

Investigating Language Factors in Aviation Accidents

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Bio

Elizabeth Mathews is Associate Professor at Embry-Riddle Aeronautical University in the Department of Applied Aviation Science. She is an applied linguist who has focused nearly thirty years on the role of language in aviation safety. She served as Linguistic Consultant to ICAO during the development of the ICAO Language Standards and Recommended Practices. She currently leads research into the Language as a Human Factor in Aviation.

Investigating Language Factors in Aviation Accidents

“[Language is] one of those nagging issues...
You can just sort of sense it sometimes beneath the surface.”

Barry Sweedler,
Former director NTSB Office of Safety Recommendations

This article is not about the ICAO language proficiency Standards and Recommended Practices that were adopted by ICAO in 2003. Although they are an important safety initiative, and one with which the industry in many parts of the world still struggles to achieve full compliance, the role of language in aviation safety extends beyond pilot and air traffic controller radiotelephony communications.

The characterization of the role of language in aviation accidents by a former investigator as a “nagging issue,” in a 1996 interview with the New York Times, captures well the difficulty that aviation accident investigators faced as they worked to clearly understand the role of language in two accidents that had recently occurred. In the 1990 crash of Avianca 052 into a neighborhood of Cove Neck, New York, the National Transportation Safety Board determined that the probable cause of the accident was “the failure of the flight crew to adequately manage the airplane’s fuel load and their failure to communicate an emergency fuel situation to air traffic control before fuel exhaustion occurred” (Report 76).

When AA 065 crashed into a mountain top near Cali, Colombia, the Colombian investigation body “urged the ICAO Member States to strictly adhere to ICAO standard phraseology and terminology in all radio telecommunications between pilots and controllers (p.60). The NTSB contribution to the Report recommended that a “program to enhance controllers’ fluency in common English-language phrases and interaction skills sufficient to assist pilots” be developed.

In neither accident report is the role of language, specifically, made explicit—as distinct from the broader concept of communications or from the narrower category of phraseology. Investigators clearly had concerns over the role of language, as an element of overall communications, in the chain or network of events and circumstances preceding the accident. However, they faced barriers to conducting a thorough consideration of the role of language in both accidents. Despite the adoption of ICAO language proficiency requirements, many barriers to the investigation of language factors remain.

To understand how language factors are addressed in accident investigation reports, researchers at Embry-Riddle Aeronautical University launched a multi-year systematic review of hundreds of accidents archived on the Flight Safety Foundation’s Aviation Safety Network Database. Our research committee includes two applied linguists and four aviation operational experts, including an experienced airline pilot (retired); an experienced air traffic controller who is also a graduate student of applied linguistics; a professor of aviation safety and certified accident investigator; and a graduate student in Aviation Safety. The research project, “Investigating Language Factors in Aviation Accidents,” is described and findings from the first

phase of the project are reported in the *Journal of Aviation Psychology and Applied Human Factors* (2022; 12(2), 99-108).

Twenty seven accidents have been identified in the first two phases of the project, a systematic review of accidents that occurred between 1990 and 2012 (Phase I), and, in Phase 2, accidents that occurred before 1990 and accidents that had been brought to the Committee's attention as language-related. The current focus of the project are on accidents that occurred between 2012 - 2019, results pending. The list of accidents identified so far is appended to this article.

It is important to be clear that our research findings neither disconfirm nor challenge the findings or conclusions of the official accident investigation reports. We are simply noting how language is reported in accident investigations and identifying the various ways that language factors affect aviation safety. By doing so, we have also been able to identify a variety of barriers that inhibit investigators' ability to perceive, identify, document, and report language factors. In each of the accidents identified, language appears as a valid investigative question.

