A Review: Language in Human Factors

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A Review: Language in Human Factors Texts

The International Civil Aviation Organization (ICAO) recently adopted Standards and Recommended Practices (SARPS) that strengthened requirements that flight crew and air traffic controllers demonstrate, and be formally tested for, language proficiency in English. Since the adoption of the ICAO language proficiency requirements in 2003, with implementation in 2008, much more attention has been focused on language issues in aviation.

In fundamental ways, language can be considered the foundational tool upon which communications are constructed. The ICAO language Standards impose new, stringent English language testing requirements upon the industry. Understanding the role of language in aviation communications is critical to implementing the new testing and test technologies.

The implementation of ICAO language proficiency requirements comes on the heels of an approximately thirty-five year push within the industry for greater awareness of human factors in aviation: the 1975 IATA conference in Istanbul is cited by Hawkins (1993) as the genesis of the field of aviation Human Factors. The importance of communications (Liveware-Liveware interactions) are largely acknowledged as fundamentally important to aviation safety. However—and this is more observation than criticism—the human factors textbooks, manuals, courses do not adequately address language issues in aviation. While communications are frequently referenced and even acknowledged to be fundamental to human factors, the role of language as a factor that makes communications possible is often overlooked.

The inadequacy of the treatment of language in the Human Factors literature is quite understandable, as language (and communications) are broad and complex areas of study. Before remedy can be applied, however, the scope of the issue must be understood. Therefore, a range of

human factors texts and documents, spanning more than thirty years of human factors research and application, were reviewed in order to evaluate the presentation of communication and language issues. The texts, manuals, and documents included in the survey are listed in Appendix A. The methodology applied was to review both the table of contents and the index for the inclusion of a chapter or section related to communications or language, including checking for key words: language, communications, Liveware-Liveware interactions, or English. Then, any possibly related sections were read and analyzed for how communications were addressed and if language was included. Although each of the texts and documents listed were reviewed and analyzed, the scope of this paper only permits a sampling of the findings to be presented.

The texts and documents reviewed can be categorized into (a) fundamental documents, from ICAO or civil aviation authorities; (b) basic Human Factors textbooks; (c) related human factors texts with an extended view (crew resource management, training, or accident investigation). The review is necessarily incomplete and is intended to be an initial study, exploratory in nature, with the aim of suggesting directions for future research. The findings of the review are presented in the chronological order in which the texts were published.

Reviews 1 and 2: *Human Factors in Aviation* and *Human Factors in Flight*

Two fundamental and early textbooks on human factors provide minimal reference to communications and no references to language or language proficiency; however it is of note that Earl Wiener and David C. Nagel, in one of the earliest texts reviewed (1989), acknowledge the gap that is the impetus for this present study: "It is probably the case that the gap between theory and practice is wider in radio communication procedures than in any other facet of aviation." Radio communication procedures include actual procedures, such as keying the mike, knowing when to communicate what information, and avoiding "stepping" on others. Perhaps even more

fundamentally, however, it can be argued that radio communication procedures include, or perhaps it is better to say that they rely upon, language proficiency and proficient language use.

The Hawkins (1987) text used in the course for which this paper is written (ERAU SFTY 320) addresses a chapter to "Communication" and several other references to language in aviation, more coverage than many of the reviewed texts. The information provided in the Hawkins text, particularly in the chapter "Communication: Language and Speech," both illustrates the complexity of language and communication factors in aviation and highlights the need for an improved and more expert treatment of language issues in aviation. Topics included range from discussions drawn from the distinct fields of communications, speech, and linguistics to automatic speech recognition, phraseology, and English-as-a-Second-Language. It is natural that a single chapter in any text cannot fully address all the language related factors in aviation communications, and the difficulty of doing so is evident in much of the information provided in this chapter. As an example, in the context of the use of datalink, the text argues that, "Spoken language provides rapid exchange of messages and uses pronunciation and accent for clarification" (Hawkins, p. 154). This statement is awkwardly problematic from a linguistic point of view. While the first premise in the statement is true, "Spoken language provides rapid exchange of messages," the meaning of the second premise, "Spoken language...uses pronunciation and accent for clarification" is unclear. Spoken language cannot be said to "use" anything. From a linguistic point of view, an additional advantage of speech over print, in terms of data link, is that speech not only provides the opportunity for speakers to transfer information quickly but speech also permits the relatively rapid negotiation of needs and requirements, rapid clarification of meaning when miscommunication occurs, and speech provides the opportunity to efficiently confirm or disconfirm intended meanings. In fact, a discussion of the linguistic advantages and

disadvantages, and possible unintended consequences of greater use of data link merits its own specialized treatment in a separate paper.

