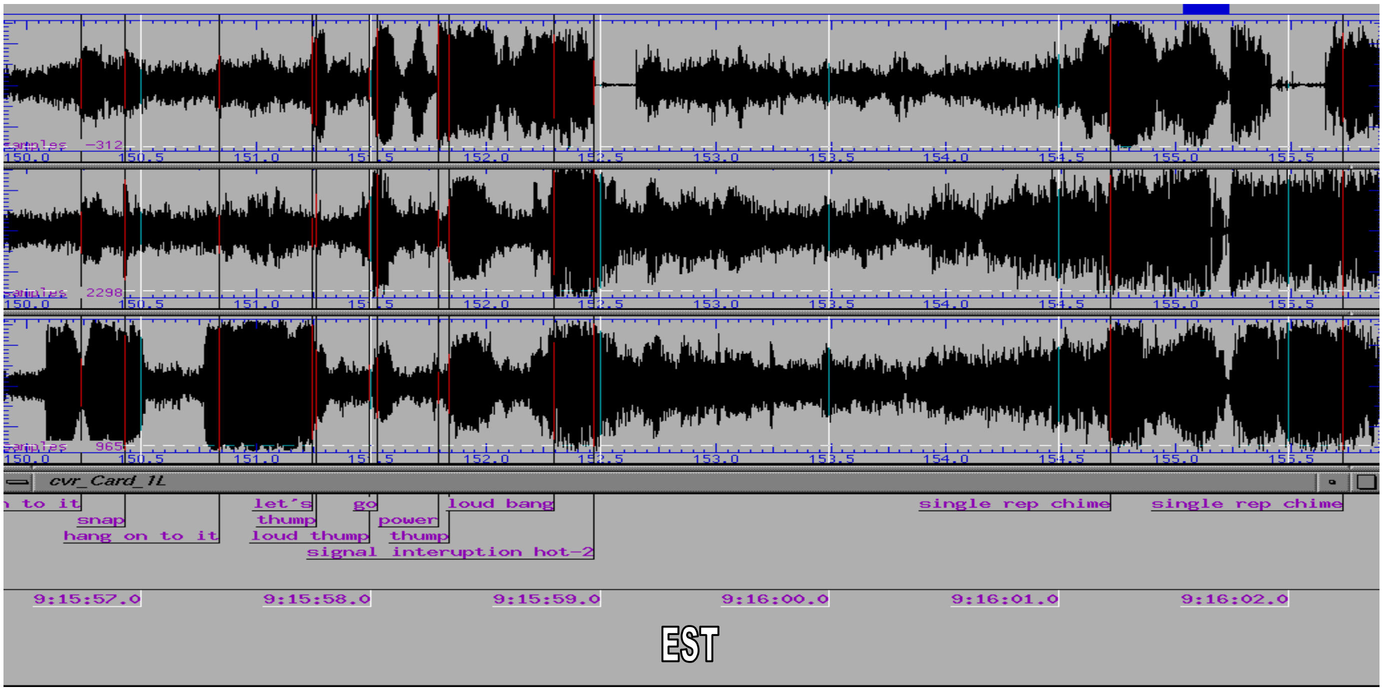


CHART 14

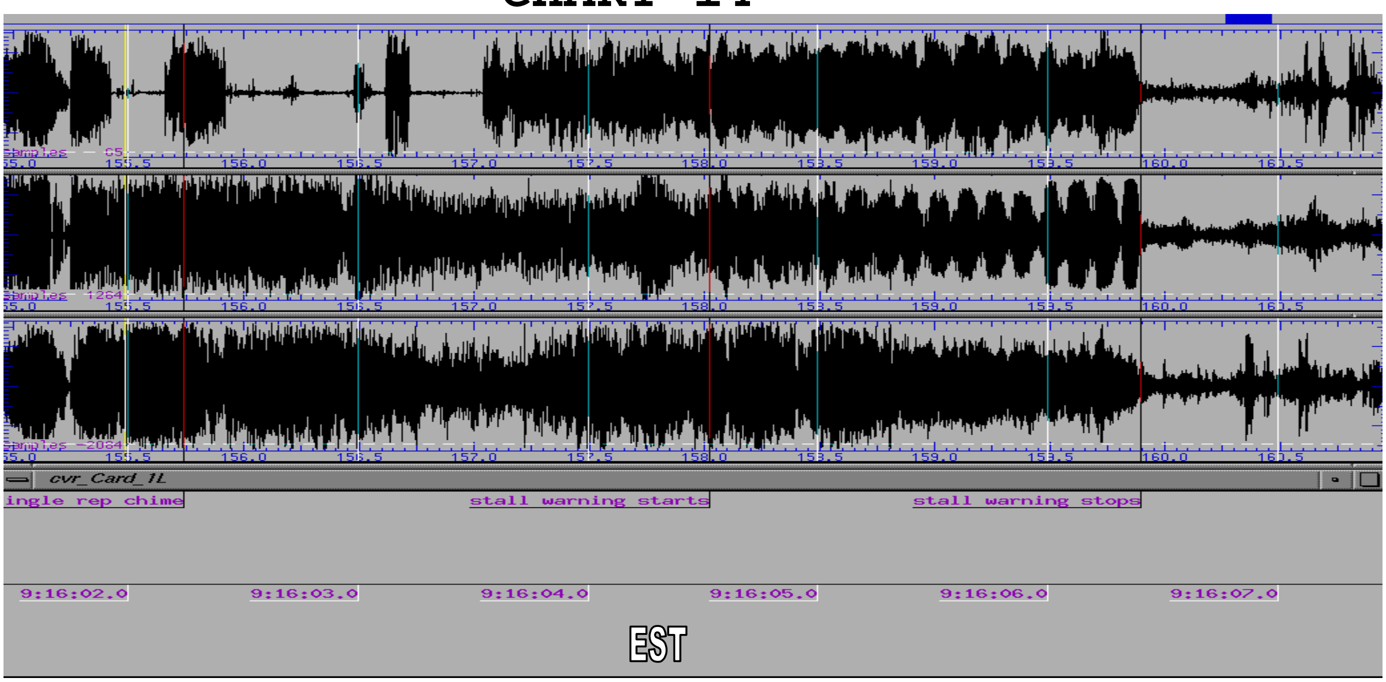


