

ACOUSTIC ANALYSIS OF AIR TRAFFIC COMMUNICATIONS
CONCERNING KOREAN AIR FLIGHT 007

AUGUST 31, 1983

Report by
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This report describes the procedures and results of a comprehensive three-year analysis of audio recordings of American and Japanese air traffic control and Soviet military communications relevant to the 1983 deviation and downing of Korean Air Flight 007 (hereafter KE007). The analysis was sponsored by the Fund for Constitutional Government, 122 Maryland Avenue, N.E., Washington, D.C., and performed under the direction of Lawrence L. Porter of Spokane, Washington (see Appendixes I and II).

BACKGROUND AND PURPOSE

On August 31, 1983, Greenwich Mean Time (GMT)¹, Korean Air Flight 007 departed New York's Kennedy Airport with a destination of Seoul, South Korea. After a refueling stop in Anchorage, Alaska, the airliner began deviating to the right of its assigned course, eventually twice overflying Soviet territory. Throughout the period of deviation, apparently routine communications to and from KE007 were recorded by air traffic control (ATC) personnel in Anchorage and Tokyo. The airliner's first intrusion into Soviet airspace over the Kamchatka Peninsula did not result in its being intercepted, although press reports tell us that at least four Soviet fighters were sent aloft to look for the intruder. During the second intrusion over Sakhalin Island, fighters were again sent aloft in an interception effort. Recordings of their communications later made public by the U.S. Government show that the Rus-

shut
downs

1. Because events occurred in numerous time zones and KE007 crossed the international date line, times have been standardized to Greenwich Mean Time.

sians' efforts to locate the plane were successful and an attack was initiated. Shortly thereafter, KE007 was destroyed with the loss of all 269 passengers and crew.

The audio recordings relevant to the Korean Air Lines tragedy have been described by Government officials as complete, unaltered, and unedited. They comprise a body of material evidence that has been used in support of official claims that the airliner deviated from course without the knowledge of its crew, or of American or Japanese ATC and military personnel. Given the evidentiary importance of these audio materials, the broad research question posed by the funding agency was whether they in fact represent a complete and authentic audio record of the events of August 31, 1983.

The purpose of this study is to provide an objective analysis and interpretation of the audio tapes free from the influence of other sources of information or outside opinions concerning the incident. Throughout, an effort has been made to appeal both to a general, non-technical readership as well as to readers with knowledge of audio matters and other areas of expertise relevant to the incident. The analysis addresses three distinct issues with respect to the tapes: anomalies of content, procedure, and technical quality. When unusual or anomalous material is present, this report will assess its nature and significance.

PERSONNEL

A number of highly qualified individuals at the University of Washington at Seattle provided assistance, cooperation, and collaboration during the course of the analysis. Most important was Professor Les Atlas, with whom I had established a Speech Enhancement Workstation in the Electrical Engineering Department. Les's contributions to this project were numerous and essential.

Also involved in the analysis were Professor Robert Marks of the Electrical Engineering Department, Professor Alan Reich of the Speech and Hearing Department, Professor Ed Belcher of the Applied Physics Department, and two Masters students, Rex Andrew and John Schlater.² Although the work was in many respects a truly collaborative effort, I bear sole responsibility for the interpretations of content and wording for each of the transmissions discussed in this report.

AUDIO TAPES

Four audio tapes pertaining to the flight, deviation, and downing of KE007 have been employed in the analysis. Transcripts for two of these, air traffic control recordings made in Alaska and Japan, are found in Appendixes III and IV. Where appropriate, these transcripts should be used in conjunction with this discussion.

VHF and HF Communications Recorded in Anchorage:

In October 1983, I personally recorded first-generation copies of the original multi-track tapes from Anchorage Tower, the Anchorage Air Route Traffic Control Center (ARTCC), and Anchorage Radio--the International Flight Service Station (IFSS). These tapes contained both high frequency (HF) and very high frequency (VHF) transmissions to and from KE007 and other aircraft covering the time period 1250-1847 GMT. Hereafter, this will be referred to as the "Anchorage tape."

VHF and HF Communications Recorded by Tokyo Radio (Narita):

According to John Keppel, the Fund for Constitutional Government's

2. I am pleased to report that both Andrew and Schlater received their Masters Degrees based upon their work on this project.

Flight 007 project director who provided this tape of communications to and from KE007 and other aircraft, it had been acquired under parliamentary procedures from the Government of Japan by Senator Yukata Hata (Upper House of the Japanese Diet) in July 1985. The tape, covering the time period 1707-1835 GMT, had been in the possession of the Government of Japan for twenty-two months prior to its release to Senator Hata. It was purported to be a true copy of the original Narita master tape. Mr. Keppel forwarded the tape to the University of Washington, Seattle, that same month. I thus do not have first-hand knowledge of the chain of ownership of this tape, how many generations of copies were made to produce the copy I received, the technical competence of the persons making the recording, the quality of the recording equipment used, or the conditions under which the recording was made. Hereafter, this will be referred to as the "Narita tape."

Video Tape Containing Portions of HF Communications with Tokyo Radio:

In September 1987, Mr. Keppel forwarded to me a video tape containing segments of news material relevant to KE007 broadcast in September 1983 by the Japan Broadcasting Corporation (NHK). I re-recorded the audio track from this tape, which contained segments of KE007's communications with Tokyo Radio, for purposes of comparison with corresponding segments of the Narita tape. Hereafter, this will be referred to as the "NHK tape."

UHF Communications from Soviet Fighters to their Ground Stations:

Audio recordings of ultra high frequency (UHF) Soviet communications were released by United States representatives to the United Nations on September 6, 1983. These officials had received the tape from the United States Information Agency. No specific account was given for how the U.S. had acquired the original recording, although it was implied that it had come from a

Japanese signals intelligence station at Wakkanai on the Japanese island of Hokkaido. The tape used in this analysis was acquired by Mr. Keppel from the American mission at the United Nations. Hereafter, this will be referred to as the "voice intercept tape."

ANALYSIS OF AUDIO MATERIALS

The Anchorage Tape

The Anchorage tape contains various anomalies of content and technical quality, as well as a number of anomalies with respect to air traffic control procedures that warrant comment. These are discussed below:

Background Conversation:

At approximately 1434 GMT, a conversation was accidentally picked up by a "hot phone" on or near Sector D10/11 in the Anchorage Air Route Traffic Control Center. The conversation went as follows:³

1434:01	OKAY, YOU GUYS GOT SOMEONE BUMPING INTO THE RUSSIANS' AIR DEFENSES OVER HERE.
1434:06	OH, YOU'RE KIDDING.
1434:08	A PERSON SHOULD WARN HIM.
1434:10	THAT'S WHY YOU SHOULD'VE GIVEN THE INFORMATION HERE, INSTEAD OF WAITING * *

In this conversation, the voice of the Sector D10/11 controller is easily identified by comparison to previous and subsequent transmissions as the speaker of the passage, "A person should warn him." KE007 was presumed to be transiting Sector D10/11, so the controller was responsible for the plane's flight pattern accuracy. The identity of the other speakers is unknown. The

3. Asterisks denote an unintelligible syllable or word.

accuracy of the interpretation of the phrase, "A person should warn him," has been verified by affidavit by a number of other experts, one of whom, Alan Reich, has a Ph.D. in speech and hearing physiology. (For additional discussion of this material, see Appendix V.)

The content of this conversation, of which the Sector D10/11 controller was a participant, suggests that both he and someone else had knowledge that an aircraft, presumably KE007, was dangerously off course. As to the other participants in the conversation, the voice speaking, "Okay, you guys got someone bumping into the Russians' air defenses over here," had a metallic sound characteristic of words coming over a loudspeaker. The controller had a loudspeaker at his position that night, capable of conveying messages to him from elsewhere in the ARTCC and other facilities. Precisely to where the phrase "over here" refers is unknown. Yet once this knowledge was conveyed to the controller, he, being responsible for the sector, should promptly have taken steps to verify the aircraft's location and issue a warning if appropriate. Indeed, the Sector D10/11 controller suggested that a warning should be issued. But there is no evidence on this tape that any warning in fact was issued.

Context of Background Conversation:

The background conversation immediately precedes five repeated attempts by the Sector D10/11 controller to contact KE007. At the time of the first, the aircraft was only two minutes beyond its estimated time of arrival (ETA) at waypoint NABIE, and thus no operational need for soliciting a report can be ascertained. Unless required for establishing or verifying separation from other aircraft, a controller would normally not solicit a position report until at least ten minutes beyond the ETA. During this same time period, the

controller also sent a message to the International Flight Service Station on a high speed communicator requesting they attempt to contact KE007 via high frequency radio with an advisement that the airliner contact Sector D10/11 on the VHF channel 127.8 MHz. Given this apparent display of concern, it might be expected that when the Sector D10/11 controller had the opportunity to communicate with KE007, his concern would find expression.

NABIE Position Report Relayed via KE015:

Another Korean Air Lines plane, KE015, departed Anchorage fourteen minutes after KE007 on the same assigned route to Seoul, Romeo-20. At 1435:11 GMT, KE015 forwarded KE007's NABIE position report to Sector D10/11 on VHF channel 127.8 MHz as follows:

ROGER, KOREAN AIR ZERO ONE AH FIVE, WE ARE FORWARD REPORT THAT AH KOREAN AIR AH ZERO ZERO SEVEN THEY ARE PASSING AH NABIE AT ONE FOUR THREE TWO, FLIGHT LEVEL THREE ONE ZERO, ESTIMATING AH NEEVA ONE AH FIVE FOUR NINE, FUEL IS TWO ZERO ZERO DECIMAL ZERO, MINUS FOUR NINE, SPOT TWO FIVE ZERO DIAGONAL SIX ZERO, GO AHEAD.⁴

The controller acknowledged the call and instructed KE015 to have KE007 report passing the next waypoint, NEEVA, on a different VHF channel, 128.2 MHz. Thus, despite the advisement that someone was "bumping into the Russians' air defenses" and his subsequent attempts to contact KE007, the Sector D10/11 controller now made no attempt to issue a warning when the opportunity presented itself. At 1436 KE015 tried to call KE007, but no further exchanges between the two aircraft were recorded.