A number of the authors in the texts and documents reviewed acknowledge that greater attention to language and communication issues needs to be made. Hawkins argues that the "human factors deficiencies in verbal communication" that contributed to accidents such as the well-known 1977 Tenerife accident, had "plagued flight operations for very many years" (p. 170). He acknowledges that, "Communication is in the mainstream of Human Factors study," and that the ICAO 1984 phraseology changes perhaps represents a first step towards a solution. Finally, he calls for "specialised [sic] monitoring of Human Factors aspects of communication in civil aviation by those with the appropriate expertise and the authority to initiate change."

In light of his argument for ongoing improvement in the area of communications in aviation, the importance of the 2003 adoption of ICAO language proficiency requirements cannot be overstated.

Review 3: *Fatal Words: Communication Clashes and Aircraft Crashes*

Stephen Cushing's book (1994), published with an eye towards both the academic linguistic, aviation operational, and public press, while not a human factors text per se, does make a significant contribution towards our understanding of the role of language in aviation communications, distinguishing between "language-based" communication problems and other communication problems not based on language. Perhaps the primary contribution of Cushing's text is to identify and categorize a large number of communication errors. The issue of English-as-a-second-language proficiency, however, is only scantily addressed.

Review 4: *Designing Instruction for Human Factors Training in Aviation*

Stepping outside a bit the traditional human factors textbook, a 1997 text edited by Dr. Graham Hunt, who is a well-known aviation educator and, incidentally, currently director of Embry-Riddle's Singapore campus, presents a collection of essays on various aspects of human factors training. Language is not explicitly covered in any single essay, but communications are mentioned repeatedly, such as in a checklist designed to aid the assessment of human factors elements: "[the candidate] "uses appropriate communication style for the situation." The threat of inadequate language proficiency to the success of pilot-ATC communications is acknowledged in a chapter on simulator training: "...communication breakdown with ESL [English as a Second Language] controllers." Language use (but not language proficiency) is addressed, somewhat indirectly, in a chapter on "Teaching Human Factors in Air Traffic Control," in which the potential for phonetic confusions is addressed, with reference to the oft-cited "to/two" and "take off power" examples (Hunt, 1997, p. 196).

Review 5: *ICAO Document 9683*

ICAO Document 9683, *Human Factors Training Manual* (1998), contains no sections linked directly to communications or language. A listing of the academic disciplines that comprise human factors is provided (p. 2-1-4) including thirteen disciplines ranging from psychology, engineering, medicine, to education, mathematics, and industrial design. Neither communication as a field related to human factors, nor linguistics, is listed.

Appendix A presents several sample Human Factors Checklists. In the first, a section titled "Information Transfer Factors" includes a number of factors related to language, including "language barrier; misinterpretation of oral communications, timeliness/accuracy of verbal communications." Under "Other Personnel Factors," there is a category for "Communications (phraseology, rate of speech, pronunciation, etc.)"

A second checklist, based on the SHEL model, lists two communication or language related categories: "understanding" appears under Physical factors, and a section on "Oral Communication" is listed under Liveware-Liveware Interface and includes noise interference, misinterpretation, phraseology, and content and rate of speech.

The third checklist is the most interesting from a linguistic point of view, or rather from the point of view of identifying gaps in human factors literature. The purpose of the checklist is to assist accident investigators in identifying human factors issues, including training deficiencies, and it includes quite detailed questions, such as "Were any problems ever noted with the pilot's performance after he assumed the duties of this position." None of the approximately sixty questions inquire about the pilot's first or second language proficiency.

Review 6: *Human Factors in Multi-Crew Flight Operations*

One of the most comprehensive and comprehensible representations of the importance of language to aviation communication is provided in Harry and Linda Orlady's 1999 text. In a chapter on "Basic Communication," they outline types of communication in aviation, the role of written versus voice communications, phraseology versus plain language, inter alia. They also acknowledge the problem of possible inadequate language proficiency in pilot-controller communications (p. 152.)

Review 7: *Cap 719, Fundamental Human Factors Concepts*

In this relatively short document, originally published by ICAO in 2002 as Human Factors Digest 1, there are 19 references to communication and 10 to language. While it is acknowledged that, "language problems" can decrease the effectiveness of communications, no further detail is provided. Additionally, the generally inadequate, albeit well-intended, quality of the treatment of

language in human factors documents can be effectively illustrated by the brief allusion to the role of language in the following statement: "It is the task of Human Factors training to prevent communication errors. This task includes the explanation of common communication problems as well as **the reinforcement of a standard of language** to ensure the error-free transmission of a message and its correct interpretation." (Doc. 9683.) From a linguistic perspective, this statement is problematic. Firstly, it is not clear if "reinforcement of a standard of language" means to reinforce that good language proficiency is necessary, or if it refers instead to native speakers of a language using that language with care and precision. Both are important in aviation communications. Furthermore, if language proficiency is found to be inadequate, the remedy will not be found in the relatively short human factors courses. Improving language proficiency *always* requires a *minimum* of 200 hours of language training contact, and, most often, more.