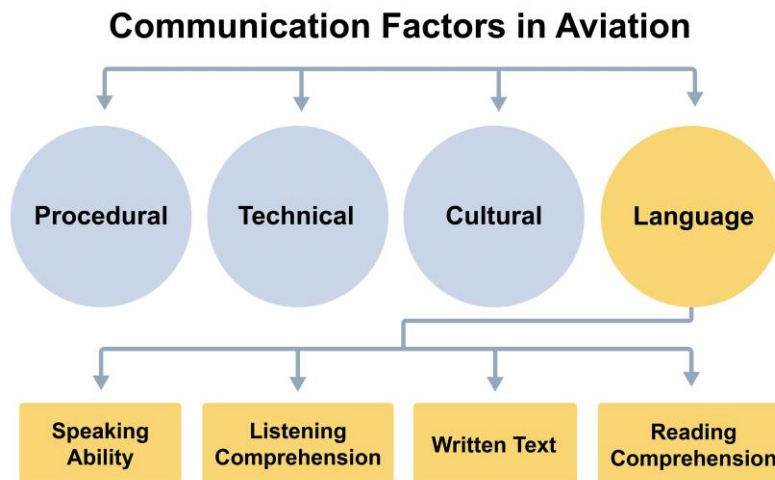
Three key findings from the research include that language impacts aviation safety in ways beyond the scope of the language Standards and Recommended Practices adopted by the International Civil Aviation Organization in 2003. The ICAO SARPS relate only to speaking and listening proficiency of pilots and controllers during radiotelephony communications; however, a number of accident reports illustrate how language impacts crew resource management communication, and that reading proficiency in English is an essential skill related to a pilot's operational proficiency.

Secondly, the research illustrates that factors identified in accident investigation reports are sometimes obscured in a variety of ways. Sometimes they are catalogued as communication issues when in fact communication is a broad category, of which language is only one element. Sometimes language factors are identified as an issue with non-standard phraseology, when the communication issue was instead related to the use of or lack of plain operational language. Sometimes language factors are identified but their relevance as a foundation upon which other errors were allowed to develop are missed or dismissed.

Third, the investigation of language as a human factor in aviation (LHUFT) is not well supported by current models of human factors or frameworks for the investigation of human factors. Industry awareness and understanding of human factors in aviation has been a key focus of accident investigations since the International Society of Air Safety Investigators devoted their 1971 seminar to "Human Factors in Accident Investigations" (DiNunno, Gary. ISASI: Becoming a Global Force for Air Safety. ISASI Forum. July - September 2014; 14 - 18.) Communications is in the mainstream of Human Factors study. All models of human factors includes communications, and communications are understood to be fundamental to all aspects of aviation safety.

However, what is not made clear in any of the models of human factors in aviation is the distinct role of language within communications. As a result, overall industry understanding of language as a human factor in aviation has not kept pace with our understanding of other aspects of human performance in aviation. Language is part of communications, but it must be understood, in its own right as one type of communication factor.

The term “Communication” is broad and encompasses more than language factors. In fact, there are FOUR types of communication factors in aviation, as illustrated in the Taxonomy of Communication Factors in Aviation (Mathews, et al. *“Language as a Factor In Aviation*



Accidents and Serious Incidents: A Handbook for Accident Investigators ed. 3.” 2023.)

The Taxonomy of Communication in Aviation includes the kinds of communication factors investigators are familiar with, such as procedural communication factors, which include blocked transmissions, an incorrect or omitted call sign, or a failure to relay information. Technical factors that impede with communications are included in the Taxonomy, such as noise or static, or equipment failure, including headsets, radio equipment, or a transponder. Cultural factors are well-known to affect aviation communications. These types of Communication Factors are ones that human factors specialists, safety experts, and accident investigators are more readily familiar with.

Language is the fourth component of communications, and the research highlights the challenges that confront investigators in their efforts to accurately perceive, document, analyze, and report language factors in aviation. The purpose of the Taxonomy of Communications Factors in Aviation is to support the investigation of language factors in aviation by situating language factors within communication factors more broadly and clarifying the types of language factors specifically that appear in accident investigation reports. Language factors include Speaking, Listening, Reading, and Written text. And each of these aspects of language have been shown to impact aviation safety.

The impact of speaking and listening proficiency in radiotelephony communications is the aspect of language use in aviation that is most familiar to safety professionals and investigators. Partly this is because pilot-controller communications are recorded and transcribed and, thus, more readily available for analysis. In addition, Speaking and Listening proficiency was also the focus of the ICAO Language Proficiency Requirements. The implementation of ICAO language requirements has not only addressed the need for English language proficiency

for safe radiotelephony communications but it has also raised industry awareness over language issues in aviation, an additional positive result of the ICAO language Standards.

In fact, it was concern over the role that language had played in radiotelephony communications in a series of high profile aviation accidents in 1977 and in the 1990's that led to the proposal for strengthened ICAO language requirements: a runway collision in Tenerife, 1977; a fuel exhaustion accident in New York, 1990; a controlled flight into terrain in Colombia, 1995; and a midair collision over India in 1996.

In the review of accidents, in addition to these well-known accidents, a number of other accidents were identified in which language factors were identified in the radiotelephony communications between pilots and air traffic controllers, ranging from incorrect use of or ambiguous phraseology; difficulty comprehending air traffic control communications; inadequate plain language proficiency required to clarify instructions, communicate intent, or manage non-routine situations.

