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INFORMATION BEHAVIOR AMONG COMMERCIAL AVIATION CFIT ACCIDENT FLIGHTCREWS: TRANSCRIPT ANALYSES

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Human Information Behavior (HIB) has been described as the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking and information use. This includes face-to-face communication as well as passive information reception, with no intention to act on the given information. Distributed use of information on the flightdeck remains a weak link between actual information, the meaning given to information, and the sensemaking involved between individuals and groups. Often times commercial aviation accident reports point to a breakdown in CRM with no indication of *how* the breakdown occurs. This work attempts to distinguish how this breakdown may occur through understanding Crew Information Behavior (CIB) on the flightdeck. This work uses principles of Information Science to analyze how commercial flightcrews involved in CFIT accidents (fail to) make use of essential, safety critical information, by analyzing the related accident transcripts though the use of a information grid. This work serves as a way to operationalize CRM measurements through understanding the social practice of information structuring and communication patterns within the distributed collective practice of the flightcrew. From this, researchers may be able to identify the role information (needs, seeking, and use) plays in critical communication patterns related to supportive or ineffectual infrastructure used in the negotiation of meaning on the flightdeck.

Introduction

Estimates point to human error contributions in 80% of all aviation accidents through such particulars as captain's authority, crew climate, and decision skills (Dismukes, et.al, 1999). While advanced equipment has been placed on the flightdeck to aid pilot flight duties, improving access to information, it has not necessarily improved the *use* of information. A case in point is the persistence of Controlled Flight Into Terrain (CFIT) accidents, in which aircraft with no mechanical problems are flown, under control, into terrain without awareness on behalf of the crew (adapted from Wiener, 1982). While CFIT can occur in any phase of flight, it is most prevalent in the approach and landing phase of flight (FSF, 1999). It is not the fact that CFIT happens often, which it does not, it is that when it happens, it has a high fatality rate, usually owing to the speed of the aircraft upon impact. CFIT ranks as the third leading cause of fatalities among US air carriers, and the second among foreign carriers (FAA, 2000).

Studies have accounted for CFIT on a cognitive level (e.g Loomis & Porter, 1983; Phillips, 1996) and pointed to more and improved technological infrastructure as a fix, yet CFIT remains to be understood on the level of the information ecology of the flightdeck, or the distributed collective practice on behalf of the flightcrew embedded in the socio-technical system. Distributed use of information on the flightdeck remains a weak link between actual information, the meaning given to information, and the sensemaking involved between individuals and groups. Often times commercial aviation accident reports point to a breakdown in crew resource management (CRM) with no indication of *how* the breakdown occurs. Stone & Babcock (1988) point to numerous accident investigations that identified discrepancies in the division of duties between crewmembers, information sharing, and communication of pilot operating intentions as factors leading to these accidents. By understanding CFIT as the process of assessing information in a collective team, errors in the breakdown of information across the team may become more apparent. Employing cross-disciplinary methods to understand critical features of crew information integration that are not understood in relation to these avoidable accidents, where information is present yet not heeded, may contribute to enhancing crew CFIT training.

The Distributed Flightdeck Environment

For crews involved with flying an airplane, there is constant need for continual information to update their flight status or situation awareness. The information is constantly changing, with limited resources and a limited amount of time in which to perform information searching. Hutchins (1996) notes that information flow in critical operations follows a specific agenda. Individual team members seek and communicate knowledge in accordance to their own position and performance of routine procedures. Processes may be designed for a specific purpose, but it is how these processes are implemented and used across the team that

determines their success. According to Hutchins "social organizational factors often produce group properties that differ considerably from the properties of individuals." Thus flightcrews have incorporated a set of heedful interactions, usually in the form of CRM protocols that provide a standard framework in which to conduct flights. Weick & Roberts (1993) discuss heedful performance as different from that of habitual performance. In heedful performance, people are still learning.

