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

July 31, 2000

Group Chairman's Factual Report Sound Spectrum Study Cockpit Voice Recorder

A. ACCIDENT

DCA00MA006

Location	:	60 miles south of Nantucket, MA
Date	:	October 31, 1999
Time	:	About 0150 Local Time
Aircraft	:	EgyptAir flight 990, a Boeing B-767-366ER, SU-GAP

B. GROUP IDENTIFICATION

Chairman : James Cash
National Transportation Safety Board

Members: : Engineer Wagiuh Hanna
Avionics Engineer
EgyptAir

Engineer Yousser Hassan
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Engineer Samia Metwally
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C. SUMMARY

About 0150 eastern standard time (EST), on October 31, 1999, a Boeing 767-366ER, SU-GAP, operated by EgyptAir, as flight 990, crashed into the Atlantic Ocean about 60 miles south of Nantucket, MA. EgyptAir flight 990 was being operated under the provisions of Egyptian Civil Aviation Regulations Part 121 and United States Title 14 Code of Federal Regulations Part 129 as a scheduled, international flight from John F. Kennedy Airport (JFK), New York, New York to Cairo International Airport in Cairo, Egypt. The flight departed JFK about 0122 EST, with 4 flightcrew members, 10 flight attendants, and 203 passengers on board. There were no survivors. The airplane was destroyed by impact forces. Floating debris from the aircraft was recovered on the morning of October 31, 1999.

The aircraft was equipped with an L-3 Communications (Fairchild Aviation Recorders) model A-100A cockpit voice recorder (CVR) S/N unknown. The CVR contained an excellent quality 31 minute 23 second recording. The recording started at 0119:15 EST just as the aircraft was cleared for takeoff at New York's Kennedy airport. The recording continues uninterrupted until 0150:38 EST when electric power was removed from the unit.

D: DETALS OF INVESTIGATION

The excellent quality CVR recording consisted of four channels of audio information. One CVR channel contained audio information from the cockpit mounted area microphone (CAM) that was mounted in the overhead panel of the airplane. The second and third CVR channels contained audio information obtained from the Captain's and the First Officer's audio selector panels[1] in the cockpit. The fourth CVR channel contained audio information obtained from the jump seat/observer's audio panel. During the takeoff and the initial climb out portion of the recording, the First Officer was wearing a headset and "hot" boom microphone. This additional audio information was recorded on his audio channel of the CVR. The original First Officer was replaced by another First Officer approximately 20 minutes after takeoff. It appeared from the recording that the first crewmember just removed his headset and placed it to the side of the cockpit leaving it connected to the aircraft's audio system. The jump seat/observer's radio channel contained no usable audio information during the flight.

The audio information from the recording was examined to document (a) any unknown sounds or electrical disturbances recorded on the CVR. (b) The recording was also examined to determine which pilot had spoken several of the phrases found in the last several minutes of the recording. (c) The recording was also examined to determine who was in the cockpit during the last few minutes of the recording.

The recording was examined on a computerized spectrum analyzer that produces a color visual/graphical presentation of the frequency and energy content of the signals. This computer program allows detailed analyses of both the analog waveform and frequency content as well as detailed timing information.

Documentation of Unknown Sounds

During the last few minutes of the CVR recording, several unknown sounds and noises could be heard. The CVR group had identified several segments of unknown thumps and clicks. To further determine the source of the noise, the sound spectrum group compared known switch activations, seat/cockpit movements with the unknown sounds. The comparison process consisted of plotting the amplitudes of the various sounds. The results are presented on Charts 1 through 9. These charts present the amplitude of the waveform in the vertical axis and time in elapsed seconds along the horizontal axis.

[1] The CVR receives the audio information from the various radios and intercoms that the crew selects on their individual audio panels.

The CVR channel that was used for charts 1-9 is the cockpit area microphone (CAM) channel. The text found on the charts is a sanitized version of the CVR group transcript.

