“Very unhappy at two thousand feet” – Towards a Framework for Analysing Pilot Language Use in Airline Accidents

「2000 フィート　燃料　危険」
ー 航空機事故におけるパイロットの言語使用の分析

A Dissertation Presented to
the Graduate School of Arts and Sciences,
International Christian University,
for the Degree of Doctor of Philosophy

国際基督教大学　大学院
アーツ・サイエンス研究科提出博士論文

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LANGUAGE

"The fact is that English is the international language of aviation."

Acting Deputy Director of ICAO's Air Navigation Bureau
(Lamy, 2008)

RISK

"While the elimination of aircraft accidents and/or serious incidents remains the ultimate goal, it is recognized that the aviation system cannot be completely free of hazards and associated risks."

Safety Management Manual, ICAO Document 9859
(ICAO, 2013b, p. 2-1)

CULTURE

"In retrospect, this accident seems to illustrate how cultural characteristics within and between cultures can combine with tragic results."

An analysis of the Avianca Flight 052 accident
(Helmreich & Merritt, 1998, p. 100)

DEDICATION

Humans have long dreamed of being able to fly, as evidenced by the ancient myth of Daedalus and Icarus trying to escape from the island of Crete on wings made of feathers and wax. Their mythical attempt ended in the tragic death of Icarus, but the dream lived on. Finally, in 1903, the Wright brothers made their first brief flights at Kitty Hawk, North Carolina, ushering in the era of heavier-than-air aircraft that are powered and controllable. Technological advances continued throughout the 20th century, and flying has now become so commonplace that airlines carried 4.3 billion passengers in 2018. Nevertheless hazards still remain. Sidney Dekker, airline pilot and academic, has written cogently about the risks inherent in modern aviation and the "good people" around the world who strive to make the air transport system as safe as possible. This dissertation is dedicated to all those good people, whatever role they play on the ground or in the air.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Professor John Maher of International Christian University (ICU) in Tokyo, Japan, for his guidance, patience and wisdom. Like the ancient master technician Daedalus, he has enabled the transmission of knowledge to successive generations of students and I greatly appreciate all he has taught me. In addition, I would like to thank my other committee members, Professor Yamaguchi and Professor Jung, for their advice and support.

As is often the way, this PhD became a lengthy project that took an inevitable toll on family life. I must thank my wife, Chihiro, and my daughters, Reina and Mirei, for their patience over the last few years. They have raised my awareness about language and cultural differences, and helped me understand some of the hidden aspects of the cultural iceberg. I owe a debt of gratitude to Chihiro for introducing me to Professor Maher.

A lot of people from many countries and cultures have contributed time, ideas or support to this project. The list includes acquaintances, colleagues, friends and family members, from Colombia to Copenhagen, and Oxford to Osaka. I would especially like to thank Penny and Derek Cornthwaite, Roger Hills, Dan Jackson, Patrik Jonzon, Paul Joyce, Tim Marchand, Peter McDonald, Mark Rentz, Ben Rowlett and Julian Williamson.

This PhD has been informed by conversations with many aviation professionals around the world: human factors researchers, accident investigators, regulators, air traffic controllers, as well as pilots who fly for airlines in Europe, Japan, the Middle East, South America and the United States. I am very grateful to everyone who participated in the survey, and I would especially like to thank the key informant, without whom the project would not have been possible.

Finally, I am indebted to Professor Robin A. East and Professor Chris J. Harris, both formerly of the Department of Aeronautics and Astronautics at the University of Southampton, for starting me on this journey many years ago.

Flying is an everyday miracle but is still imbued with risk. Next time you board an airplane, take a moment to savour the awe. And thank all the good people who work to make this miracle possible. Here’s wishing you a safe flight!

Simon Cookson

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CHAPTER 1: Introduction

In the opening chapter, I first outline the global scale of air transportation, before discussing safety in commercial aviation compared with other modes of transport. I present a brief overview of ICAO, which is the United Nations agency responsible for overseeing international civil aviation. Then I describe the ICAO language proficiency programme that came into full effect in 2011. The programme is intended to improve the language proficiency of commercial pilots and air traffic controllers around the world. A number of accidents involving language factors were cited by ICAO to justify this major undertaking. This dissertation offers a response to the language proficiency programme by presenting an analysis of one of the accidents cited by ICAO: the 1990 crash of Avianca Flight 052. The structure and aims of the dissertation are outlined in the final section of the chapter.

1.1 Civil Aviation Worldwide in the 21st Century

The relentless development of civil aviation continued in the first two decades of the 21st century despite major external shocks. During this period the world was rocked by successive bouts of economic turbulence: the terrorist attacks of September 11 (2001), the SARS epidemic (2002-2003), and the global financial crisis (2007-2009). Civil aviation fully recovered from each of these shocks. Statistics reported by the Air Transport Action Group (ATAG, 2016) in 2014 reflected its tremendous scale:

- 26,605 commercial aircraft were in service;
- 51,554 airline routes were in operation;
- 62.7 million jobs worldwide were supported by aviation;
- the total economic impact was $2.7 trillion.

Following forty years of deregulation in successive regional markets around the world, aviation operations have come to impact the lives of increasing numbers of people. In 2018, according to the International Air Transport Association (IATA), airlines carried 4.3 billion passengers, more people than ever before. They also transported 64 million tonnes of cargo and linked almost 22,000 city pairs (IATA, 2019a). Long-term forecasts from Airbus and Boeing, the world's largest manufacturers of airliners, anticipate that civil aviation will continue to grow. In a report published in 2018, Boeing (2019) noted that the number of passengers flying each year had increased from 100 million in 1960 to more than 4 billion in 2016. Similarly, Airbus (2018) stated that the volume of air traffic has continued to double every 15 years in terms of revenue passenger kilometres (RPK), despite regular external shocks.

At the time of writing, the world is reeling from the Covid-19 pandemic, which has caused a huge reduction in air traffic. ICAO (2020) estimates a decrease of 53-60% in the total number of passengers for 2020 compared with 2019. It is not clear how long or what form the recovery from this crisis will take. However, the Asia-Pacific region is certain to be an important engine for the future growth of civil aviation. Airbus (2018) predicted that over the next 20 years this region will account for 42% of new passenger aircraft demand. Boeing (2019, p. 16) likewise declared that in the next two decades "Air travel growth within Asia is set to make it the world's largest overall travel market, with rapid growth within China making its domestic market the largest of all."

In summary, despite the collapse in air traffic during 2020 due to the Covid-19 pandemic, the long-term outlook is for the continued growth of civil aviation. Furthermore, markets outside of North America and Europe will be increasingly prominent, especially those in the Asia-Pacific region. These markets have diverse languages and cultures, and their emergence underscores the importance of effective communication and intercultural understanding in ensuring safe and efficient flight operations.

1.2 How Safe is Air Transportation?

It is commonly said that flying is safer than other forms of transport (Scott, 2013; Smith, 2013). A cursory glance at accident statistics seems to support this view. Table 1 lists the number of fatalities for various transport modes in the United States. The figures are shown at five-year intervals for the last three decades. These data are only for a single country, albeit a large and influential one, but they illustrate two important points.

The first point is that aviation is responsible for a very low proportion of the total number of transportation fatalities. In 2015, the most recent year shown in Table 1, there were 404 fatalities due to air travel. This figure is two orders of magnitude lower than the 35,092 deaths caused by road travel. Air travel fatalities accounted for just 1.09% of the total number of fatalities in all transportation accidents in the US in 2015.

Table 1: Fatalities by transportation mode in the United States (BTS, 2017).

	1990	1995	2000	2005	2010	2015
Air	866	963	764	603	477	404
Highway	44,599	41,817	41,945	43,510	32,999	35,092
Railroad	1,297	1,146	937	884	735	749
Transit	339	274	295	149	221	254
Water	865	829	701	829	821	692
Total fatalities[1]	47,297	44,507	44,276	45,641	35,036	36,973

[1] For a given year, the total fatalities may be less than the sum of deaths in the modes because some accidents involve more than one mode (e.g., a car and train colliding at a railway crossing).

The second point is that the table indicates a significant downward trend in the number of air-transport-related deaths in the US. There were 404 fatalities in air accidents in 2015, which was 46.7% of the 1990 figure. This trend reflects major improvements in aviation safety that have taken place in many countries. Within commercial aviation the changes range from increasingly reliable jet engines to numerous initiatives for managing risk. Examples of the latter include: the Safety Management System (SMS), the Flight Operations Quality Assurance system (FOQA), the Fatigue Risk Management System (FRMS), the Alternative Training and Qualification Programme (ATQP), and the Traffic Collision Avoidance System (TCAS) (Scott, 2013).

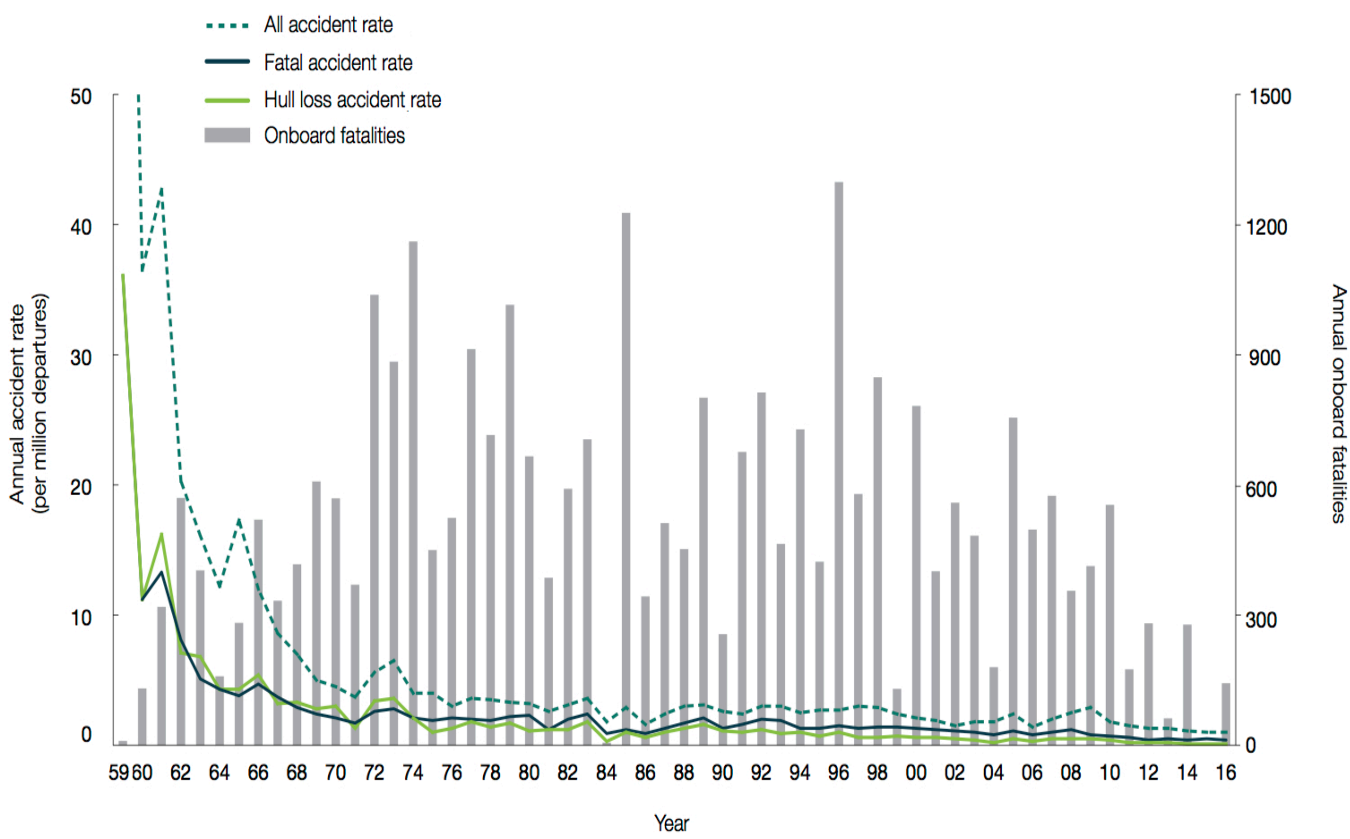
Statistics that contrast the huge scale of airline flight operations with low numbers of accidents and deaths are often cited as evidence of the relative safety of flying. Each year IATA produces a worldwide review of safety in the airline industry. In 2018, it stated that more than 4 billion people flew safely on 46.1 million flights. There were 11 accidents resulting in passenger deaths, with a total of 523 fatalities. This was a significant increase on the previous year, when there had only been six fatal accidents resulting in 19 deaths. For all accidents, not just those involving fatalities, IATA calculated that the accident rate in 2018 was just 1.35 accidents per million flights (IATA, 2019b, 2019c).

On the surface, the IATA figures appear reassuringly low, but there are significant caveats. Firstly, the figures only include accidents involving turbine-powered aircraft that weigh 5,700kg or more. Secondly, acts of suicide or terrorism are excluded. This was starkly illustrated in 2015, when IATA statistics indicated four fatal accidents with 136 fatalities. They did not include the Germanwings Flight 9525 (pilot suicide) and Metrojet Flight 9268 (terrorism) disasters in which a total of 374 lives were lost. IATA accident statistics clearly do not report all flights that have fatalities, and IATA’s definition of an accident may differ substantially from a layperson’s understanding.

Similar statistics are produced by other aviation organizations including aircraft manufacturers (e.g., Airbus and Boeing) and regulatory agencies (e.g., ICAO). These statistics typically paint a historical picture of aviation safety that is characterized by two clear trends. On the one hand, they show a dramatic reduction in the *rate* of accidents per million flights from the turbulent start of the jet age until now. On the other hand, the *number* of accidents and fatalities continues to fluctuate widely each year. Both trends are illustrated in the Boeing graph shown in Figure 1.

In summary, aviation safety statistics present a mixed picture. The annual accident rates indicate that air transportation has become safer, but the statistical metrics are subject to significant qualifications. Fluctuating fatality figures have seen a significant number of lives being lost in some recent years (e.g., 2005, 2007 and 2010 in Figure 1). Furthermore, as Boeing's chief engineer for safety and reliability noted, "The public is sensitive to the number of accidents, not the accident rate" (Lavin, 1990).

Figure 1: Annual accident rates and fatalities in the worldwide commercial jet fleet. Reprinted from *Statistical summary of commercial jet airplane accidents: Worldwide Operations 1959-2016* (p. 16), by Aviation Safety, 2017, Seattle, WA: Boeing Commercial Airplanes. Copyright 2017 by Boeing. Reprinted with permission.



Despite evidence of improved safety, flying may *feel* more dangerous than other forms of transport, such as driving. Risk perception is based on diverse factors including emotion, intuition and heuristics (Fischhoff & Kadvany, 2011).The mass media exerts a significant influence on the public's perception of flying. Aircraft carry large numbers of passengers at high speeds and high altitudes as a matter of routine. Their potential for causing disasters is far greater than that of automobiles. As a consequence, newspapers and television give more attention to shocking (but infrequent) air accidents than to seemingly mundane (but daily) car crashes (Hawkins, 1993). This is despite the cumulative death tolls of road accidents being many times greater than those of aviation accidents.

1.3 The International Civil Aviation Organization (ICAO)

There has been a phenomenal increase in the scale and scope of international air transport since the middle of the 20th century. An important driver of this growth has been the International Civil Aviation Organization (ICAO). Based in Montreal, Canada, ICAO is a specialized agency of the United Nations that is tasked with overseeing the worldwide development of civil aviation.

ICAO was conceived in the closing stages of World War Two. As the war entered its final phase in 1944, delegates from 52 nations drew up the Convention on International Civil Aviation in Chicago. The agreement has since come to be known as the “Chicago Convention”. This led to the official establishment of ICAO in 1946. The organization’s mission was framed as a clear and concise imperative: “Achieve the sustainable growth of the global civil aviation system.” There has been a remarkable expansion in international civil aviation since ICAO was established, to the point that aircraft now take off or land every few seconds in “one of the most complex systems of interaction between human beings and machines ever created” (ICAO, 2011).

Concurrent with the growth of the civil air transport system, ICAO has developed into a global organization. There are currently 191 Contracting States and the organization is divided into nine regions: (1) Africa-Indian Ocean, (2) Asia, (3) Caribbean, (4) Europe, (5) Middle East, (6) North America, (7) North Atlantic, (8) Pacific and (9) South America. These regions differ considerably in terms of the typical flight operations that take place within them. In Europe, for instance, the main problem is coordinating trans-continental traffic with short-haul flights, while an essential feature of the North Atlantic region is long-range overseas navigation.

ICAO is tasked with overseeing the safe, efficient and orderly development of international air transport. It is also responsible for systematically arranging the principles and techniques of international air navigation. So that operations may proceed smoothly, the agency works to standardize the ways in which flights are handled around the world.

The drive to standardize is a vital undertaking. As MacKenzie (2010, p. ix) noted in his history of the organization: "At the heart of ICAO's mission is the goal of international standardization of civil aviation." Examples of standardization include the ICAO code systems that are used to designate airlines and airports. Each airline has a unique 3-letter code (e.g., AVA for Avianca) and each airport has a unique 4-letter code (e.g., KJFK for John F. Kennedy International Airport). The ICAO codes are used for the purposes of airline flight planning and air traffic control (ATC).[2]

To implement its policies, ICAO has a range of instruments. These vary in several ways: the level of detail that they specify; the regions in which they are applicable; and whether they are mandatory or not. The instruments are:

- <u>Standards and Recommended Practices (SARPs)</u> – broadly formulated rules and recommended practices for worldwide application that are included in ICAO Annexes;
- <u>Procedures for Air Navigation Services (PANS)</u> – operating practices for worldwide application that are too detailed for SARPs;
- <u>Regional Supplementary Procedures (SUPPs)</u> – similar to PANS but only applicable to certain regions;
- <u>Guidance Material</u> – attachments, manuals and circulars that are designed to facilitate the implementation of SARPs and PANS.

Individual member states are responsible for the actual implementation of the policies and for ensuring that service providers follow them. In terms of obligations, member states *must* notify the ICAO Council in the event that they are non-compliant with Standards. On the other hand, they are *invited* to notify ICAO of non-compliance with Recommended Practices and PANS (ICAO, 2011).[3]

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[2] IATA has separate systems of codes that are used for airline timetables, reservations and ticketing. IATA uses 2-letter codes for airlines (e.g., AV for Avianca) and 3-letter codes for airports (e.g., JFK for John F. Kennedy International Airport).

[3] The process sometimes breaks down, as in the 2015 crash of a Jazz Aviation DHC-8-102 aircraft in Ontario, Canada (TSB, 2017c). Several years before the crash, the airline implemented a safety management system (SMS) approved by Transport Canada, in accordance with ICAO SARPs. Due to cost pressures and uncertainty about the future, some aircraft types were not included in the SMS flight data monitoring. As a result, data about unstable approaches for DHC-8-102 aircraft were not collected. Such data might have prevented the 2015 accident.

In practice, ICAO has limited powers with which to enforce its standards and procedures. This is a legacy of disagreements between the United States and Great Britain dating back to the early days of the organization. The United States championed a laissez faire approach towards international civil aviation so that its airlines could access world markets. Britain, by contrast, wanted an agency with powers strong enough to regulate international aviation. The United States prevailed. As a result, ICAO became essentially an advisory organization which “has the ability to influence, cajole, and, on the odd occasion, threaten, but it cannot force any member to act against its national interest” (MacKenzie, 2010, p. 195). There are, however, two significant penalties that ICAO may invoke, as detailed in Articles 87 and 88 of the Convention on International Civil Aviation. Firstly, if a particular airline refuses to comply with a decision, member states may be asked to deny that airline access to their airspace. Secondly, if a state does not comply, its voting rights may be suspended (ICAO, 2006).

ICAO uses instruments such as SARPs and PANs to improve air navigation, prevent unlawful interference, and facilitate border-crossing procedures for international flights. The organization also defines air accident investigation protocols for member states. In recent years, ICAO has increasingly addressed environmental issues to reduce the noise and engine emissions of civil aircraft. In addition, following a series of catastrophic accidents, it established a language proficiency programme to improve communications between aircraft flight crew and ground stations.

1.4 The ICAO Language Proficiency Programme

Between 1976 and 1996, five tragic accidents occurred that involved breakdowns in communication between pilots and ATC. More than 1,000 people lost their lives. In response to the accidents, ICAO initiated a programme in 1998 to improve the language proficiency of commercial pilots and air traffic controllers worldwide. The Proficiency Requirements in Common English Study Group (PRICESG) was set up to review all aspects of air-ground and ground-ground voice communications. Subsequently two more accidents involving language factors took place in 2000 and 2001.

The PRICE Study Group reported its findings, and in 2003 the ICAO Council adopted amendments relating to language proficiency for the Air Traffic Management

PANS and Annexes 1, 6, 10 and 11 of the Convention on International Civil Aviation.[4] A set of Language Proficiency Requirements (LPRs) was drawn up, which describe the minimum acceptable language proficiency level for pilots and air traffic controllers. The intention was that all member states would comply with these requirements by 2008. However, the programme could not be implemented within this timescale, and a three-year transition period was adopted. As a result, the ICAO programme finally came into full effect on 5th March 2011.

The language proficiency programme is a huge and unprecedented undertaking. It is embedded in a complex web of documentation, including Annexes, PANS and guidance material. In essence its complexity can be boiled down to one simple requirement: pilots and air traffic controllers around the world must demonstrate a certain level of language proficiency before they can carry out international flight operations.

ICAO has not developed a standardized test for evaluating the language proficiency of pilots and controllers. Instead, different countries are permitted to use different tests, but they must all conform to descriptors set out in the LPR rating scale. This scale is a matrix that consists of six assessment criteria and six proficiency levels. The assessment criteria are: (a) pronunciation, (b) grammatical structure, (c) vocabulary, (d) fluency, (e) listening comprehension, and (f) interactions. In other words, the construct of language proficiency is broken down into six assessment criteria within the LPR rating scale.

For each of the criteria, individuals are assessed as being at one of six proficiency levels, from Level 1 ("Pre-elementary") to Level 6 ("Expert"). Pilots and controllers who are involved in international flight operations must demonstrate proficiency at Level 4 ("Operational") or higher for all the criteria. If they do so, their licence is endorsed for a certain period of time. For personnel evaluated at Level 4, this period is no more than three years. Before the end of the period they are evaluated again. The Level 4 descriptors for the assessment criteria are reproduced in Appendix 1. As an example of the requirements for Level 4, the pronunciation descriptor states that: "Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation, but only sometimes interfere with ease of understanding." (ICAO, 2010, p. 4-9)

[4] The Chicago Convention has 19 Technical Annexes. Annex 1 covers "Personnel Licensing"; Annex 6 is titled "Operation of Aircraft"; Annex 10 is "Aeronautical Telecommunications"; and Annex 11 is "Air Traffic Services".