At 1444:09, KE007 contacted the International Flight Service Station on

4. KE015 reports KE007 passing NABIE at 1432 GMT at an altitude of 31,000 feet; estimating its arrival at the next waypoint, NEEVA, at 1549 GMT; its remaining fuel as 200,000 pounds; the outside temperature as -49 degrees Celsius; and the wind coming from a direction of 250 degrees at a speed of 60 knots.

HF radio and re-stated the entire content of his NABIE position report. The information was identical to that given by KE015 to controllers at the Anchorage Air Route Traffic Control Center with several exceptions. First, the estimated time of arrival at waypoint NEEVA was changed to 1553, four minutes later than the previous estimate. Next, it was reported that the outside wind speed had increased by five knots, an insignificant amount. Finally, KE007 requested a selcal check⁵ and a change in altitude to flight level three three zero (33,000 feet).

There are a number of oddities here. The first is the very fact that KE007, having already forwarded a position report via KE015, would give his entire position report again. Because of the method by which information is shared and disseminated within the air traffic system, there was no reason whatever for KE007 to re-state information previously reported, although to a different facility. Position reports and other information are put in message form and promptly sent to all interested parties, eliminating the need for such repetition. The correct procedure would simply have been for KE007 to note any revisions to the earlier report, such as its estimated time of arrival at waypoint NEEVA.

It is also unusual that the IESS's instruction for KE007 to contact the ARTCC directly on 127.8 MHz to request the altitude change failed to evoke comment from KE007's pilot. Since an inability to contact the ARTCC directly on 127.8, its assigned frequency, was the ostensible reason KE007 had forwarded its position report via KE015 in the first place, any instruction to continue using the frequency should have produced demurrals and a discussion

5. Selcal is a "selective call" feature that is tied to the aircraft's HF communication system. The ground controller dials a four letter group assigned to the aircraft, which produces a chime and blinking green light in the cockpit.

of the problem. But there was no mention of a problem in using the frequency.

Another oddity is that there appears to be no reason for KE007 to have requested a selcal check this early into the flight unless the pilot had misgivings about his VHF radio performance. This seems unlikely, however, since the aircraft should have been within VHF coverage until at least waypoint NEKVA, at this point in the flight still over an hour away. According to the report later released by the International Civil Aviation Organization (ICAO), the aircraft was equipped with three VHF transceivers. The possibility of all three experiencing a simultaneous malfunction to the extent that none were capable of communicating with a ground station is remote.

The behavior of ATC personnel in Anchorage was also odd. Since the last direct VHF contact between the ARTCC and KE007 had been at waypoint Bethel at 1350 GMT, over an hour and a half earlier, the Sector D10/11 controller should have been curious about the total lack of contact. At a minimum, he should have initiated a dialogue through KE015 to determine if KE007 was in fact, and to what extent, experiencing a radio malfunction. This type of information would be vital to Tokyo Radio, the receiving facility to which control of the airliner would soon be handed over. Tokyo Radio, as well as the ARTCC, rely upon VHF communications once the aircraft leaves the boundaries of the Flight Information Region and enters their domestic area of responsibility. If there was any chance that an aircraft was experiencing radio difficulties, it is required that this information be forwarded. Controllers at the ARTCC had reason to suspect that KE007 was experiencing radio problems. But no dialogue was begun to examine the possibility of radio malfunction and no report of possible radio problems was forwarded to Tokyo Radio on a recorded channel.

An additional curiosity is that, despite the lack of a report to Tokyo Radio, there is an indication that controllers at that facility may somehow

have been aware of the possibility of radio trouble aboard KE007. Immediately following KE007's NIPPI position report, Tokyo Radio advised him that his secondary frequency was 100.48 MHz. This is not a normal procedure, and, as far as can be determined, KE007 was the only aircraft in the system during the period in question that was issued a secondary frequency. A few seconds after the advisory there were two extremely weak radio calls from KE007 which apparently went unanswered by Tokyo Radio. (These calls do not appear on the transcript in Appendix IV because they represent a new finding since that transcript was produced.) It should be pointed out that if Tokyo did in fact have information concerning possible radio trouble with KE007, it was not passed via normal channels. We also have no record of what information, if any, may have been forwarded at the supervisory level, or by other means.

In summary, with the exception of the heightened activity surrounding the NABIE position report, I am critical of the Sector D10/11 controller for his casualness, lack of curiosity, and lack of initiative regarding the handling and absence of communications from KE007.

NEEVA Position Report Relayed by KE015:

At 1600:46 GMT, a second report for KE007 was forwarded to Anchorage Sector D10/11 by KE015, this time for waypoint NEEVA. The report indicated KE007 to be over the waypoint at 1558, five minutes beyond its revised ETA. KE015 initiated the report as follows:

"OKAY, AH GOOD MORNING, FORTUNATELY CAUGHT THE DELAYED REPORT OF KOREAN AIR ZERO ZERO SEVEN..."

This is a curious choice of phraseology. Recall that at waypoint NABIE KE007 was assigned and was supposed to be using the channel 127.8 MHz. At NABIE, the controller had instructed the aircraft to give his subsequent report, for

NEEVA, on a different frequency; 128.2 MHz. Prescribed procedures dictated that KE007 remain on 127.8 until NEEVA, at which point the pilot would switch to 128.2 to make the position report. At this time KE015 had not yet reached NEEVA, and so procedurally he should himself have been both monitoring and transmitting on 127.8. In order for KE015 to have "caught" KE007's report, as he said he did, implies that he was monitoring the 128.2 channel and overheard an attempt by KE007 to forward a NEEVA position report. In addition to monitoring 128.2, it also appears that KE015 was transmitting on that frequency. The phrase "good morning" was consistently used by the pilot when he initiated a call-up on a newly assigned frequency. At this point in the flight, there appears to be no reason for KE015 to have been either monitoring or transmitting on channel 128.2.

More unusual still is what was not said. If KE007 in fact made an unsuccessful attempt to contact Sector D10/11, then a lengthy dialogue should have followed in order for KE007 to pass to KE015 all of the information required for a position report. We would expect to hear at least one side of this dialogue, yet no evidence of this exists on the tape.

An additional problem concerns the timing of the relayed position report. Between 1558 GMT, KE007's reported time of arrival at NEEVA, and 1600:46, the time of KE015's relayed report, a number of things had to have taken place: KE007 had to note and record the information for his position report; he had to attempt to report it to Sector D10/11; he had to wait and see if Sector D10/11 would respond, and, when it did not, he had to arrange for KE015 to relay the information; finally, he had to relay the report to KE015, which would have had to be written down because of the volume of information it contained. Even if KE007 had initiated this process immediately upon waypoint passage, something that itself would be unusual since there is

normally a minute or two delay, in my opinion there simply was not sufficient time for all of these actions and back-and-forth exchanges to have taken place. Parenthetically, KE015 made no mention of having received the report directly, only of having "fortunately caught" it.

Also unusual was the behavior of the Sector D10/11 controller. By the time KE015 relayed KE007's NEEVA position report, KE007 was almost eight minutes beyond his revised estimate of 1553, and almost twelve minutes behind the schedule printed on his computerized flight plan. Yet despite the unusual and unexpected delay, the controller made no comment.

Digital Time Code:

At 1837:32 GMT, the digital time code⁶ on the Anchorage tape suddenly drops six decibels from its normal level, while the corresponding voice track remains at a constant level. This drop remains constant for three minutes, and then suddenly returns to the original level. This condition should not occur during a continuous, uninterrupted recording. During review of the tape, it was also noted that at 1839:14 the time code reader began to give erroneous indications which lasted for seven seconds. On the eighth second the reader returned to normal. The seven seconds of elapsed time is consistent with what is normally required for the reader to re-acquire on the generated pulse following an interruption and a re-start. Repeated tests produced identical results each time. It is unknown why such an interruption would have occurred during this critical period of time--the minutes surrounding KE007's ultimate destruction. Unfortunately, it is not possible to provide cross-checks using the other audio material covering the same period, the Narita

6. A digital time code is a series of recorded pulses in the 100 Hz range. When played back through a digital readout device, the code gives the time in hours, minutes, seconds, and fractions of seconds.

tape described below, because that tape contains a gap of approximately six-and-a-half minutes covering precisely the time in question.

The Narita Tape

The Narita tape presented a number of both usual and highly unusual and severe problems. There was an abundance of random white noise, rumble, echoing, fading, and drifting. The tape was badly over-recorded, causing serious distortion and problems with intelligibility. This was further compounded by having been recorded at too slow a speed. In addition, the tape travel speed was uneven, producing what is called "wow and flutter." There was also a very loud overriding 1500 Hz tone which was unstable, at times drifting to 1600 Hz. This drifting is consistent with the wow and flutter. Finally, there was a problem of interfering and mixing voices from other aircraft from the time of KE007's transmission at 1815 GMT, through the last known transmission at 1827. At issue is whether the problems encountered during the analysis were accidentally induced onto the tape through carelessness or incompetence, or whether they represent a deliberate attempt to obscure the contents of the tape by making it unnecessarily difficult to understand.