Chart number	Elapse Time depicted On Chart	Equivalent CVR Time (rounded to tenth of sec)
Chart 1	1741 - 1761	0148:13.7 - 0148:33.7
Chart 2	1759 - 1779	0148:31.7 - 0148:51.7
Chart 3	1773 - 1793	0148:45.7 - 0149:04.7
Chart 4	1789 - 1808	0149:01.7 - 0149:16.7
Chart 5	1806 - 1825	0149:18.7 - 0149:37.7
Chart 6	1821 - 1841	0149:33.7 - 0149:53.7
Chart 7	1839 - 1858	0149:51.7 - 0150:10.7
Chart 8	1857 - 1876	0150:09.7 - 0150:28.7
Chart 9	1868 - 1886	0150:20.7 - 0150:38.7

During the final few seconds of the CVR recording, a noise identified as an unsquelched background radio noise, was heard on the First Officers radio channels of the CVR recording. This noise starts at 0150:25.04 EST and continues until the end of the recording.

Examination of the Spoken Phrases at End of Recording

During the last few minutes of the CVR recording, several spoken phrases were heard. An examination of the phrases was undertaken in an attempt to determine the person who spoke the words. This effort was in conjunction with a similar effort undertaken by the Speech Examination Group (see Speech Examination Study). The Speech group examined the spoken phrases by using linguistic and formant dispersion techniques. The sound spectrum group examined the speech from a purely fundamental frequency and voice harmonic characteristics standpoint. This type of analysis uses voice print methodology in which the speech characteristics are visually compared to known speech samples

The various speech phrases were processed by plotting the frequency spectrum of the individual phrases. These spectrum or voice print plots, depict time in seconds along the horizontal axis. The frequency of the speech phrases in hertz is shown along the vertical axis. The colors shown on the charts depict the various sound or energy levels of the signals at any particular frequency or time. Charts 10 through 32 depict the various phrases identified during the last two-½ minutes of the CVR recording.

Chart number	Similarity Group	CVR Time EST	Spectrum Time in elapsed seconds	Generic Text of the Phrase[2]
Chart 10	C	1:48:39.92	1767.80	F/o repeated Phrase 1
Chart 11	A	1:49:48.42	1836.40	F/o repeated Phrase 2
Chart 12	A	1:49:57.33	1845.30	F/o repeated Phrase 3
Chart 13	C	1:49:58.75	1846.05	F/o repeated Phrase 4
Chart 14	C	1:50:00.15	1847.56	F/o repeated Phrase 5
Chart 15	A	1:50:01.60	1849.07	F/o repeated Phrase 6
Chart 16	A	1:50:02.93	1850.38	F/o repeated Phrase 7
Chart 17	A	1:50:04.42	1851.67	F/o repeated Phrase 8
Chart 18	A	1:50:05.89	1853.14	F/o repeated Phrase 9
Chart 19	C	1:50:06.37	1853.46	repetitive general inquiry
Chart 20	C	1:50:07.07	1854.53	F/o repeated Phrase 10
Chart 21	C	1:50:08.48	1856.18	F/o repeated Phrase 11
Chart 22	D	1:50:08.53	1856.26	repetitive general inquiry
Chart 23	D	1:50:15.15	1862.78	repetitive general inquiry
Chart 24	C	1:50:24.92	1872.18	engine status inquiry
Chart 25	B	1:50:26.55	1873.80	engine instruction 1
Chart 26	B	1:50:28.85	1875.84	engine instruction/question 2
Chart 27	C	1:50:29.66	1876.87	response
Chart 28	B	1:50:31.25	1878.45	pull comment 1
Chart 29	B	1:50:32.75	1879.96	pull comment 2
Chart 30	B	1:50:34.78	1882.00	pull comment 3
Chart 31	B	1:50:36.84	1884.03	pull comment 4
Chart 32	C	1:48:30.69	1758.41	unintelligible phrase

The attached plots graphically show the individual harmonic structure of the speech. Human speech consists of many complex harmonic frequencies. The inter-reactions of these various harmonics are what make one person sound different from another. Basic speech starts when the vocal cords vibrate producing a primary frequency (called the fundamental frequency) as well as multiple harmonics of this frequency. As these various sounds pass up the throat past the tongue and the lips the intensities of the fundamental frequency and of the various harmonics are altered. The complex alteration of the sounds is how an individual forms all of the unique sounds needed for aural language. This unique alteration of the sound is also what makes one person's speech characteristic different from another's.