Estival, Farris and Molesworth (2016) pointed out the importance of distinguishing between ICAO guidance material and ICAO requirements. In practice this may be difficult because the content overlaps. ICAO Document 9835, "The Manual on the Implementation of ICAO Language Proficiency Requirements", is a guidebook to the language proficiency programme. It was first published in 2004 and then in revised form in 2010. This document serves as *guidance material* to facilitate implementation of the programme. Confusingly, some parts of Document 9835 are also included in ICAO Annexes, which means they are *requirements* that member states must comply with. For example, the LPR rating scale appears in both Document 9835 and Annex 1.[5] Since the scale is in Annex 1, it must be complied with. By contrast, elements such as "specific recommended practices for native English or expert-level speakers in English as lingua franca (ELF) interactions" appear in Document 9835 but not in the Annexes (Estival et al., 2016, p. 57). Hence such elements are only guidance material.

The aim of improving the language proficiency of pilots and air traffic controllers is laudable. It goes without saying that clear communication is essential for the smooth and safe operation of the international air transport system. Nevertheless, the ICAO language proficiency programme has been criticized on a range of issues. One contentious area is testing. Alderson (2009, p. 180) questioned whether language tests are an appropriate way of assessing language use in flight operations, asking: "What is the value of a language test for ensuring flight safety: Is it not more important to observe how language is used under stressful conditions?"

Another aspect of the language proficiency programme to have attracted criticism is the LPR rating scale, part of which is shown in Appendix 1. Estival et al. (2016) noted that ICAO had not explained the theoretical and empirical underpinning of the assessment criteria. Additionally, Farris and Turner (as cited in Estival et al., 2016, p. 185) called for "careful, evidence-based consideration of the assumptions that underlie the ICAO LPRs". Problematic issues include the distinctions, in the context of civil aviation, between the following pairs of items: standard phraseology and plain language, English and other languages, and native speakers and non-native speakers. These issues are addressed in Chapter 2 of this dissertation.

[5] The LPR rating scale is in Attachment A to Appendix 1 of Annex 1.

1.5 Accidents Involving Language Factors

The ICAO language proficiency programme is a complex undertaking on a global scale. It was initiated in response to a series of tragic accidents, each of which was caused (at least partly) by language factors. During the implementation stage of the programme, ICAO cited seven accidents in official documents and regional workshops. The accidents are summarised in Table 2. (Further details are provided in Appendix 2.)

Table 2: Accidents involving language factors cited by ICAO (Lamy, 2008; ICAO, 2010).

	DATE	LOCATION	ACCIDENT TYPE	FATALITIES
1	10th Sep 1976	Zagreb, former Yugoslavia	Mid-air collision	176
2 *	27th Mar 1977	Tenerife, Canary Islands, Spain	Runway collision	583
3 *	25th Jan 1990	Cove Neck, New York, USA	Fuel exhaustion	73
4 *	20th Dec 1995	Buga, Valle del Cauca, near Cali, Colombia	Controlled flight into terrain	160
5 *	12th Nov 1996	Charkhi Dadri, near New Delhi, India	Mid-air collision	349
6	25th May 2000	Charles de Gaulle Airport, Paris, France	Runway collision	1
7	8th Oct 2001	Milano Linate Airport, Milan, Italy	Runway collision	118

* Accidents referred to in ICAO Document 9835.

The opening chapter of ICAO Document 9835 refers to four of the accidents shown in Table 2. Curiously the accidents are not identified. The document simply mentions the numbers of fatalities and type of accident, as well as, in one case, the year of occurrence (ICAO, 2010). From this information it may be inferred that the accidents referred to in Document 9835 were: the 1977 runway collision at Tenerife; the 1990 fuel exhaustion crash at Cove Neck, New York; the 1995 controlled flight into terrain (CFIT) near Cali, Colombia; and the 1996 mid-air collision near New Delhi, India. These are accidents 2, 3, 4 and 5 in Table 2.

More explicit information about the accidents was provided at regional workshops held by ICAO to facilitate the launch of the language proficiency programme. In a 2008 workshop at the ICAO Asia and Pacific Office, the Acting Deputy Director of the ICAO Air Navigation Bureau listed all the accidents shown in Table 2 and made the point that they had resulted in the deaths of 1,460 people (Lamy, 2008).

The accidents shown in Table 2 took place over a period of 25 years at different locations in Europe, North America, South America and Asia. They involved various types of accident, although it is striking that five out of seven were collisions (two mid-air and three on runways). The pilots and air traffic controllers spoke an assortment of native languages; no single airline was involved in more than one accident; and the number of fatalities ranged from 1 to 583. In short, the accidents were diverse and the only obvious common feature is that language factors contributed to all of them.

ICAO has not provided or cited any analysis of the language factors involved in the accidents. Document 9835 simply notes that "insufficient English language proficiency on the part of the flight crew or a controller" was a contributory factor (ICAO, 2010, p. 1-1). The literature review for this dissertation indicates that limited research has been carried out on the communication problems in the accidents, with no systematic analysis of the language use in all seven events. This is surprising, given the prominence of the accidents when cited by ICAO during implementation of the language proficiency programme.

Previously, I have examined the communication problems in three of the accidents: the 1976 Zagreb mid-air collision, the 1977 Tenerife runway collision, and the 1990 crash of Avianca Flight 052 at Cove Neck (Cookson, 2009, 2011). These analyses highlighted several commonalities between the three events. In each case:

- the accident was complex and resulted from multiple causal factors;
- a combination of linguistic factors and non-linguistic factors was involved;
- the linguistic factors were exacerbated by high workload, stress and fatigue;
- the pilots and air traffic controllers were a mixture of native English speakers (NESs) and non-native speakers (NNSs).

Almost a decade has passed since ICAO's language proficiency programme came into effect. There has not yet been a comprehensive analysis of the language factors that contributed to the seven accidents listed in Table 2. Such an analysis would improve our understanding of the processes that led to the accidents. It would also contribute to aviation safety by reducing the risks of similar accidents happening again in the future.

1.6 The Structure & Aims of the Dissertation

This dissertation is a response to the ICAO language proficiency programme. It addresses the concerns raised by Alderson (2009) and Estival et al. (2016) by investigating the language used by pilots during *actual* flight operations. The overall aim is to provide a framework for analysing the language use of pilots in airline accidents. The framework is intended to be applicable to the accidents cited by ICAO, and other accidents or incidents from the past or future that involve communication breakdowns.

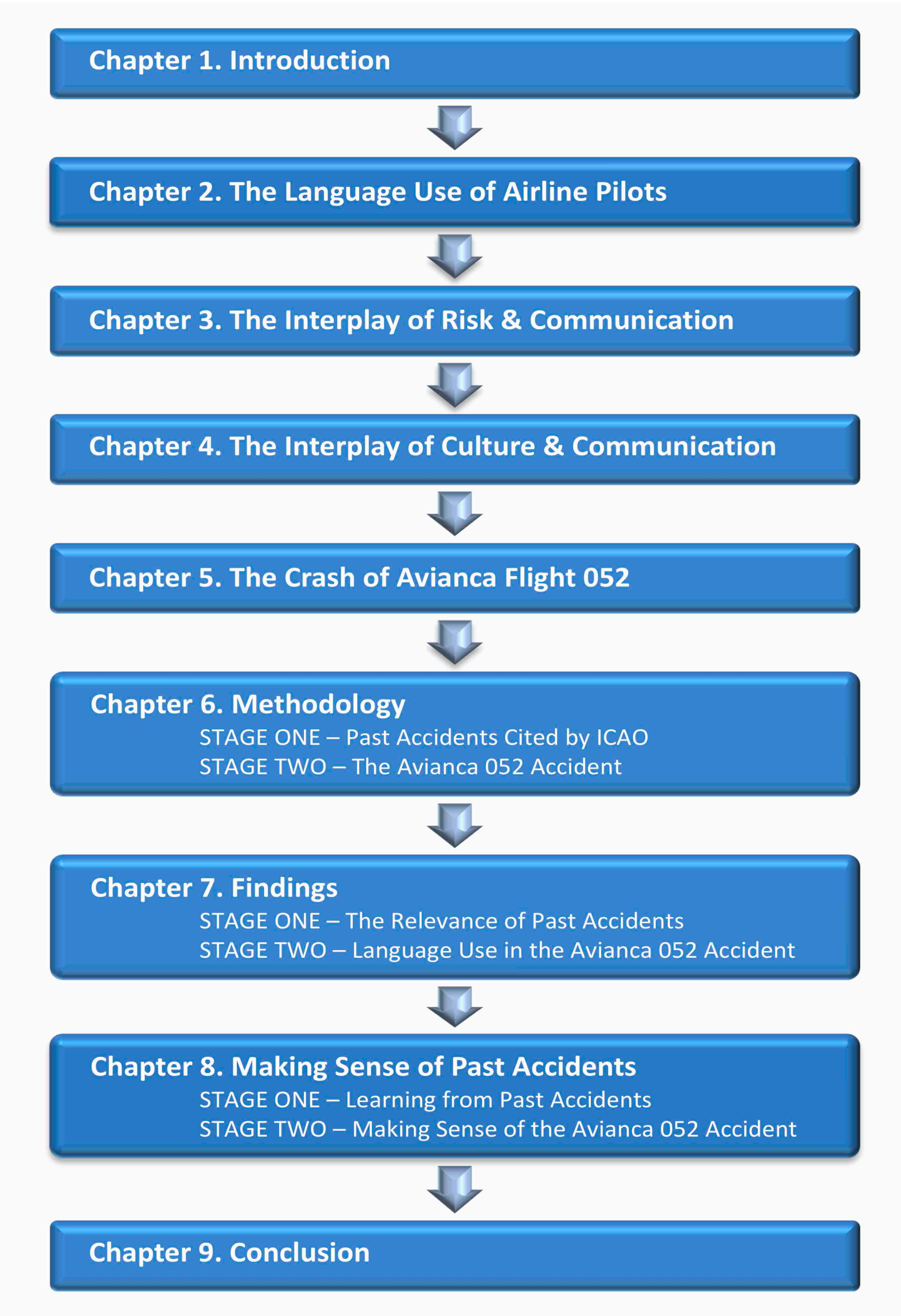
Figure 2 provides an overview of the structure of the dissertation. Following the introduction, the three areas of the literature review are reported in Chapters 2, 3 and 4. Chapter 5 contains a description of the context for one of the accidents cited by ICAO. The methodology and findings of the analysis are in Chapters 6 and 7 respectively. Chapter 8 presents a discussion of the findings, and the conclusion is in Chapter 9.

The analysis in this study is divided into two sections: Stages One and Two (shown in Chapters 6-8 in Figure 2). Stage One investigates the relevance of the accidents cited by ICAO for current airline operations. Stage Two examines how communication problems contributed to one accident: the 1990 crash at Cove Neck, New York. Multiple methods are used including a survey of current airline pilots, semi-structured interviews with one pilot, and linguistic analysis of pilot and ATC communications.

Stage One of the analysis asks: *How relevant are the accidents cited by ICAO to current airline operations?* The language proficiency programme has become an integral part of international air transport since it came into effect in 2011. However, the accidents cited by ICAO date back to the 1970s, which raises the question of their relevance to contemporary aviation. To explore this question, I conducted a survey of the attitudes of current airline pilots towards the accidents mentioned in Document 9835. The survey was followed up by interviews with one pilot to probe the results in detail.

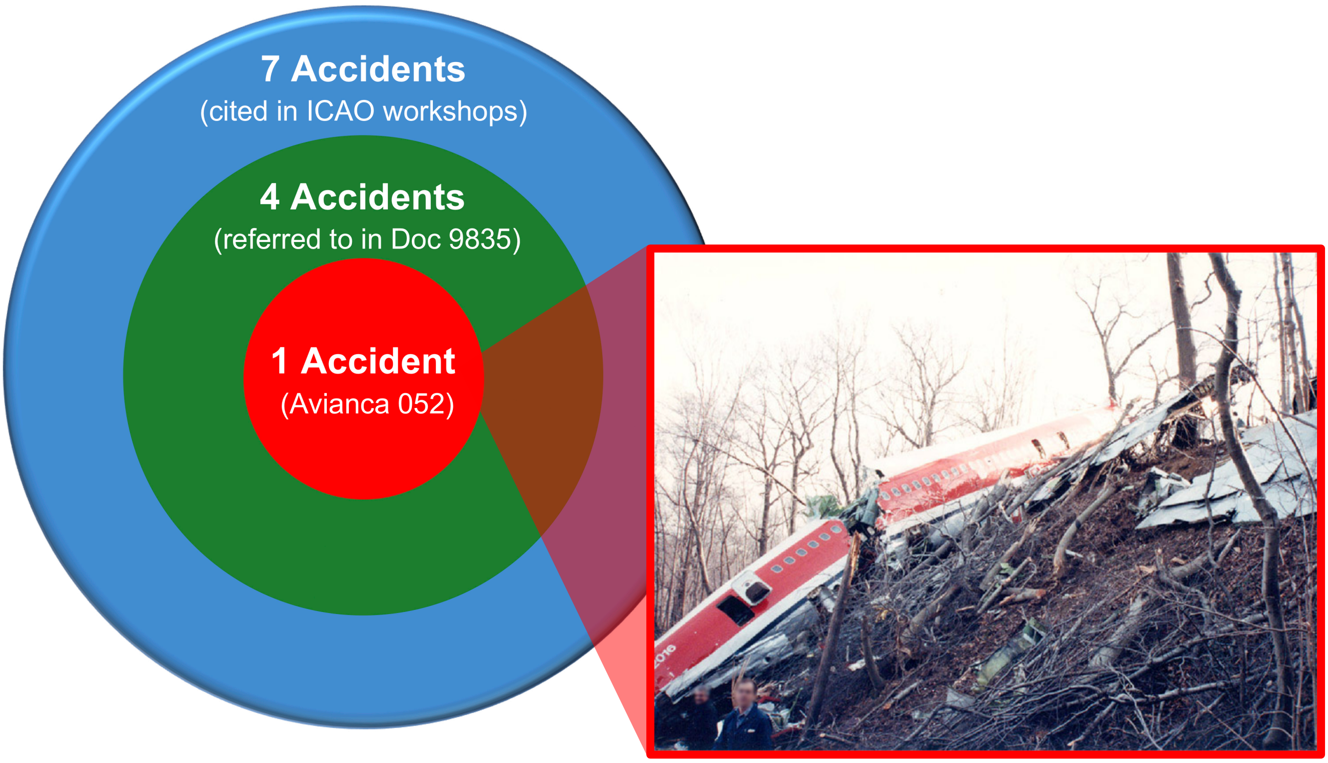
Stage Two focuses on one of the accidents cited by ICAO: the 1990 crash of Avianca Flight 052 near New York. This stage asks: *How did the language use of pilots and controllers contribute to the Avianca 052 accident?* After the official report for this accident was released in 1991 several issues relating to pilot-ATC communication were unresolved, as noted in dissenting comments from the investigating team (NTSB, 1991). Other analyses were subsequently published, most notably by Duke (1992) and Helmreich (1994). However, the 1990 Avianca accident has not been examined as thoroughly as the 1977 Tenerife collision (CIAIAC, 1978; Roitsch, Babcock & Edmunds, 1978; Weick, 1990) or the 1995 Cali crash (CAD,1996a; Simmon, 1998). This dissertation provides new insights into the communication problems involved in the crash of Avianca 052.

Figure 2: Structure of the dissertation.



The research focus of this study is illustrated in Figure 3. The blue outer circle represents the seven accidents cited by ICAO, which are listed in Table 2. The green circle stands for the four accidents mentioned in Document 9835, which are the subject of the pilot survey in Stage One. The red inner circle is the focus of the analysis in Stage Two: the crash of Avianca Flight 052.

Figure 3: Research focus of the dissertation. The photograph is a public domain image of the Avianca 052 crash site (FAA, n.d.).



Through the analysis of the Avianca 052 accident, a framework is developed for analysing the language use of pilots in emergency situations. The framework allows for the analysis of both verbal and non-verbal language, as well as cultural factors. Its purpose is twofold: (1) to provide a better understanding of the processes that lead to communication breakdowns in accidents; and (2) to identify specific communication factors involved in accidents so that this information may be fed back into pilot training. A key element in the framework is the Aviation Communication Toolkit (ACT), a glossary of factors which contribute to communication breakdowns between pilots and air traffic controllers.

This dissertation provides a reassessment of the crash of Avianca 052 that attempts to make sense of how communication broke down between the pilots and controllers. In addition, it presents a framework for analysing the language use of pilots in accidents. This will facilitate a long overdue, systematic analysis of all the accidents cited by ICAO. The framework is robust enough to be applicable to other accidents or incidents, past or future, which involve communication breakdowns. The ultimate aim is to publish a guide to good practice that is amenable to translation into different languages.

CHAPTER 2: The Language Use of Airline Pilots

This chapter, which is the first section of the literature review, describes different aspects of the language use of airline pilots. Chapters 3 and 4 contain the remainder of the literature review, and address risk and culture. These three chapters together provide complementary perspectives on communication problems that pilots may encounter during international flights. The differing perspectives offer a multi-layered view of the issues involved in the language use of airline pilots, especially in communication with air traffic controllers.

In this chapter I first present key concepts that provide a foundation for discussing the language use of NES and NNS pilots. The second section defines *aviation language* and outlines contexts in which it is used. The third section offers a brief description of the communication of pilots inside a cockpit, known as intra-cockpit communication. Next I address pilot-ATC communication, also known as pilot-ATC radiotelephony, which consists of two language varieties: standard phraseology and plain language. The following sections look at the influence of language for specific purposes (LSP) on aviation language training, and the application of conversation analysis (CA) to the communication of pilots. Finally, I discuss the role of English within ICAO's language proficiency programme, as well as the tension between *language* proficiency and *English* proficiency.

To catalogue the literature review, and to facilitate the analysis stage of the project, I set up a database using the FileMaker Pro database management system. This database contains more than 600 records that catalogue documents, technical manuals, accident and incident reports, journal papers and books. References for a significant proportion of the database records are listed in the Bibliography. Appendix 3 shows a sample record from the database.

2.1 The Language Use of NESs & NNSs

This section introduces key concepts from applied linguistics, English as a second language (ESL), second language acquisition (SLA) and sociolinguistics. These concepts provide a foundation for analysing pilot-pilot and pilot-ATC communication involving native English speakers (NESs) and non-native speakers (NNSs).

2.1.1 Communication & Communicative Competence

The word *communication* is commonly defined in terms of the exchange of information. Merriam-Webster's dictionary, for example, defines communication as "a process by which information is exchanged between individuals through a common system of symbols, signs, or behavior" (Communication, 2018). This dissertation adopts a broader definition: communication is a dynamic process of mutual exchange in which two or more people negotiate meaning using a common language (Oxford, 1990).

Communication includes both spoken and written language, and therefore involves the language skills of listening, speaking, reading and writing. In addition, it encompasses paralinguistic features (e.g., intonation) and various forms of non-verbal communication such as kinesics (i.e., body language), proxemics (i.e., the use of space), eye contact, kinesthetics (i.e., touching) and artifacts (e.g., jewelry).

In simple terms, the construct of *communicative competence* relates to the ability to communicate. Hymes (1972a) proposed the concept of communicative competence in response to Chomsky's concept of linguistic competence. Chomsky had distinguished between a speaker-listener's linguistic competence (i.e., knowledge of language) and performance (i.e., use of language in real situations). This was similar to the fundamental linguistic distinction made by Saussure between langue and parole. The concept of communicative competence proposed by Hymes accounted for speakers not only acquiring grammatical knowledge of a language but also learning how to use language appropriately in specific social contexts.

Several models of communicative competence have been developed. The model of Canale and Swain (1980), later developed by Canale (1983), has had a strong influence on second language teaching (Brown, 2000; Oxford, 1990). This model is broken down into four competences:

- Grammatical competence – the extent to which someone has mastered the linguistic code, including vocabulary, phonology, morphology and sentence-level grammar;

- Discourse competence – the ability to combine ideas coherently and cohesively beyond the level of a single sentence;
- Sociolinguistic competence – knowing the sociocultural rules which determine whether an utterance is appropriate in a particular social context;
- Strategic competence – the ability of a person to overcome limitations in their language knowledge, to make repairs and sustain communication.

A more comprehensive model of communicative competence, or *language competence*, was developed by Bachman (1990) and Bachman and Palmer (1996). There are two major components in this model:

- Organizational competence – consisting of grammatical competence and textual competence (which is equivalent to discourse competence);
- Pragmatic competence – consisting of sociolinguistic competence (relating to politeness, formality, metaphor, register, dialect, etc) and illocutionary competence (relating to functional aspects of language).

In this model, compared to that of Canale and Swain, sociolinguistic competence has been re-defined, and strategic competence has become a separate element within the overall construct of communicative language ability (Brown, 2000).

Finally, the Common European Framework of Reference for languages (CEFR) was developed to facilitate language teaching and the assessment of foreign language proficiency (Council of Europe, 2001). This framework includes a model with three major communicative language competences:

- Linguistic competence – including knowledge and skills of lexical, phonological and grammatical aspects of language;
- Sociolinguistic competence – including linguistic markers of social relations, politeness conventions, register differences, dialect and accent;
- Pragmatic competence – the principles of language use, including discourse competence, functional competence and design competence.

Document 9835, the guidebook to the ICAO language proficiency programme, includes an overview of communicative competence with the same components as the CEFR framework (ICAO, 2010). One difference is that Document 9835 places strategic competence within the construct of pragmatic competence. In the CEFR framework, communicative strategies are a separate element of overall language proficiency.

2.1.2 Varieties, Styles & Registers

A *language variety* (or lect) is a flexible linguistic concept that may have a wide range of referents. Trudgill (1992, p. 77) defined it as: “A neutral term used to refer to any kind of language - a dialect, accent, sociolect, style or register - that a linguist happens to want to discuss as a separate entity for some particular purpose.” Examples of language varieties spoken in the United States include American English, African American Vernacular English and New York Latino English.

A *language style* can be simply defined as “a variety of language used for a specific purpose” (Brown, 2000, p. 260). Adult native speakers have access to a range of language styles within their idiolects, or their individual patterns of language use. This allows them to choose appropriate styles for particular communicative contexts, depending on factors such as the audience, amount of shared experience, and purpose of communication.

Language styles are often associated with degrees of formality. Joos (1962) developed a widely-used classification of styles with five levels of formality:

- Frozen or oratorical – the most formal level, in which a text that has been carefully planned in advance is delivered to a large public audience;
- Formal or deliberative – a text presented to an audience that is too large for effective interaction, for example in a university lecture;
- Consultative – a dialogue between strangers, for instance a doctor-patient consultation or a business transaction;
- Casual – a dialogue between friends or acquaintances in which social barriers are low and there is shared knowledge;
- Intimate – communication between family members or very close friends in which there are no social barriers.

Classifications of style apply not only to spoken discourse, but also to written discourse. Aircraft manuals may be written in a deliberative style, whereas text messages between family members are usually casual or intimate.

Style is manifested through verbal and nonverbal features. Verbal manifestations include lexical and grammatical variation. Trudgill (1992) suggested that in English stylistic differentiation is mainly signalled by differences in lexis. The following words, for example, may all refer to aircraft: aeroplane, airliner, bird, bus, crate, flying machine, heap, jet, kite, plane, ship and taxi. In many languages, including English, one grammatical feature of casual or intimate styles is the use of contractions or deletions. Variations in style can also be conveyed non-verbally through paralinguistic features such as intonation and facial expressions.