Historically, information needs on the flightdeck have been studied through the lens of individual cognition, performance and perception. In recent years, the focus has begun to shift to the study of what Clark (1996) refers to as joint activity, recognizing that working in the external system, the act of communication and understanding, complements traditional approaches to (cognitive) behavior. Hutchins' (1995) work with intercockpit communication suggests that in collaborative tasks the appropriate unit of analysis is the distributed cognitive system of human and system actors, technological artefacts and external information representations. Taking this idea further, Kling (1999) notes in his discussion of social informatics that the research focus of many information ecologies necessarily needs to shift toward, "the interdisciplinary study of the design, uses and consequences of information technologies that take into account their interaction with institutional and cultural contexts." Nardi and O'Day (1997) define information ecology as a system of people, practices, values, and technologies in a particular local environment. In information ecologies, the focus is not on technology, but on human activities served by technology. The flightdeck represents an information ecology, incorporating not only the physical representation of cognitive artefacts, but the distributed collective practice of engaging in the activity that is flying an aircraft. As noted by Bar-Yam (1997), "to understand the behaviour of a complex system we must understand not only the behaviour of the parts but how they act together to form the whole."

The social characterization of information also implies an important dimension of study on the flightdeck, the linguistic dimension. According to Bakhtinian theory, language is not something added to a society, but it is its very essence, the way of being (Morson & Emerson, 1990). Our thoughts are constrained by the precise language to which we have been socially acclimatized, the social norms and the history we have shared with others. Therefore, it can be said that people act out of their beliefs, not just their situation. Information is a representation, relative to a social and/or practical pre-understanding. The onus is upon the human agents for this awareness.

Since communication on the flightdeck is primarily non face-to-face (pilots rarely turn and look at each other when speaking, instead focusing attention on instruments or the external environment), the information ecology of the flightdeck then, may be studied through the use of crew language as a tool to understand the distributed practice of the flightcrew. With regard to aviation, these concepts are important to the recognition of where acting out of standard procedure ends and heedful interrelating begins.

Integrating Information Science

There are indications in CFIT accidents, however subtle or glaring, about the perilous state of the aircraft trajectory. Through the use of communicative analysis, can it be determined if there is a consistency among the way CFIT accident flightcrews search for information?

Human Information Behavior (HIB) has been described as the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking and information use (Wilson, 2000). This includes (face-to-face) communication as well as passive information reception (e.g. viewing TV advertisements), with no intention to act on the given information. Marchionini (1995) describes information seeking as, "a process in which humans purposefully engage in order to change their state of knowledge." Ellis (1989; Ellis, et. al., 1993) proposes a general model of information seeking behavior as: starting, chaining, browsing, differentiating, monitoring, and extracting. *Starting* comprises activities that form the initial search for information, identifying sources that could be used for information. These sources are likely to point to, suggest, or recommend additional sources or references. *Chaining,* as a way to follow up on initial sources, can be backward or forward. Backward chaining takes place when pointers from an initial source are followed. Forward chaining takes place through identifying and following up on other sources that refer to an initial source, thus broadening a search. *Browsing* is semi-directed or casual search in areas of potential interest. This is looking for information at the micro-event level and remaining unconstrained, or open to serendipitous findings; finding new connections or paths to information. *Differentiating* refers to filtering and selecting from

among identified sources scanned, by noticing differences between the nature and the quality of the information offered. Differentiating is likely to depend on prior experiences with sources, or recommendations from others. *Monitoring* refers to keeping abreast of developments in an area through regularly following particular, or core, sources. *Extracting* is the process of systematically working through a particular source or sources to identify material of interest, directly consulting a source and using the information provided.

