ATTACHMENT 9

Report prepared for this investigation by Dr. Barbara Kanki
(7 pages)

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Reply to Attn of: AFO: 262-4

Malcolm Brenner, Ph.D.
National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington D.C. 20594

Dear Dr. Brenner,

The following is a summary of a communication analysis I performed on the CVR transcript associated with DCA 94 MA 076. The summary focuses on aspects of crew performance which are related to the transcribed speech.

I have been a research psychologist at NASA Ames Research Center for over ten years, conducting and overseeing research in the area of Crew Factors and Crew Resource Management. Although my area of specialization is communication and issues pertaining to information transfer, I am also concerned with task, environment, social, and organizational effects on team performance, leadership and the management of resources. The basic goal of this type of research is to identify how crew factors influence overall team performance so that we can better safeguard against human error and enhance system safety. Most of our crew factors research has focused on aeronautical flightdeck operations, but we have begun to extend this work to other aerospace domains such as air traffic control, aircraft maintenance, and launch operations. In all domains, we are concerned with gaining a deeper understanding of the crew processes which underlie human error, so that effective training and procedural interventions may be developed.

If you have any questions about the following report, please feel free to call. I will be happy to help in anyway I can on this, and any future investigations.

Sincerely,

[redacted]

Barbara G. Kanki, Ph.D.
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MS 262-4
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Communication Analysis
DCA 94 MA 076

Executive Summary

This discourse analysis of the CVR (cockpit voice recorder) transcript (DCA 94 MA 076) focuses on task-related speech, procedural speech, and nontask-related speech. Task-related speech occurs during 30.5 minutes of routine flight and 25 seconds of emergency. During routine flight, patterns of requests for information and their responses are analyzed as an indicator of how the crew coordinates their task activities and obtains the information they need. While there is not an abundance of data (speaking turns), this aspect of crew performance can be described as complete, cooperative interactions among the flightcrew members and air traffic control (who is also part of the communication loop).

During emergency phase, speech is analyzed as an indicator of the problem solving process. Unfortunately, speech during these 25 seconds is minimal and often fragmented. Although abbreviated speech may be adequate for successful communication in some situations, it makes an analysis very difficult. A lack of contextual information including linguistic completeness and access to nonverbal behaviors contribute to the ambiguity inherent in the speech. Consequently, speech analysis alone is inadequate for judging crew response to the emergency.

Procedural speech is interpreted as an indicator of crew adherence to regulations, policies and protocol. Throughout the transcript, procedural speech (ATC communications, checklist and PA announcements) generally appear to fall within expectations. Finer distinctions with respect to procedural speech would have to be provided by the FAA or the company who may have a more detailed understanding of the regulations and policies.

Finally, nontask-related speech is interpreted as an indicator of the cockpit atmosphere and interpersonal relationships among the flightcrew members. Instances of nontask-related speech, or social communications are normal and responsive. There is casual, friendly interaction among both pilots and flight attendant, implying that, at least on a professional level, there is no particular social barrier or problem that would impede their working together during the emergency.

Background

Voice communications may be analyzed in a variety of ways but their interpretation and significance always depend upon the context in which they occur. At least three types of context may be relevant: 1) the physical context, 2) the social/organizational context, and 3) the context of the operational task (see Attachment 1). For example, a communication analysis may focus on acoustic features of human vocalizations in order to discover patterns which are indicators of the individual's physiological state (Belan, 1995; Mayer, Brenner & Cash, 1996). The significance of emergent patterns would depend upon where and when in the event and task sequence they were found.

This report focuses strictly on the discourse level of voice communication. As such, only the content and patterns of verbal speech are of direct concern. Vocalizations (e.g., inhale/exhale, outcries, laughter) and acoustic aspects of speech (e.g., pitch, loudness, frequency) are omitted from this analysis. Because verbal communication is so often the means by which flightcrews perform their tasks, patterns of speech are potential indicators of how crewmembers coordinate their work, how they relate to each other and others in the system. In some cases, speech itself *is* the action taken, such as conducting a briefing or performing a checklist. Again, the interpretation and significance of what is said depends on what we know about the physical, social/organizational and task contexts. In addition, we must consider the linguistic context of what is spoken because speech is also influenced by formal and informal rules of language, rhetoric, rules of interaction, and possibly one's culture and individual speaking style.