The answer to that question has several relevant dimensions. It is clear that much or all of the random white noise, rumble, echoing, fading, and drifting is characteristic of high frequency communications, and could thus be accidental. Other problems, such as the over-recording, slow record speed, and the "wow and flutter," could have occurred at any point in the chain of possession of this tape, and thus do not necessarily indicate deliberate obfuscation. Certain other peculiarities, however, would normally not be encountered during routine recording of the original tape or subsequent recordings of copies of the original. They could only have been induced on the tape

while in the possession of the Japanese Government. Some of these were obvious from the beginning of the analysis, while others only became apparent later, as the analysis proceeded over its three-year course. The Narita tape's key anomalies are discussed below. Where applicable, comparisons to the NHK tape are made:

Frequency Shift of KE007's Transmissions:

As the intelligibility of KE007's transmissions on the Narita tape was very poor, the audio material was subjected to a variety of filtering processes including notch filters, high and low pass filters, comb filters, and automatic adaptive filters. These efforts provided a much cleaner tape, but did little to enhance intelligibility. It was only through the use of spectrograms that a clue to the problem finally emerged. It appeared that portions of the entire signal spectrum of KE007's transmissions had been shifted upward in frequency by approximately 300 Hz, the effect of which was to render the transmissions less intelligible. (Other analysts who had previously examined the tape mistakenly attributed the rise in the voice to stress or panic.) All other aircraft and Tokyo Radio transmissions were unaffected by the 300 Hz shift. While the condition and quality of the Narita tape made the use of spectrograms unreliable in determining what was said or the identity of individual speakers, the frequency shift theory ultimately resulted in the only technique that provided an improvement in intelligibility.

The initial procedure involved the use of a computer program designed to shift the entire frequency spectrum of the Narita tape upward by 5000 Hz. This process was then input into a voltage demodulator that allowed scanning both sides of the spectrum of the center frequency without being restricted to

a "floor." Later, a computer program was written to perform this task by entering a set of coefficients designed to correspond to an upward or downward shift in increments of 5 Hz. Finally, software and hardware were designed that would allow for instantaneous, real-time variance of the shift required to track the fluctuations in frequency on the tape.

The frequency shift on the airliner's transmissions was first noted at 1815:05, when KE007 requested a climb to flight level 350. The series of communications that followed, along with interfering transmissions from Japan Air Lines Flight 47 (JA47), are presented below:

1815:05	JA47 KE007	ONE EIGHT ONE ZERO FLIGHT LEVEL THREE HEY, TOKYO RADIO KOREAN AIR ZERO ZERO SEVEN
1815:09	JA47 TOKYO	THREE ZERO EXTIMATE PORT HEIDEN KOREAN AIR ZERO ZERO SEVEN TOKYO
1815:12	JA47 KE007	ONE EIGHT FIVE SIX AH KOREAN AIR ZERO ZERO
	JA47	REMAINING <u>ZERO</u> REQUESTING
1815:17	JA47 KE007	ONE NINE FIVE DECIMAL ZERO CLIMB TO THREE FIVE ZERO
1815:19	JA47 TOKYO	MINUS FOUR FOUR REQUESTING THREE FIVE ZERO?
1815:20	JA47 KE007	TWO EIGHT ZERO DIAGONAL ONE ZERO FIVE THAT IS AFFIRMATIVE [AND PRESENTLY I'M] AT THREE THREE ZERO, KOREAN AIR ZERO ZERO SEVEN
1815:25	ANCHOR TOKYO	SAY YOUR PRESENT POSITION AGAIN ROGER, STAND BY [AND] CALL YOU BACK
1815:29	KE007	ROGER

The result was an improvement in intelligibility. Before the application of the frequency shift technique, the original interpretation of the passage

beginning at 1815:12 was, "They're at three zero zero zero, request immediate climb to three five zero." After the technique was applied, it was determined that the "imm" in the word "immediate" was actually the "ing" on the end of the word "request," and the "ediate" was a product of noise. Note that in the same transmission the underscored word "zero" is not the expected "seven." The reason for this is unknown--the pilot may simply have misspoken. On the next line, the word "zero," spoken by Japan Air 47, falls just behind the word "zero" spoken by KE007, and sounds like an echo. In summary, it was necessary to devote considerable time and apply a number of techniques to the Narita tape in order to render KE007's transmissions intelligible.

The need for such techniques becomes a very real issue when the Narita tape is compared to the NHK tape. Recall that the Narita tape was released under parliamentary procedures by the Government of Japan to a member of the Diet in July 1985. As an official release, the tape might be expected to exhibit audio quality equal or superior to other, unofficial recordings of the same material. By the same reasoning, the audio track of the video tape obtained from NHK would have been expected to be inferior in quality to the official tape. Instead, just the reverse was found. On the NHK tape, material that, at a minimum, had passed through several generations from audio to video and back to audio, a level of intelligibility that took more than two years of work to achieve and verify from the Narita tape already existed without the need for any signal processing. There was no evidence of frequency shifting on the NHK tape, suggesting that this had been induced on the official Narita tape. For whatever reason, when the Government of Japan released a tape containing the transmissions of KE007, its audio quality was markedly inferior to recordings of the same material obtained by the Japan Broadcasting Corporation two years earlier.

Interfering Transmissions from other Aircraft:

The official Narita tape evidenced a problem of interfering and mixing voices from other aircraft each time KE007 transmitted. These interfering voices, from JA47 and other aircraft, produced substantial difficulties in ascertaining the content of transmissions by KE007. Yet there was no reason for the presence of these interfering transmissions. On the Narita tape the interfering voices were recorded on the same audio channel as KE007, meaning that it was technically impossible to separate them. However, on the NHK tape covering the same period of time, there is a total absence of interfering transmissions from other aircraft. This demonstrates that at one time the transmissions from KE007 and other aircraft had existed on separate channels of the original Japanese master tape. As with the high-pitched tone, there was no reason to record them on a single channel. The Government of Japan thus released a tape recorded in a fashion that unnecessarily reduced intelligibility.

Overriding, High-pitched 1500 Hz Tone:

A very loud overriding 1500 Hz tone appears on the Narita tape. Most speech energy is found in the range of 300-3000 Hz, placing the tone right in the middle of that range. The tone evidenced drifting, a finding consistent with the interpretation that the recording speed was too slow and that there was a troublesome degree of moderate "wow and flutter." The tone on the NHK tape, to the contrary, was at 1656 Hz and was very stable. This irritating tone has the effect of fatiguing and otherwise discouraging the listener. As with the interfering voices, however, there was no reason for the tone to have been on the tape. Consider that during KE007's NIPPI position report, beginning at 1709:00 GMT and continuing for some forty-nine seconds, the 1500 Hz

tone was present throughout.⁷ Had the tone been recorded on the same audio channel as KE007's transmissions, as the Narita tape suggests, there would be no possible way to separate tone from voices. That is, when the voices stop, the tone should also stop. On the NHK tape, however, the audio material ends on the underscored word "zero" (below), but the tone continues for 3.2 seconds. This period of time should have contained the words, "estimating NOKKA one eight two six," but those words did not accompany the tone. The continuance of the tone after speech had ceased on the NHK tape demonstrates that the tone and speech had once existed on separate channels of the original Japanese master tape. As such, there was no reason for them to have been blended on a single channel, as they were on the Narita tape. The effect of the blending was to reduce intelligibility and make listening difficult.

1709:00	KE007	AH, TOKYO RADIO KOREAN AIR ZERO ZERO SEVEN
1709:02	TOKYO	KOREAN AIR ZERO ZERO SEVEN TOKYO, GO AHEAD
1709:03	KE007	ROGER, KOREAN AIR ZERO ZERO SEVEN POSITION [AH] NIPPI ONE SEVEN ZERO SEVEN, AH WE'RE AT THREE THREE ZERO, ESTIMATING NOKKA ONE EIGHT TWO SIX, ONE THREE TWO DECIMAL ZERO, MINUS FOUR NINER, THREE TWO ZERO DIAGONAL FOUR FIVE, REQUESTING SELCAL CHECK, GOLF- FOXTROT-HOTEL
1709:37	TOKYO	-SEND SELCAL-
1709:38	KE007	AH, KOREAN AIR ZERO ZERO SEVEN SELCAL OK
1709:40	TOKYO	TOKYO, AND SECONDARY ONE ZERO ZERO FOUR EIGHT
1709:49	KE007	ROGER, ONE ZERO ZERO FOUR EIGHT, THANK YOU

7. KE007's NIPPI report did not contain the problems of unintelligibility or frequency shift encountered in transmissions on the same tape beginning at 1815 GMT and continuing through the last transmission at 1827. I judge the quality and signal strength of this transmission to be good despite the over-riding tone.

Use of Oxygen Masks:

It is my judgment that throughout a transmission by KE007 beginning at 1823:05 GMT, an oxygen mask was being worn in the cockpit. The transmission went as follows:

1823:05 KE007 TEST (pause) TOKYO RADIO KOREAN AIR ZERO
ZERO SEVEN WE'RE AT THREE FIVE ZERO

Immediately before the word "test," a very clear word, there is an audible sucking sound identical to that produced when speaking into an oxygen mask's built-in microphone. I myself have had considerable experience over the years with these types of microphones. They have specific properties that are easily identified by an experienced listener. The reason for the crew to have donned oxygen masks at this stage of the flight is unknown, since their transmissions provide no indication of problems with oxygen or other difficulties.

This transmission, one of the most distorted on the entire Narita tape, contains several additional anomalies. For example, while the word "test" is very clear, the words "Tokyo Radio" are very muddled. Before the application of the frequency shifter, the words "Korean Air Zero Zero Seven" were completely unintelligible, while the phrase "we're at three five zero," was very clear. I was also puzzled by the lack of an initial call-up by KE007, to be followed by a waiting period for Tokyo to respond. Such a call up is customary at the outset of all air traffic communications, and characterized all of KE007's other transmissions. Why it was absent in this instance is unknown.