Ellis updated this work in 1997 adding features of *filtering, verifying, ending*, and improving upon the original distinctions of *starting* and *differentiating*. *Filtering* capitalizes on personal criteria or mechanisms used to increase information precision and relevancy. This can involve restricting a search for information. *Verifying* is where the accuracy of information is checked. *Ending* refers to the conclusion of the information seeking process. Ellis improved upon the feature of starting to *surveying*, which further stresses the activity of obtaining an overview of the subject terrain or key sources of information. Differentiation has been changed to *distinguishing* (or discriminating) where information sources are ranked, including noting where information comes from. Ellis notes that information channels, such as discussions or conversations, as well as secondary sources, are normally ranked higher than primary sources.

An Information Behavior Model

In a study using information seeking frameworks as a background to examine thepractice of researchers using the World Wide Web, Choo, Detlor & Turnbull (2000) focused on behavioral models of information seeking to describe the process a user follows to satisfy an information need. While this study dealt with the behavior of experienced web researchers, it lends itself to adaptation into a behavioral framework with which to study HIB practice on the flightdeck. Choo, et al., incorporated a separate category of research on this topic, rooted in organizational science. Originally based on fieldwork by Aguilar (1967) and expanded by Weick and Daft (1983), this work suggests that organizations scan in four distinct modes: *undirected viewing, conditioned viewing, informal search,* and *formal search*. *Undirected viewing* refers to scanning broadly with no specific information need in mind, with the overall purpose to detect signs of early change. *Conditioned viewing* refers to viewing information about selected topics or certain types of information. The purpose is to evaluate the significance of the information in order to assess its impact on the system. *Informal search* refers to actively look for information that involves a relatively limited and unstructured effort, to elaborate an issue and determine action. *Formal search* refers to deliberate or planned efforts to obtain specific information about particular issues, following a pre-established procedure; the search is focused and systematic.

In their study, Choo, et. al., amplified the information seeking implications of each of the aforementioned modes by elaborating on how directed the scanning would be and the amount and kind of effort expended by combining the aspects of these models into a multidimensional framework (figure 1). On one axis, the four scanning modes, on the other, the categories of information seeking behavior identified by Ellis.

Scanning Modes	Information Need	Information Seeking	Information Use
Undirected Viewing	General areas	**Sweeping**	**Browsing**
Conditioned Viewing	Topics of interest	**Discriminating**	**Leaning**
Informal Search	Formulate queries	**Satisfying**	**Selecting**
Formal Search	Specify targets	**Optimizing**	**Retrieving**

Figure 1. Modes of scanning. *From Choo, Detlor & Turnbull (2000).*

Crew Information Behavior (CIB) is (necessarily) different that that of web users. Among other factors, there are limited resources and a limited amount of time in which pilots have to perform a search. Pilots frequently have to make decisions based on incomplete information and must choose what appears to be the most favorable option among the choices present at that time in space. The behavioral model was updated to reflect actual practice in the aviation environment (figure 2). Simon's term "satisficing" is used here (rather that "satisfying") to address the boundedness of information available at any given time (Simon, 1956). Pilots must either exploit their current information, or take time to explore another path of information, which may or may not prove to be helpful (i.e. March, 1996). To better illustrate the dynamic process of CIB, Marchionini's (1995) term e*xtracting*, as opposed to r*etrieving*, was added. *Extracting* bears more resonance with pilot duties in that it refers to using information by reading, scanning, listening, etc. As information is extracted it is manipulated and integrated into the domain. Mode descriptors such as viewing and searching were also dropped, as the relationship of discursive data does not lend itself to the characterizations of viewing and searching.