Style shifting occurs when a person switches to a different language style due to a change in the communicative context. During an airline flight, a captain may use a deliberative style when making an announcement to passengers then switch to a casual style for a conversation with a first officer.

Communication accommodation theory (CAT) offers an explanation for some instances of style shifting in terms of convergence and divergence. Accommodation is the process of adjusting one's language use (e.g., accent, rate of speech, vocabulary selection) according to the language style of an interlocutor. Convergence occurs when a speaker makes adjustments to suit the style of a speech partner, which may reduce the social distance between them. Divergence is the use of speech patterns accentuating linguistic differences between a speaker and interlocutor, which may increase social distance and strengthen the speaker's identity as a member of a separate social group. Giles (2009, p. 3) made the observation that "effective accommodation is really an integral component of communicative competence".

One form of accommodation encountered in intercultural contexts is foreigner talk (or xenolect), which is defined as "a variety of a language employed [when speaking] to a person identified as a foreigner, usually in order to ease communication" (Clyne, 1998, p. 303). Foreigner talk often involves a simplification of grammar and lexis. In addition, it may be informed by attitudes, as when a speaker slows his or her speech rate and increases the volume because a foreign interlocutor is assumed to have low second language (L2) proficiency.

For non-native speakers, acquiring stylistic adaptability is an important aspect of learning a language. NNSs have to acquire a repertoire of language styles so that they can appropriately encode and correctly decode discourse in their second (or third) language. This is complicated by cross-cultural variation in what are considered appropriate styles for particular contexts. It is not uncommon for foreign students learning English in the United States, for example, to be surprised by the level of informality of American professors. As Brown (2000, p. 262) noted, "the acquisition of both styles and registers thus combines a linguistic and culture-learning process".

Related to stylistic variation are *registers*, which are varieties of language typically associated with particular activities (e.g., football and flower arranging) or professions (e.g., medicine and aviation). They are commonly identified by distinctive lexis (including idioms) connected to activities or occupations, but grammatical and phonological features may also be involved. The use of a register by members of a particular group may be labelled (in a non-technical sense) as jargon by outsiders who do not participate in the activity or occupation. Registers are sometimes associated with socioeconomic groups, making it difficult to differentiate them from dialects.

2.1.3 Interlanguage & Error Analysis

In the field of SLA, *interlanguage* is a concept developed by Selinker (1972) which refers to the linguistic system that an individual constructs when learning a second (or third) language. An interlanguage is an intermediate system between a learner's native language and the target language as used by native speakers. Referring to the same phenomenon, Nemser (1971) used the term *approximative system* to emphasise how learners make successive approximations to a target language.

The most straightforward way to analyse interlanguage is to study the spoken and written language produced by learners. Comprehension cannot be directly observed and is therefore more difficult to examine. The study of learners' production errors provides insights into their interlanguage and is called *error analysis*.[6]

A distinction is made between errors and mistakes. As Brown (2000, p. 217) noted, an error is "a noticeable deviation from the adult grammar of a native speaker" of the target language, and is thus a reflection of the learner's competence. A mistake, on the other hand, is "not the result of a deficiency in competence but the result of some sort of temporary breakdown or imperfection in the process of producing speech". All language users make mistakes, in both native and non-native contexts.

The errors that second language learners make when producing a target language may come from various sources. These sources include:

- <u>Interlingual transfer</u> – interference, or negative interlingual transfer from the native language (e.g., "ship" pronounced as "sheep");
- <u>Intralingual transfer</u> – transfer within the target language, such as when learners of English overgeneralize regular past tense endings (e.g., "flied" instead of "flew");

[6] SLA error analysis should be differentiated from the techniques used to analyse errors in accident or incident investigations (e.g., human error analysis or cognitive error analysis).

- Context of learning – misleading explanations provided by teachers, textbooks or instruction manuals.

The concept of interlanguage is relevant to all speakers of other languages who have not yet achieved mastery. In the field of aviation, it may offer valuable insights when analysing the language use, in particular the errors, of NNS pilots and controllers.

2.1.4 Communication Strategies

Communication strategies are mechanisms that individuals employ (consciously or subconsciously) to solve problems in order to achieve their communicative goals. These strategies constitute elements of the overall strategic competence that language users are able to draw on. Brown (2000) presented a taxonomy adapted from Dörnyei (1995) that divides communication strategies into two broad categories:

- Avoidance strategies – message abandonment and topic avoidance;
- Compensatory strategies – circumlocution, approximation, using all-purpose words, word coinage, prefabricated patterns, nonlinguistic signals, literal translation, foreignizing, code switching, appealing for help, and stalling or time-gaining strategies.

While not exhaustive, this listing indicates the range of strategies available to second (or third) language users. Avoidance strategies operate at the level of phonology, lexis, syntax or topic, or a combination of these. Avoidance of grammatical structures may occur when particular structures in the L2 are very different from those in the L1. Topic avoidance can result from speakers either lacking requisite cultural knowledge or judging that a particular topic requires grammar or vocabulary they have not mastered (Macaro, Vanderplank & Murphy, 2013). Topic avoidance appears to have been a factor in the 1995 American Airlines crash in Cali, Colombia, one of the accidents cited in Chapter 1.[7]

Two of the compensatory strategies listed above are based on phenomena that are explored in detail in subsequent sections of this dissertation. Using prefabricated patterns as a communication strategy involves the rote memorization of stock phrases or sentences

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[7] According to the Colombian accident report, a request made by the crew of American Airlines Flight 965 did not make sense to the approach controller. However, the controller did not articulate his misgivings "because of limitations in his command of English" (original Spanish: "debido a sus limitaciones en el dominio de Inglés") (CAD, 1996a, p. 29).

without internalizing their grammatical and lexical components. Prefabricated lexical patterns, or chunks, are the subject of Section 2.1.5 below. The use of code switching as a communication strategy involves an individual reverting from L2 to L1 in order fill in a gap in knowledge. Code switching is discussed in Sections 2.7 and 4.4.1.

2.1.5 Prefabricated Patterns & Skehan's Dual-Mode System

In the traditional, structural view of linguistics, lexis and grammar were considered to be separate entities. According to that view, speakers produce language by matching items of vocabulary to appropriate grammatical slots, while listeners decode language by applying structural rules. However, there is now widespread acknowledgment, in both linguistics and second language acquisition, that lexis and grammar are not separate but instead exist on a continuum (Cowie, 1998; Ellis, 2001; Ellis, 2003; Lewis, 1996; Skehan, 1996; Widdowson, 1990).

In the new view, the lexico-grammatical continuum has words at one end and grammatical structures at the other. In between lie a range of lexical items: idioms, phrases, fixed expressions, polywords, routine formulae, composites, sentence heads, lexicalized sentence stems, sentence frames and collocations. In the context of English language teaching, Willis (2003) suggested that lexical items could be grouped into four main categories: polywords, frames, sentences and sentence heads, and patterns. A *polyword* is defined as a phrase made up of a string of words that act as if they were a single word. Examples include phrasal verbs and adverbials such as “in fact” and “over there”. Polywords have little room for variation and are thus found near the word end of the continuum. Other lexical items vary in the degree of flexibility allowed in their form. Some, such as frames, may be altered considerably and resemble grammatical structures.

It is now recognised that a considerable amount of everyday conversation makes use of prefabricated lexical phrases, or *chunks*. This offers a clear benefit in that a chunk may be recalled from memory as a single lexical item, in the same way a word is. Thus the cognitive load required to produce stretches of language is reduced. Similarly, a chunk may be decoded as a single lexical item, without recourse to grammatical rules. Using such prefabricated forms therefore allow native speakers to produce and decode language in real time without undue cognitive load (Ellis, 2003; Skehan, 1996).

There are occasions when novel messages need to be produced (or decoded) and prefabricated chunks will not suffice. At such times, the speaker (or listener) makes use of grammatical rules to generate (or decode) language. Accordingly, Skehan (1996) proposed a dual-mode system in which native speakers are able to call upon both a lexical mode and a structural mode, depending on the context and their needs.

The extent to which non-native speakers are able to make use of the lexical mode depends on their language proficiency and the amount of prefabricated phrases they have internalized. It follows that one of the aims of language training should be to help learners develop automacity with prefabricated phrases in order to reduce their dependence on grammatical rules and the cognitive burden this imposes.

2.2 An Overview of Aviation Language

Aviation language encompasses the language used by a wide range of personnel working in all manner of aviation contexts. These personnel include aircraft mechanics, airport staff, air traffic controllers, cabin crew, cargo staff, dispatchers, engineers, flight crew, ground handlers, industry officials and management. In their work they draw upon numerous lexical domains, from aerodynamics and computer-aided design to VIP flights and weather conditions. In addition to oral communication skills, they may also need proficiency in reading and writing. Aircraft engineers, for example, have to read technical manuals and documents, and read or write emails, letters, reports and other professional communications (Lin, Wang & Zhang, 2014).

In the case of commercial pilots, a typical flight consists of a number of phases: preflight, taxi, takeoff, departure, climb, en route (or cruise), descent, approach, landing, taxi and arrival.[8] During these phases, pilots communicate with other personnel including air traffic controllers, dispatchers, gate agents, ground crew, flight attendants, maintenance technicians and other pilots, as shown in Figure 4.

The interactions that pilots take part in necessitate the use of various registers and language skill areas. Some tasks require pilots to read (e.g., completing checklists) or write (e.g., filling out weight and balance sheets) whereas others, such as communicating by radio with ATC, "require speaking and listening skills, but not reading and writing" (ICAO, 2010, p. 3-2). This dissertation is primarily concerned with two varieties of

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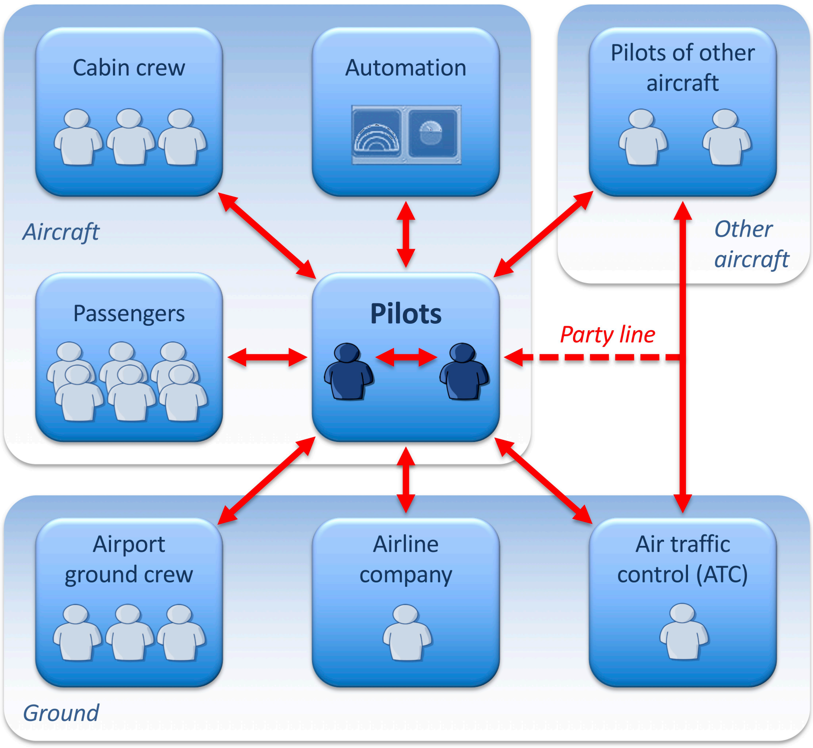
[8] This is a simple listing of flight phases. More sophisticated taxonomies have been developed, especially for use in accident and incident reporting systems. See, for example, the taxonomy drawn up by the CAST/ICAO Common Taxonomy Team (ICAO, 2013a).

aviation language that pilots use during flight: (1) intra-cockpit communication between pilots on the flight deck; and (2) radio communication between pilots and ATC, also known as *radiotelephony* or RT. While the main focus is on the communication of pilots, it is important to recognise the role that their interlocutors, especially air traffic controllers, play in shaping the communication.

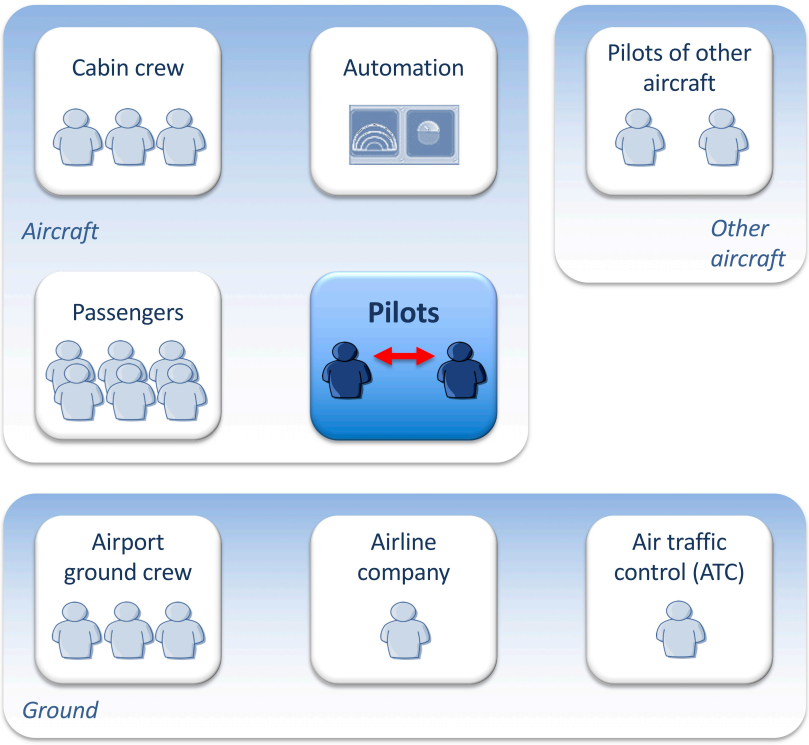
Figure 4: Pilot interactions during a flight.



2.3 Intra-Cockpit Communication

In the 1950s, at the start of the jet age, a flight crew of four or five members was required to deal with all the tasks involved in flying an aircraft: handling flight controls, controlling the engines, operating the radio and navigating. Advances in technology since that time, especially in cockpit automation, have seen successive reductions in flight crew size. By 1990, when the Avianca 052 accident occurred, airliners typically had a flight crew consisting of three people: a captain, a first officer and a flight engineer. Nowadays passenger aircraft are usually operated by just two pilots, a captain and first officer, as shown in Figure 5. The pilots sit side by side, facing forward, with domains of attention that overlap but are significantly different. This seating configuration allows some use of non-verbal gestures such as pointing, but makes it difficult for them to see each other's facial expressions clearly.

Figure 5: Pilot interactions within the cockpit.



Speech is an important element that enables pilots to coordinate their actions inside the cockpit. The language used depends on the airline and crew composition. For airlines based in English-speaking countries, intra-cockpit communication is naturally in English, as it is for multicultural airlines with a high proportion of NES pilots (e.g., Emirates). In other airlines, a national or regional language may be used, or a mixture of languages. By way of example, Hutchins, Nomura and Holder (2006, p. 3) reported on the languages used by Japanese flight crews:

> In Japanese airlines, most utterances in the flight deck (revenue flights) are produced in Japanese. English is used only for communication with ATC, reading text that arrives in the flight deck in English (for example, the text of electronic checklists displays,

> ACARS messages, and dispatch paperwork), and some technical call-outs such as 'V one,' 'Flaps five,' and 'Push Autopilot'. All other utterances, for example conversations about how to fly an approach, where traffic or weather are located, how the airplane is performing, as well as informal conversations, public address messages to the cabin (on domestic routes), communication with cabin crew, and communications with company personnel, are conducted in Japanese.

The working hypothesis developed by Hutchins, Nomura and Holder is that constraints in the environment (e.g., linguistic representations in the cockpit, such as labels, or ATC communications in English) affect the choice of language for non-native speakers of English. When not constrained, NNS pilots revert to their native language (L1) since it is cognitively easier than communicating in English, which is for them a second language (L2). This is especially true for tasks that involve complex processing.

Considering whether NNS pilots should be required to use English for flight deck communication, the German linguist Rainer Dietrich (2004, p. 193) noted that "even very professional speakers of a foreign language have a slower word recognition in the non-native language, showing that understanding, and certainly speaking, in a foreign language takes it toll on the speaker." He recommended against mandating the use of English for pilots sharing a common L1, reasoning that its use would involve an extra cognitive burden that could be critical in high workload flight phases, such as final approach and landing.

Intra-cockpit communication does not feature prescribed language to the extent that pilot-ATC communication does, but some communicative tasks – notably the reading of checklists – must be carried out in a particular way. Pilots otherwise have more freedom to communicate using so-called plain language. One significant constraint, though, is the *sterile cockpit rule*, which prohibits non-essential speech in operations below 10,000 feet. This rule was introduced by the Federal Aviation Administration (FAA) in the United States following accidents such as the 1974 crash of Eastern Airlines Flight 212 in North Carolina. In that accident, the pilots were found to have been distracted by "conversations not pertinent to the operation of the aircraft" (NTSB, 1975a, p. 15; for further details see Sumwalt, 1993, 1994).

2.4 Pilot-ATC Communication

Pilot-ATC communication is described in Document 9835 as “a specialized subcategory of aviation language corresponding to a limited portion of the language uses of only two aviation professions – controllers and flight crews” (ICAO, 2010, p. 3-2). Pilots and controllers communicate orally using a radio system known as radiotelephony (RT). This allows the transmission of signals in both directions but not simultaneously.

As Shawcross (2009) observed, pilot-ATC communication takes place under challenging conditions. It is conducted largely without visual contact in environments that are often time-pressured and stressful. The medium of communication is a VHF radio link that can be noisy and is subject to problems such as microphone clipping and interference. Clipping occurs when an operator either starts speaking before activating the microphone or deactivates it before finishing speaking. Interference happens when simultaneous radio transmissions are made on the same frequency, with the result that transmissions are degraded or blocked. This was a causal factor in the 1977 Tenerife collision, one of the accidents cited in Chapter 1.[9]

Given these constraints, one might expect miscommunications to occur more frequently than they actually do. Mell (1993) cited several important characteristics of radiotelephony to explain why problems are in fact quite rare. Firstly, the communications have a “predictable and repetitive nature”. Secondly, they make use of “an internationally recognised phraseology”. Thirdly, there are “a restricted number of topics... associated with a restricted terminology”.

As indicated in Figure 6, one controller is responsible for multiple aircraft within a particular sector. As planes progress through the airspace, the controller contacts one pilot at a time. All aircraft in a sector can hear the controller speak to other planes on a common radio frequency. When aircraft leave the sector, they are assigned a new radio frequency and handed over to the next controller. Drawing on the work of the sociologist Erving Goffman (1981), Sullivan and Girginer (2002) characterized this as “successive one-to-one interaction with multiple ratified participants, both addressed and unaddressed”.

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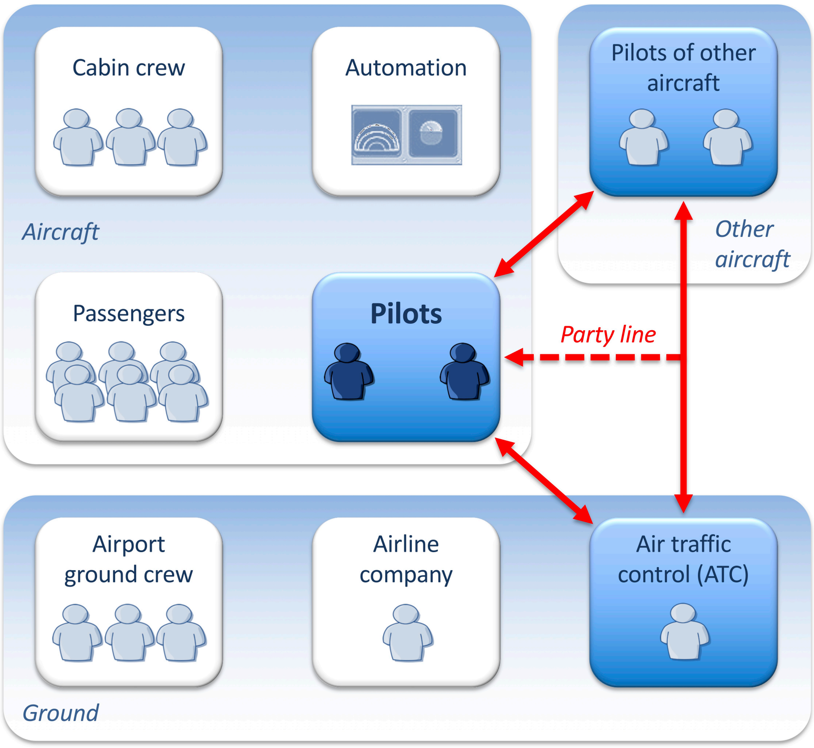
[9] There was interference between transmissions from the tower and one of the aircraft involved in the 1977 Tenerife collision (Pan Am Flight 1736). Either message could have alerted the other aircraft (KLM Flight 4805) before the collision. However, neither message could be heard clearly because of the near-simultaneous transmission (CIAIAC, 1978; Roitsch et al., 1978).

Figure 6: Pilot interactions with ATC.



Howard (2008, p. 372) highlighted four socio-environmental features of pilot-ATC discourse: "It is completely mediated, it is highly regulated, it is an intense environment, and the primary actors (flight crews and ATCs) emerge from different organizational structures and cultures." Discussing the latter point, Garzone et al. (2010) noted that pilots and controllers must work as a team to coordinate their actions, especially during takeoff and landing, despite having different backgrounds and possibly different nationalities. Furthermore, there are significant cognitive differences between the two groups:

> The ATCs are resident in the sites where operations take place and know the local environment very well. This profound knowledge has its linguistic counterpart in their familiarity with local contextual elements, for which there are often shared denominations and conventional Community-of-Practice (cf. Wenger 1999) forms - often shorthands - used to refer to them. On the other hand, pilots have to operate in settings of which in many cases they have never had any first-hand experience. So, they use direct visual input (whenever possible), also counting on a degree of standardization in airport design, and - above all - they rely on maps and on the

recognition of landmarks (natural or artificial, e.g. signs on the ground). (Garzone et al., 2010, pp. 224-225)

Pilot-ATC communication is generally considered to be made up of two varieties of language: standard phraseology and plain language (ICAO, 2007c, 2010). Standard phraseology is designed for routine flight operations. Plain English is meant to be used for non-routine operations. These two language varieties are described in Sections 2.4.1 and 2.4.2 below. Their use within pilot-ATC communication may be considered an example of diglossia, when two languages or language varieties are used under different conditions within a single linguistic community (Maher, 2017, 2019).