By examining charts 10 through 32, it can be seen that they can be assigned into three distinct groups based on their voice print characteristics. Group A consists of charts 11, 12, 15, 16, 17,and 18. They all have similar vocal characteristics. Charts 25, 26, 28, 29, 30, and 31 can also be grouped together (Group B) with similar voice print characteristics. Charts 10, 13, 14, 19, 20, 21, 24, 27, and 32 (Group C) could not be sorted into either of the previous Groups A or B. Group C does not resemble either of the previous two groups nor do they resemble each other. Charts 22 and 23 (Group D) could not sorted into any of the other 3 groups but they do resemble each other. The majority of the charts sorted into Groups C and D contained very poor speech signal definition. This was attributed to either coincident loud background noises masking the speech signals or the words were spoken very softly.

[2] Text and Source information was obtained from CVR Group transcript

In an attempt to identify the most probable speaker, several statements representing all of the known crewmembers were sampled and graphed. These selected speech segments were taken from the accident flight's CVR recording. The CVR group had identified the individuals that spoke the sampled statements. The speakers were identified as follows:

Source	Chart Number	CVR Time EST of Sample
Capt. Habashi	Chart 33	0135:10.0
Capt. Hatem	Chart 34	0137:48.0
1st Officer Batouti	Chart 35	0147:55.0
1st Officer Adel	Chart 36	0135:43.0
1st Officer Hisham	Chart 37	0147:03.0
1st Officer Aiad	Chart 38	0135:07.3

By comparing the known speech voice print charts with the charts sorted in Group A and Group B it can be seen that the voice print chart representing 1st Officer Batouti (chart 35) matches the charts in Group A. Additionally the chart that was associated with Capt. Habashi (chart 33) matches the charts sorted in Group B. The charts sorted in Group C could not be associated with any of the known crewmember speakers identified on the CVR transcript

Who Was In the Cockpit During The Last Two Minutes of the Recording

The sound of the cockpit door opening was recorded on the CVR at 0148:18.5 EST. After this time, there was no additional sound heard on the remainder of the CVR recording that could be associated with the cockpit door either closing or opening again. Based on the voice print study above, it can be concluded that as a minimum Capt. Habashi and First Office Batouti were in the cockpit during the final minutes of the recording. First Officer Batouti is heard at 0149:48.42 EDT, 0149:57.33 EDT, 0150:01.60 EDT, 0150:02.93 EDT, 0150:04.42 EDT and finally at 0150:05.89 EDT. Capt. Habashi is heard at 0150:24.9 EDT, 0150:26.6 EDT, 0150:28.7 EDT, 0150:31.3 EDT, 0150:32.8 EDT, 0150:34.8 EDT, and finally at 0150:36.9 EDT only 2 seconds prior to the end of the recording. It should be noted that there are several statements during the last several minutes of the CVR recording that could not be positively associated with either Capt. Habashi or 1st Officer Batouti.

Examination of Unintelligible Comment at 0148:30.69

The unintelligible comment that was recorded from the CAM on the CVR at 0148:30.69 EST was examined to document the characteristics of the comment. It can be seen from the spectrum plot shown on Chart 32 that the phrase appears to contain human speech characteristics. Unfortunately, as stated previously, the speech segment was not of sufficient length or clarity to positively determine what was said and who said it. The fundamental frequency of the unknown segment resembled the patterns

developed for first Officer Batouti, but the harmonic and formant structure did not match other segments known to be him.