GROUP INFORMATION GATHERING PATTERNS/NEED	GROUP INFORMATION SEEKING	GROUP INFORMATION USE
UNDIRECTED General areas monitored Informal communication/viewing No specified information need Passive attention	**DISTRIBUTED SWEEPING** Broad scan of many & various sources Detect change signals Take advantage of easy accessibility	**DISTRIBUTED BROWSING** Serendipitous discovery from a large number of different sources and different types of sources
CONDITIONED Areas of interest (trends) recognized Habitual communication/viewing patterns Passive search/recognition (schema)	**DISTRIBUTED DISCRIMINATION** Browse in pre-selected sources (instruments) using pre-specified protocols to acquire information	**DISTRIBUTED LEARNING** Increase/Communicate knowledge about areas/events of interest/relevance
INFORMAL/UNCONSTRAINED Broad search areas Simple queries formulated/addressed Active search	**DISTRIBUTED SATISFICING** Search is focused on a bounded (limited) area or instrument. A good enough search is satisfactory	**DISTRIBUTED SELECTION** Increase/Communicate knowledge on area within narrow boundaries, verify
FORMAL/METHODICAL Specific, detailed targets sought Ongoing search, update, expand	**DISTRIBUTED OPTIMIZATION** Systematic gathering of specific information, following some method or procedure (checklists)	**DISTRIBUTED EXTRACTING** Formal use of relevant information for decision making or course of action

Figure 2. Crew Information Behavior grid.

Method

Based on the research of Choo, Detlor, and Turnbull (2000) a multidimensional framework was adapted to examine the cockpit voice recording (CVR) portion of CFIT accident transcripts for Crew Information Behavior using qualitative discourse analysis coupled with quantitative measures. Crew discourse was analyzed for instances of information gathering or need, information seeking, and information use. The transcribed 10-minute segment directly preceding the accident was used in the analysis.

In this study, transcript dialogue was broken down using a bracketing scheme (Wang and Waibel, 1997). A bracketing scheme breaks dialogue into sequences of segments, or speech acts. Each speech act can then be labeled according to a predefined set of parameters, in this case crew information behavior. A random set of 10 commercial aviation CFIT accident transcripts were qualitatively analyzed and marked for instances of CIB. The last 10 minutes of each CVR transcript was used as this most often represents the critical time when the flight is nearing terrain and would allow plenty of time for recognition and evasive action. Instances of conversation not pertinent to the disposition of the flight (e.g. "Can I get a cup of coffee?") were excluded from coding. These codifications were then transferred to the data grid and assessed quantitatively for crew information behavior.

Results and Discussion

The highest occurrence of CIB among CFIT accident flightcrews was Selecting at 30%, followed by Extracting at 16%, Optimizing at 13% and Methodical gathering at 12% (figure 3). In Distributed Selection, crews are engaged primarily in communicating and increasing knowledge within narrow boundaries, and verifying data. When crews are Extracting, they are engaged in formally using relevant information for decision-making or in executing a course of action. Crews engaged in Optimizing are formally, systematically gathering specific information or following a specific procedure, such as a checklist. Methodical gathering refers to seeking specific details on prior relevant information, actively searching to update and expand the information. This portion of the grid (figure 3,

dark gray) features localized extracting, characterized by participants searching directly where they expect to find results/hard data (such as the flight director). These formal episodes most frequently feature intensive and thorough extraction and monitoring, characterized by working through metadata representations and checklists to determine the important available information about an item. This suggests that crews are searching where they expect to find information, but where the quality of information needed to update their situation awareness to avoid CFIT may not be present or correct.

Information Need	Information Seeking	Information Use
Undirected <1%	Sweeping 2%	Browsing <1%
Conditioned 1%	Discriminating 7%	Learning 8%
Unconstrained 5%	Satisficing 5%	Selecting 30%
Methodical 12%	Optimizing 13%	Extracting 16%

Figure 3. CFIT crew information behavior.

The next highest set of results center around the categorizations of Learning (8%), Discriminating (7%), Satisficing (5%), and Unconstrained searching (5%) (Figure 3, light gray). In distributed Learning, crews are attempting to increase their knowledge and communicate relevant events. When crews are Discriminating, they are using standard operating procedure, or running through pre-specified protocols to acquire more information and differentiate it based on what was previously known. Satisficing involves a bounded, or good enough, search; to find useable information, whether complete or not, is the goal. Gathering information through an Unconstrained Search, crews tend to form broad questions that can be easily answered while actively seeking new information.