2.4.1 Standard Phraseology

To facilitate effective and efficient communication, pilots and air traffic controllers are required to use *standard phraseology*, which is also called standardized phraseology, RT phraseology or airspeak. An outline of ICAO standard phraseology is provided in Chapter 3 of Document 9835, and detailed descriptions of the requirements are given in the following publications:

- Volume II of Annex 10 (ICAO, 2007a);
- Chapter 12 of Document 4444 (ICAO, 2007b);
- Document 9432 (ICAO, 2007c).

The last of these publications, Document 9432, is the ICAO "Manual of Radiotelephony". It is available in English, French, Spanish and Russian versions. However, the main emphasis of the ICAO language proficiency programme is on the use of English, so the following paragraphs focus on English standard phraseology. The relationship of English to other languages in the civil aviation context is discussed in Section 2.7.

2.4.1.1 Features of Standard Phraseology

Standard phraseology may be differentiated from general language by a number of distinct features, examples of which are listed in Appendix 4. The main features include the following:

- Pronunciation protocols – prescribed ways in which numbers and letters should be spoken;

- Limited lexicon – the vocabulary consists of less than a thousand words, each of which is assigned a single, precise meaning;[10]
- Modified syntax – compared with general language, many grammatical words are deleted and frequent use is made of nominalizations, imperatives and the passive voice;
- Standardized message structures – the elements of a message (identifying the sender, addressee and message content) should be spoken in a particular order;
- Specific exchange patterns – exchanges of messages typically follow specific patterns, such as three turns initiated by ATC, with repetition conventions such as *read-back*, whereby a pilot repeats a message to confirm correct reception.

In an oft-cited study of ICAO standard phraseology, Philps (1991) documented differences from natural English on all of the main linguistic levels: phonology, lexis, semantics, discourse and syntax. Using a transformational-generative framework to analyse the syntax, Philps listed sentence-level and phrase-level transformations. His analysis highlighted "a pronounced tendency towards ellipsis" in standard phraseology (Philps, 1991, p. 123). To give one simple phrase-level example, the preposition of direction is deleted from the natural language phrase "climb **to** [flight level]" to produce the phrase "climb **Ø** [flight level]". This modification has two effects. Firstly it makes the phrase shorter so it can be spoken more quickly. Secondly, it removes the potentially dangerous possibility of listener confusion between two homonyms: the preposition "to" and the number "two".[11]

Estival et al. (2016) provided a comprehensive linguistic description of the aviation English used by pilots and ATC, including discussions of grammatical and lexical word categories that feature in standard phraseology. In terms of grammatical words, some pronouns and determiners are used, but the most prominent category is that of prepositions, as in these examples: "cleared **from** [location] **to** [location]" and "commence approach **at**

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[10] According to Document 9835, the vocabulary of standard phraseology is "around 400 words" (ICAO, 2010, p. 3-4). Lopez, Condamines, Josselin-Leray, O'Donoghue and Salmon (2013) reported that it was "less than 1000 different words".

[11] Confusion between homonyms was a causal factor in the 1989 crash of Flying Tiger Flight 66 at Kuala Lumpur. The controller said, "Tiger 66, descend **two** four zero zero [i.e., 2,400 feet]", which the captain read back as, "Okay, four zero zero". The captain apparently interpreted the instruction as "descend **to** four zero zero [i.e., 400 feet]" (Cushing, 1994; McMillan, 1998; NTSB, 1989a).

[time]”. The content words include a limited number of adjectives and adverbs, with many more verbs and nouns. One of the few adjectives is “clear(ed)”, which, as pointed out by Estival et al., is used with two distinct meanings: “sky **clear**” (i.e., weather information) and “**cleared** to land” (i.e., authorization). The lexis includes special categories for proper names, call signs, time expressions, units of measurement, and the clock code (e.g., “traffic 11 o’clock” to indicate the direction of other aircraft). Estival et al. (2016, p. 45) also noted that phraseology is regularly updated to improve safety: “When a possibility for confusion has been recognized, ICAO and other bodies may recommend changes which then become part of the regulations”.

Standard phraseology has been categorized in a variety of ways. Varantola (1989) labelled it a “semi-artificial code”, while Breul (2013) used the term “semi-artificial sublanguage”. The use of the word “artificial” by these researchers was presumably intended to contrast a code developed for a special purpose (i.e., standard phraseology) with natural language (e.g., English). However, the distinction between artificial and natural is problematic when applied to languages (or sublanguages or codes) that have all been developed, in one way or another, by humans. Since standard phraseology was intentionally devised for the purpose of human communication, it may alternatively be thought of as a constructed language or a posteriori language.

As noted above, standard phraseology has a grammar and lexis patterned on a simplification of existing language. In Document 9835 it is referred to as a “restricted sublanguage” and defined as “the formulaic code made up of specific words that in the context of aviation operations have a precise and singular operational significance” (ICAO, 2010, p. 6-6). Ragan (2007), coming into aviation from a background in ESL teaching, described standard phraseology as both a “restricted register” and a “singularly context bound special language”.

Others have simply labelled standard phraseology as a “restricted code” (Hall, 1976; Varantola, 1989; Estival et al., 2016). The concepts of restricted code and elaborated code were developed by Bernstein (1964) to account for differences in the speech systems of children from different social backgrounds. Characteristics of restricted codes applicable to standard phraseology include: rapid and fluent speech; interlocutors’ shared knowledge and expectations; and a low level of vocabulary and syntactic selection. The latter is important because it facilitates prediction, allowing high levels of listening comprehension even under conditions of time pressure. As McMillan (1998, p. 17) noted in a study of

ATC miscommunications: “Listeners are able to discriminate more effectively among a small number of possibilities than among a large number.”

2.4.1.2 The Purpose of Standard Phraseology

According to Document 9835, standard phraseology has a twofold purpose: “to reduce the possibility for ambiguity and to facilitate efficiency” (ICAO, 2010, p. 5-5). With the implicit assumption that efficiency requires short communications, this twofold purpose is expressed in different ways in ICAO documents, which variously call for “clear, concise, unambiguous language”, “clarity, conciseness and correctness” and “maximum clarity, brevity, and unambiguity” (ICAO, 2010, pp. 1-1 & 5-5; ICAO, 2007c, p. 3-2). The words *clear* and *clarity* are not defined in the documents, and it is therefore not evident whether they refer to language coherence, intelligibility, pronunciation, or a combination of these. For some researchers, clarity seems to take on the meaning of a lack of ambiguity. For example, Varantola (1989) and McMillan (1998) simply described the purpose of phraseology as “brevity and clarity”. Similarly, the Radiotelephony Manual published by the UK’s Civil Aviation Authority noted the need for “clear, concise, standardised phraseology” (CAA, 2015).[12]

There is, however, a conflict between the need for concise communications and the requirement to minimize ambiguity because, generally speaking, ambiguity is minimized by the use of elaborate communications. In a pioneering work on aviation human factors, Hawkins (1993, p. 169) noted this problem: “In other fields, such as law and government, messages are lengthened to ensure they are unambiguous. In aviation, phrases are being shortened, due to time pressures, but they still need to be unambiguous.”

Hall (1976, p. 133) observed that the tension in pilot-ATC radiotelephony between the simultaneous needs for “great parsimony” and “low ambiguity” was resolved by using a restricted code in which “everything is condensed: grammar, vocabulary, intonation”. From this perspective, standard phraseology is a form of high-context communication that is fast and efficient because pre-programmed information is in the receiver and setting, with minimal information in transmitted messages (Hall, 1976). For such a system to work effectively, pilots and controllers require extensive training, and they must necessarily all

[12] The need for language that reduces ambiguity and increases efficiency is not new. One of the recommendations in the report for the 1977 Tenerife runway accident was: “Use of standard, concise and unequivocal aeronautical language” (CIAIAC, 1978, p. 60).

learn the same set of information. An idea of the degree to which language is condensed in this restricted code may be gleaned from the amount of information contained in training materials: the ICAO Manual of Radiotelephony (Document 9432) contains 102 pages and the UK's CAA Radiotelephony Manual (CAP 413) runs to 358 pages.

2.4.1.3 Problems with Standard Phraseology

One problem associated with phraseology is that the standard varies from country to country. In the UK, 6 pages of significant differences from ICAO phraseology are listed in the Radiotelephony Manual (CAA, 2015). The differences reflect characteristics of the UK national airspace, such as large numbers of trainee pilots flying solo, as well as items of phraseology that the national authority thinks might lead to misunderstandings. As a consequence, pilots who fly between the UK and other countries must switch between different phraseologies.

A further complication is that there may be different standards *within* a country. For the UK, the Radiotelephony Manual lists 6 pages of significant differences between civil and military phraseology (CAA, 2015). These inconsistencies can cause problems when civilian planes land at military aerodromes. Differences in phraseology were identified as one of the causal factors that led to the 1996 crash of a Spanish Learjet at Royal Air Force Station Northolt in the UK (AAIB, 1997).

Another problem occurs when pilots and controllers do not adhere to standard phraseology. As stated in Annex 10, "ICAO standardized phraseology shall be used in all situations for which it has been specified" (ICAO, 2007a, p. 5-1). However, one study highlighted by ICAO found that "70 per cent of all speech acts uttered by native and non-native speakers, and for which a phraseology is prescribed, are not compliant with the recognized standards" (Mell, 1992, as cited in ICAO, 2010, p. 1-1). Document 9835 suggests that non-compliance may be due to various factors, including "respectable reasons such as pressure of work, and less respectable reasons such as carelessness and insensitivity" (ICAO, 2010, p. 3-5). It continues with an illustration of the risks of not using phraseology accurately, in this case the protocol for numbers:

> One example of such failure would be to identify a runway by saying 'Runway ten left' instead of 'Runway one zero left'. The word 'ten' could very easily be heard as 'turn', with obvious risks for the safety of ground movements. (ICAO, 2010, p. 3-5)

Instances of non-adherence to standard phraseology have been widely recorded in the research literature. In a review of 43 papers addressing pilot-ATC radiotelephony, Prinzo and Britton (1993) found that pilots and controllers used qualitatively different communication techniques, and they noted a tendency for pilots to use non-standard phraseology. Cushing (1994) suggested that a contributory factor to the 1981 accident at John Wayne Orange County Airport, California, was pilots switching codes from standard phraseology to plain language. Orasanu, Fischer and Davison (1997, p. 9) cited examples of American controllers using "local jargon, colloquialisms, or non-standard phraseology" such as the idiomatic expression, "keep your eyes peeled". Using the ASRS database, Cardosi, Falzarano and Han (1998) analysed 386 reports of pilot-ATC miscommunication, which they classified into three types of exchange pattern errors.[13] Prinzo, Hendrix and Hendrix (2006) investigated pilot-ATC communication errors using 50 hours of ATC recordings from American airports, and – noting that pilots and controllers have been encouraged to send shorter and less complex messages – identified a tendency for some pilots to use non-standard contractions for altitude and speed. Howard (2008) analysed over 15 hours of pilot-ATC dialogue recorded at US airports and found that deviations from ATC protocol increased the likelihood of problematic communication.

Concern about non-adherence to ICAO standard phraseology was also reported in a worldwide survey conducted by the International Air Transport Association (IATA) in collaboration with the International Federation of Air Line Pilots' Associations (IFALPA) and the International Federation of Air Traffic Controllers' Associations (IFATCA). Analysis of responses from 2,070 pilots and 568 controllers indicated that "non standard phraseology" and "use of general aviation English in lieu of standard phraseology" were two operational factors that increased the likelihood of communication errors. The study concluded that the use of non-standard phraseology was "a major obstacle" to effective communications between ATC and pilots (IATA, 2011, p. 53).

Anecdotal evidence that I gathered during the implementation of ICAO's language proficiency programme indicated significant variations in the use of standard phraseology by region. At an ICAO regional workshop in Bangkok, controllers from Indonesia and

[13] Identifying and classifying errors in pilot-ATC communications is not straightforward. Citing a study by Hollnagel and Amalberti (2001) which used data from the Human Error in Air Traffic Management (HERA) project, Dekker (2005) noted significant differences in the errors identified by trained observers when evaluating the same ATC session with the same taxonomy.

Brunei said that 80-90% of their communication was standard phraseology versus 10-20% plain English. These numbers were echoed by the Director of the Air Traffic Services Department of the Japanese Civil Aviation Bureau. By contrast, a tower supervisor at Juan Santamaria International Airport in Costa Rica stated during a plenary session at the 2007 ICAEA Forum that over 50% of pilot-ATC communication in the Central American region was in plain English. The difference in the figures may be partly due to wishful thinking. The Asian controllers were keen to show adherence to ICAO phraseology whereas the Costa Rican controller wanted to stress the importance of plain English. Nevertheless, the figures are suggestive of significant regional differences in language use and may reflect differences in practice resulting from different national culture characteristics.

In addition to the problems outlined above, standard phraseology is characterized by one fundamental limitation: as a consequence of the limited vocabulary and syntax, it is not sufficient to cover all possible situations that arise during flight operations. It has been designed to deal with most normal operations and some non-normal ones (e.g., emergency descents). However, if an unexpected event happens for which there is no phraseology, pilots and controllers must resort to plain language.

2.4.2 Plain Language

In contrast to standard phraseology, *plain language* is not clearly defined in ICAO regulations. Document 9835 describes it as "the spontaneous, creative and non-coded use of a given natural language" (ICAO, 2010, p. 6-6). One way of describing plain language is to define it as any language used by pilots or controllers that is *not* standard phraseology. An important aspect of plain language is that is used for resolving situations not covered by phraseology. As a result, plain language necessarily includes all of the lexicogrammar that individuals may draw on to handle a range of non-routine situations which cannot be exactly specified. Consequently it is not feasible to compile a directory of plain language, as is possible with the restricted code of standard phraseology.

In practical terms, some pilots consider plain language to be synonymous with general language or natural language. Estival et al. (2016) acknowledged that plain English is sometimes referred to as "Standard English" or "conversational English", but stressed that it is not the same as natural conversation. In terms of regulations, ICAO documents specify constraints on the use of plain language that serve to differentiate it from natural language. These constraints are outlined in the next section. Since they are only defined in broad terms, the exact nature of plain language and its relation to natural language are "still a source of debate and discussions" (Estival et al., 2016, p. 23).[14]

2.4.2.1 Constraints affecting Plain Language

The first constraint specified by ICAO relates to *when* plain language may be used. As stated in Annex 10, the use of plain language in radiotelephony is permitted "only when standardized phraseology cannot serve an intended transmission" (ICAO, 2007a, p. 5-1). Document 9835 outlines several example situations in which plain language may be used, including emergencies when pilots need to inform ATC about equipment failure or medical problems. More mundane situations are also mentioned, such as when a pilot makes a request to continue flying at high speed.

The second constraint concerns *how* plain language should be used. Echoing the need for clarity, brevity and unambiguity noted earlier in the discussion of phraseology, individuals are similarly "required to be fluent, clear, concise and unambiguous" when using plain language (ICAO, 2010, p. 3-6). While this requirement may be appropriate and realistic for the restricted code of phraseology, plain language is not as simple. Pilots and controllers habitually use natural language in non-aviation contexts where they do not face stringent requirements for conciseness or unambiguity. Their habitual use of natural language in daily life may interfere with their use of plain language in operational contexts, making it difficult for them to comply with the ICAO requirement. Kim (2013, pp. 107) provided an illustration of this problem in a study of communications between Korean air traffic controllers and foreign pilots:

> All three NES pilots were observed to use general English habitually and in an unnecessarily wordy manner. Their lack of sensitivity in using general colloquial English when plain English was required was emphasised along with their unduly fast rate of speech and choice of words whose meanings were unlikely to be shared.

In addition to the ICAO requirements, there are other constraints affecting plain language that relate to the pilot-ATC radiotelephony system. Non-verbal communication is not possible between pilots and controllers, and prosody is of limited utility due to radio bandwidth limitations. Both of these features are available for pilot-pilot communication

[14] There is no connection between aviation plain language and the Plain English movement that campaigns for more comprehensible official documents in English-speaking countries.

inside the cockpit, although only to a limited degree due to constraints imposed by seating arrangements and noise levels on the flight deck.

2.4.2.2 Features of Plain Language

The essential benefit of plain language is that it allows pilots and controllers to deal with unexpected situations not covered by standard phraseology. These may be situations that the individuals have not faced before or, in extreme cases, situations that no person has ever encountered. Innovative use of language is required in order to negotiate unexpected or even unprecedented situations. Chomsky (1975) noted that, despite being exposed to only a limited set of utterances, a typical language user can produce an indefinite number of novel utterances that are acceptable to members of the same speech community. In the context of aviation, the creative aspect of language, which allows novel utterances to be generated, is a vital tool for dealing with situations not covered by phraseology.

The importance of innovative language use was illustrated in the crash landing of United Airlines Flight 232 in Iowa in 1989. The aircraft was flying at 37,000 feet when it suffered a catastrophic failure of one engine that disabled the hydraulic system. This "billion to 1" situation was an unprecedented emergency and yet the crew, despite losing all control surfaces, managed to control the aircraft with differential thrust from the remaining two engines and fly to Sioux Gateway Airport (Haynes, 1991). The pilots and controllers involved in the accident were American, so communication was entirely in English. In the extract shown in Table 3, the captain uses plain language to describe the status of the flight controls to a controller. Some characteristic features of spoken English are illustrated in this brief extract, especially in the captain's first utterance. Drawing on the lexico-grammar work of Willis (2003), the features are as follows:

- <u>Additive discourse</u> – the captain starts by establishing a topic (i.e., "we have almost no controllability") and then adds a series of short statements giving extra information about the topic (e.g., "very little elevator", "almost no ailerons", and so on);
- <u>Ellipsis</u> – elements that can be easily retrieved from context are omitted (e.g., "**we have** very little elevator and **we have** almost no ailerons" is shortened to "**Ø** very little elevator, and **Ø** almost no ailerons");
- <u>Fillers</u> – working out what to say at the same time as producing language can be difficult, especially in a stressful situation; both the captain and controller use "ah" to

provide time to compose the next section of discourse; some of these fillers occur at possible turn completion points, signalling the speaker wants to continue talking;

- Untidiness – spoken words do not always express what a speaker means but the interlocutor may be able to retrieve the intended meaning; in this extract, the captain makes contradictory statements about left and right turns but the controller correctly understands that they "can only make right turns".

Table 3: Extract from ATC transcript of United Airlines 232.[15]

SPEAKER	CONTENT
Captain (UAL232)	So you know we have almost no controllability. Ah very little elevator, and almost no ailerons. Ah, we're controlling the turns by power. I don't think we can turn right. I think we can only make left turns. We're starting a little bit of a left turn right now. Maybe we can only turn right. We can't turn left.
Controller (Sioux City)	United two thirty-two heavy, ah, understand, sir, you can only make right turns.
Captain (UAL232)	That's affirmative.

The extract in Table 3 also highlights several points that distinguish plain language from standard phraseology. As noted in Appendix 4, phraseology features the deletion of subject pronouns, auxiliary verbs and determiners, as well as frequent use of the passive voice. By contrast, the captain's first utterance includes: 9 occurrences of the first-person pronouns "I" and "we"; two occurrences of the auxiliary verb "are"; the determiners "a" and "the"; and only the active voice.

In addition, the captain's first utterance has instances of vague language, which is characteristic of spoken English (Cutting, 2012). Using quantifiers such as "almost no", "very little" and "a little bit of" allows the captain to give essential details about a difficult

[15] This extract is a composite based on one transcript listed by Haynes (1991), which omits fillers and some words, and another from ASN (2003), which includes fillers but not the start of the first utterance. The accident report does not contain any audio transcripts (NTSB, 1990).

situation despite having limited information available and being under high levels of workload pressure and stress. This use of vague language is appropriate in the context of the accident, but at odds with the standard phraseology mantra that communications should have "maximum clarity, brevity, and unambiguity".

2.4.2.3 Problems with Plain Language

Using plain language for non-routine situations, including emergencies, provides the flexibility of natural language, which standard phraseology lacks, and allows the innovative use of language to deal with unexpected problems. There is an inherent risk, though, of increased complexity and ambiguity in the language used. Garzone et al. (2010, p. 219) noted that this can lead to miscommunication:

> But what really lies at the heart of miscommunication is, as Cushing pointed out in an early article (1989: 4), the complexity and flexibility of language [...], because of the confusion and misunderstandings that can result as a result of ambiguity, unclear reference, intonation peculiarities, implicit inference and presupposition.

Some of the problems of plain language are illustrated in another real-life example. Mell (1993) analysed an emergency transmission from an English-speaking pilot whose plane ran low on fuel in French airspace. The pilot did not use the standard procedure for distress signals, but instead used plain language. Several features of his transmission made it more difficult to understand: the use of colloquial expressions, the placing of message elements in non-standard order, a high density of information in a single message, and the use of complex grammatical structures. As a result, the main element of the message was masked, and it was difficult for French air traffic controllers to understand that the pilot needed assistance.

ICAO requires plain language to be "clear, concise and unambiguous", but this can be very challenging for both native and non-native speakers in the highly stressful and time-constrained context of an emergency situation. As noted in Document 9835, the features of plain language "can be far from plain and [they] present a challenge to listening skills" (ICAO, 2010, p. 3-5).

2.4.3 Intermixing of Standard Phraseology & Plain Language

As we have seen, pilot-ATC communication consists of two language varieties: standard phraseology and plain language. The separation of these varieties is a key tenet of ICAO's language proficiency programme, which stipulates that language tests for pilots and controllers should only assess plain language, not standard phraseology. The reasoning is that standard phraseology is a technical aspect of the work of pilots and controllers, which is already assessed in training, and should not be assessed by language experts who may not be familiar with flight operations. Estival et al. (2016, p. 85) acknowledged this concern, but pointed out a fundamental problem in the argument: standard phraseology and plain language "are intertwined in the real life context". Given that ICAO's goal is to improve language proficiency so that pilots and controllers can cope with unexpected situations, the authors questioned whether "the assessment of standard phraseology can or should be disregarded in the assessment of language proficiency".

A related issue is that the ICAO language proficiency programme associates phraseology with routine situations and plain language with non-routine situations. This division does not reflect actual language use, since plain language is found in *both* routine and non-routine situations. To give a commonplace example, pilots and controllers often add phatic expressions such as "Good morning" and "Thanks" (or equivalents in other languages) to routine messages which otherwise adhere to standard phraseology. Estival et al. (2016, p. 85) observed that:

> …one of the difficulties in developing tests in response to the ICAO LPRs is that tests are to be developed in response to policy and to largely theoretical notions of language use in the aviation context, as opposed to being developed in response to empirical studies of the way language is actually used in this context.

Standard phraseology and plain language have different characteristics. One challenge facing pilots and controllers is that they regularly have to switch between the two, or combine them. Another challenge is that the two varieties require different skills. To become proficient at standard phraseology, both NESs and NNSs need to practise until production and comprehension of the limited vocabulary and syntax become automatic. By contrast, plain language requires both a sufficient level of language proficiency *and* the ability to use language innovatively according to the needs of the situation.