Review 8: *Aircraft Safety: Accident Investigations, Analyses and Applications*

A useful and well-organized general-purpose text by Shari Stamford Krause makes the important point that not only was inadequate English language proficiency a factor in the 1990 Avianca crash in New York, but that also a breakdown in Spanish-as-a-first-language communications occurred and played a significant role in the accident. The Tenerife accident is also highlighted. Although the purpose of the text is to outline lessons that can be learned from accident analysis, nonetheless, no recommendations specifically related to English language proficiency are made, the kind of oversight that is generally found in human factors literature regarding language use and proficiency as a factor in aviation communications.

Review 9: *Contemporary Issues in Human Factors and Aviation Safety*

The 2005 text edited by Don Harris and Helen Muir includes no chapter specifically corresponding to communications and does not include any references to language. Multiple refer-

ences to communications in other chapters do not deal with communication from the perspective of language use, but rather from the more technical focus on communication channels (radio).

Review 10: *Aircraft Accident Investigation*

In one step away from human factors texts, no reference to language is found in the otherwise detailed 2006 "Aircraft Accident Investigation" manual by Richard H. Wood and Robert W. Swegginnis. Communications are mentioned briefly in the chapter on investigating human factors in accident investigations (p. 187).

Review 11: *Human Factors for Aviation: Advanced Handbook*

An undated manual published by Transport Canada provides a succinct but comprehensive chapter on communications, told from an English-as-a-first-language perspective, with no reference to language proficiency issues. However, the text points out that, "...at the heart of CRM is communication." In some sense, the role of the applied linguist in aviation is to help the industry understand that, "...at the heart of communication is language." The manual also acknowledges that many aviators and controllers feel uncomfortable when CRM deals with "so called 'soft' subjects such as communication…" (p. 69) Add to that observation the fact that language is a very complex topic, and it is not difficult to understand why current treatments of the subject within the still relatively new field of aviation Human Factors do not yet represent fully mature expression of the topic.

Review 12: *Human Error in Aviation*

In an otherwise comprehensive collection of diverse essays found in the 2009 text edited by Key Dismukes, no single chapter addresses communication or language directly. Because this text is a collection of essays, of which many were originally published in other sources, rather

than a more cohesive set of chapters written specifically for the text itself, the text has no index

to make checking for instances in which language or communication is cited.

Review 13: *Handbook of Aviation Human Factors*

A second collection of essays presents a very brief discussion of language in a chapter on

"Processes Underlying Human Performance" (Wise, 2010). Clearly, in this text, the authors

grapple with the same problem the industry, in general, experiences around the issue of language

use in aviation: unsure of whether to approach language issues from the perspective of communi-

cation, speech and hearing, or from the perspective of linguistics and language acquisition.

Review 14: *ICAO CAST Taxonomy*

Promise new directions for the future of language as a human factor in aviation safety is

found in ICAO's Commercial Aviation Safety Team's (CAST) "Common Taxonomy Group,"

the purpose of which is to "develop common taxonomies and definitions for aviation accident

and incident reporting systems." (CAST, 2011, p. 1) CAST publishes the Human Factors Taxon-

omy and categorizes human factors elements as follows: environmental, experience and knowl-

edge, organization oversight, perceptual, physical or sensory, procedural or task performance,

and psychological. "Communications" appears under the category of "procedural or task per-

formance" factors and is defined as "Factors related to communication between crew members

and other groups." The definition is supplemented by usage notes: "Communication includes but

not limited to lack of communication, accuracy of communication, use of phraseology, language

or accent interference, misinterpretations or misunderstandings of communication and readback

issues" (CAST, p. 10.)

Communication factors in aviation are broad and varied. It is noteworthy and encouraging

that the previous edition of the CAST Human Factors Taxonomy (2002), published prior to the

2003 adoption of ICAO language Standards, did not include "communications" as a distinct category, but the 2011 edition not only does so but also specifically references language. This is a distinct and positive departure from previous generations of ICAO documents, and a development that will encourage further research and support better understanding of the role of language in aviation human factors.

Nonetheless, without diminishment of appreciation for the progress being made, the categorization of communication factors under "Procedural or task performance," more broad in scope than the CAST group likely realize, is still somewhat problematic and probably inaccurate. Communication factors more accurately range across a number of the CAST categories, and the argument can be made that the full range of "Communication" factors justify a separate category. In any case, in this matter, as in all issues related to language factors in aviation, input from specialists in the area of Applied Linguistics would ensure a better treatment of the matter.