The Final Transmission:

It is beyond the scope of this report to elaborate on all of the methodology and interim interpretations that came about during the extended course of analysis of the transmissions falling in the time period 1827:02-

1827:26 GMT, collectively comprising what is considered to be KE007's "final transmission." An effort has been made below to align the words as closely as possible on paper to their correct relationship as one listens to the tape.⁸

1827:02	KE007	[HEY] TOKYO RADIO KOREAN AIR ZERO ZERO SEVEN
1827:05	TOKYO	KOREAN AIR ZERO ZERO SEVEN, TOKYO
1827:10	KE007	THAT WAS KOREAN AIR ZERO ZERO SEVEN
1827:17		REPEATING [HO - * * * LO [ST]
1827:18	ANCHOR	AH DYNASTY THREE ONE TWO ANCHORAGE
	KE007	REPEAT CONDITIONS
	[KE007]	## * GONN'A BE A
	[KE007]	BLOODBATH, REAL BAD
1827:21	DN312	AH DYNASTY THREE ONE TWO POSITION PAYON ONE EIGHT TWO FIVE
1827:26	TOKYO DN312	KOREAN AIR ZERO ZERO SEVEN, AND THAT'S LEVEL THREE THREE ZERO
	TOKYO DN312	UNREADABLE, UNREADABLE, RADIO CHECK ON ESTIMATE AH SHEMA ONE NINER THREE FIVE, REMAINING...
	TOKYO DN312	ONE ZERO ZERO FOUR EIGHT ...ONE TWO SIX DECIMAL ZERO MINUS FIVE ZERO ZERO ONE ZERO DIAGONAL FOUR ZERO AND AH ROMEO DELTA AARDVARK GO AHEAD

At 1827:17, the segment in brackets represents a very serious distortion. There is an abundance of material in this segment, as well as several reasons for the severity of the distortion. There are two radio carrier releases, one lying directly behind the other at the point where the letters "ST" appear in brackets. It is my opinion that one of the carriers is respon-

8. Bracketed words represent best interpretation; asterisks denote an unintelligible syllable or word; the symbol ## indicates a noise completely blocking the speech.

sible for the sound, and possibly tricks the listener into perceiving a word. In my judgment there are three voices within the bracketed area. One is from Anchorage Radio, as indicated. I judge another to be KE007, while the third source is unknown. Throughout the one hour and twenty-eight minutes of the Narita tape, there are several instances when transmissions from Anchorage Radio would suddenly burst upward, generating a wild rise in pitch. When the Narita and Anchorage tapes were aligned and played simultaneously, Anchorage Radio's response to Dynasty 312 fell directly within this segment. Spectrograms of this area revealed that the high pitched tone previously discussed (which appeared on the spectrogram as a flat, broad, dark line on the rest of the tape) took a wild excursion at this point. The reason for this occurring during this critical transmission is unknown.

Comparison of the official Narita tape to the NHK tape reveals an additional anomaly. On the Narita tape, KE007's words "real bad" end at 1827:20. Six seconds later, the Tokyo controller responded. Throughout, the characteristic high-pitched tone continues without change. Things were quite different on the NHK tape, however. Following the words "real bad" the high-pitched tone continues for sixteen seconds without speech. At the six second point, precisely when we would have expected the Tokyo controller's voice to appear, the tone drops in frequency from 1656 Hz to 750 Hz. There is a sound similar to that of a switch, probably induced by laboratory equipment. The reason for these observed differences is unknown.

Finally, we can point to a logical contradiction in the content of the final transmission. The words "gonn'a be a bloodbath, real bad" clearly suggest that KE007's cockpit crew was cognizant of an emergency situation. If the aircraft was in distress, however, why did the pilot precede those words with a standard call-up to Tokyo, and then wait for Tokyo to respond?

It is useful to compare the above rendering of the final transmission with that contained in the report issued by the International Civil Aviation Organization in December 1983. The ICAO interpretation of the portion beginning at 1827:10 was enclosed in parentheses and described as a "best interpretation":

[KOREAN AIR ZERO ZERO SEVEN ... (unintelligible) ... RAPID
COMPRESSION ... DESCENDING TO ONE ZERO THOUSAND.]

The ICAO version thus contains errors of both omission and commission. It totally fails to identify the words "that was" and the word "repeating," all of which stand alone and are totally intelligible. The phrase "bloodbath, real bad" also does not appear, although the words are intelligible following appropriate signal processing. Finally, the words "descending to one zero thousand" are simply not on the Narita tape (nor on the comparison NHK tape), and represent a wholly erroneous interpretation of the audio material.

Six-and-a-half Minute Gap:

The Narita tape is comprised of high frequency and very high frequency transmissions recorded by Tokyo Radio, and VHF transmissions recorded by the Tokyo Aircraft Control Center. Following a transmission at 1835:02 GMT, the HF portion of the Narita tape ends. The VHF portion does not begin until 1842:17, meaning that the tape contains more than a six-and-a-half minute gap in radio coverage. The gap surrounds the critical time period 1837-1838, when, according to early American and Soviet reports, KE007 disappeared from radar. Since there is no gap in either HF or VHF radio coverage in that area, there is no technical reason for the Government of Japan to have released a tape containing such a gap.

The Utility of the NHK Tape

The acquisition of the NHK tape was a welcome companion to the official Narita tape, providing a much needed basis for comparison. In the effort to arrive at an objective and meaningful work product, it satisfied any doubts that were raised about the accuracy of the evaluation of existing problems. It showed that the signal processing that had been developed was correct. In my judgment at least three, perhaps four channels of the original master multi-track tape were simultaneously re-recorded and merged onto a single track of the official Narita tape released by the Government of Japan. We know by comparison that we are dealing with the same tape. However, there is no avoiding the conclusion that the Narita tape was not a faithful, or accurate reproduction of the information as it existed on the original master tape, despite the fact that it was represented to be a "true copy" of the original. The manner in which it was presented is an obfuscation of individual bits of evidence, which, when singled out, may well provide a new or different approach to solving the remaining mysteries of KE007's "final transmission." Until the original master tape from which the Narita tape was made is re-examined, and until competent individual recordings of each and every channel of the master tape are produced, the result will be continuing and unnecessary differences of opinion about a piece of evidence that was flawed from the very outset.

The Voice Intercept Tape

On September 6, 1983, before playing a tape of the UHF transmissions by Soviet pilots involved in the effort to intercept KE007, U.S. Permanent Representative to the United Nations Jeane J. Kirkpatrick remarked, "Nothing was cut from this tape. The recording was made on a voice-actuated recorder and,

therefore, it covers only those periods of time when conversation was heard." Analysis of this tape, however, reveals a series of anomalies that appear inconsistent with Kirkpatrick's claims. Throughout this discussion, reference should be made to the spectrograms in Appendix VI.

Pauses Not Followed by a Voice:

The spectrogram in Appendix VI-1 shows the pause between transmissions as a white empty region. On a voice-actuated recording, each pause, by definition, should be preceded and followed by a voice. As can be seen, on the voice intercept tape this is not always the case.

Excessive Sharpness of Pause Borders:

Because a voice-actuated recorder is continually turning itself on and off in response to voices, the pauses between voices should reflect this. That is, the edges of the pauses as shown on the spectrogram should not be absolutely sharp, but instead should reflect the brief transit time in changing signal strength associated with the voice-activated recorder turning on and off. The spectrograms produced from the voice intercept tape, however, show the edges of pauses to be abnormally sharp. See the spectrogram in Appendix VI-2.

Pauses Vary in Length:

Between segments of speech, a voice-activated recorder should produce pauses that are identical in length. As can be seen in Appendix VI-3, the pauses vary in length on the voice intercept tape.

Intrusive Carrier Tone:

On the top of the spectrogram in Appendix VI-4, a high frequency carrier tone is visible as a dark band. Since the carrier tone was part of the

original Soviet transmissions, it should stop precisely when the voice-activated recorder turns off. As can be seen, however, in this and several other instances the carrier tone intrudes into the pauses.

Oscillating Tones:

On the voice intercept tape are found a series of brief oscillating tones that appear, for the most part, at one-second intervals. There is no technical reason for the tones to be present, nor to have been recorded on the same audio channel as the voice material. It is possible that the tones were put there by those who made the recording to mark the passage of time (although the tones fail to identify the time of day). If they were for this purpose, the intervals between the tones should be constant and not vary in length. At several points on the tape the intervals *do* vary, however, suggesting that material may have been removed or added.

Suggestion of Editing:

One of the pauses on the voice intercept tape is preceded by an audible click. On the spectrogram in Appendix VI-5, this is represented as a vertical double bar. This type of mark closely resembles one produced by editing. When asked about the possibility of editing on the tape, former deputy representative to the United Nations Charles M. Lichenstein noted that the U.S. mission to the United Nations had received assurances from the U.S. Information Agency that the tape was voice-activated and unedited. "We had no reason to think any misrepresentation was made to us," Lichenstein said. He acknowledged that USIA technicians may have edited the recording to "speed it up between voice bursts" and to "get rid of background noise."⁹ This suggestion

9. John Horgan, "KAL 007: Did the U.S. 'Misrepresent' a Key Piece of Evidence?" *Scientific American*, Vol 259, No. 2, August 1988, pp. 15-16.

can be seen as entirely specious, however, when it is noted that the whole purpose behind voice-activated recorders is to make the tapes they produce as short and speedy as possible by eliminating the "dead spaces" between voice transmissions. By definition, a voice-activated recorder "speeds it up" between voice bursts and "gets rid of background noise," thereby eliminating the need for editing by the USIA or anyone else. Any editing, then, would have been for some other purpose.

SUMMARY OF FINDINGS

I. A tape of communications to, from, and about KE007 was recorded by air traffic control facilities in Alaska and released by the Federal Aviation Administration. The tape contained the following anomalies of content, procedure, and technical quality:

1. A conversation in which the controller responsible for KE007 was a participant suggests that both he and other parties had knowledge that an aircraft, presumably KE007, was off course and heading toward the Soviet Union. No evidence exists that a warning was issued.

2. KE007's NABIE position report, forwarded by another Korean airliner, KE015, was soon followed by a similar full-length report by KE007 itself. Given the way information is distributed within the ATC system, there was no reason to re-state information previously reported.

3. KE015 also forwarded KE007's subsequent NEEVA position report. No evidence exists that the two Korean airliners ever engaged in the lengthy exchange of information necessary for such a relay. Indeed, there appears to have been insufficient time to have done so.