The use of two languages in a single operational environment was also cited, in four accident investigation reports.

The research also highlighted how language proficiency impacts crew resource management. The need for mutual proficiency in a shared language for effective CRM communications will not surprise aviation professionals. What may surprise aviation professionals is that the ICAO language proficiency requirements do not specify a level of language proficiency required for safe and effective crew resource management communications. Crew resource management communications differ from the relatively more constrained and limited communications required for radiotelephony communications. Three accidents cited language factors in their exploration of the impact of poor crew resource management.

However, investigators face a number of barriers to conducting a thorough examination of language as a human factor. Very often, the information that would be required to consider the effect of limited language proficiency is not available. What can be stated with certainty is that when poor crew resource management is identified as a latent or contributing factor in an accident investigation, in that case, language is often a valid investigative question. A more detailed consideration of how language can effect crew resource management discussions can be found in a review of the 2005 accident in Greece, in which the flight crew were overcome by the effects of hypoxia ("Overlooked: Language skills is play an often unrecognized role in aircraft accidents" *Aerosafety World*: 18 October 2019. <https://flightsafety.org/asw-article/overlooked/>).

A key finding of the research project relates to the impact of reading proficiency on flight operations. Again, it should be noted that there are no ICAO requirements related to reading proficiency. Yet, pilots must read and understand complex documents written in English, on the flight deck and during training events. English language reading proficiency is of fundamental importance during training events that are conducted in English.

Our review of aviation accidents identified several in which investigators "peeled the onion back," and linked poor operational proficiency on their aircraft to limited language proficiency, including reading proficiency, during training events that required the pilots to read

and comprehend complex operational documents. One example is the crash of an ATR 72 shortly after take off from Tyumen airport on Russia, in 2012.

Every accident is the result of a chain of events, and in this case accident investigators determined that the “immediate cause” of this accident was the flight crew’s failure to de-ice prior to take off, despite the fact that snow and ice deposits were present on aircraft surfaces. The ice was noticed by the flight crew during taxi. Failing to de-ice the aircraft resulted in degradation of the aircraft’s aerodynamic performance, and it stalled during the climb.

What is significant about this accident investigation report is that it is one in which accident investigators did specifically and thoroughly consider possible language factors. Radiotelephony communications were not a factor in this accident. As a domestic flight on a Russian airline with Russian pilots, the communications were in Russian. However, one of the investigators on the investigation team was an applied linguist who additionally had significant experience working in the domain of aviation operations and communications. (Applied linguistics is an academic field in which practitioners are trained to bring a scientific understanding of language to language problems in society.) What investigators found was that the training documents and the de-icing procedures were written in complex English. As a part of their investigation, they reviewed the flight crew’s language tests. Although the pilots were officially certified as ICAO Operational Level 4—the required level of operational proficiency—based on a review of the language test recordings, the investigators determined that actual proficiency of both pilots was lower than ICAO Operational Level 4: the captain demonstrated English language proficiency at an ICAO Pre-Operational Level 3, and the First Officer at only an ICAO Elementary Level 2.

Because the language tests did not include reading tests, investigators had to extrapolate from the very limited speaking and listening proficiency that both pilots demonstrated on testing records to estimate probable reading proficiency. They, correctly, determined that the pilots did not have adequate English language reading proficiency to permit comprehension of complex operational documents.

Because of their lack of English language proficiency, these pilots were, in essence, disadvantaged in their flight training. In this case, investigators linked inadequate operational proficiency to inadequate language proficiency during training.

It would not be reasonable to point to the role of reading proficiency in aviation safety without also considering the impact of how documents are written for the aviation industry. Most technical documents written in English do not account for readers of English as a foreign language. There were three accidents we reviewed between 1990 and 2012 in which investigators referred to the complexity, or translation, of manuals and texts in their consideration of the accident.

ICAO says that “No accident investigation can be complete without a thorough consideration of Human Factors issues involved” (*ICAO Circular 298: Training Guidelines for Aircraft Accident Investigators*. 2003). In the investigation into the role of reading proficiency in this and other accidents, and in identifying the possible impact of language proficiency on crew resource management communications, some barriers to conducting a thorough consideration of language factors have been identified. First, taxonomies and models of human factors do not support a systematic consideration of language factors. Secondly, as was highlighted in the 2012

investigation into reading proficiency in the accident in Tyumen, Russia, language testing is often irregular and unregulated (Clark 2013) Thirdly, accident investigators are not provided with the tools nor background training in language that would support a thorough investigation of language as a human factor in aviation.