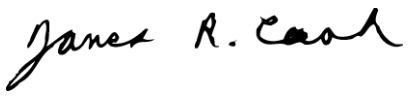
In an attempt to determine the origin of the unknown speech segment, several comparison segments were examined. Chart 39 depicts the unknown speech segment as recorded on the cockpit area microphone channel. The top trace of the chart depicts the waveform of the speech. The graph below the waveform depicts the representative energy or loudness of the signal. Several conversations from earlier in the flight were examined to document the energy levels during normal inter-cockpit conversations. Chart 40 shows the energy level of Captain Habashi during normal conversation and Chart 41 shows First Office Batouti conversation levels. Additionally Chart 42 depicts the energy levels of First Officer Hisham's conversation and Chart 43 depicts a statement made by Captain Hatem. A comparison of Chart 39 with Charts 40, 41, 42 and 43 indicates the amplitude of the unknown phrase is at a level that is considerably lower than cockpit conversation levels previously recorded. However, the low level of the amplitude could also have resulted from a sound source located much farther away from the area microphone.

Timing Information

Specific phrases and events near the end of the CVR recording are presented below with timing derived from two sources. One time set is from the CVR transcript and those times were used in several group chairmen factual reports and studies for this investigation. The other time set was developed by examining the spectrum charts contained in this report. The spectrum charts can provide timing to a higher resolution than possible when using the CVR recording/playback equipment. When comparing the two time sets, minor differences in elapsed time between specific phrases are noted. The CVR times can be adjusted to provide precise correlation based on the spectrum time set. In the example below, the times associated with the master warning provide the base time to which all other times were compared. The time increments are the fractions of a second to be added or subtracted to the CVR times in order to achieve a precise correlation between the CVR time set and the spectrum time set. The correlated time set is presented in the last column. Note that the CVR transcript and the correlated spectrum times for the master warning do not change. The correlated time set may be used in place of the CVR Transcript time set if desired.

Comment	CVR Transcript Time	Spectrum Time from charts in seconds	Time Increment	CVR time correlated to Sound Spectrum time
F/o repeated Phrase 1	1:48:39.92	1767.80	0.58	1:48:40.50
F/o repeated Phrase 2	1:49:48.42	1836.39	0.67	1:49:49.09
F/o repeated Phrase 3	1:49:57.33	1845.30	0.67	1:49:58.00
F/o repeated Phrase 4	1:49:58.75	1846.05	0.00	1:49:58.75
F/o repeated Phrase 5	1:50:00.15	1847.56	0.11	1:50:00.26
F/o repeated Phrase 6	1:50:01.60	1849.07	0.17	1:50:01.77
F/o repeated Phrase 7	1:50:02.93	1850.38	0.15	1:50:03.08
F/o repeated Phrase 8	1:50:04.42	1851.67	-0.05	1:50:04.37
F/o repeated Phrase 9	1:50:05.89	1853.14	-0.05	1:50:05.84
repetitive general inquiry	1:50:06.37	1853.46	-0.21	1:50:06.16
F/o repeated Phrase 10	1:50:07.07	1854.53	0.16	1:50:07.23

F/o repeated Phrase 11	1:50:08.48	1856.18	0.40	1:50:08.88
repetitive general inquiry	1:50:08.53	1856.26	0.43	1:50:08.96
repetitive general inquiry	1:50:15.15	1862.78	0.33	1:50:15.48
engine status inquiry	1:50:24.92	1872.18	-0.04	1:50:24.88
engine instruction 1	1:50:26.55	1873.80	-0.05	1:50:26.50
engine instruction/question 2	1:50:28.85	1875.84	-0.31	1:50:28.54
response	1:50:29.66	1876.87	-0.09	1:50:29.57
pull comment 1	1:50:31.25	1878.45	-0.10	1:50:31.15
pull comment 2	1:50:32.75	1879.96	-0.09	1:50:32.66
pull comment 3	1:50:34.78	1882.00	-0.08	1:50:34.70
pull comment 4	1:50:36.84	1884.03	-0.11	1:50:36.73
unintelligible phrase	1:48:30.69	1758.41	0.41	1:48:31.11
master caution	1:49:58.78	1846.09	0.01	1:49:58.79
master warning	**1:50:08.20**	**1855.50**	**0.00**	**1:50:08.20**



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