4. An instruction by ATC personnel for KE007 to continue using a radio frequency whose failure to perform had been the ostensible reason for the relayed reports in the first place failed to evoke comment from the Korean pilot.

5. The lack of direct radio contact with KE007 should have suggested a radio malfunction. Yet American ATC personnel failed to initiate a dialogue to determine if KE007 was experiencing difficulties, or to report the problem to controllers in Tokyo, as required.

6. KE007's seriously delayed arrival at waypoint NEEVA failed to evoke appropriate comment and questioning from ATC personnel.

7. Although there was no apparent reason to do so, KE015 both monitored and transmitted on an unassigned radio frequency, 128.2 MHz.

8. A selective call (selcal) check was requested by KE007 at an unusually early point in the flight.

9. At one point on the tape, the digital time code used to mark the passage of time suddenly dropped six decibels from its normal level while the corresponding voice track remained constant. This is a condition that should not have occurred during continuous uninterrupted recording.

II. A tape of KE007's communications with Japanese ATC personnel, officially released by the Government of Japan, contained additional anomalies:

1. Portions of the entire signal spectrum of KE007's transmissions were shifted upward in frequency approximately 300 Hz. The transmissions by all other aircraft and ATC personnel were unaffected. Comparison with other recordings shows the frequency shift to have been induced on the tape before its release by the Government of Japan. The effect was to render KE007's transmissions less intelligible.

2. Interfering and mixing voices from other aircraft were present each time KE007 transmitted. These voices were recorded on the same audio track as KE007, although this was not necessary. Comparison with other recordings shows that they had previously existed on separate tracks. The tape was thus recorded in a fashion that unnecessarily reduced intelligibility.

3. A loud, irritating, and overriding 1500 Hz tone is present on the tape, recorded on the same audio track as the voices. Comparison with other recordings shows that the tone and speech had once existed on separate tracks, meaning that there was no reason for them to be blended together. The effect was to reduce intelligibility and make it difficult to listen to the tape.

4. The tape provides evidence that the crew of KE007 had donned oxygen masks several minutes before the reported firing of the Soviet air-to-air missiles. The reason for them to have done so at this stage of the flight is unknown, since their transmissions provide no indication of problems with oxygen or other difficulties.

5. During certain key communications, KE007 failed to follow the customary procedure of making an initial call-up to ATC personnel, waiting for a response, and only then continuing with his transmission.

6. Severe problems with intelligibility and clarity characterize certain of KE007's communications, although the transmissions of no other aircraft in the region evidence similar difficulties.

7. KE007's final transmission contains words suggesting that the crew was aware of emergency conditions on board their aircraft: "Repeat conditions...gonn'a be a bloodbath, real bad." Yet no "Mayday" call to ATC personnel was ever initiated by the airliner.

8. Despite the seriousness of the situation suggested by the content of the final transmission, the pilot inexplicably preceded the message with a standard call-up to Tokyo and then waited for a response.

9. The tape contains a gap of approximately six-and-a-half minutes covering the most critical portion of the flight--when KE007 was destroyed.

III. A tape of communications by Soviet pilots involved in the effort to intercept KE007 over Sakhalin Island, released by the U.S. Government, also contained numerous anomalies:

1. Recording of the Soviet transmissions was said to have been done on a voice-actuated recorder. If so, each pause on the recording should, by definition, be preceded and followed by a voice. Spectrograms show this is not always the case.

2. The pauses between the voices should reflect the brief transit time in changing signal strength associated with the voice-activated recorder turning on and off. Spectrograms show the edges of pauses to be unexpectedly sharp.

3. A high frequency carrier tone was present on the tape. Since the tone was part of the original Soviet transmissions, it should stop when voice-activated recorder turns off. In several instances, however, the carrier tone intrudes into the pauses.

4. On the tape are a series of brief oscillating tones denoting the passage of time in one-second intervals. There are several oddities here: First, the tones do not appear to be a true time signal. Second, there is no technical reason for the tones to be present on the tape. Third, the tones should not be recorded on the same audio track as the voice material, but they are. Finally, the intervals between the tones should not vary in length, but they do, suggesting that material may have been removed or added.

5. One of the pauses on the tape is preceded by an audible click. On a spectrogram this is represented as a vertical double bar, a type of mark closely resembling one produced by editing.

CONCLUDING REMARKS

This report represents a state-of-the-art analysis of a number of pieces of audio material relating to the 1983 Korean Air Lines tragedy. Many of the individual findings in this report are provocative and disturbing. Collectively, they comprise a catalog of anomalies of content, procedure and technical quality that cannot easily be reconciled with official claims that the tapes made public by the American and Japanese governments represent a complete and authentic audio record of the events of August 31, 1983. It might seem reasonable, therefore, to expect copies of the tapes to accompany this report as hard evidence so members of the press and public can "hear it for themselves."

Unfortunately, such an assumption misunderstands the dual nature of the analytic process. One side of the process involves the technologies employed; the computer hardware and software, vocal stressors, parametric equalizers, and various types of filters. These can be necessary, but not necessarily sufficient elements in the analysis of difficult audio materials. The other side of the process is the human dimension. Once the technologies have been appropriately applied, the quality of the analysis frequently comes down to the professional abilities of the listener. Deciphering difficult acoustic material requires experience, extraordinary patience, and hard work. Hundreds, indeed thousands of listenings are often necessary before a syllable, word, or passage is intelligible. As an example, consider that I have devoted a minimum of thirty hours of work for each second of KE007's final transmission, which is nineteen seconds in length. To turn over the tapes to inexperienced listeners for a few playings to "prove" a point would in fact accomplish nothing except a devaluation of this complex and painstaking professional process.

Because of this, it is inappropriate to furnish copies of my tapes to interested parties upon request. First, I would lose control over the tapes, meaning that I would have no way of knowing how others might use or misuse them. Second, in the same way that hearing an orchestra in a concert hall differs from playing the same music on a stereo at home, it is simply not possible to produce a recording identical to the way it is heard through professional processing equipment. Finally, it would not be possible to evaluate the technical qualifications of listeners or the quality of the equipment they use, both of which affect the ability to hear the material and judge its content. This is not to say that I refuse validation of my work and techniques. I will cooperate to the extent time permits with anyone who has a need to know and an objective approach to the materials in question. However, they must be willing to come to me, use my equipment, and be prepared to spend the considerable amount of time necessary.

Thus in conclusion, both I and my colleagues at the University of Washington, Seattle, concur that all reasonable efforts have been exhausted in the analysis of the audio materials described in this report. Unless and until new and compelling evidence is forthcoming, we view the present analysis to be definitive and consider the matter closed.

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APPENDIX V

This Appendix discusses the conversation picked up by a "hot phone" at or near working position D10/11 in the Anchorage Air Route Traffic Control Center at approximately 1434 GMT. As pointed out in the body of this report, my analysis concludes that the content of that conversation is as follows:¹

1434:01	Okay, you guys got someone bumping into the Russians' air defenses over here.
1434:06	Oh, you're kidding.
1434:08	A person should warn him.
1434:10	That's why you should've given the information here, instead of waiting * *

An FBI report, dated October 21, 1985, described laboratory tests conducted by the Bureau on the Sector D10/11 portions of the Anchorage ARTCC tape. The actual date of the testing was not specified. The report concluded that the conversation was generally unintelligible. The report went on to say that any statement by anyone regarding the background conversation should be treated as "pure and unwarranted speculation." The purpose of this Appendix is to provide criticism of the Bureau's methodology.

The FBI also conducted tests on the Sector D10/11 equipment and associated recording device within the ARTCC to determine the capability of the equipment to pick up speech, even when it was not activated. These tests support my earlier opinion regarding the pick-up source of the 1434 conversation. One of the worksheets stated, "Great wiring job--no wiring crosstalk possible at the limited dynamic range the recorder handles." This leaves the only

1. Asterisks denote an unintelligible syllable or word.

other possible pick-up sources to be the loudspeaker, headset, or handset. Supervisory personnel at the ARTCC verified that the handset was in use on the morning of the incident due to the late hour and the light volume of traffic. The test of the ability of these three sources to pick up conversation revealed that, within a distance of two to three feet: (1) the sensitivity and quality was best on the handset; (2) voices through the loudspeaker were only partially understandable; (3) test recordings made through the handset had slightly better intelligibility than the loudspeaker.

There are a number of problems here. The FBI report offers no transcript indicating what words were spoken by its personnel during the test, nor does it indicate what percentage of these words were understandable. "Partially understandable" without such a transcript is a meaningless term. The report does not clarify whether the handset was placed face down, or laid on its side. If it was on its side, with the mouthpiece and earpiece facing outward, the ability to pick up speech would obviously be enhanced. In addition, tests conducted on the ARTCC equipment at any time other than when the original remarks were recorded assume that conditions at the time of testing were identical to those at the time of the incident, over two years earlier. This assumption is wholly unwarranted since it fails to consider differences including: (1) existing line noise levels; (2) the condition of the tape in use on the recorder at the time of testing compared to the tape in use at the time of the incident; (3) gain settings on the position amplifier on the two different dates; (4) calibrations, sensitivity settings, and recording levels of the recorder on the two different dates; (5) whether the handset used in the test was the same one used on the night of the incident, and, if so, whether repairs, abuse, or other factors could have altered its sensitivity.

There are also questions about the quality and condition of the original

Anchorage master tape at the time the FBI made its test recordings. I personally recorded a first-generation copy of the master tape in October 1983, shortly after the incident took place. A Federal Aviation Administration source in Anchorage has informed me that by the time the FBI made its test copies several dozen requests to copy the tape had already been granted. Repeated recordings of a tape will degrade its quality.

The point of this discussion is that the FBI's testing was seriously methodologically flawed in that it failed to ascertain and appropriately replicate the conditions at the ARTCC on the night of the incident. Because of this, the Bureau's findings are suspect, and the conclusion that any rendering of the 1434 background conversation should be treated as "pure and unwarranted speculation" is itself wholly unwarranted.