CHART 15

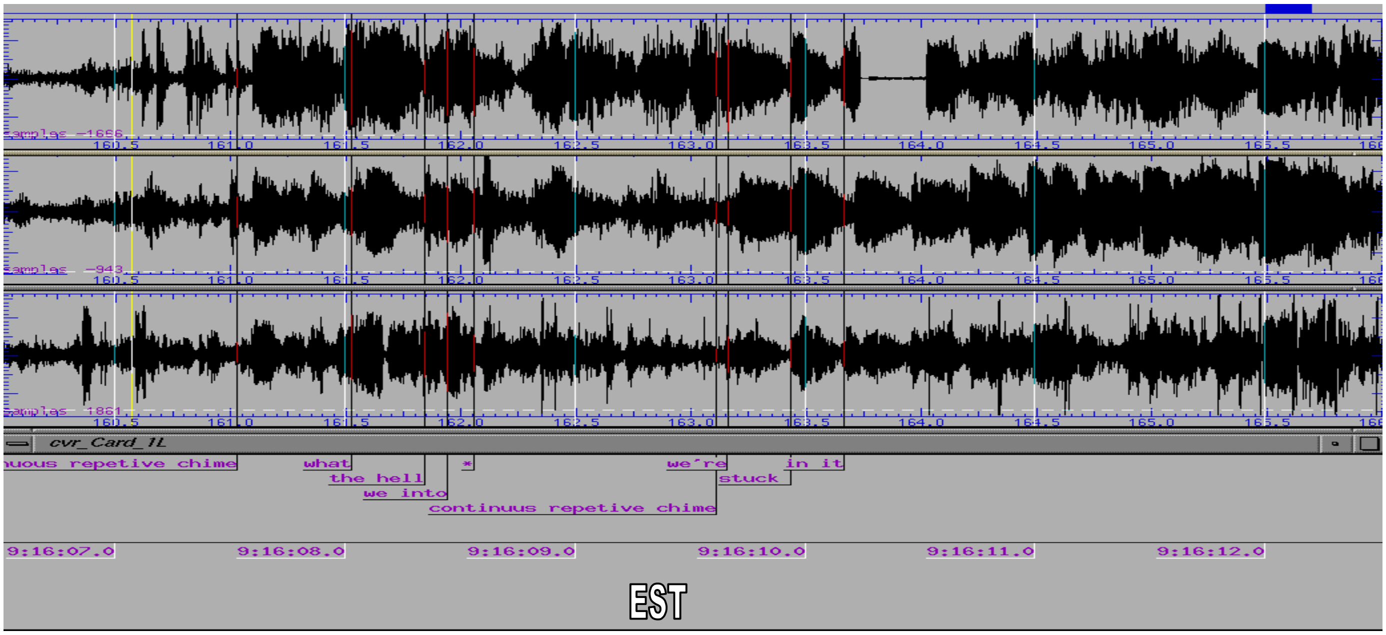
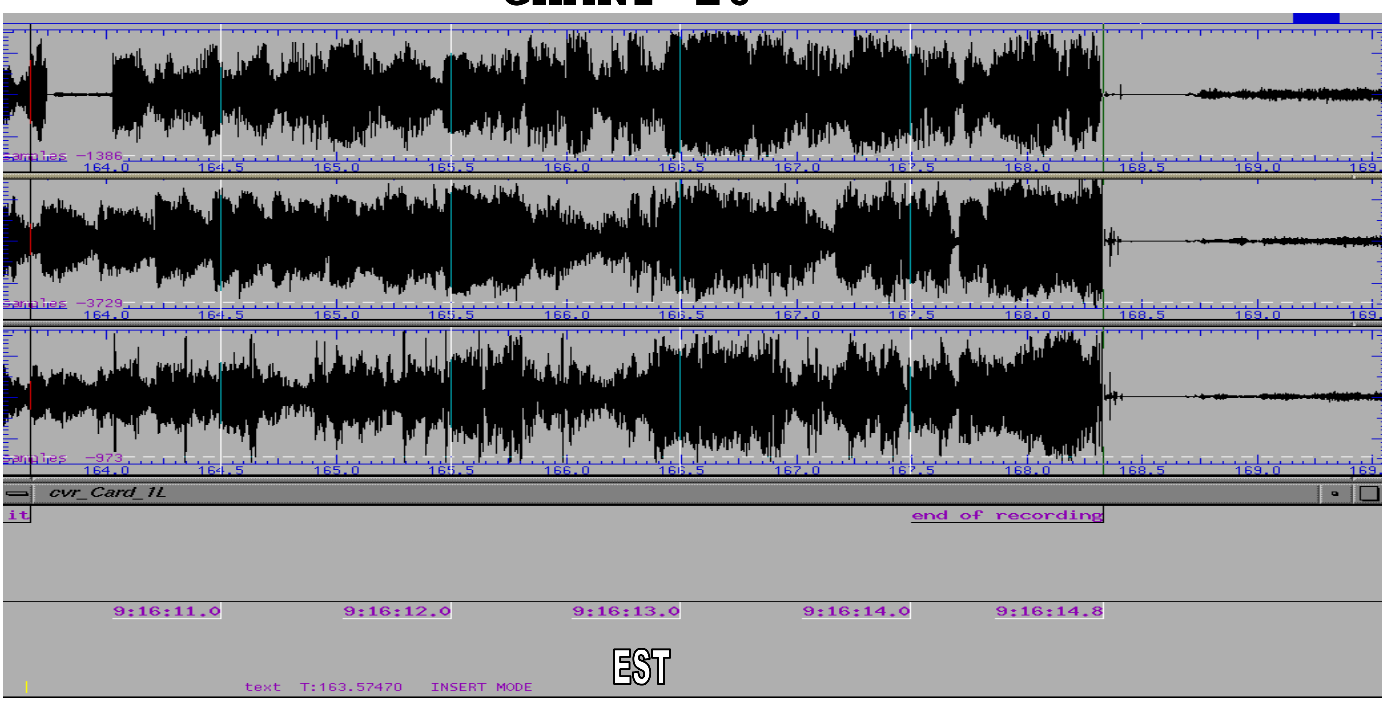


CHART 16



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