2.4.4 Data Link Technology

The discussion in the preceding sections has concentrated on spoken language because pilot-ATC communication is mostly oral communication. This is a fundamental premise of ICAO's language proficiency programme: the rating scale includes listening and speaking skills but does not address reading or writing. However, communication between pilots and ATC is changing with the increasing use of data link technology, which allows text messages to be transmitted. Known as controller-pilot data link (CPDL) or controller-pilot data link communications (CPDLC), this technology is already being used to send flight clearances from ATC towers and centres in the United States and Europe (Baumgartner, 2017; Karp, 2016). The aim is to make communications more efficient, thereby reducing delays and increasing airport capacity.

Data link systems allow air traffic controllers to transmit routine messages to aircraft, with messages shown on a visual display in the cockpit. Controllers can send various types of message: ATC clearances (e.g., level and speed assignments), radio frequency assignments, and requests for information. Pilots can respond to ATC messages, request and receive clearances and information, and report information. There is also a free text function for exchanging information that does not conform to defined formats.

In the future, these systems will play an increasingly important role in pilot-ATC communication. As noted by Baumgartner (2017), this raises a number of questions:

- Do pilots and controllers trust a human voice more than an electronic text message?
- How will the new technology affect the distribution of attention in the cockpit?
- Will data link systems eventually replace oral communication altogether?

In addition to these questions, a significant limitation of data link systems is the possible degrading of pilot situational awareness due to the loss of *party line* information, which comes from listening to the radio communications of other aircraft (Estival et al., 2016; Midkiff & Hansman, 1992). Another important issue is the vulnerability of data link systems to cyber attack (Gurtov, Polishchuk & Wernberg, 2018).

2.5 Language for Specific Purposes (LSP)

There is widespread acceptance of the binary model of pilot-ATC communication discussed above, which features the two language varieties of phraseology and plain language. Alternative models have, however, been proposed. In the early days of ICAO's language proficiency programme, Mitsutomi and O'Brien (2003) outlined a framework that divided aviation language into three critical components: (1) ATC phraseology, corresponding to standard phraseology; (2) English for General Purposes, corresponding to plain language; and (3) English for Specific Purposes.

Implicit in the Mitsutomi and O'Brien model was the assumption that English is the language of international civil aviation. Hence the model referred to *English* for General Purposes (EGP) and *English* for Specific Purposes (ESP) rather than the more inclusive *Language* for General Purposes (LGP) and *Language* for Specific Purposes (LSP). Within the model, ESP was described as a subset of EGP consisting "mostly of aviation-specific topics and vocabulary" (Mitsutomi & O'Brien, 2003, p. 125).

The Mitsutomi and O'Brien model appears to have been informed by the work of the PRICESG study group, which laid the groundwork for ICAO's language proficiency programme by reviewing pilot and controller communications. During the course of the PRICESG meetings in 2000-2001, there was discussion of the need to balance "common English" proficiency with "aviation specific English" training (PRICESG, 2001, p. 2-2). References to specific-purpose language teaching subsequently appeared in Document 9835, first published in 2004 and revised in 2010. However, the core concept of the ICAO language proficiency programme is the binary model of phraseology and plain language. The notion of aviation specific English has disappeared, partly subsumed within standard phraseology and partly within the nebulous concept of plain language.

The Mitsutomi and O'Brien three-part model of aviation language failed to gain wide currency, possibly because the distinction between phraseology, ESP and EGP does not map smoothly onto the world of flight operations, unlike the straightforward distinction between phraseology and plain language. There is little or no mention of ESP or LSP in language textbooks for pilots and controllers. The textbooks either focus on phraseology (Robertson, 2008) or plain English for non-routine situations (Cookson & Kelly, 2012; Ellis & Gerighty, 2008; Emery & Roberts, 2008). Nevertheless, curriculum design theory from the domain of LSP, especially ESP, plays an important role in informing the language training of aviation professionals (Cutting, 2012; Lin, Wang & Zhang, 2014; Sullivan & Girginer, 2002; Tajima, 2004; Wang, 2008).

Two LSP studies in particular demonstrate valuable contributions from this field. Firstly, in a frequently cited paper, Sullivan & Girginer (2002) reported on a project to design ESP courses for pilots and air traffic controllers in Turkey. Data collection included observations in a control tower, audio recordings of pilot-ATC communications, and questionnaires and interviews with pilots and controllers. In addition to providing a model for prospective ESP course designers, this study identified deviations from standard phraseology in the language use of pilots and controllers. These included the non-standard pronunciation of numbers (e.g., “triple six” in place of “six six six”) and the use of greetings and closings (e.g., “good afternoon” or “iyi gunler”). The authors also identified a notable use of Turkish instead of English, especially during approach and landing.

In the second study, Cutting (2012) reported on an ESP project to develop materials for NNS staff working in a variety of jobs at Charles de Gaulle Airport in Paris. The aim was to produce “realistic dialogues that could serve as models for pseudo-beginners to emulate, with the features of effective service encounters, such as clarity, informativeness and politeness” (Cutting, 2012, p. 5). Although data collection was limited to observations at the airport, the paper highlighted significant differences in the English language use of four trades: security guards, ground handlers, catering staff and bus drivers. The author suggested that a future research project might construct a corpus of real interactions. This could include features of spoken language such as code switching and incomplete or incoherent utterances, as well as possibly even body language.

2.6 Conversation Analysis (CA) in Aviation

Conversation analysis (CA) has been defined as the “analysis of real-world, situated, contextualised talk” (Liddicoat, 2007, p. 8). It is an area of microsociolinguistics that examines the organization of naturally occurring conversation during face-to-face interaction. The origins of CA date back to the 1960s when Harvey Sacks, Emanuel Schegloff and David Sudnow were graduate students in the Sociology Department at the University of California, Berkeley. One early influence on CA was Erving Goffman’s work investigating the social organization of interactions. Another influence was the ethnomethodology approach established by Harold Garfinkel to study the practical methods that people use to make sense of everyday interactions.

Some CA analysts prefer to use the term *talk-in-interaction* because this makes clear that the talk is not studied in isolation but instead as an integral part of real-world interaction. For example, the interaction of pilots has been studied as they sit in a cockpit and operate an aircraft. During the course of their interaction, participants may draw upon a range of resources including physical objects, features of the setting, body movement and silence (Nevile, 2004; Hutchby & Wooffitt, 2008).

2.6.1 Key Concepts in CA

A key part of CA is the meticulous transcribing of audio or video recordings of naturally occurring talk using conventions that have been developed over several decades. The transcriptions include a large amount of detail: tokens such as "ah" and "um"; periods of silence; overlapping talk; laughter, applause or other responses; and prosodic features of speech such as changes in pitch or speed, or the lengthening of sounds. These features are all included because they may be significant. Detailed transcribing is time-consuming, but repeatedly listening to the same recordings allows analysts to discover patterns in the data without imposing preformulated theories. This process is known as *unmotivated looking* (Liddicoat, 2007; Have, 2007).

One of the claims made for CA is that it is an objective methodology that does not make assumptions about the intentions of participants, unlike other forms of discourse analysis such as speech act theory. Nevile (2006, p.3) commented that CA "is data driven and does not start with pre-determined and analyst driven categories". He went on to state that it "does not guess at what people are thinking, or at the motivations of their actions, but looks for evidence in the transcription data themselves". Krifka, Martens and Schwarz (2004, p. 77) acknowledged this point of difference, but noted that "arguably, insightful analysis of communication must also refer to speakers' intentions".

A fundamental principle of CA is that conversation, in contrast to monologue, is an organised social phenomenon based on turn-taking: one speaker speaks at a time; changes of speaker occur; and patterns of turns can be identified. Turns may consist of simple sounds, words, phrases or complete sentences. CA emphasises that they are sequentially ordered and collaboratively produced by participants, with successive turns building on each other. When looking at transcribed talk, it is important to remember that the speakers' understanding was developing moment to moment during the course of the interaction. Turn-taking therefore "works at the level of each next bit, not at the level of the whole conversation because speakers in a conversation only have access to the conversation as it unfolds" (Liddicoat, 2007, p.54).

A basic building block from which sequences of conversation are built up is the *adjacency pair*, which is a sequence of two ordered turns. There are many types of adjacency pair: question-answer, greeting-greeting, terminal-terminal, summons-answer, telling-accept, invitation-accept/decline, request-accept/decline, offer-accept/decline and assessment-agreement/disagreement (Schegloff, 2007; Liddicoat, 2007). Adjacency pairs contribute to the organization of talk by creating expectations about how a conversation will proceed as it unfolds. Talk is considered problematic if expectations are not met.

Another key concept is *recipient design*, defined as the "idea that a speaker builds an utterance in such a way that it fits its recipient" (Have, 2007, p. 136). Based on the knowledge that participants in a conversation are assumed to share, there are various ways in which speakers design talk so it is understood by interlocutors. Recipient design may, for instance, take the form of word selection, topic selection or sequence organization. Liddicoat (2007, p. 6) made the salient observation that recipient design is a resource not just for speakers but also for listeners, because "listeners are motivated to hear a turn that is designed for them, and participants track the trajectory of the talk to hear a turn if a turn is designed for them".[16]

2.6.2 CA Studies in Aviation

Using data from audio and video recordings, and drawing on ethnomethodology and conversational analysis, Nevile (2004) investigated talk-in-interaction in the cockpit during a series of airline flights in Australia. This research investigated routine pilot communications. Although the primary focus was intracockpit dialogue, the study also looked at how the pilots integrated "talk within the cockpit" with ATC communications "beyond the cockpit". In addition, the use of video data allowed Nevile to analyse how pilots coordinated talk and non-talk activities as they carried out the tasks involved in flying the plane.

One of the main findings was that pilots made pronominal choices related to their cockpit identities. Nevile (2004, p. 198) noted occasions when crew members invoked an individual identity (e.g., as a captain or as the pilot flying) through the use of singular first person or second person pronouns (e.g., "I/my/me" or "you/your"). These were contrasted with occasions when they used plural first person pronouns (e.g., "we/us") to invoke "a

[16] Listeners may fail to hear a turn that is not clearly designed. In an analysis of the 1977 Tenerife collision, Roitsch et al. (1978 p. 22) identified several missed opportunities to prevent the accident. One was a transmission in which the controller "for the first and only time that day" addressed the Pan Am aircraft using the phonetic alphabet, "Papa Alpha", instead of the familiar term "Clipper". The suggestion is that the crew of the other aircraft involved in the collision did not perceive this message because of the unfamiliar address.

shared identity of crew member, and present some action, circumstance or understanding as experienced by both pilots together".

The study also examined the ways in which pilots modified officially prescribed wordings found in manuals of standard operating procedures and checklists. Nevile (2004, p. 200) noted that pilots "occasionally substituted spontaneous wording for prescribed wordings, and very frequently embellished officially prescribed wordings". Examples of embellishment included the addition of pronouns or phrases such as "thank you". The modifications were coordinated with non-talk activities and did important interactional work, for instance allowing crew members to show their understanding of the current situation. The study highlighted the need of pilots to invoke their identities as active human participants in a highly automated workplace. For these reasons, Nevile (2004, p. 202) recommended that the "commercial aviation industry should not necessarily treat such local changes to 'what's in the book' as a matter of concern". He suggested that allowing pilots leeway to improvise linguistically during routine operations could be beneficial in terms of helping them to develop a resource for dealing with non-routine or emergency situations for which there are no prescribed wordings.

In a separate study, Nevile and Walker (2005) used CA to analyse intracockpit communications in the 1995 crash of a business jet near Alice Springs, Australia. The analysis highlighted: a significant amount of overlapping talk between the pilots; many instances when an expected response was replaced by silence; and lots of repair by the pilot in command (PIC) of the copilot's talk. The analysts concluded that "such aspects of interaction contribute to a working relationship that can be conducive to an error occurring and not being identified". This process was labelled *collaborative construction of error* (Nevile & Walker, 2005, p. 16). The study noted that the proximal cause of the accident, an incorrectly set descent altitude, was not the sole responsibility of either pilot, but was at least partly due to the communication between them.

Building on these studies, Nevile (2006) developed a CA tool that can be used in investigations of aviation or other transport accidents. The tool includes protocols for transcribing and analysing voice data. It enables an analyst to identify both recurring communication phenomena of special interest and also key periods of interaction that warrant close analysis.

2.7 English as "the international language of aviation"

The ICAO language proficiency programme is intended to improve the language proficiency of pilots and controllers worldwide. As noted in Chapter 1, several aspects of the ICAO programme have been criticised. One of the most controversial issues is the degree to which English is being promoted as the language of international civil aviation. The question may be framed succinctly: is the aim to improve *language* proficiency or *English* proficiency?

ICAO has faced language problems before, as disputes over language have been part of the organization's history since its inception at the Chicago Convention in 1944. MacKenzie (2010) recorded how English was the dominant working language within ICAO during its early years, despite the efforts of other nations to promote French or Spanish as a counterbalance. As he observed: "Language was a problem that never went away" (MacKenzie, 2010, p. 87).

Since ICAO's founding there has been a phenomenal increase in airline passenger numbers. These were boosted by the start of the jet age in the 1950s, the introduction of wide-body jets in the 1970s, and the deregulation of regional markets starting with the United States in 1978. Advances in aircraft technology have been instrumental in the growth of civil aviation. When ICAO was established in the 1940s, a typical airliner such as the Douglas DC-3 could carry its maximum payload of a few dozen passengers less than 1,000 kilometres. Nowadays, Boeing 777s routinely fly trips in excess of 11,000 km with a load of several hundred passengers, crossing entire regions en route. Air transportation is now truly global and there is a strong common-sense argument that it requires a common language to operate smoothly and safely.

The case for English to be adopted as the official language of international aviation may be expressed as two propositions. Firstly, communication would be simpler and safer if all pilots and controllers spoke the same language. Secondly, English is the obvious choice as it is already in widespread use in aviation, as well as being the de facto language of international business.

The reasoning put forward to support the first proposition is as follows. When all pilots and controllers in a particular airspace communicate using a common language, everyone can understand all the radio transmissions. In this situation, pilots listening to messages between ATC and other aircraft (on the party line) can maintain situational awareness about their location and potential hazards in their vicinity, including other planes.[17] However, if code switching occurs and one speaker changes to a different language, other pilots in the airspace might not understand the communication. As a result an important source of information may be lost with significant implications for safety (Borins, 1983; Estival et al., 2016; IATA, 2011; Orasanu et al., 1997).[18]

The opposite position was outlined by Borins (1983) in a detailed study of the bilingual ATC conflict that took place in Quebec in the mid-1970s. He reported two arguments in favour of using more than one language for pilot-ATC communications. Firstly, when controllers use another language instead of English (e.g., French in Quebec), safety is enhanced for local pilots (who may be unilingual francophones). Secondly, this reduces the workload and anxiety of controllers as they can simply issue an instruction once in the other language rather than repeating it several times in English to ensure comprehension. It is probable that air traffic controllers have in the past averted accidents by switching languages to help pilots who could not understand English instructions, but there does not appear to be any research evidence to support this hypothesis.

The second proposition is that English is the obvious candidate to be the official language of international aviation. Kachru and Nelson (1996, p. 96) labelled English "the cross-cultural medium of choice". They noted it "has become – or at least is perceived as – indispensable in many areas of international business and for such special purposes as air and sea traffic control". Many English-speaking pilots regard English as "the universal language" of aviation (Estival et al., 2016, p. 5). The Acting Deputy Director of ICAO's Air Navigation Bureau addressed this issue at a regional workshop held in Bangkok. Other languages – such as Spanish, Russian or French – are used in certain regions of the world, but he noted that English allows pilots to fly further and with more route flexibility. He stated that English is the only language used throughout the aviation world and concluded: "The fact is that English is the international language of aviation" (Lamy, 2008).[19]

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[17] This argument may be undermined in the future if data link technology significantly reduces the importance of party line information (see Section 2.4.4).

[18] Code switching was a factor in the 1976 mid-air collision near Zagreb (AAIB, 1977, 1982), the 2000 runway collision in Paris (BEA, 2001) and the 2001 runway collision in Milan (ANSV, 2004).

[19] During the implementation phase of ICAO's language proficiency programme, some pilots and language instructors objected to the new requirements. At the ICAO workshop, the Acting Deputy Director mentioned French pilots being told by airline management that if they resisted they might be reassigned to smaller and less prestigious aircraft (Lamy, 2008).

A strong case can be made for English as the international language of aviation, but it is not the universal language of aviation. English is not widely spoken in China or South America, which both represent significant aviation markets. The lack of trained personnel with the necessary language skills seems to preclude the worldwide imposition of a single language policy based on English. This was acknowledged in Document 9835, which noted "there are significant national, cultural, economic and organizational impediments that make such a move impractical" (ICAO, 2010, p. 4-3).

Furthermore, the implication that there is a single English language is misleading. Kachru and Nelson (1996) listed 45 countries in which English had official status. In many of these countries there are distinctive varieties of English, such as Indian English or New Zealand English. Mutual intelligibility between speakers of different varieties of world Englishes is a critical issue in international aviation. Seiler (2009, p. 47) discussed the phonological distinctions between these varieties in the aviation context, making the salient point that mutual intelligibility requires a certain amount of mutual exposure and time before speakers can tune into "unfamiliar dialects or accents/pronunciations".

The issues surrounding aviation language and aviation English are complex, and perhaps unsurprisingly ICAO has adopted a compromise position. As stated in Annex 10: "air-ground radiotelephony communications shall be conducted in the language normally used by the station on the ground or in the English language" (ICAO, 2007a, p. 5-3). The language used by a ground station may be the national language or a regional language (e.g., Spanish in the Central American region or large parts of South America). There is an important additional requirement: "The English language shall be available, on request from any aircraft station, at all stations on the ground serving designated airports and routes used by international air services" (ICAO, 2007a, p. 5-3). In other words, pilot-ATC communications can be conducted in national or regional languages, but English must be available at all ground stations that serve international air routes.

The actual position of ICAO, as reflected in official documents, is subtly different. English plays a dominant role in the language proficiency programme. Document 9835 states that "proficiency in English will be the major preoccupation in the implementation of the requirements" (ICAO, 2010, p. viii). The document, which is the official guidebook for the programme, refers in general terms to *language* proficiency but contains multiple specific references to *English* proficiency (ICAO, 2010):

- Assembly Resolution A32-16 was formulated in 1998 "to consider, with a high level of priority, the matter of English language proficiency" (p. vii);

- the Proficiency Requirements in Common English Study Group (PRICESG) was set up to review all aspects of pilot-ATC communications (p. vii);
- Assembly Resolution A36-11, "Proficiency in the English language used for radiotelephony communications", was adopted in 2007 to initiate implementation of the proficiency programme (p. vii);
- all four accidents cited in the document to justify the programme were caused in part by "insufficient English language proficiency" (p. 1-1);
- all examples of pilot-ATC exchanges cited in the document are in English (pp. 3-4, 3-6, 3-9, 3-10, etc);
- the Glossary of Basic and Complex Structures in Appendix B contains only English grammatical structures (pp. B-13 – B-16).

This dissertation recognizes the importance of English in international aviation. However, it also acknowledges that aviation language encompasses a complex web of languages, language varieties and codes. These are used by a variety of operators in the global air transportation system. This study focuses on one particular aspect of aviation language: communication between airline pilots and ATC involving NESs and NNSs. Modern flight operations take place in a transportation system of tremendous scale and technological complexity. The fundamental problem is not new. It may be traced back to the story of Babel from the Book of Genesis in the Old Testament. The essential question is this: How to overcome language and cultural barriers so that teams of workers can communicate safely and effectively?

CHAPTER 3: The Interplay of Risk & Communication

This chapter, which is the second section of the literature review, addresses risk factors that may adversely affect pilot communication. The start of the chapter reviews fundamental concepts of uncertainty and risk, including risk perception, bounded rationality and the contrast between external risk and manufactured risk. In the second section I give definitions and examples of hazards, and distinguish hazards from risks. Then I define the concept of acceptable risk and review two important case studies: the Binghampton chemical fire and Challenger space shuttle accident. The following section briefly introduces safety management systems (SMS) in aviation. I then describe some techniques used in aviation for identifying hazards, assessing risks and controlling risks. The final section discusses risk factors that may affect pilot communication and outlines the format adopted in Canadian TSB accident reports to express “findings as to risk” in the form of factual conditional sentences.

3.1 Uncertainty & Risk

Renn (2008) provided an overview of risk concepts across a variety of disciplines. He observed that risk has been a key topic in multiple areas of academic and professional activity, ranging from "natural hazards, technological threats, working conditions, ambient health impacts, crime, terrorism, and pollution to leisure activities" (Renn, 2008, p. 50). In his overview, approaches to risk are grouped into the following broad categories:

- risk concepts of the natural and technical sciences (including actuarial analysis and probabilistic risk assessment);
- economic approaches (including revealed preferences and expressed preferences);
- the psychology of risk perception (including the heuristics that individuals use to process risk information);
- social and cultural concepts of risk (including the "Risk Society" concept and the cultural theory of risk).

Approaches from each of the categories are described in this chapter. In the first section, I start by distinguishing between risk and uncertainty. Then I discuss risk perception and bounded rationality. The final part of this section addresses the concepts of external risk and manufactured risk.

3.1.1 Distinguishing Uncertainty from Risk

There is often confusion between the terms *uncertainty* and *risk*. In a study of decision-making, Klein (1998, p. 277) pointed out that the word "uncertainty" embraces a range of meanings: "A review of the literature shows that people discuss uncertainty in terms of risks, probabilities, confidence, ambiguity, inconsistency, instability, confusions, and complexity". In an attempt to define the concept more clearly, Klein stated that uncertainty may arise because information is missing, unreliable, ambiguous or complex, and that there may be uncertainty at the level of data, knowledge or understanding.

Other commentators have highlighted a lack of preciseness in the way the terms "uncertainty" and "risk" are used. The economist Frank Knight, writing in 1921, proposed that "uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated" (as cited in Fischhoff & Kadvany, 2011, p. 10). He stated that a distinction should be made between risks, which are measurable, and uncertainties, which are not.

Clarke (1999) acknowledged Frank Knight's concerns and argued the usefulness of his distinction, while pointing out that economic theories of choice under uncertainty have led to probabilities being incorporated in later conceptions of uncertainty. Clarke also noted that the economists James March and Herbert Simon had similarly distinguished between risk and uncertainty in their seminal book "Organizations". Clarke (1999, p. 11) summed up the difference between the two concepts as follows:

> Risk in its general form is when it is possible, at least in principle, to estimate the likelihood that an event (or set of events) will occur; the specific forms of those estimates are the probabilities of adverse consequences. Uncertainty is when such estimations are not possible.

To illustrate the distinction, Clarke said that it was possible to estimate the risk of divorce for first-time marriages, but whether any particular marriage would end in divorce was uncertain. Similarly, in the aviation context, we can estimate the overall risk of airline accidents happening each year (e.g., by extrapolating historical accident rates per million flights), but whether any given flight will suffer an accident is uncertain.

3.1.2 Risk Perception & Bounded Rationality

Renn (2008, p. 56) made the fundamental observation that "risk perceptions vary among individuals and groups". All people face choices involving risks, but they judge the level of risks differently. Within the psychological domain of risk studies, Slovic and Weber (2002) cited research showing differences in risk perception between technical experts and the general public, men and women, and individuals from different cultures. Experts, for instance, might have access to data enabling them to examine specific risks in detail. Lay people, on the other hand, may rely on intuitions to make decisions.