Discourse Analysis

As shown in Figure 1, this discourse analysis considers three types of speech acts: task-related speech, procedural speech (which is a standardized form of task speech), and nontask-related speech. The corpus of speech analyzed is the entire CVR transcript which is approximately 30.5 minutes of routine flight and 25 seconds of emergency. Because there is so little time during the emergency phase, the speech patterns established during the routine phase are used to describe aspects of the crew to that point.

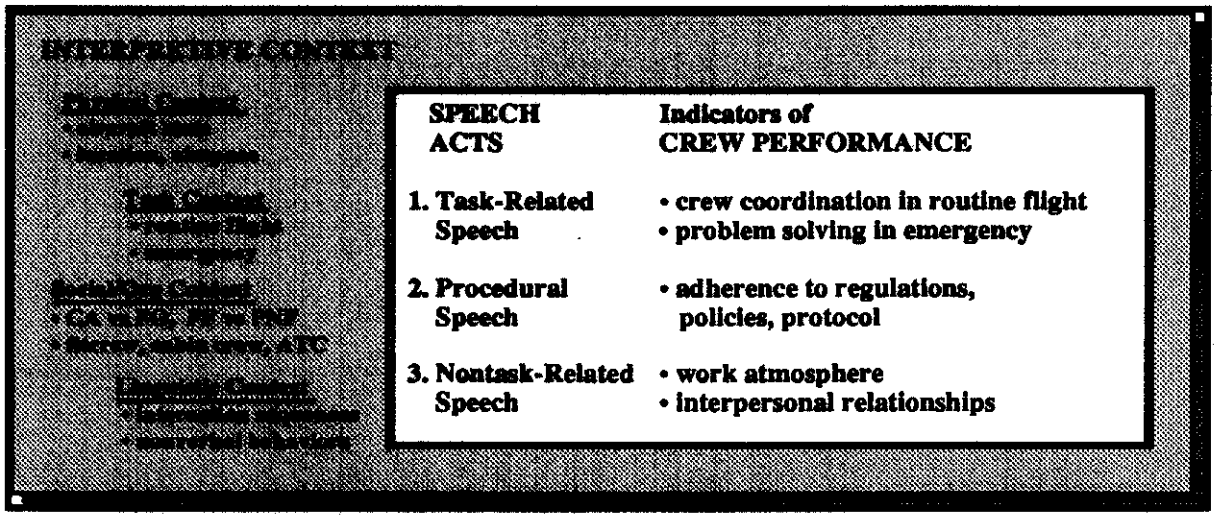

Figure 1: Elements of Discourse Analysis

Speech is coded with respect to their speech act functions (e.g., statement, re-statement, question, answer, verification, command, acknowledgment), and patterns are explored in order to describe the way in which the crew is working together, coordinating their workload, confronting the emergency, etc. (see Kanki & Palmer, 1993). Interpretation of patterns depends on whether there is enough contextual information available to support or rule out alternative explanations. In this analysis, 1) task-related speech is analyzed in order to describe crew coordination during the routine flight conditions and problem solving during the emergency conditions; 2) procedural speech is analyzed in order to describe adherence to regulations, policies and protocol; 3) nontask-related speech is analyzed in order to describe the general cockpit atmosphere and interpersonal relationships among crewmembers.

Task-Related Speech in Routine Flight

At a simple descriptive level, much of the captain's speech is devoted to air traffic control (ATC) communications. However, in addition to ATC speech, the remainder of his task-related speech consists of six task observations, one statement of intent and one suggestion/directive. Responses by the first officer to these statements are exceptionally high (i.e., no completed speech by the captain is left hanging or un-acknowledged). There are fewer first officer speaking turns since he is not handling ATC. Thus, his entire pattern of task-related speech consists of three task observations, five questions/verifications, one statement of intent, and one suggestion/directive. Consistent with the first officer, the captain responses are high, especially in cases of question/ verifications (see below).