Conclusions

In summary, language use and language proficiency affect aviation communications in many, varied, and profound ways. As is well-known, inadequate language proficiency has been found to be a contributory factor in a number of high profile accidents and has been frequently cited as a factor contributing to numerous incidents. The fundamental role of communications to successful crew resource management is widely acknowledged. While communications are universally acknowledged to have an impact human factors, especially in terms of crew resource management, the role of language use and language proficiency is inadequately considered. Operational specialists acknowledge the key role of language, but the subject matter is simply so varied and complex that it is arguably an area of human factors that merits specialist investigation and treatment.

The International Society of Air Safety Investigators suggest that accident investigation "findings" be defined as "all significant conditions and events, causal and non-causal, found in the investigation." Relatedly, "Cause" has been defined as a "deficiency the correction, elimination or avoidance of which would likely have prevented or mitigated the mishap, damage, or significant injuries. A cause is an act, an omission, a condition or a circumstance [that] either starts or sustains the mishap sequence," (Wood and Swegginnis, 2006, p. 8). Without adequate awareness of and understanding of language as a human factor, accident investigators, and the industry, in general, too often miss particularly more subtle aspects of language use in aviation safety. For example, in many anonymous incident reporting systems, the variety of language factors are lumped together under "communication," or "language barrier." In addition, without a standardized taxonomy of language factors, it is difficult for researchers to investigate how frequently language issues occur as a factor contributing to incidents. This prevents the industry from having a clear picture of the impact of language on aviation.

As the foundation of communications, the role of language needs to be better understood within the human factors community. As a first step, a taxonomy of language factors in aviation communications will assist the industry in better identifying language factors in accidents and incidents.

Next, awareness about language as a human factor should be increased. It is not only important that pilots and air traffic controllers who speak English as a foreign language be trained to communicate adequately in English, but also it is important that pilots and controllers who speak English as a first language be aware of the safety threats in cross-cultural and cross-linguistic communications. In order for the industry to make progress on vital training and language testing issues, it is fundamentally important that human factors specialists and accident investigators

have an adequate awareness and understanding of how language factors contribute to safety. If we continue to consider language as a "soft" issue that remains "someone else's problem," a problem solvable by one or other short training course, then the industry will not be able to adequately address the language and communication problems that have plagued the industry since the beginning of international air transport. In some ways, the awareness and understanding of language issues in aviation safety mirrors the development of human factors and CRM as components of aviation safety programs. In the beginning, there was a general awareness of the role of human error coupled with great lack of understanding of human factors and the importance to safety of understanding and implementing human factors training. In addition, there was some resistance to human factors training. The same can be said to be true for increasing the awareness of language issues in the industry.

The benefit of CRM, although difficult to quantify, is universally acknowledged; no serious aviation professional will dispute the importance of CRM training and awareness. I believe the same will be true for language issues in aviation. There is initial resistance and widespread misunderstanding. With time, and with improved input from the Applied Linguistics community and language teaching specialists, with better identification of language factors in aviation communications, will come greater acceptance of the responsibility of all aviation operational and safety professionals to properly and more fully understand how language affects all aspects of aviation safety.

Works Cited

Aviation Occurrence Categories, Definitions, and Usage Notes. ICAO CAST Document. July 2011.

Fundamental Human Factors Concepts. UK CAA. 2002

Crew Resource Management. Flight Safety Foundation ALAR Briefing Note 2.2. Accessed on http://www.skybrary.aero/bookshelf/books/851.pdf on 17 December 2012.

Cushing, Steven. *Fatal Words: Communication Clashes and Aircraft Crashes*. The University of Chicago Press. 1994.

Dismukes, R. Key. *Human Error in Aviation*. Ashgate Publishing. 2009.

Harris, Don, and Helen C. Muir, eds. *Contemporary Issues in Human Factors and Aviation Safety*. Ashgate Publishing. 2005.

Hawkins, Frank H. *Human Factors in Flight,* ed. 2. Ashgate Publishing.1993 and 1987.

Human Factors for Aviation: Advanced Handbook. Air Canada Human Factors Project Team. Transport Canada.

Human Factors Training Manual. ICAO Document 9683. 2008.

Hunt, Graham J.F., *Designing Instruction for Human Factors Training in Aviation*. Avebury Aviation, Ashgate Publishing. 1997.

Krause, Shari Stamford, Ph.D., *Aircraft Safety: Accident Investigations, Analyses & Applications*, ed. 2. McGraw-Hill. 2003.

Orlady, W. Harry. And Linda M. Orlady, *Human Factors in Multi-Crew Flight Operations.* Ashgate Publishing. 1999.

Wiener, Earl L., and David G. Nagel. *Human Factors in Aviation*. Academic Press; Gulf Professional Publishing. 1989.

Wise, John A., David V. Hopkin, and Daniel J. Garland, editors. *Handbook of Aviation Human Factors*., ed. 2. CRC Press. Taylor and Francis Group. Boca Raton, USA. 2010.

Wood, Richard H., Sweginnis, Robert W., *Aircraft Accident Investigation*, ed. 2. Endeavor Books, 2006.