Decision-making often takes place under conditions in which knowledge and awareness is limited, and multiple goals may be competing for an individual's attention. The economist Herbert Simon developed the concept of *bounded rationality* to account for these conditions. In place of the classical theory of omniscient rationality, the concept of bounded rationality recognised "the limits of man's abilities to comprehend and compute in the face of complexity and uncertainty" (Simon, 1978, p. 354). One of the key ideas in this framework is *satisficing*: the suggestion is that people do not search for optimal solutions to problems, but instead stop searching once a satisfactory solution has been found. The concept of bounded rationality has had a profound influence on research into human error. In the context of accident investigations, it underscores the importance of trying to understand retrospectively how individuals perceived their situation as events were unfolding, rather than simply assuming they had perfect knowledge of the risks they faced (Dekker, 2001; Meadows & Wright, 2009).

Fischhoff and Kadvany (2011) outlined a number of factors that influence risk perception. They highlighted the work of psychologists Amos Tversky and Daniel Kahneman in identifying *heuristics* that guide intuition. These simple mental strategies allow solutions for complex problems to be found quickly. One example is the availability heuristic, which holds that an event is judged to be probable if instances of the event come to mind readily. Another example is the affect heuristic proposed by psychologist Paul Slovic and his colleagues, by which an individual's emotional response to a situation is thought to influence his or her perception of risk. In conditions of limited information, heuristics are useful shortcuts that allow people to judge risks, but they may lead to poor choices (Fischhoff & Kadvany, 2011).

Within the cultural domain of risk studies, Douglas and Wildavsky (1982) argued that public perception of risks is often at odds with scientific assessments. They suggested that "public perception of risk and its acceptable levels are collective constructs, a bit like language and a bit like aesthetic judgment" (Douglas & Wildavsky, 1982, p. 186). In other words, people have different levels of awareness of the hazards around them, and their awareness is informed by the societies or social groups to which they belong.

Stokes and Kite (1994) listed a number of cultural and societal factors that affect the ways in which individuals perceive risk. These include people's faith and confidence in society, organizations, government, leadership and colleagues, as well as their training and ability. Stokes and Kite (1994, p. 224) posited that these factors allow normal people to negotiate their way through life "systematically overestimating the control that they have over events and unconsciously downplaying the risks". The behaviour of normal people is contrasted with that of depressed individuals who, clinical studies suggest, "suffer from 'depressive realism', a pessimistic but, in probabilistic terms, all too accurate assessment of the real risks of everyday life" (Stokes & Kite, 1994, p. 215).

3.1.3 External Risk & Manufactured Risk

From a social approach to risk research, Giddens, Duneier and Appelbaum (2005) noted that risk is part of the human condition. People have always had to endure natural disasters such as typhoons, hurricanes, flooding, earthquakes, famines and drought. These are examples of *external risk*, so-called because they arise from the natural world and are outside human control. In the modern world, though, people are increasingly faced with various kinds of *manufactured risk* that arise from human knowledge and technology. Examples of manufactured risk include adverse health effects from pesticides, radiation leaks from nuclear power plants, and aviation accidents.

Ulrich Beck's influential book, "Risk Society", was published following the 1986 Chernobyl nuclear power plant disaster. The book documented the transition of a world threatened by external risks to one characterized by relentless change and the fear of manufactured risks. The personal risks faced by explorers such as Christopher Columbus were contrasted with the global dangers that toxins, pollutants or radioactive waste pose to modern humanity. Beck (1992, p. 22) argued that the dangers resulting from the global spread of high-risk industries are such that "the unknown and unintended consequences come to be a dominant force in history and society." An important aspect of the concept of *risk society* is that hazards are not confined to a single time, place or social group. People in modern societies face risks that are characterized by transboundary effects, globalizing impacts, increased penetrating power, incalculable nature, and lack of accountability. The result is "social dependency upon institutions and actors who may well be - and arguably are increasingly - alien, obscure and inaccessible to most people affected by the risks in question" (Beck, 1992, p. 4).

Beck's thesis has attracted criticism for its abstract and conceptual nature (Jarvis, 2007). However, the notion of hazards propagating beyond the boundaries of time, place or social group is undeniably a defining characteristic of the Chernobyl nuclear power plant accident and other large-scale disasters. In the case of the 1984 Bhopal chemical leak, organizational decisions made in the Union Carbide headquarters in Connecticut, USA, had a catastrophic impact on the lives of thousands of villagers in central India. Within aviation, on a smaller but no less tragic scale, accidents have occurred in which decisions taken at company head offices generated risks that impacted the lives of people hundreds or thousands of kilometres away. Each of the following plane crashes led to the deaths of dozens of people on the ground who had no connection to the flights:

- <u>El Al Flight 1862, Holland, 1992</u> – an Israeli cargo flight carrying toxic chemicals from New York to Tel Aviv, with a scheduled stopover at Schiphol Airport, crashed in the Bijlmermeer suburb of Amsterdam causing 43 deaths *including 39 on the ground* (NASB, 1994);

- Mandala Airlines Flight 91, Indonesia, 2005 – a passenger flight from North Sumatra to Jakarta crashed shortly after takeoff from Polonia International Airport in Medan causing 149 deaths *including 49 on the ground* (KNKT, 2009);
- Turkish Airlines Flight 6491, Kyrgyzstan, 2017 – a cargo flight operated by Turkish carrier ACT Airlines from Hong Kong to Istanbul crashed while attempting to make a scheduled landing at Bishkek, Kyrgyzstan, causing 39 deaths *including 35 on the ground* (AAIC, 2017).

3.2 Hazard, Threat & Risk

In this section I define the term *hazard*, and note that hazard and *threat* may be used interchangeably in aviation. I give examples of typical aviation hazards, and also outline how hazards are distinguished from risks.

3.2.1 Definitions of Hazards & Threats

The ICAO Safety Management Manual (Document 9859) contains an overview of the fundamentals of safety management in aviation and guidance for implementing a safety culture.[20] It defines a hazard as "a condition or an object with the potential to cause death, injuries to personnel, damage to equipment or structures, loss of material, or reduction of the ability to perform a prescribed function" (ICAO, 2013b, p. 2-24). The FAA Risk Management Handbook provides a similar definition: "a hazard is a present condition, event, object, or circumstance that could lead to or contribute to an unplanned or undesired event such as an accident" (FAA, 2009, p. 1-2). Both of these definitions express the idea that hazards have the potential to cause undesired events such as accidents or incidents.

Hazards are often confused with consequences or outcomes. To illustrate the difference, Document 9859 gives the example of a 15-knot wind. If the wind blows in the direction along which a runway lies, it is beneficial because it improves the takeoff or landing performance of an aircraft. By contrast, if the wind blows perpendicular to the runway as a crosswind, it is a hazard since it may lead to a runway excursion (i.e., the aircraft departs from the side of the runway). In this example, a 15-knot crosswind is a hazard and a runway excursion is a possible consequence or outcome.

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[20] Safety culture is discussed in Section 4.2.3.

Within aviation, the terms “threat” and “hazard” are often used interchangeably (ICAO, 2013b). The former term has gained widespread use in the last two decades with the development of the Threat and Error Management (TEM) safety taxonomy. (TEM is one of the models and taxonomies outlined in Appendix 5.)

3.2.2 Hazards in Aviation

While stating that “the elimination of aircraft accidents and/or serious incidents remains the ultimate goal”, Document 9859 acknowledges that hazards are an inevitable aspect of aviation (ICAO, 2013b, p. 2-1). One reason for this is simply the great number of hazards associated with flying.

Many aviation hazards are related to meteorology: rain, snow, ice, wind shear, turbulence, thunderstorms, precipitation static, white out and volcanic ash. The FAA Aeronautical Information Manual (AIM) contains a large amount of information about weather hazards. The section about thunderstorms alone contains 35 paragraphs. This short excerpt has advice about flying in the vicinity of thunderstorms:

> a. Thunderstorm Avoidance. Never regard any thunderstorm lightly, even when radar echoes are of light intensity. Avoiding thunderstorms is the best policy. Following are some Do’s and Don’ts of thunderstorm avoidance:
>
> 1. Don’t land or takeoff in the face of an approaching thunderstorm. A sudden gust front of low level turbulence could cause loss of control.
>
> 2. Don’t attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence and wind shear under the storm could be hazardous. (FAA, 2015, p. 7-1-59)

Other hazards described in the FAA AIM include antenna towers, smoke stacks, cooling towers, unmanned balloons, unmanned aircraft systems (UAS), overhead wires, bird activity, lasers, mountainous terrain and wake turbulence. Hazards in restricted airspace include the firing of artillery or guided missiles in military areas (FAA, 2015).

3.2.3 Distinguishing Risks from Hazards

Renn (2008) stressed the importance of distinguishing risks from hazards. Citing the example of a chemical substance, he noted that the substance’s toxicity is a hazard, which has the potential “to cause harm to what people value”. However, it only becomes a risk if “a person may be exposed to this substance and suffer the toxic effects” (Renn, 2008, p. 50). If there is no possibility of exposure, there is no risk.

The distinction between risks and hazards is captured succinctly by the FAA Risk Management Handbook: “Risk is the future impact of a hazard that is not controlled or eliminated” (FAA, 2009, p. 1-2). This idea is elaborated in Document 9859, which breaks “the future impact of a hazard” down into two elements: “the predicted probability” and the “severity of the consequences or outcomes of a hazard” (ICAO, 2013b, p. xii).

Kern (1998) discussed risk in the context of airmanship and pilot decision-making. Drawing on notions of actuarial analysis from the insurance industry, he defined risk in terms of a simple mathematical equation:

Risk = probability of loss x cost of loss x length of exposure
(Kern, 1998, p. 297)

This equation underscores the importance of the length of time that someone is exposed to a hazard. The risk is increased if the exposure time is high. On the other hand, as noted above, there is zero risk if the exposure time is zero. It follows that one of the basic tenets of risk management is to minimize the length of time that individuals are exposed to hazards (Kern, 1998).

3.3 Acceptable Risk

Just as individuals and groups differ in terms of risk perception, so they may differ in what they judge to be an *acceptable risk*. This section reviews various perspectives of acceptable risk for individuals and organizations. It also describes two case studies which analysed the construct of acceptable risk in environmental and technological disasters: the 1981 Binghampton chemical fire and 1986 Challenger space shuttle accident.

3.3.1 Definitions of Acceptable Risk

Early studies by the nuclear engineer Chauncey Starr used a revealed preferences approach to investigate what kind of risks were acceptable to society. He concluded that people accept greater risks from hazards that are deemed to provide greater benefits. They also accept greater risks from voluntary hazards (e.g., general aviation flying) compared with involuntary ones (e.g., flying on commercial aviation). Starr’s work was influential, but a number of his underlying assumptions were subsequently questioned, such as the reliance on a rational decision-making model.

Later studies, including the work of bioethicist William Lowrance, investigated the ways in which people define risks by identifying risk attributes and dimensions of risk. It is now understood that individuals differ in how they define risks and benefits. Therefore something that is considered an acceptable risk by one person may not be acceptable to another (Fischhoff & Kadvany, 2011).

Anthropologist Mary Douglas and political scientist Aaron Wildavsky contended that "there is no single all-purpose number that expresses 'acceptable risk' for a society" (Douglas & Wildavsky, 1982, p. 4). Any decision-making under conditions of risk is dependent upon the alternatives that are considered as well as the values and beliefs that are brought into play. In other words, the search for an objective method is a search for a chimera. Douglas and Wildavsky (1982, p. 4) cited a study of acceptable risk by Fischhoff, Lichtenstein and Slovic, which concluded that "acceptability is always a political issue". This theme is developed in the following section with the case study of the Binghampton chemical fire.

Regarding levels of acceptable risk in organizational contexts, Reason (2008, pp. 126-127) highlighted the tension that exists in many organizations between the conflicting goals of safety and production: "Every company must obey both the ALARP principle (keep the risks as low as reasonably practicable) and the ASSIB principle (and still stay in business)". He added that for certain high risk organizations, such as in the oil exploration and production industry, the levels of risk and profitability are closely related. As a result companies sometimes face pressure to operate at levels of high risk in order to boost their return on investment.

Within aviation, the ICAO Safety Management Manual (Document 9859) outlines three levels of safety risk that are key elements in the risk assessment process: acceptable, tolerable and intolerable risks. Acceptable risks are "acceptable as they currently stand and require no action to bring or keep the probability and/or severity of the consequences of hazards under organizational control" (ICAO, 2013b, p. 2-30). By contrast, tolerable risks require the organization to implement risk mitigation strategies, while intolerable risks are of such a probability and/or severity that immediate action must be taken to mitigate them. These levels are discussed further in Section 3.6.

3.3.2 The 1981 Binghampton Chemical Fire

At 05:33 on 5th February 1981, the failure of an electrical protection system led to a fire in a government office building in Binghampton, New York State. The fire vaporized the coolant of an electrical transformer, causing the building to be covered with oily soot. The soot was contaminated with dioxin, which was released into the atmosphere. So severe was the contamination that six months after the accident, during which time the building had been left undisturbed, scientists from the Environmental Protection Agency (EPA) were amazed to find no evidence of infestation by rodents or insects.

Clarke (1989) conducted a case study which analysed the processes by which risk was defined in the aftermath of the Binghampton fire. He found that the response to the accident was not driven by rationality. Instead it was "decisively shaped by organizational interests, the bounded rationality of decision makers, and the social environment of their organizations" (Clarke, 1989, p. 138). Clarke contended that, if the decision-making process had been completely rational, state officials and organizations would have taken different steps. They would have: clearly defined the problem; drawn up a full set of options; evaluated each option on a range of dimensions; and selected the option with maximal value. In reality, he found that "no alternative other than decontamination was seriously considered by the state, even though there were very good reasons to demolish the building" (Clarke, 1989, pp. 137-138).

The study analysed the process by which the contaminated garage in the building was deemed safe enough to be re-opened. The decision turned on the question of whether the level of toxic chemicals was low or high. An apparently simple question, but Clarke found that the definitions of "low" and "high" were constructed through a complicated process involving political and organizational forces. One of the factors was a shortage of downtown parking space. This echoes the earlier comments by Reason about the tension that often exists in organizations between safety goals and production goals.

After examining this accident and other similar cases, Clarke (1989, p. 84) came to the conclusion that "assessment and acceptability of risk are, at bottom, the results of bargaining among organizations". He declared the most important implication of his study to be that, when investigating disasters such as the Binghampton fire, it is essential to understand the political and organizational context in which decisions regarding acceptable risk are made.

3.3.3 The 1986 Challenger Space Shuttle Accident

The National Aeronautics and Space Administration (NASA) Space Shuttle Challenger was launched from the Kennedy Space Center at Cape Canaveral, Florida, at 11:38 Eastern Standard Time (EST) on 28th January 1986. An O-ring seal in one of the solid rocket boosters failed at liftoff. This allowed burning gas to escape which led to the structural failure of the external fuel tank. After just 73 seconds of flight, the shuttle was engulfed in a fireball and disintegrated. All 7 crewmembers died.

Vaughan (1996) conducted a case study of this disaster. She described how NASA, an organization rich in resources and expertise, had drifted towards reduced safety margins and increased risk for a number of years prior to the accident. Vaughan's study focused on two aspects of deviance:

> (1) the statistical deviation of booster technology from expected performance, and how it was normalized, and (2) the contrast between outsider interpretations of NASA actions as deviant after the disaster and insider definitions of these same actions as normal and acceptable at the time they occurred. (Vaughan, 1996, p. 72)

Since the start of the space shuttle flight programme in 1981, NASA had been using a formal Acceptable Risk Process which detailed the actions to be taken whenever an anomaly or questionable condition arose. As Vaughan (1996, p. 81) noted: "The shuttle could not fly unless the hazard was eliminated or controlled by some corrective action and/or engineering calculations and tests establishing that the condition was not a threat to flight safety." This procedure was followed despite ongoing problems with the O-rings including damage sustained during two shuttle missions in 1985.

There is a sense in which NASA's decision to classify the O-ring hazard as an acceptable risk mirrored the decision after the Binghampton fire to declare the level of toxic chemicals in the building's garage as low. There were, however, two significant differences in the decision-making contexts for the two disasters. Firstly, NASA engineers and managers were not dealing with a one-off decision, but a procedure that had to be followed every time an anomaly was identified. Secondly, they made their decisions prior to the accident, without any knowledge that it would take place.

Vaughan observed that from 1977 to 1985 NASA continued classifying a flawed design as an acceptable risk. To explain how this happened, she outlined a "nascent theory of the normalization of deviance in organizations" which had three elements: production of culture, a culture of production and structural secrecy (Vaughan, 1996, p. 396). The case study concluded it was these cultural drivers that eroded safety margins and increased the risk, not "'immorally calculating managers' who pushed the production goal in the face of obvious safety flaws" (Dekker, 2001, p. 257). Vaughan's (1996, p. xiv) conclusion was an indictment of the organization:

> No extraordinary actions by individuals explain what happened: no intentional managerial wrongdoing, no rule violations, no conspiracy. The cause of disaster was a mistake embedded in the banality of organizational life and facilitated by an environment of scarcity and competition, elite bargaining, uncertain technology, incrementalism, patterns of information, routinization, organizational and interorganizational structures, and a complex culture.

As with the Binghampton chemical fire, in order to make sense of the Challenger space shuttle disaster it is necessary to understand the organizational context in which decisions were made regarding acceptable risk.

3.4 Safety Management Systems in Aviation

Over the last two decades, there has been widespread implementation of safety management systems (SMS) in civil aviation. The aim is to manage aviation safety by providing organizations with a systematic means of continuously identifying hazards and controlling risks. Similar systems are employed in other high-risk domains such as the petroleum, chemical, electricity generation, maritime and rail transport industries. For civil aviation, a range of SMS frameworks have been developed by national and international regulatory bodies. These draw heavily on risk concepts from the natural and technical sciences. Stolzer, Halford and Goglia (2008) compared the frameworks implemented by the FAA and ICAO. Although they use different terminology and emphasise different components, both frameworks essentially consist of a three-step process:

1. identifying hazards;
2. assessing risks;
3. controlling risks.

The following sections describe some of the techniques that are used within civil aviation for hazard identification, risk assessment and risk management.

3.5 Identifying Hazards

As noted previously, there are many hazards associated with flying. One simple way for a pilot to identify hazards (or threats) is by talking to other pilots and asking questions about hypothetical situations, so-called “hangar flying” (Kern, 1998, p. 297). When informal discussions include the sharing of “war stories”, they can be an effective method of training less experienced individuals. Cognitive psychologist Gary Klein (1998) has documented the value of this approach in studies of pilots, firefighters, nuclear power plant operators and other experts working in high-risk workplaces. Using ethnographic studies of crew interactions on the flight deck and in training, Hutchins, Holder and Pérez (2002) similarly reported how airline pilots used storytelling to warn other pilots about hazards associated with automation and in-flight fires.

Mnemonics are widely used throughout civil and military aviation. Because they are easy to memorize and recall, they are a useful tool for helping pilots to remember safety checklists. Table 4 shows two mnemonics discussed in the FAA Risk Management Handbook which help pilots to identify threats (FAA, 2009).

Table 4: Mnemonics for identifying flight hazards (FAA, 2009).

	KEYWORDS	MEANINGS
P	**P**ilot	Competency, health condition, level of fatigue, mental & emotional state
A	**A**ircraft	Performance, equipment & airworthiness
V	En**V**ironment	Weather, ATC, navigational aids, takeoff & landing areas, terrain & surrounding obstacles
E	**E**xternal pressures	Purpose of flight & how critical it is to maintain schedule
I	**I**llness	Q. Am I sick?
M	**M**edication	Q. Am I taking any medicines that might affect my judgment or make me drowsy?
S	**S**tress	Q. Am I under psychological pressure from the job? Do I have money, health, or family problems?
A	**A**lcohol	Q. Have I been drinking within 8 hours? Within 24 hours?
F	**F**atigue	Q. Am I tired and not adequately rested?
E	**E**motion	Q. Have I experienced any emotionally upsetting event?

The first mnemonic in Table 4, PAVE, is a simple aid to remind pilots to check critical categories for risk before a flight. “P”, for example, stands for pilot. This is a prompt for a pilot to ask, “Am I ready for this trip?” in terms of flight experience and currency, or physical and emotional condition (FAA, 2009, p. 3-3). The second mnemonic, IMSAFE, helps pilots to identify hazards relating to their physical and mental health. “I” stands for illness and is a reminder for pilots to check whether they are currently suffering from any sickness which might affect their ability to fly. (See Abbe, 1998, for a fuller list of mnemonics and other memory aids commonly used by pilots.)

A more formal tool, called SHEL, is a conceptual human factors (HF) model that may be used to identify areas of risk. The SHEL model has the following components:

- Software (S) – operating manuals, checklists and policies;
- Hardware (H) – the airplane, instrument panel and avionics equipment;
- Environment (E) – the weather, atmosphere and ATC system;
- Liveware (L) – pilots, cabin crew and air traffic controllers.

This model is useful for identifying hazards arising from interactions between components. For instance, if pilots neglect to use a checklist because they are familiar with a procedure then that corresponds to a Liveware-Software (L-S) interaction. Excessive temperature, noise or vibration in the cockpit is a Liveware-Environment (L-E) interaction (Fallucco, 2002). The SHEL model has been used in accident investigations to provide a framework for analysing complex interactions between people and systems (AAIB, 2003). It is also referred to as SHELL, in acknowledgement that Liveware, the central element, can interact with Software, Hardware, the Environment or other Liveware. (The SHEL model is outlined in Appendix 5. See also CAA, 2002; Stolzer et al., 2008.)

3.6 Assessing Risks

Risk assessment is the process of quantifying or characterizing risk. It may take place at a range of levels. Within aviation it may range from a private pilot preparing for a flight to a sophisticated computer simulation of runway collisions at a major airport. This section describes several tools and techniques that allow risks to be estimated.

The CFIT checklist is a tool used by pilots to evaluate risk before a flight. It was designed by the Flight Safety Foundation (FSF) in response to a significant category of accidents called *controlled flight into terrain*, or CFIT. In a CFIT accident an airworthy plane is unintentionally flown into the ground or sea. In the first part of the checklist there are risk factors such as "no ATC service" at the destination or "airport located in or near mountainous terrain". Each factor has a numerical score. Three factors are related to communication: "controllers and pilots speak different primary languages"; "controllers' spoken English or phraseology poor"; and "pilots' spoken English poor". There are also risk multipliers whereby, for example, flights to South America are considered five times more risky than the United States or Canada. The second part of the checklist includes risk-reduction factors relating to safety culture, the pilot's training and aircraft equipment. Pilots calculate the total score before flying. A negative score "indicates a significant threat", and the pilot is urged to review the risk-reduction factors and "determine what changes can be made to reduce CFIT risk" (FAA, 2009; Kern, 1998).