Crew Coordination.: One indicator of crew coordination is the pattern shown by the pilots in their requests for information and verification. Since these are potential areas of miscommunication, the completion of these task-related communication sequences is important. From this transcript, the following general pattern is shown: when a question or request for verification is initiated, the other responds immediately, except for outside interruptions. On task-related topics, the first officer (F/O) initiates questions to the captain (C) 5 times, and the C initiates questions to the F/O once (see Table 1). Since all of the questions are requests for clarification or verification regarding ATC instructions or ATIS, and C is handling radio communications, it is reasonable that he is the responder more often than the initiator. Both C and F/O resolve the questions in all cases, and ATC is considered an integral part of the communication loop. There is no apparent reluctance to seek or incorporate information from each other or ATC. Assessing these patterns on the basis of pilot and ATC roles in routine operations, level of coordination and communication appears to be adequate for accomplishing the task. At the point at which the emergency begins, there is no question or verification issue left unresolved.

Time	Initiation	Response	ATC/ATIS Context
1851:08	F/O: Verification *ten Cutta*	C: Verified	CLE4 1850:56
1851:57	F/O: Verification *32 & 28R*	C: Verified	ATIS 1851:22
1856:45	F/O: Question *210 or 250*	C: Acknowledged - to be verified	CLE4 1856:16
1857:26	F/O: Question *speed?*	C: Answered - via ATC response	APR 1857:23
1857:40	C: Question *runway?*	F/O: (?) - plan for 28R	APR 1857:23
*1901:04	C: Question *28L?*	APR: Answered 28R	"
*1901:10	C: Re-statement *28R*	F/O: Acknowledged 28R, as planned	APR 1901:04
1900:31	F/O: Question *temperature?*	C: Answered 75	ATIS 1851:22

* Note: These are not new items; they follow up on the previous question

Table 1. Task-related questions and verifications.

Task-Related Speech in Emergency

Assuming the emergency phase begins when crewmembers notice a problem (approximately 1902:57.5),the amount of analyzable speech is very small (primarily speech fragments, repetitions and expletives). However, since crew performance would logically be focused on responding to the emergency and solving the problem, the speech fragments from 1902:57.5 to the end of the transcript are categorized according to how they relate to the problem solving process.

Problem Solving Process: For the purposes of this analysis, we assume that a completed problem solving process has at least three steps:

1) recognition that there is a problem
2) identification of the problem
3) response to problem, immediate and/or strategic.

While it is reasonably clear that the crew recognizes a problem exists, it is never clear after this point, that either pilot reaches step 2 and identifies the problem. According to Lipshitz (1993), most theories of naturalistic decision making consider 1) situation assessment and 2) understanding the context surrounding the decision process as critical elements in decision making. In this sequence, verbal evidence of either would contribute to accomplishing step 2.

However, in the transcript of 25 seconds of emergency phase, there is no verbal evidence that clearly reveals the C or F/O's explicit assessment of the situation or problem context. Rather, C mostly speaks in speech fragments and directives, and there is no speech by F/O other than expressives and expletives. While the F/O vocalizations and the C's directives appear to be responses to *something*, there are no stated referents. Therefore, we cannot know whether these actions are responses to an *identified* problem. Furthermore, because there are no explicit statements made, we cannot know whether both pilots are responding to the same thing.

"Hang On" Sequence: Because the referent of the "Hang On" sequence is left unstated, the linguistic context is ambiguous; that is, more than one interpretation is possible. In theory, the referent of "Hang On" can be literal; for example, the F/O should "hang on" to *something*. However, it may also be *monitoring* speech; for example C may be monitoring:

1) his own mental activity (e.g., meaning wait, I'm thinking)
2) an external activity (e.g., watching for the aircraft to respond in a certain way)
3) the other's activity (e.g., watching the consequences of the F/O's actions)
4) any combination of 1-3.

If C is in the process of assessing the situation in order to identify the problem, any of these monitoring alternatives would be a possible means of obtaining an answer. Clearly a conclusive answer has not been reached at 1903:08 (C: *what the hell is this*), but even this statement could be a part of a problem identification process if more time was available.

It is not unusual to leave out the referent of a statement. Pronouns, for example are used routinely to stand for nouns. In situations in which the physical context is shared by the interactants, it is particularly compelling to leave out referents because they may be obvious. Since we cannot see the pilots, we cannot know the nonverbal behavioral context for their speech. Speech may be accompanied by gestures, pointing, looking, and/or specific actions (see Segal & Jobe, 1995). External conditions may be so compelling in this situation that stating the referents would be highly redundant. We have no way of knowing from the words alone whether the C and F/O are completely in tune with each other and therefore don't need to use referents and complete sentences or whether they are responding to different aspects of the situation. Because the pilots seem to have been cooperative and responsive to each other within the last 30 minutes, there would not seem to be any interpersonal barrier to their being in tune with each other at this time.