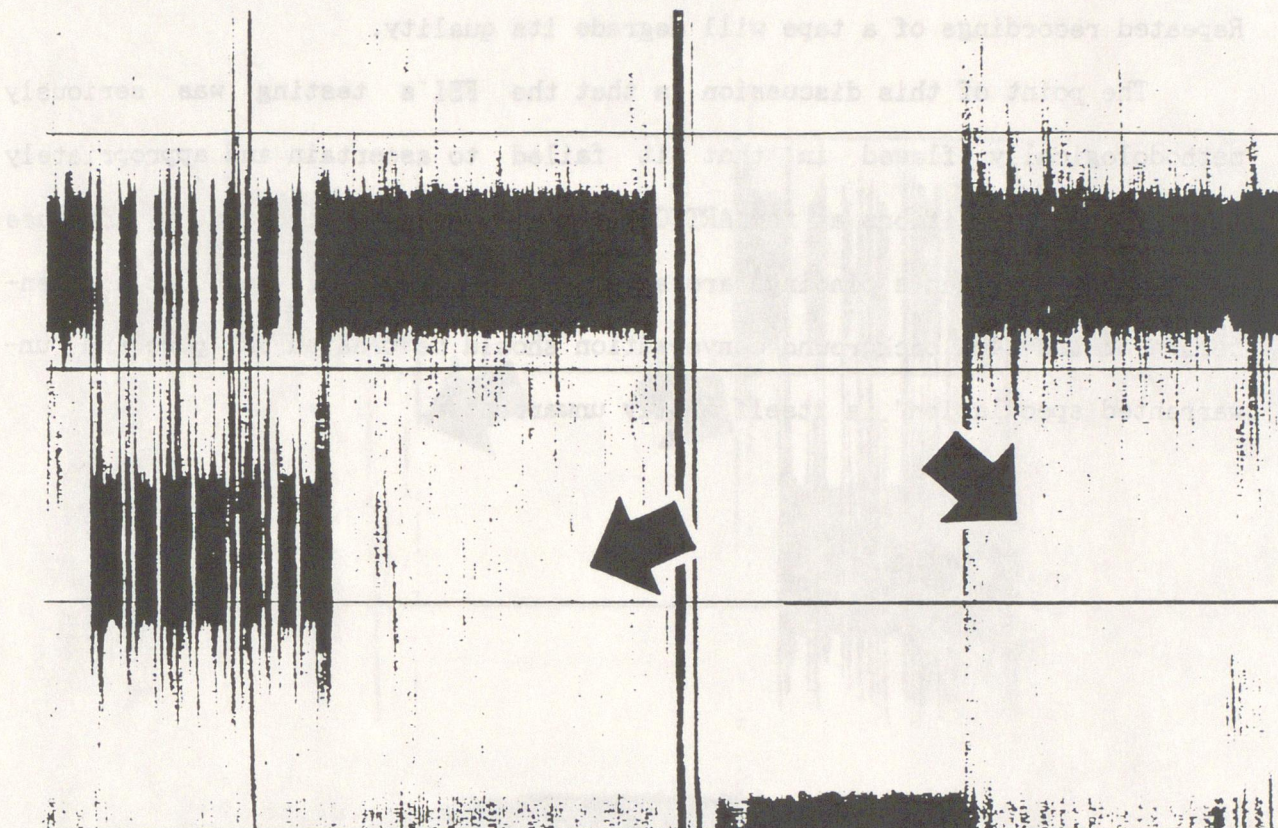
Handwritten: "Click" with an arrow pointing to the right.

The pause between transmissions is shown as an empty white area. On a voice-activated recorder, by definition, a pause should be both preceded and followed by a voice. As indicated by the shaded area, the background conversation is present. The dark band at the top of the recording is the carrier wave. The shaded area at the bottom is the noise floor.

Handwritten: "See 1434 - 2/18/83", "Article 2", "8/18/83", "Amman".

APPENDIX VI

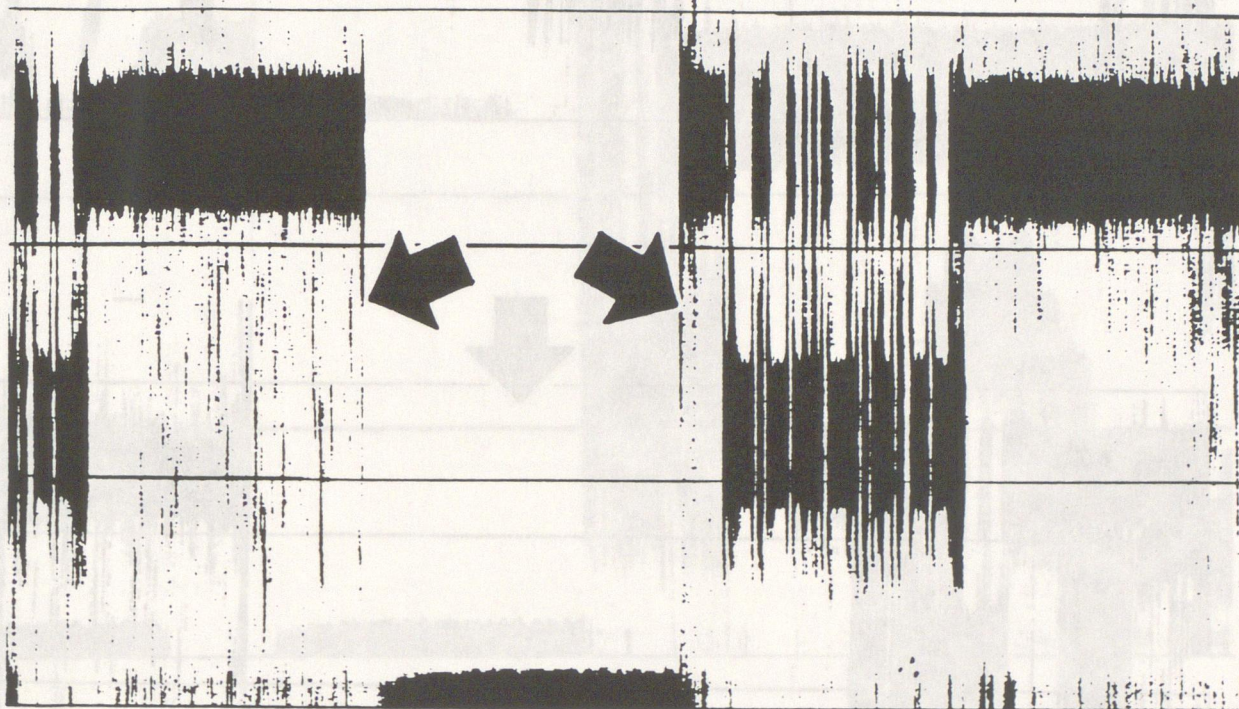
Anchorage master tape at the time the FBI made its test recordings. I personally recorded a first-generation copy of the master tape in October 1983. Shortly after the incident took place. A Federal Aviation Administration source in Anchorage has informed me that by the time the FBI made its test recordings several dozen requests to copy the tape had already been granted.



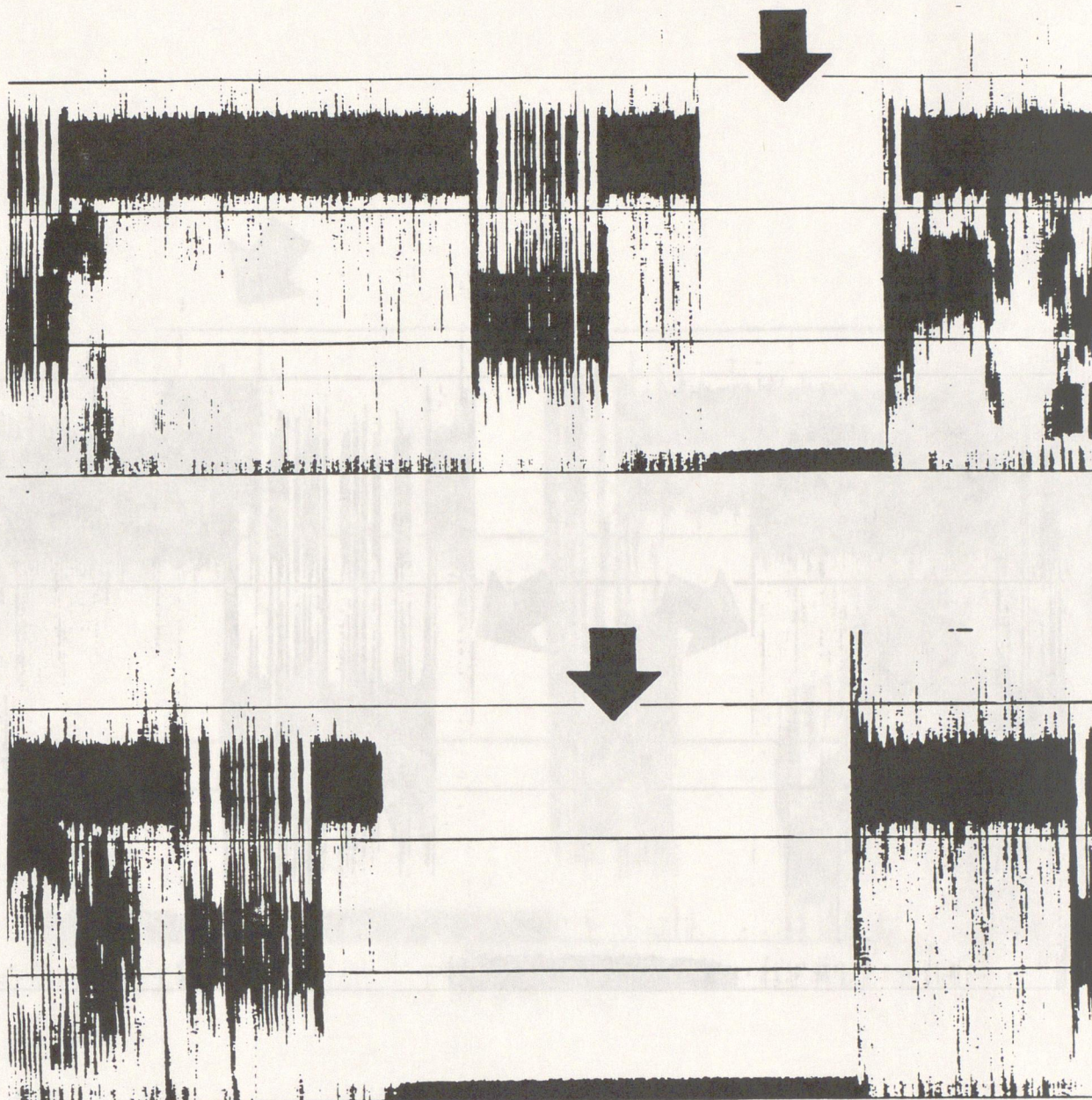
↑ Audible Click

The pause between transmissions is shown as an empty white area. On a voice-activated recorder, by definition, a pause should be both preceded and followed by a voice. As indicated by the arrows, however, no voice is present. The dark band at the top of the spectrogram represents a carrier tone.