Another general-purpose tool for evaluating risk within organizations is the risk matrix. This consists of a chart and accompanying tables. The chart is typically (though not always) a 5x5 matrix with risk probability levels shown on one axis and risk severity levels on the other. In the ICAO risk matrix shown in Figure 7, the risk probability ranges from "frequent" to "extremely improbable" (on the vertical axis), while the risk severity runs from "catastrophic" to "negligible" (on the horizontal axis).

Figure 7: Risk assessment matrix. Reprinted from *Safety management manual (3rd edition)* (p. 2-29), by ICAO, 2013, Montreal, Canada: International Civil Aviation Organization. Copyright 2013 by ICAO. Reprinted with permission.

Risk probability		Risk severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

The chart shown in Figure 7 is accompanied by tables with definitions for the levels of risk probability and risk severity. For example, a “Remote” probability means “Unlikely to occur, but possible (has occurred rarely)”, and a “Catastrophic” severity level indicates “Equipment destroyed” and “Multiple deaths” (ICAO, 2013b, pp. 2-28–2-29). The risk matrix is used by first calculating the probability and severity of a particular outcome, and then plotting it in the appropriate matrix cell. If the cell is green, the risk is acceptable; if it is yellow, the risk is tolerable and mitigation may be required; if red, the risk is intolerable and immediate mitigating action is necessary. Depending on the result, a cost-benefit analysis may be carried out to determine what action should be taken (ICAO, 2013b; Stolzer et al., 2008).

A more sophisticated tool developed from risk studies in the natural and technical sciences is probabilistic risk assessment (PRA). This is a methodology for evaluating risks in complex systems such as nuclear power plants or modern jet airliners. PRA and the techniques of event tree analysis and fault tree analysis were developed from the 1974 Reactor Safety Study (Wash-1400) led by American physicist Norman Rasmussen. This was an early and widely-criticised investigation of nuclear power plant safety (Fischhoff & Kadvany, 2011). The PRA process seeks to identify an undesired top event and then map out all of the hazards leading to that event. Fault trees are used with probabilities assigned to the basic events. From these the probability of the undesired top event can be calculated. PRA methodology was adopted by NASA following the 1986 Challenger space shuttle disaster (Stolzer et al., 2008).

The final methodology, Monte Carlo analysis, uses computer simulation with a risk equation incorporating multiple probability distributions. Risk probabilities are calculated by running the simulation for a particular scenario thousands or even millions of times (Stolzer et al., 2008). Stroeve (2016) reported on the use of Monte Carlo simulations to analyse airport runway collisions and thereby evaluate the effectiveness of runway incursion alerting systems.

3.7 Controlling Risks

The following sections review two categories of methods for controlling risks: risk mitigation techniques used by individual pilots to minimize risks, and risk communication processes used by flight crews and organizations to disseminate safety information.

3.7.1 Risk Mitigation

There are several basic techniques that pilots can use to mitigate risk. Firstly, as noted previously, it is important to minimize the time of exposure to risk as well as the severity of risks that are faced. For instance, a pilot can mitigate risks associated with a thunderstorm (e.g., due to turbulence, wind shear or icing) by making a request to ATC to be rerouted around bad weather. For airline crews, another way to mitigate risk is to share the workload to prevent individual crew members from becoming overloaded. In adverse weather conditions, for example, a captain may decide to reduce risk by making a landing that he or she initially intended to give to the first officer (Fallucco, 2002).

The FAA Risk Management Handbook, in a section about the aforementioned PAVE mnemonic, includes specific items of advice for mitigating risks. In order to cope with external pressures, for instance, it suggests that pilots use personal standard operating procedures (SOPs) such as the following: "Allow time on a trip for an extra fuel stop or to make an unexpected landing because of the weather" (FAA, 2009, p. 3-9).

A more formal method that can be used for risk mitigation is the Threat and Error Management (TEM) model, as described in Appendix 5. TEM was developed following flight deck observations of regular airline flights in the United States made by Robert Helmreich's human factors team at the University of Texas (Grote et al., 2004). The main components of the model are threats, errors and undesired aircraft states. If undesired aircraft states are not managed effectively, they may result in unsafe outcomes. For example, an aircraft on an unstabilised approach (i.e., undesired aircraft state) may end up overrunning the runway in a runway excursion (i.e., unsafe outcome). A key assumption underlying TEM is the acknowledgement that threats and errors are a normal part of flight operations. In terms of risk mitigation, Maurino (2005) gave examples of countermeasures that pilots use to prevent safety margins from being reduced: SOP briefing, stating plans, workload assignment, contingency management, monitoring the other pilot, workload management, automation management, evaluation and modification of plans, inquiry and assertiveness. The TEM model has proved influential in airline training, providing the framework for sixth-generation crew resource management (CRM) airline training (Helmreich, Wilhelm, Klinect, & Merritt, 2001; Stolzer et al., 2008). As a taxonomy, it has been observed that "TEM accurately describes what pilots 'do' under that intangible heading of 'Airmanship'" (Maurino & Murray, 2010, p. 10-16).

3.7.2 Risk Communication

Effective communication within flight crews, and between them and other personnel such as cabin crew, air traffic controllers and ground crew, is essential for maintaining safety. Airline CRM programmes train pilots to assertively communicate problems, including threats and errors that pose a risk to the safe completion of a flight. Outside of the cockpit, there are a number of channels through which individuals may report hazards, safety problems or incidents. These include internal safety reporting systems set up by airlines, airport operators, air navigation service providers and maintenance organizations.

At the organizational level, if a risk assessment identifies a hazard that requires immediate action, it is important to notify all relevant personnel. Stolzer et al. (2008) gave the hypothetical example of an audit at an airport fixed-base operator (FBO) that revealed a widespread problem of fuel contamination. In this example, a risk matrix was used to evaluate the risk level, which was found to be unacceptably high. Stolzer et al. (2008, pp. 141-142) concluded that in such a case:

> …there should be clear mechanisms for the entire management chain responsible for the fuel quality – that is, from the depot manager all the way up to the CEO – to be aware of the results of the study, to know that corrective and preventive action is a requirement, and that such action must be accomplished within a predetermined period.

Several industry-wide safety reporting systems have been established to which pilots may confidentially submit concerns about hazards or reports of incidents. Safety information is published in newsletters and reports, and may also be made available via online databases. These confidential systems are essential mechanisms for disseminating safety information so that accidents are not repeated.[21] One well-known example is the Aviation Safety Reporting System (ASRS), operated by NASA on behalf of the FAA (Stolzer et al., 2008). ASRS produces a monthly safety newsletter, named CALLBACK, and maintains an online database with over 1.4 million incident reports that are accessible

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[21] On 1st December 1974, TWA Flight 514 crashed into Mount Weather about 50 km from Dulles International Airport, Washington DC, with the loss of 92 lives. Less than two months previously a United Airlines flight had narrowly avoided crashing on the same approach at the same location, but news of that incident was *not* shared with other airlines (NTSB, 1975b; Stolzer et al., 2008). If it had been, the crash of TWA Flight 514 might have been prevented.

by the general public (see Appendix 5). Similar systems have been established in other countries, such as the Confidential Human Factors Incident Reporting Programme (CHIRP) in the UK (Flin, O'Connor & Crichton, 2008). There are also commercial systems, including the British Airways Safety Information System (BASIS), which was developed in the 1990s and has evolved through several generations into the Sentinel system. This system is now operated by the Emirates Group and used by airlines in Europe, Asia and Africa (GAIN, 2003).

Other bodies that publish information about risks and hazards include national regulators (e.g., FAA in the United States and CAA in the UK), accident investigation agencies (e.g., NTSB in the US) and international organizations (e.g., ICAO and IATA). These organizations disseminate safety information through reports, documents, manuals and videos. A number of their documents are cited in this dissertation, including the FAA Risk Management Handbook (FAA, 2009), the ICAO Safety Management Manual (ICAO, 2013b) and the IATA Safety Report (IATA, 2019c).

3.8 "Findings as to Risk" in Aviation

In the final section of this review of risk literature, I address findings from accident and incident investigations about factors that increase risk during flight operations. Firstly, I describe two recording devices that are essential sources of data for accident and incident investigations: the CVR and FDR. Secondly, I discuss the approach taken in investigations by the Transportation Safety Board (TSB) of Canada, which explicitly communicates risk through a category of "findings as to risk". Examples are given of some of the findings from TSB investigations that involved pilot communication.

3.8.1 CVR & FDR Data Recording Devices

Large commercial aircraft are required to carry two "black boxes" to facilitate the investigation of accidents and incidents. One is the cockpit voice recorder (CVR), whose purpose is to record sounds on the flight deck, and the other is the flight data recorder (FDR), which records performance data from engines and other aircraft systems. Both devices are located at the rear of an aircraft to improve their survivability in the event of a crash (Bibel, 2008).

The CVR uses microphones located in pilots' headsets and overhead in the cockpit. It records crew conversations as well as other sounds such as radio transmissions, warning alarms, engine noise, and the extension or retraction of the landing gear and flight controls. Aircraft used to have CVRs with magnetic tape recorders that recorded approximately 30 minutes of sound on a continuous loop. Modern aircraft use digital devices that record two hours of audio. The devices record continuously, so that data recorded more than two hours previously are overwritten. If a safety event occurs during a long flight, or pilots fly another leg before submitting a report, the relevant data are liable to be lost.[22]

3.8.2 Findings from Accident & Incident Investigations

Dismukes, Berman and Loukopoulos (2007) pointed out that the type of findings included in accident and incident reports varies depending on the country that conducts the investigation. In the United States, reports issued by the National Transportation Safety Board (NTSB) list a number of findings followed by a single probable cause. Other countries, such as Australia, the UK and Canada, deliberately refrain from stating a single primary cause. Instead they provide lists of causal factors, contributing factors or other factors that increased risk.

In Canada, accident and incident reports compiled by the TSB are characterised by the explicit way in which they communicate risk. Investigation findings are divided into two categories: (1) findings as to causes and contributing factors, and (2) findings as to risk. The latter relate to risks identified during the course of the investigation, which are expressed as factual conditional sentences. As an example, an investigation was conducted following a 2014 runway incursion in Ottawa that almost led to a collision between a medical helicopter and a cargo plane. One of the risk findings was: "If air traffic control uses non-standard phraseology, there is a risk of inconsistencies and miscommunication between air traffic control and the pilot." (TSB, 2015b, p. 11)

Examples from other reports of findings that are related to communication are listed in Appendix 6. These examples do not represent an exhaustive survey of TSB

[22] In recent years there have been numerous accidents and incidents for which investigators were unable to retrieve pertinent CVR data. As a result, ICAO and the European Union are introducing requirements from 2021 for newly-manufactured transport aircraft over 27,000 kg to be equipped with 25-hour CVRs (Cookson, 2019a).

reports, but they serve to illustrate the format of the findings as to risk. They also give a taste of the range of communication issues that have arisen in recent years. Some themes that emerge related to communication issues are as follows:

- Risk communication – reports A12Q0216 and A15O0015 both stated risks arising when flight crews fail to report non-compliant practices;
- Standard phraseology & plain language – reports A14H0002 and A16O0016 noted risks associated with not adhering to standard phraseology and with the use of inappropriate plain language;
- Cockpit voice recorders (CVRs) – reports A14O0165 and A15H0002 both involved the problem of not being able to retrieve CVR data after an accident or incident;
- Passenger announcements – reports A15H0002 and A15F0165 contained findings related to inadequate or ineffective safety announcements and safety briefings;
- Declaring an emergency – finally, report A16O0066 warned of the risks of flight crews failing to declare an emergency, which was one of the key issues in the crash of Avianca Flight 052.

CHAPTER 4: The Interplay of Culture & Communication

This chapter looks at ways in which culture impacts on communication. It is the final area of the literature review. In the first part of the chapter, I cover key terms and general definitions of culture. This includes material and non-material culture, as well as culture as a means for groups to deal with problems. Then I consider the culture of social groups, especially national, organizational, professional and safety cultures. The first part concludes with a discussion of how culture changes over time.

The second part of the chapter provides an overview of approaches in intercultural communication that are relevant to international civil aviation: key concepts identified by anthropologist Edward T. Hall; the ethnography of communication (EOC) approach established by linguistic anthropologist Dell Hymes and the interdiscourse communication framework developed by Scollon, Scollon and Jones; the studies of cultural dimensions carried out by social psychologist Geert Hofstede and management consultant Fons Trompenaars; and important concepts in Brown and Levinson's politeness theory and Ting-Toomey's face negotiation theory.

Intercultural interactions are an essential element of international airline operations. The chapter concludes with an overview of studies of intercultural communication in the aviation context (Section 4.9). These studies draw on much of the research described in the preceding sections of this chapter, and also on Chapters 2 and 3.

4.1 Definitions of Culture

Culture is all around us, pervading our lives and informing all our thoughts, words and actions. As a consequence, it is inherently difficult to define (Friedman et al., 2013). Williams (1985, p. 87) described the origins of the word *culture* in several European languages and its subsequent development within different intellectual disciplines. He found it to be "one of the two or three most complicated words in the English language". The difficulty in defining culture has not stopped a large number of people from trying. As Hall (1990, p. 20) wryly observed: "Culture is a word that has so many meanings already that one more can do it no harm".

In this section I review the following: the concepts of *values*, *norms* and *attitudes*; general definitions of culture; the distinction between material and non-material culture; and culture as a means by which social groups deal with the problems they face.

4.1.1 Values, Norms & Attitudes

4.1.1.1 Values

Values are "collective ideas about what is right or wrong, good or bad, and desirable or undesirable in a particular culture" (Williams, 1970, as cited in Kendall, 2007, p. 85). Values incorporate ideas or beliefs about behaviour, but they do not explicitly tell people how to act. They may be held consciously or unconsciously.

Values vary widely across cultures. To illustrate their influence on behaviour in business, Adler and Gundersen (2008) contrasted managers in Latin America with their counterparts in the United States. They suggested that Latin American managers hire competent members of their own family because they value family loyalty, while those in the United States emphasize the achievements and performance of individual candidates.

4.1.1.2 Norms

Norms may be simply defined as "established rules of behavior or standards of conduct" (Kendall, 2007, p. 87).[23] There are several categories of norms. Prescriptive

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[23] Gudykunst, Ting-Toomey and Chua (1988, pp. 61-62) distinguished between norms and rules: "While norms are culturally ingrained principles that are imparted systematically to children through the socialization process, cultural rules are situationally and interpersonally negotiable".

norms state the kinds of behaviour that are appropriate or acceptable (e.g., how much tax citizens should pay). They are differentiated from proscriptive norms, which tell people what is inappropriate or unacceptable (e.g., speed limit laws). Formal norms are written down and may be enforced by sanctions (e.g., laws), whereas informal norms are unwritten but commonly understood by the members of a social group.

Norms may also be classified according to their social importance. Folkways are informal norms that direct everyday behaviour (e.g., whether to kiss or shake hands when greeting another person). Mores are strongly held norms that embody a culture's morals and ethical principles (e.g., rules against plagiarism). Violators of mores face sanctions ranging from ridicule to shunning or expulsion from a social group. In some cases, if the mores are protected by laws, the punishment may be imprisonment.

As with values, there is wide variation in norms across cultures, which may lead to misunderstandings. Giddens, Duneier and Appelbaum (2005) observed that there are different norms for eye contact between the Navajo and most Americans. Avoiding eye contact is a sign of respect for the Navajo, but averting eye contact indicates weakness or rudeness for most Americans. A misunderstanding may result when a Navajo and an American tourist meet for the first time: "The Navajo may see the tourist as rude and vulgar, while the tourist may see the Navajo as disrespectful or deceptive" (Giddens et al., 2005, p. 52).

4.1.1.3 Attitudes

An attitude is "a favorable or unfavorable evaluative reaction toward something or someone, exhibited in one's beliefs, feelings, or intended behavior" (Myers, 1998, p. 130). Similar to values and norms, there is considerable diversity in attitudes across cultures. Adler and Gundersen (2008, p. 20) gave an example of market research in Canada which indicated differences in attitudes towards deodorants: "French Canadians have a positive attitude toward pleasant or sweet smells, whereas English Canadians prefer smells with efficient or clean connotations".

4.1.2 General Definitions of Culture

Many commentators have noted the profusion of definitions of culture (Adler & Gundersen, 2008; Chávez, 2009; Gudykunst et al., 1988). Some general definitions are provided below. Each of the definitions highlights one aspect of the complex web of ideas that constitutes culture. These aspects are developed in the following sections.

From his perspective as an anthropologist, Hall (1990, p. 20) stated that “culture has long stood for the way of life of a people, for the sum of their learned behavior patterns, attitudes, and material things.” This definition points to the existence of both material and non-material dimensions of culture. The distinction is elaborated in the following definition by Giddens et al. (2005, p. 52), which also expresses the notion that social groups may have their own cultures: “Culture consists of the values the members of a given group hold, the languages they speak, the symbols they revere, the norms they follow, and the material goods they create, from tools to clothing.”

In order to participate in a social group, it is necessary for individuals to learn about the group’s culture, which provides “the common denominator that makes the actions of individuals intelligible to other members of their society” (Haviland, Prins, McBride & Walrath, 2016, p. 31). As a corollary, the actions of individuals from one group may not be readily intelligible to the members of other groups. This may lead to misunderstandings between different social groups.

Trompenaars and Hampden-Turner (1997, p. 13) observed that culture provides people with a common way of interpreting the world: “Culture is a shared system of meanings. It dictates what we pay attention to, how we act and what we value.” By noting the influence of culture on what people “pay attention to”, this definition carries the important implication that people in different cultures pay attention to different things.

Similarly but more succinctly, Pennycook (1994, p. 61) defined culture as “an active process by which people make sense of their lives”. In describing culture as a process, Pennycook evoked the origins of the word. As Williams (1985, p. 87) noted, “Culture in all its early uses was a noun of process: the tending of something, basically crops or animals.” The agricultural sense of tending or growing something persists through to the present day in related words such as “cultivate”.

The FAA (1996, p. 117), in its role as the regulator of civil aviation in the United States, provided a straightforward definition of culture as “the norms, attitudes, values, and practices that members of a nation, organization, profession, or other group of people share”. This definition highlights important social groups whose members share a common culture. Section 4.2 develops this theme in a discussion of national, organizational and professional cultures.

4.1.3 Material & Non-Material Culture

A fundamental distinction may be made between material culture and non-material culture. Material culture refers to the physical things that humans create and use, such as clothing, houses, cars and aircraft. Non-material culture refers to things not embodied in physical objects, such as social roles, language, rules, norms and beliefs (Little, 2014). These two aspects interact with each other, for instance when a physical object symbolizes a cultural idea or when people have a belief in a physical object. Kendall (2007, p. 78) cited the example of travelling by plane: "we believe [i.e., non-material aspect] that it is possible to fly at 33,000 feet and to arrive at our destination even though we know that we could not do this without the airplane [i.e., material aspect] itself."

Williams (1985) contrasted two differing views of culture: on the one hand, as the production of materials, which is common in archaeology or cultural anthropology; and on the other hand, as the production of symbols, more commonly found in history or cultural studies. In aviation, it is important to recognise the value of both of these aspects. Material culture includes the uniforms of pilots and the aircraft they fly, while non-material culture includes the phraseology that pilots and ATC use to communicate.

4.1.4 Dealing with Problems

Another perspective regards culture as a defensive adaptation for dealing with the problems of life. In order to do this, Csikszentmihalyi (1990, p. 81) posited that cultures direct attention towards a limited set of goals and solutions:

> Cultures are defensive constructions against chaos, designed to reduce the impact of randomness on experience. They are adaptive responses, just as feathers are for birds and fur is for mammals. Cultures prescribe norms, evolve goals, build beliefs that help us tackle the challenges of existence. In so doing they must rule out many alternative goals and beliefs, and thereby limit possibilities; but this channeling of attention to a limited set of goals and means is what allows effortless action within self-created boundaries.

Similarly, Trompenaars and Hampden-Turner (1997, p. 6) described culture as "the way in which a group of people solves problems and reconciles dilemmas". Drawing on the work of anthropologists Florence Kluckhohn and Fred Strodtbeck, they suggested that humans face certain universal problems. These problems arise from the relationships that people have with other people, time, activities and nature. The central idea proposed by Trompenaars and Hampden-Turner (1997, p. 27) is that "all cultures are similar in the dilemmas they confront, yet different in the solutions they find". Starting from categories of universal problems, they derived seven intercultural dimensions, which are discussed in Section 4.7.

4.2 The Culture of Groups

A key aspect of culture is that it is something shared by the members of a group. For Trompenaars and Hampden-Turner (1997, p. 3), "the essence of culture … is the shared ways groups of people understand and interpret the world." In this section I review definitions of culture that relate to social groups. Then I discuss distinctive forms of culture that manifest themselves in different social groups, especially national, organizational and professional cultures. I also describe safety culture, which in recent decades has become increasingly important in high risk industries such as nuclear power generation and civil aviation. Finally, I consider processes by which cultures change over time.

4.2.1 Definitions of Group Culture

One view of culture holds that it forms an inextricable part of the identity of certain social groups. Merritt, for example, defined culture as "the values and practices that we share with others that help define us as a group, especially in relation to other groups" (as cited in Engle, 2000, p. 109). Likewise, after noting multiple ways in which the word "culture" has been defined, Scollon, Scollon and Jones (2012, p. 3) suggested that it is best thought of as "a way of dividing people up into groups according to some feature of these people which helps us to understand something about them and how they are different from or similar to other people."

Hofstede (1983, p. 76) labelled culture as "collective mental programming" and indicated that it operates at a range of social levels: "it is that part of our conditioning that we share with other members of our nation, region, or group but not with members of other nations, regions, or groups". Echoing the aforementioned view of culture as a means of coping with problems, Usunier (1998, p. 16) defined it in terms of "pre-set and agreed upon solutions" that allow people to effectively communicate and coordinate their actions with other members of their group. Adler and Gundersen (2008) observed that culture is transmitted from older to younger group members and is shared by all, or nearly all, members of a social group.

There are two qualifications to these definitions of culture as it pertains to social groups. Firstly, Maznevski and Peterson (1997, p. 66) cautioned that "individual members of a culture do not always reflect the norms of the culture, either in values or behavior". Section 4.6.2 discusses this in the context of Hofstede's cultural dimensions. Secondly, Usunier (1998, p. 17) pointed out that individuals may belong to several social groups and switch between different operational cultures depending on the situation:

> Culture can be viewed as a set of beliefs or standards, shared by a group of people, which help the individual to decide what is, what can be, how one feels about it, what to do, and how to go about doing it.… Consequently, individuals may share different cultures with several different groups - a corporate culture with colleagues at work, an educational culture with other MBA graduates, an ethnic culture with people of the same ethnic origin. When in a particular situation, they will switch into the culture that is operational.

In other words, an individual may be informed by multiple cultural influences, and the dominant influence may vary depending on the situation or context.