Human factors are complex, and language is a complex aspect of human factors. If we do not clearly discern and identify the problem, if language is not specifically identified in accident reports, as distinct from other communication factors, then the industry will continue to misunderstand the critical role of language in all aspects of aviation safety. Language problems not addressed will continue to be a threat to safety.

Examples of the Role of Language Factors in Aviation Safety

1. SPEAKING AND LISTENING

RADIOTELEPHONY COMMUNICATION

Incorrect phraseology

1973	March 5	Midair collision	France	DC-9 / Convair CV-990
1977	March 27	Runway Collision	Spain	Boeing 747/Boeing 747

Issuing or interpreting ambiguous ATC instructions

1980	April 25	CFIT	Tenerife, Spain	Boeing 727
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Difficulty comprehending ATC communication

1996	Nov 12	Midair collision	India	Boeing 747/Ilyushin 76
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Inadequate plain language proficiency to clarify instructions, communicate intent, or manage non-routine situations

1990	Jan 25	Fuel exhaustion	New York	Boeing 707-321B
1996	Aug 29	Crash on approach	Norway	TU 154M
1995	Dec 20	CFIT	Cali, Colombia	B 757-223
1997	Dec 17	CFIT	Greece	Yakovlev Yak-42
2000	Mar 24	Fuel exhaustion	Sri Lanka	Antonov 128K
2002	Apr 15	CFIT	Korea	B767-200ER
2006	Sept 29	Midair collision	Brazil	B 737 / Legacy 600
2007	Jun 4	Serious Incident	London	B 737-500

TWO LANGUAGES USED IN A SINGLE OPERATING ENVIRONMENT

The use of two languages in a single operating environment may contribute to loss of situational awareness.

1960	Feb 25	Midair collision	Brazil	DC3 / DC6
1976	Sept 10	Midair collision	Croatia	Trident Three / DC-9
2000	May 25	Runway collision	Paris, France	Shorts 330-200 / MD83
2001	Oct 8	Runway collision	Milan, Italy	Cessna Citation / MD-87

Note: Limited English language proficiency can result in flight crew being unable to request, direct, or assist emergency services. Emergency rescue personnel who did not understand directions in English from the First Officer on how to access accident victims still on the aircraft, was reported (personal communication) in the following accident.

2000	Oct 31	Crash on take off	Taiwan	B747-41
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CREW RESOURCE MANAGEMENT

Bilingual flight deck communications in English as a foreign language may impede Crew Resource Management. Poor CRM among flight crew who do not share a common first language may be a result of language factors.

2000	Jan 10	Loss of control	Switzerland	Saab 340-B
2005	Aug 14	Crew incapacitation	Greece	B737-31S

READING

Low levels of reading proficiency can affect the operational understanding of the aircraft or of procedures when manuals, safety updates, or procedures are written in complex technical English. The impact of limited English proficiency during training that was conducted using operational and training manuals written in English has been linked to inadequate operational proficiency in some accidents. It should also be noted that the operational manuals are usually written in a style not specifically intended for non-native English readers.

1994	Apr 26	CFIT	Japan	Airbus A300
2008	Sept 14	Crash on approach	Russia	B737-505
2012	Apr 2	Ice on wings	Russia	ATR 72
2013	Nov 17	CFIT	Russia	Boeing 737

WRITING

Operational or maintenance manuals written in, or translated into, non-standard or unclear English can cause comprehension difficulties.

2002	May 25	Loss of control	Taiwan	B747-209B
2011	May 7	CFIT	Indonesia	Xian MA60
2011	July 13	Loss of control	Brazil	Let 410U-VP
2005	Aug 14	Crew incapacitation	Greece	B737-31S
2009	Mar 6	Engine Failure	India	NAL Saras

READING

Documents on board the aircraft

1974	Mar 3	Crash after take off	France	MD DC-10
2011	Jul 18	Fire on board	South Korea	B747

Reading during flight training

1994	Apr 26	CFIT	Japan	Airbus A300
2008	Sept 14	Crash on approach	Russia	B737-505
2012	Apr 2	Ice on wings	Russia	ATR 72
2013	Nov 17	CFIT	Russia	Boeing 737

WRITING

2002	May 25	Loss of control	Taiwan	B747-209B
2011	May 7	CFIT	Indonesia	Xian MA60
2011	July 13	Loss of control	Brazil	Let 410U-VP

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