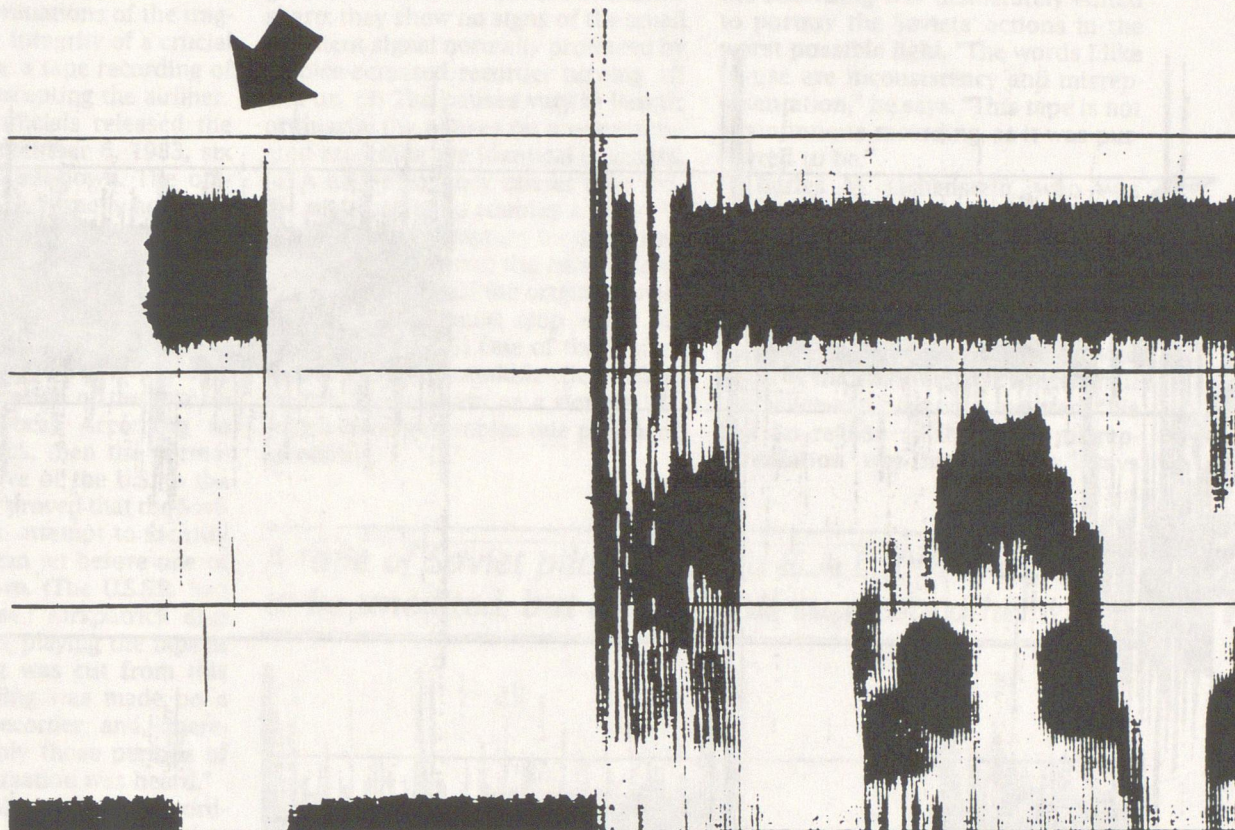
See Hargen
Article - Scientific
American 8/88



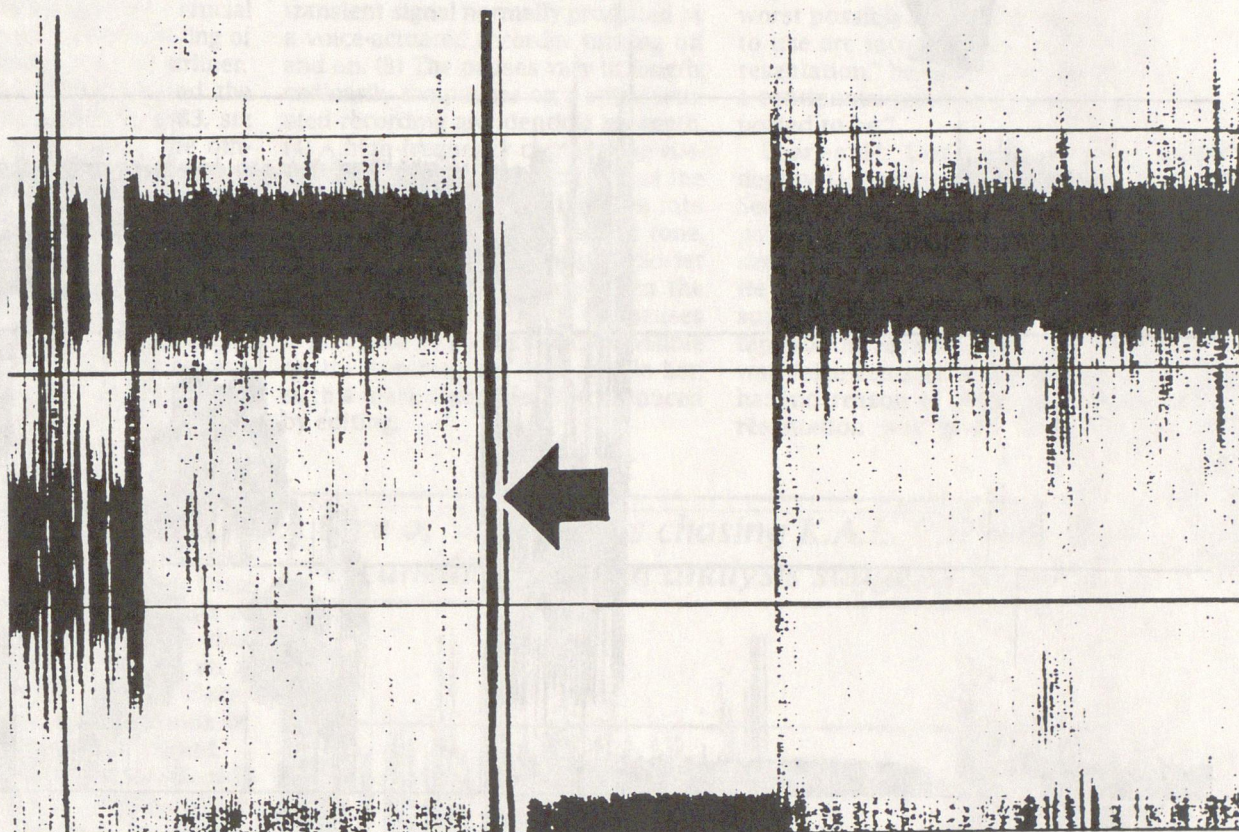
The edges of the pauses between transmissions should not be absolutely sharp, reflecting the brief transit time associated with the voice-activated recorder turning on and off. The pause edges above are abnormally sharp.



A voice-activated recorder should produce pauses between segments of speech that are identical in length. The pauses indicated by the arrows are of markedly different lengths.



A high frequency carrier tone was present as part of the Soviet transmissions. It is represented by a dark band at the top of the spectrogram. The tone should stop when the voice-activated recorder turns off. As indicated by the arrow, however, the tone can occasionally be found intruding into the pauses.



One of the pauses on the tape is preceded by an audible click, represented on the spectrogram as a vertical double bar (indicated above by arrow). This mark closely resembles one produced by editing.

job training. It is ironic, Holmes noted, that in recent years funds for the treatment of other sexually transmitted diseases have been diverted to the fight against AIDS.

K.A.L. 007

Did the U.S. "misrepresent" a key piece of evidence?

Nearly five years after a Soviet jet destroyed Korean Air Lines flight 007, questions still linger. One question not yet raised in the many public examinations of the tragedy concerns the integrity of a crucial piece of evidence: a tape recording of Soviet pilots intercepting the airliner.

White House officials released the recording on September 6, 1983, six days after the shoot-down. The officials never explained exactly how they acquired the recording (they implied that it came from a Japanese signals-intelligence post) or why it lacked transmissions from the ground-based controllers with whom the Soviet pilots were conversing. But the Administration's interpretation of the recording was unequivocal. According to Jeane J. Kirkpatrick, then the permanent representative of the U.S. to the United Nations, it proved that the Soviet pilots made no attempt to identify or warn the Korean jet before one of them shot it down. (The U.S.S.R. had claimed otherwise.) Kirkpatrick also announced before playing the tape at the UN: "Nothing was cut from this tape. The recording was made on a voice-actuated recorder and, therefore, it covers only those periods of time when conversation was heard."