The lowest set of results falls in the general and more passive areas of Sweeping (2%), Browsing (<1%), Undirected (<1%), and Conditioned (1%) information behavior. These areas feature starting and chaining as the most frequent activities, usually with back and forth movement, general recognition of trends, and chance discovery from varied sources.

The data was further reduced to assess differences in accidents where Ground Proximity Warning Systems (GPWS) alerted the crew before impact (figure 4). Five of the accident crews were alerted by GPWS. A comparison of the CIB between these accidents resulted in no statistically significant difference between scenarios. This is actually not surprising sine the GPWS in each case sounded only seconds before each impact, with only a small amount of discussion after the alert and before impact.

Information Need	Information Seeking	Information Use
Undirected <1% | <1%	Sweeping 1% | 1%	Browsing <1% | <1%
Conditioned 1% | 1%	Discriminating 3% | 7%	Learning 6% | 9%
Unconstrained 5% | 5%	Satisficing 5% | 5%	Selecting 36% | 28%
Methodical 11% | 12%	Optimizing 13% | 13%	Extracting 18% | 18%

Figure 4. Comparison of GPWS | NonGPWS alerted crews in CFIT accidents.

What is most striking about this data is what is *not* there. This study suggests that socially CFIT accident crews use a low percentage of undirected, sweeping behaviors, preferring to employ formal patterns and rules for information seeking when assessing situations. On those occasions when CIB falls into the realm of undirected, sweeping or browsing type behavior, it is met with a habituated response, bringing it back to the more formal, systematic areas of CIB. While crews are trained to stick to protocols and when in doubt consult a checklist or manual, this socially constructed habituated information practice may limit the use of information and provide a barrier to seeking new information. This appears to operate paradoxically with crew resource management (CRM) protocols. While CRM instructs crews to validate and verify information (which these crews appear to do), it also calls for employing any and all resources for the safe and efficient handling of a flight, which means thinking and acting outside the box. In these examples, it must be noted that while the quality of information from the instruments was generally high, the quality of the information ecology was generally low. Which is to say, crews were making decisions based on high quality signals from their environment, but on low quality assessments about the information. Had they practiced undirected or sweeping information behaviors sooner, they may have detected the quality mismatch and noticed their situation assessment was faulty.

Conclusion

This study goes beyond the large body of literature in cognitive psychology relating to aviation operations and CFIT. This study suggests that *socially*, pilots appear to maintain a standard of information behavior

as a form of established pattern. Methodical, formal searches and uses of information appear to be preferred to those of a more undirected, sweeping nature. It is suggested that this socially constructed communicative practice may limit the distributed use of information, providing a barrier to seeking new information, thus partially hampering CRM efforts. While this may hold true for CFIT accidents, future research in this area may shed light on differences in information behavior between accident involved flight crews and non-accident involved flight crews. Work is currently underway to discern if there exist differences in the information practice of flight crews in non-CFIT accidents and those who do not have accidents (with the latter performed in a simulated environment). Early results of this research are promising, suggesting that there are differences in crew information behavior.

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The following official CVR transcripts were used:
EAL Flt 401, Everglades, FL, 29 Dec 1972
World Airways Flt 802, King Cove, AK, 8 Sep 1973
Air NZ Flt 901, Mt Erebus, Antarctica, 28 Nov 1979
Ind Air Flt 185, Azores, Portugal, 8 Feb 1989
Markair Flt 3087, Unalakleet, AK, 2 June 1990
GP Express Flt 861, Anniston, AL, 8 June 1992
NWA Flt 5719, Hibbing, MN, 1 June 1993
Ansett Flt 703, Palmerstown, NZ, 9 June 1995
AAL Flt 965, Cali Columbia, 20 December 1995
KAL Flt 801, Guam Intl Airport, 6 Aug 1997