On the other hand, the emergency conditions themselves may be pulling their attention in different directions. In either case, the communications and actions may be altogether appropriate.

A clear interpretation is not possible because so much of the speech is inherently ambiguous. Even if we knew more about the physical and task context, we still could not assume the meaning of unstated referents. A videotape of the cockpit might provide partial evidence, but it would not guarantee that the missing information would be visible. In short, interpretability of speech during this phase is severely limited and cannot provide strong evidence for evaluating crew response to the emergency.

Procedural Speech

With respect to adherence to standard operating procedures in communication, both pilots generally follow the expected protocols (ATC communication, checklist, PA announcement). More precise adherence to regulations and policies is more appropriately evaluated by the FAA and company. There are several repeated clarifications and verifications of ATC instructions and ATIS information, but as mentioned earlier, these questions are resolved in routine fashion.

Nontask-Related Speech

Socially, the communications are not out of the ordinary. The pilots seem to be responsive and friendly with each other and with the flight attendant. There is normal joking and casual conversation. I am making no assumption that these individuals are actually friends; merely that they are behaving in a normal interaction, in a socially acceptable manner. Non-responsive behavior would include joke attempts, and other nontask-related statements which are met with either "no response" or a response that shuts down the interactive dialog. Instead, nontask statements are met with laughter, acknowledgments and statements that keep the conversation going and participants engaged. Nontask conversation is curtailed when task activities accelerate

References

Belan, A. S. (1995). The main directions of CVR data analysis during the accident/incident investigation. *In Proceedings of the International Aerospace Congress, IAC'94*, Moscow, Russia (pp. 160-165).

Kanki, B. G. & Palmer, M. T. (1993). Communication and crew resource management. In E. L. Wiener, B. G. Kanki, & R. L. Helmreich, (Eds.) *Cockpit Resource Management,* San Diego: Academic Press, pp. 99-136.

Lipshitz, R. (1993) Converging themes in the study of decision making in realistic settings. In Klein, G. A. Orasanu, J. Calderwood, R. & Zsambok, C. E. (eds.) *Decision Making in Action: Models and Methods*. Norwood, NJ. Ablex Publishing Corporation, pp. 103-137

Mayer, D. L., Brenner, M. & Cash, J. R. (1996). Development of speech analysis protocol for accident investigation. In B. G. Kanki, O. V. Prinzo & S. Schiflett (eds.) *Proceedings of Methods and Metrics of Voice Communications Workshop*, San Antonio, TX, pp. 87-91.

Segal, L & Jobe, K. (1995). On the use of visual activity communication in the cockpit. In *Proceedings of the 8th International Symposium on Aviation Psychology*. Columbus, OH: Ohio State University, pp. 712-717.

INTERPRETIVE CONTEXT	ACOUSTIC ANALYSIS sounds & vocalizations	DISCOURSE ANALYSIS speech
Physical Context includes the ambient environment, (noise, light), external conditions, equipment, communication media **Social/Org. Context** includes the speakers and hearers: crew members, PAX, ATC and the roles they represent **Task Context** includes crewmember actions, operational conditions, phase of flight, procedures **Linguistic Context** includes grammatical, pragmatic & rhetorical patterns; interactive & individual styles (e.g. formality, mitigation)	**Flightdeck Sounds** • flight control sounds • alerts & warnings • systems, engines, etc. • radio noise, static **Outside Flightdeck Sounds** • cabin, cargo • external environment **Human Vocalizations** • inhale/exhales, grunts • yawns, laughs • vocal aspects of speech: frequency, intensity, etc.	**Task-Related Speech** • statements & observations • questions & answers • commands & suggestions • acknowledgments • resource management • repetitions • expressives & expletives **Procedural Speech** • briefings & checklists • ATC communications **Nontask-Related Speech** • social topics • joking

Attachment 1: Elements of Acoustic and Discourse Analysis