A spectral analysis of the recording suggests it may have been neither voice-actuated nor unedited, according to Lawrence L. Porter, an investigator of aviation accidents who specializes in audio analysis. Porter, who spent 22 years with the Federal Aviation Administration before becoming a private consultant, analyzed the recording for the Fund for Constitutional Government. This nonprofit watchdog group, which was founded by liberal philanthropist Stewart R. Mott in 1974 and is based in Washington, had obtained a tape of the recording from the American mission at the UN.

Porter's suspicion centers on frequent pauses in the recording that, ostensibly, represent points at which the recorder shut off in response to a lull in the Soviet transmissions. The pauses last for only a fraction of a

untrained ear. On a spectrogram, a plot of the frequencies of the various sound waves that make up a sound track, the pauses show up clearly as blank spaces above a thin band of low-frequency noise.

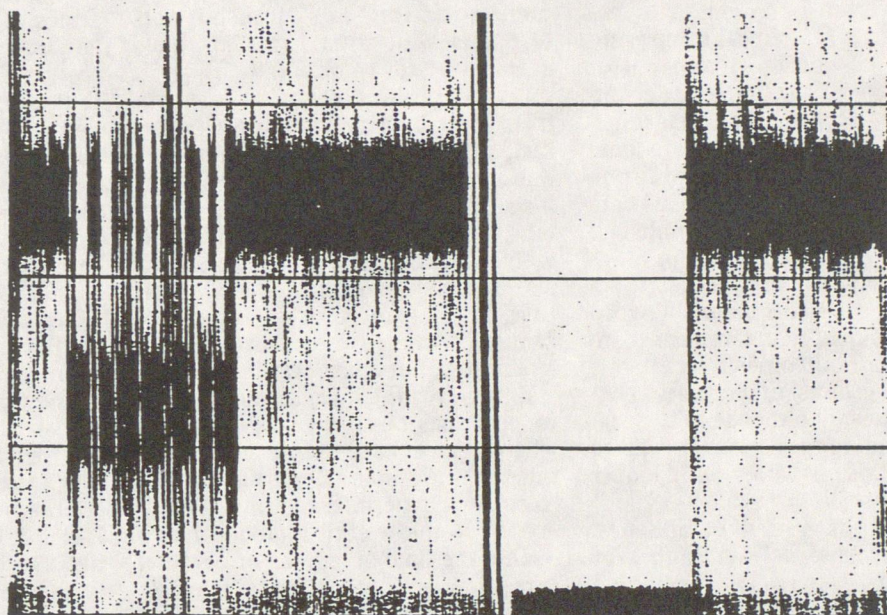
According to Porter, these pauses seem to differ from ones normally produced by a voice-actuated recorder in at least five respects: (1) Some of the pauses are not immediately followed by the sound of a voice, as one would expect of pauses in a voice-actuated recording. (2) The blank spaces produced by the pauses on the spectrogram have borders that are unusually sharp; they show no signs of the small transient signal normally produced by a voice-actuated recorder turning off and on. (3) The pauses vary in length; ordinarily the pauses on a voice-actuated recording are identical in length. (4) A high-frequency carrier tone visible as a dark band running across the top of the spectrogram intrudes into some of the pauses; the carrier tone, since it was part of the original Soviet transmission, should stop when the recorder stops. (5) One of the pauses is preceded by an audible click, visible on the spectrogram as a double bar; such a mark resembles one produced by editing.

Porter is also puzzled by the presence on the tape of brief oscillating tones that recur, for the most part, at one-second intervals. "There is no reason for them to be there," he says. He speculates that whoever made the recording added the tones to mark the passage of time. But, he adds, if that is the case, the intervals between the tones should not vary in length; actually at several points on the tape the intervals between the tones do vary, suggesting material may have been removed or added.

Porter interprets his findings cautiously. He says he cannot be certain the recording was deliberately edited to portray the Soviets' actions in the worst possible light. "The words I like to use are inconsistency and misrepresentation," he says. "This tape is not a continuous recording, as it was purported to be."

Charles M. Lichenstein, who was deputy U.S. representative to the UN Security Council in 1983, helped Kirkpatrick to prepare her dramatic presentation of the recording at the UN. He says the U.S. Information Agency supplied Kirkpatrick and him with tapes of the recording and told them it was voice-actuated and unedited. "We had no reason to think any misrepresentation was made to us," says

A tape of Soviet pilots chasing K.A.L. 007 was said to be unedited, but an analysis suggests otherwise



SPECTROGRAM of a recording of Soviet pilots pursuing K.A.L. 007 shows a click (vertical bar) followed by a pause (empty region). The dark band near the top of the spectrogram represents a carrier tone. A brief oscillating tone (left) periodically interrupts the recording. No speech is detectable in this segment.

← See p. 25-26 of final report

Lichenstein, now a senior fellow at the Heritage Foundation. He suggests, however, that USIA technicians may have edited the recording to "speed it up between voice bursts" and to "get rid of background noise."

John Keppel, manager of the Fund for Constitutional Government's K.A.L. 007 investigation, says Porter's work adds to other findings that suggest U.S. officials may have altered or withheld evidence related to the tragedy. Keppel, who served in the State Department for 22 years, says his own participation in the Eisenhower Administration's effort to conceal the true nature of a U-2 spy plane shot down over the Soviet Union in 1960 taught him "not to believe everything our Government says." He thinks Congress should reopen an inquiry into the 007 affair. Senator Edward M. Kennedy apparently agrees. According to his staff, he is asking the Permanent Subcommittee on Investigations of the Senate Governmental Affairs Committee to examine the role of the U.S. in the tragedy. —John Horgan

What Price Cost Controls? *Hospital belt tightening may be linked to poorer care*

Are government attempts to cut the costs of medical care resulting in poorer treatment for patients? There is abundant anecdotal evidence—stories of particular patients who have received inadequate treatment because of cost-cutting policies—but there is not much hard data on the subject. Now a study published in the *New England Journal of Medicine* shows that in some cases there has indeed been a correlation between strict government-mandated cost controls and poor outcomes for patients: for certain groups of patients, hospitals in states that imposed tight regulations had higher mortality rates than hospitals in states with looser regulations.

The authors of the study, Stephen M. Shortell and Edward F. X. Hughes of Northwestern University, considered two kinds of cost controls, known respectively as rate-review programs and certificate-of-need programs. Under rate-review programs, hospitals are not allowed to increase their yearly revenues by more than a certain percentage each year. The percentage differs from state to state, as do the level of enforcement and the harshness of the penalties that are imposed for exceeding the limit.

Under certificate-of-need programs, hospitals are prevented from spending more than a certain amount of capital on such projects as added beds, new technology or expanded programs; they can exceed the limit if they first obtain a certificate of need justifying the expense. In states that have certificate-of-need programs, the dollar limit on capital expenditure and the difficulty of acquiring a certificate of need vary from state to state.

Shortell and Hughes examined data on Medicare patients receiving care for any of 16 selected conditions in 981 hospitals in 45 states. (They studied Medicare patients because an extensive data base is maintained for patients within the Medicare system.) Having controlled for such variables as the size of the hospitals, their mix of cases and the median incomes of the counties where they were situated, the workers found that the ratio of actual to predicted death rates of hospitals in states with stringent rate-review programs was from 6 to 10 percent higher than that of hospitals in states with less stringent programs. The ratio of actual to predicted death rates of hospitals in states that have strict certificate-of-need programs was from 5 to 6 percent higher than that of hospitals in states with less strict programs. "This is significant," notes Hughes, "because it corresponds with what clinicians have been saying for years."

Do these results mean that cost controls are killing patients? Not necessarily. The study shows a correlation, not a strict cause-and-effect relation; it reveals nothing about why the mortality rates differed between states with strict cost-control measures and states with loose ones. As Shortell says, "There are a lot of things we cannot conclude from our study. It is a first step, not a last step."

He believes the investigation's chief function has been to point out areas where further research is needed. In this study the hospital was viewed as a "black box": the investigators considered only the overall regulatory limits and the final outcomes of hospital care. Now it is time, says Shortell, "to look inside the black box. What are hospitals doing to control costs? We need to develop better monitoring systems to look at patient outcomes and the quality of care."

Shortell adds that such an examination will raise even deeper questions: How can the quality of care be measured? What constitutes an appropriate level of care? Assuming that some cost-control measures can be effected

without harming patients, what is the threshold level at which a further reduction in cost inevitably leads to worse care?

—Ari W. Epstein

PHYSICAL SCIENCES

Complexity Counted?

*Physicists ponder a new way
to measure an elusive concept*

Most people would agree that a rose is more complex than a gas. But how much more complex? And is a rose more or less complex than a fruit fly? Various ways of measuring the complexity of numbers have been proposed in recent decades, but there is as yet no generally accepted measure of the complexity of a physical object.

A possible approach has been outlined by Seth Lloyd and Heinz Pagels of Rockefeller University, who have devised a measure called thermodynamic depth. The measure links complexity with thermodynamics. Lloyd explains that thermodynamic depth was formulated so that it would be zero for totally ordered states, such as the regular array of atoms in a diamond, and also for totally random states, such as the molecules in a gas. It would be high for intermediate states. Another requirement was that attaining complexity should not be easy: two bacteria should be considered less than twice as complex as a single bacterium, since bacteria can make copies of themselves easily.

These requirements and a few other stipulations led Lloyd and Pagels to a concept based on the process by which an object is created. The thermodynamic depth of making a car from scratch, for example, is equal to the thermodynamic depth of making all the parts from scratch plus the thermodynamic depth of putting them together. Technically the present thermodynamic depth of a system is the difference between two quantities. The first is its entropy (a measure of the observer's lack of exact knowledge about the system). The value of the second quantity depends on the amount of information needed to specify all the paths by which the system might have reached its present state from its measured state at some earlier time. There are many possible paths, because the system might originally have been in any one of many different but quite indistinguishable states.