4.2.2 National, Organizational & Professional Cultures

Numerous social groups have been identified as possessing a distinctive culture. Hofstede's research concentrated mainly on national culture. However, he also noted that a range of other social groups, or categories of people, may be distinguished by their culture, or their "collective programming of the mind":

> The 'category of people' may be a nation, a region or an ethnic group, women or men (gender culture), old or young (age group and generation culture), a social class, a profession or occupation (occupational culture), a type of business, a work organization or part of it (organizational culture), or even a family. (Hofstede, 1994, p. 8)

Trompenaars and Hampden-Turner (1997, p. 7) narrowed their focus to three important social levels on which culture is exhibited:

- "the culture of a national or regional society";

- “the way in which attitudes are expressed within a specific organisation”;
- “the culture of particular functions within organisations” where people “tend to share certain professional and ethical orientations”.

For aviation studies, a similar approach has been adopted. Initially, research on culture was largely concentrated on the national level, but subsequently the organizational and professional levels were also embraced. This approach was codified in a seminal study of the effects of culture in aviation and medicine by Helmreich and Merritt (1998). Culture was divided into the overlapping constructs of national, organizational and professional cultures, as illustrated in Figure 8. Such an approach has continued to inform research in aviation and other areas such as international business (Dahlstrom & Heemstra, 2009; Helmreich, Wilhelm, Klinect & Merritt, 2001; Sirmon & Lane, 2004).

Figure 8: Venn diagram of national, organizational & professional cultures.

4.2.2.1 National Culture

Helmreich and Merritt (1998, p. 103) stated that *national cultures* embody unique characteristics derived from multiple sources: “National culture is a product of heritage. Religion, history, language, climate, population density, availability of raw materials and resources, political movements and wealth all play a role in the development of unique national characteristics.” The idea that national cultures may be differentiated by unique characteristics is intuitively appealing, since nations often exhibit clear differences in their economic, political and educational systems (Sirmon & Lane, 2004). A large amount of research has been carried out to identify dimensions along which national cultures may be differentiated, most notably by Hofstede (2001) and Trompenaars and Hampden-Turner (1997). Their studies and frameworks are discussed in Sections 4.6 and 4.7 respectively.

One significant limitation of the construct of national culture is that it ignores variations between the regions or peoples making up a particular nation (Dahlstrom & Heemstra, 2009). The regions of a nation may, for instance, have significant differences in their religion, history, language or climate. Macdonald (1995) examined this issue, citing the examples of Japan and Australia. She argued that national culture, as a product of the nationalism which created modern nation states, prevents the expression of intra-national cultural diversity.

4.2.2.2 Organizational Culture

There are numerous definitions of *organizational culture*. One of the simplest describes it figuratively as "social or normative glue that holds an organization together" (Smircich, 1983, p. 344). This metaphor imparts the idea that organizational culture provides some kind of control over the behaviour and attitudes of an organization's members (Sirmon & Lane, 2004).

Another way of defining organizational culture is to think of it "as the shared assumptions, values, beliefs, language, symbols, and meanings systems in an organization" (S. J. Tracy, 2009, p. 713). Using a similar definition, Helmreich and Merritt (1998, pp. 109-110) outlined two separate layers of organizational culture:

- an outer layer consisting of "observable behaviors and recognizable physical manifestations such as members' uniforms, symbols and logos, organizational routines and rituals, and printed documents";
- an inner layer made up of values, beliefs and assumptions "which underlie the surface structure and provide the logic which guides the members' behaviors".

There may be considerable variation within the organizational culture of a single company. In terms of Helmreich and Merritt's outer layer, an organization's symbols and rituals are not necessarily shared by all of its members. In an airline, cabin crew and pilots wear different uniforms and are guided in their work by different operating procedures. Furthermore, distinct subcultures may exist within a large company. In an airline, these subcultures may lead to differences in, for example, attitudes towards automation or CRM training in different airplane fleets (FAA, 1996).

Adopting the problem-solving perspective, Schein (1985, p. 9) provided an alternative definition of organizational culture:

> …a pattern of basic assumptions – invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration – that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.

This definition encompasses the processes of formal training and informal learning that take place in organizations in order to sustain common assumptions and approaches to problems.

Organizational culture is sometimes referred to as *company culture* or *corporate culture* (Strauch, 2010; Trompenaars & Hampden-Turner, 1997). Strictly speaking these alternative terms are more restrictive as they only apply to organizations whose purpose is to make a profit (Dahlstrom & Heemstra, 2009).

4.2.2.3 Professional Culture

Sirmon and Lane (2004, p. 311) observed that a *professional culture* "exists when a group of people who are employed in a functionally similar occupation share a set of norms, values and beliefs related to that occupation". Professional culture, also referred to as *occupational culture*, transcends individual organizations. It develops through a process of socialization that occurs during occupational education, personnel selection, training and on-the-job experience. As a result, individuals learn professional culture (and also organizational culture) at a later age than national culture, which is acquired from birth (Hofstede, 1994).

The boundaries between organizational and professional cultures are fuzzy. Sirmon and Lane (2004) distinguished the professional cultures that exist within certain functional areas of an organization (e.g., accounting, sales or marketing) from the organizational subcultures in the same company that link people with common backgrounds (e.g., ethnic, educational or regional). Guirdham (2005, p. 65) reasoned that occupational social groups "do not meet the full criteria for cultures". She argued that occupational groups (as well as other social categories such as gender or social class groups) should instead be considered subcultures because they typically conform to some norms and values of the dominant culture while deviating from others.[24]

The construct of professional culture would appear to be more relevant to some occupations than others. A case study by Stewart highlighted considerable differences in the decision making styles of engineers and nontechnical managers (as cited in Kume, 2009). Within aviation, Chute and Wiener (1995, 1996) investigated differences between the "two cultures" of pilots and flight attendants. They examined factors that impacted crew communication and flight safety, including differences in operational knowledge and attitudes to work.

In the context of aviation and medicine, Helmreich and Merritt (1998) stated that the characteristics of a professional culture include a sense of belonging to a community and the passing on of norms and values by senior to junior members. They noted that, for both doctors and pilots, "professional membership can provide a much stronger bond than company loyalty or national identity" (Helmreich & Merritt, 1998, p. 30).

4.2.2.4 Interplay of National, Organizational & Professional Cultures

A member of an organization may also be a member of a profession, a country, a religion and various other social groups, all of which influence the individual's behaviour and, by extension, the values and norms he or she introduces into the organization (Grote et al., 2004). It is difficult to distinguish between these influences and in some cases the constructs overlap. Hutchins et al. (2002, p. 36) noted that even in the analysis of routine radio exchanges between pilots and ATC "where the authors…are well versed in the national, organizational and professional cultures surrounding the activity, it is difficult to identify the boundaries of the different sorts of culture".

Within a single organization, the relative influence of the three constructs may vary markedly depending on individuals' working contexts. Dahlstrom and Heemstra (2009) described the impact of culture on operations at a large multicultural airline. They stated that professional culture is much more important than organizational culture for pilots at

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[24] A *subculture* is defined as "a category of people who share distinguishing attributes, beliefs, values, and/or norms that set them apart in some significant manner from the dominant culture" (Kendall, 2007, p. 90). Guirdham (2005) noted that the alternative term *co-culture* is sometimes used to avoid connotations of superiority and inferiority.

the airline, in contrast to cabin crew and ground staff. Reasons for the relative importance of pilot professional culture include: the similarity of uniforms and procedures across the profession, international regulations and worldwide standards for pilot training, and the limited amount of contact with other members of the organization. The airline in question has approximately 100 nationalities amongst its flight crew but no dominant national group. Therefore, the influence of national culture is also diminished when compared with flag carriers such as British Airways (in the UK) or Avianca (in Colombia).

4.2.3 Safety Culture

The term *safety culture* was coined in a series of reports published after the 1986 Chernobyl nuclear power plant disaster. The reports were published by the International Nuclear Safety Advisory Group (INSAG), an advisory group to the International Atomic Energy Agency (IAEA). Report No. 75-INSAG-4 outlined roles that organizations and individuals should play in a safety culture, and also provided assessment guidelines. The report included the following definition: "Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance." (INSAG,1991, p. 1)

In the decades following the Chernobyl disaster, the safety culture concept has spread beyond nuclear power generation to other high-risk domains including aviation, mining, construction, hospital operating rooms, and offshore oil and gas extraction. Definitions of safety culture have proliferated (Cole, Stevens-Adams & Wenner, 2013; Guldenmund, 2000; Martinussen & Hunter, 2010; Wiegmann, Zhang, von Thaden, Sharma & Gibbons, 2004). In a literature review listing 13 definitions, Wiegmann et al. (2004, p. 123) derived a set of common features which included:

- a concern with "formal safety issues in an organization";
- an emphasis on "the contribution from everyone at every level of an organization";
- a "willingness to develop and learn from errors, incidents, and accidents";
- a culture that "is relatively enduring, stable, and resistant to change".

Either explicitly or implicitly, these definitions typically situate safety culture within organizational culture, as shown in Figure 9.

Safety culture, as originally conceived by INSAG, was a prescriptive construct, which dictated how organizations and their members should operate in order to ensure safety. By contrast, national, organizational and professional cultures are descriptive constructs. Tension between prescriptive and descriptive approaches may account for some of the differences in definitions of safety culture. The review conducted by Wiegmann et al. (2004) cited several prescriptive definitions, such as: “A safety culture exists within an organization in which each individual employee, regardless of their position, assumes an active role in error prevention, and that role is supported by the organization” (Eiff, 1999). In contrast, other definitions were descriptive: “Safety culture is defined as the attitudes, values, norms, and beliefs that a particular group of people share with respect to risk and safety” (Mearns, Flin, Gordon & Fleming, 1998).

Figure 9: Venn diagram of national, organizational, professional & safety cultures.

According to the ICAO Safety Management Manual, a safety culture should be an integral part of an organizational culture: “A safety culture cannot be effective unless it is embedded within an organization’s own culture” (ICAO, 2013b, p. 2-10). However, as Dahlstrom and Heemstra (2009) pointed out, there may be difficulties in implementation. Effective reporting of accidents and incidents requires openness. This can, however, conflict with an organization’s desire to limit the disclosure of sensitive information. Furthermore, tension may exist between the flexibility demanded by a safety culture, so that the organization can adapt and learn from problems, and the requirement for strict adherence to procedures, which is a fundamental tenet of safety in high-risk industries such as civil aviation.

The related concept of *safety climate* likewise has numerous definitions, and the distinction from safety culture is “an ongoing subject for debate” (Noort, Reader, Shorrock & Kirwan, 2016, p. 517). Safety culture is generally held to consist of “the deeper and historically derived aspects of safety within an organization”, which may be investigated using ethnographic techniques. On the other hand, safety climate refers to “surface features of safety culture”, typically assessed by surveys of employee attitudes and perceptions at a given time (Grote et al., 2004, p. 122).

4.2.4 Changes in Cultures over Time

Cultures change over time as new ideas or ways of doing things are introduced. One process of change is the *discovery* of something previously unknown. For instance, although its existence was postulated in 1807, aluminium was not isolated until 1825. This discovery was to later play an important role in the development of aviation, as foretold by J. W. Richards in the 1880s: “It has been well said that if the problem of aerial flight is ever to be solved, aluminium will be the chief agent in its solution” (as cited in Budd, 1999, p. 6). Aluminium alloys began to be used for aircraft skins following the First World War. Due to its lightness and strength, aluminium later became an essential material in the manufacture of aircraft.

A second process of cultural change is *invention*, when existing items of material or non-material culture are reconfigured into new forms. Drawing on their knowledge of bicycle technology and observations of bird flight, the Wright brothers made the first powered flight by a heavier-than-air aircraft in 1903.[25] This invention has subsequently transformed the spheres of transportation, trade and warfare, with consequences that have touched every corner of the world.

Cultures also change by *diffusion*, when items or practices are transmitted from one social group to another. Air transportation has facilitated cultural diffusion by allowing ever increasing numbers of people to travel. The effects are not always positive, as when

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[25] The primacy of the Wright brothers is contested. The foreword to the 100th edition of “Jane’s All the World’s Aircraft” argued that Gustave Whitehead made controlled flights in Connecticut in 1901. If true, these flights predated the Wright brothers by more than two years (Jackson, 2013).

air travel inadvertently helps spread infectious diseases such as severe acute respiratory syndrome (SARS) or avian influenza (Pavia, 2007). At the time or writing, the risk posed by the Covid-19 pandemic has led to a huge reduction in air traffic.

Empirical evidence exists to support the notion that changes occur over time in national, organizational and professional cultures. Regarding national culture, studies were conducted in the same countries at different times by Trompenaars. Commenting on these studies, Hodgetts, Luthans and Doh (2005, p. 113) highlighted a marked increase over time in scores for the individualism dimension for Thailand, “possibly indicating an increasing entrepreneurial spirit/cultural value”.

Vaughan (1996) carried out a comprehensive analysis of the organizational culture of NASA in the years leading up to the Challenger space shuttle disaster. She documented changes over time in the organizational culture that enabled the deviant performance of a critical component to be normalized, a process she labelled *normalization of deviance*.

Concerning professional culture, Hutchins et al. (2002) conducted ethnographic studies of the effects of culture on airline flight decks. The authors observed that iconic accidents led to changes in pilot professional culture. Changes came about through the mechanism of pilots retelling stories of the accidents and the lessons to be learned. The accidents and lessons taught were as follows:

- crashes of early Airbus A320 aircraft that led to “a deep-seated mistrust of automation”;
- the accidents involving Aloha Airlines Flight 243 (in 1988) and United Airlines Flight 232 (in 1989) which “highlight the value of pilot decision making and CRM”;
- the 1996 ValuJet Flight 592 and 1998 Swissair Flight 111 disasters which “drive home the lesson that one must land ASAP when there is a fire in flight” (Hutchins et al., 2002, p. 22).

4.3 Hall’s Intercultural Communication

During a career that spanned most of the twentieth century, anthropologist Edward T. Hall identified numerous ways in which culture informs human behaviour. Collier (2009, p. 280) observed that Hall’s work was “noteworthy because he brought attention to face-to-face interaction between members of different cultural groups and also introduced the importance of nonverbal forms of communication”. Hall focused on *intercultural* communication, when members of different cultural groups are interacting with each other.

By contrast, previous anthropological research had either investigated one cultural group at a time, or made *cross-cultural* comparisons of communication patterns in one cultural group with those in another group. In this section I discuss three of the intercultural communication concepts that Hall identified, some of the criticisms levelled at his work, and implications of his research for airline operations and training.

4.3.1 Hall's Hidden Culture

Hall (1990, p. 32) investigated "what people do and the hidden rules that govern people". He suggested that people remain largely unaware of this *hidden culture* because it operates below the level of consciousness. Hall's cultural framework is complex, but may be distilled down to four basic components relating to communication style, relationship context, time context and space context (Adair, Buchan & Chen, 2009). The following paragraphs describe three sets of concepts identified by Hall that are relevant to cockpit interactions and pilot-ATC communication: *high-context* and *low-context*, *monochronic* and *polychronic* time, and *action chains*.

4.3.1.1 High-Context & Low-Context

Hall (1976) contrasted high-context cultures with low-context cultures. People in high-context cultures have deep relationships and share information using messages that are superficially simple but actually rich in meaning. People in low-context cultures are not bonded tightly and make less distinction between insiders and outsiders. The United States is an example of a low-context culture, while Colombia is a high-context culture.[26]

Hall cautioned that interactions between individuals from high- and low-context cultures could present problems. Difficulties may arise due to differences in expectations or the norms for acceptable ambiguity:

> People raised in high-context systems expect more of others than do the participants in low-context systems. When talking about something that they have on their minds, a high-context individual will expect his interlocutor to know what's bothering him, so that he doesn't have to be specific. The result is that he will talk around and

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[26] Hall did not discuss Colombia, but other authors have cited it as an example of a high-context culture (Costalas, 2009; Gudykunst et al., 1988).

> around the point, in effect putting all the pieces in place except the crucial one. Placing it properly – this keystone – is the role of his interlocutor. (Hall 1976, p. 113)

Applying these concepts to communications, Hall stated that high-context systems are fast and efficient because pre-programmed information is contained in receivers and settings, with minimal information in messages. Low-context communications, by contrast, encode most of the information in messages, with very little in the internal or external contexts. The standard phraseology used by pilots and controllers in aviation is an example of a high-context communication system (Hall, 1976). It is essentially just a collection of pre-fabricated phrases used for typical flight situations. Considerable time must be spent training operators to use the system, but the payoff is that information can be exchanged quickly and efficiently. It is possible that individuals with a predisposition for low-context communications will require more training to master this kind of system than those already familiar with high-context communications.

The constructs of high-context and low-context *cultures* are problematic. With specific reference to French and Japanese people, Hall (1976) stated that an individual may exhibit both high-context and low-context aspects depending on the situation (Hall, 1976). Scollon et al. (2012) resolved this dilemma by proposing that the constructs of high- and low-context be applied to particular speech events or situations, but not used to describe entire national groups.

4.3.1.2 Monochronic & Polychronic Time

A second cultural scale described by Hall (1983) differentiates between mono-chronic people, who like to do one thing at a time, and polychronic people, who prefer doing several different activities at once. Interactions between the categories may again lead to problems, with polychronic behaviour liable to disorientate monochronic people. This has implications for flight crew composition. For example, a monochronic American captain and a polychronic Latin American first officer may adopt different approaches to the same task. In the context of international business interactions, Hall (1969) suggested that judicious office design could ameliorate such problems. In aviation this is currently not a viable option on the confined flight decks of passenger aircraft.

Hisam and Hampton (1996) noted that monochronic people are vulnerable to interruptions. In airline operations it is commonplace for disturbances, such as unexpected calls from ATC, to put task completion at risk. Loukopoulos, Dismukes and Barshi (2009) studied dozens of incidents in which American flight crews experienced disturbances. They stressed the importance of CRM training in techniques for managing workload effectively. As part of this training, techniques for dealing with interruptions would seem to be especially important for monochronic personnel. There does not appear to have been any aviation-related research conducted on the effects of interruptions on monochronic versus polychronic people. However, instruments for measuring polychronicity have been applied to other organizational contexts (Bluedorn, 2002).

4.3.1.3 Action Chains

An action chain is a sequence of actions that two or more individuals carry out in order to complete a task. Action chains play a vital role in the work of airline pilots. One example is found in the formulaic exchanges that characterize RT communication between pilots and ATC. Another example is in the standard operating procedures (SOPs) which describe tasks that pilots have to complete in each phase of flight. Hall (1976) noted that monochronic people tend to focus on completing tasks, whereas polychronic people place more emphasis on maintaining good human relations.

Misunderstandings may occur when monochronic and polychronic people work together on the same action chain. An illustration of such a misunderstanding is provided by the transcripts of the Avianca Flight 052 accident. Shortly before the crash, one of the Colombian flight crew commented that an American air traffic controller was angry. In his analysis of the accident, Helmreich (1994) interpreted this comment as indicating a failure of the flight crew to focus on the task of safely landing the plane. However, a polychronic interpretation suggests the crew member was not neglecting the task of landing, but was instead expressing concern about the human relations involved in the situation.

4.3.2 Criticism of Hall's Concepts

As mentioned previously, Scollon et al. (2012, p. 40) were "reluctant to label cultures or discourse systems as high context or low context". They pointed out that the degree to which individuals rely on context for meaning varies depending on the situation. They proposed that these constructs should not be applied to cultures, but should instead be used to analyse "high context and low context situations".

Hutchins et al. (2002, p. 26) were more outspoken in their criticism of Hall’s work. They stated that much of it was “based on rather dated and over-simplified models of the role of cultural and linguistic knowledge in thought”. Additionally, they warned against regarding culture as a set of traits exhibited by all members of a group, and they stressed the importance of cultural variability within social groups. This charge, while important, may be equally directed at many other studies of national culture.

Nakata (2009) commended Hall’s concept of high- and low-context for being more nuanced than Hofstede’s dimensions. She also suggested one reason for Hall’s concepts not being applied more widely was the lack of quantitative instruments. The standardized scores and survey tools produced by Hofstede lend themselves to quantitative research studies in a manner not yet possible for Hall’s concepts.

Notwithstanding these limitations, researchers in aviation, organizational studies and intercultural communication continue to make use of Hall’s concepts (Dahlstrom & Heemstra, 2009; Hisam & Hampton, 1996; Scollon et al., 2012).

4.3.3 Implications for Aviation

Dahlstrom and Heemstra (2009, p. 83) reported on the training of pilots at a large multicultural airline. They emphasised the value of facilitated discussions about cultural factors in providing newly recruited pilots “with an awareness of this new environment and advise [sic] on how to navigate it safely”. For this purpose, they noted that Hall’s concepts (e.g., high- and low-context, monochronic and polychronic time) may be used as an alternative to Hofstede’s dimensions.

In a paper about airline training, Hisam and Hampton (1996) commented that the concepts of high- and low-context had implications for several aspects of flight operations including briefings, conflict resolution, communications and teamwork. They added that, although existing CRM training was appropriate for communication in the United States, it might not be appropriate for other cultures as it did not “take into account the additional variables created by high-context communications” (Hisam & Hampton, 1996, p. 11).

4.4 Ethnography of Communication (EOC)

Ethnography of communication (EOC) is a field of study linking linguistics and anthropology that was established by linguistic anthropologist Dell Hymes. It was initially called ethnography of speaking, but Hymes (1972b) broadened the scope to include nonvocal communication (e.g., whistling) and nonverbal communication (e.g., silence and gestures). EOC is a framework for analysing naturally occurring speech and interaction in the context in which it emerges. A key principle is that culture and communication are inseparable.[27] When the members of a community communicate, they express cultural elements specific to their community. At the same time, they also create value systems that organize the community through their communication (Covarrubias Baillet, 2009a).

Drawing on EOC and also on Basil Bernstein's concept of communication codes, Gerry Philipsen developed speech codes theory (SCT). SCT is a framework for analysing communication that allows the analyst to uncover the precepts or rules within a given community that help people to live their lives and interact with others (Covarrubias Baillet, 2009b). Central to this framework is the concept of a speech code, defined by Philipsen (2002, p. 56) as "a historically enacted, socially constructed system of terms, meanings, premises and rules pertaining to communicative conduct".

4.4.1 Key Concepts in EOC

The following paragraphs describe fundamental concepts in EOC which are relevant to the analysis of interactions within the cockpit and pilot-ATC communications: *speech acts*, *speech events* and *speech situations*; the SPEAKING framework; personal address and silence; *communicative competence*; *speech community* and *community of practice*; and *code switching*.

4.4.1.1 Speech Acts, Speech Events & Speech Situations

Three basic social units that are used for the study of communication practices are the speech act, speech event and speech situation. A speech act is the minimal unit for analysing conversational interaction, for example, a greeting, request or command; a speech event is made up of a number of speech acts; and a speech situation is the general context of the communication (Hymes, 2001). Thus each request or command spoken by a pilot or air traffic controller is a speech act; an exchange between a controller and a pilot is

[27] Hall (1990, p. 186) expressed a similar sentiment when he wrote that "culture is communication and communication is culture".

a speech event; and an air traffic controller communicating with a series of aircraft is a speech situation.

Hymes (2001, p. 53) observed that the process of interpreting a speech act goes beyond mere syntactic analysis: "much of the knowledge that speakers share about the status of utterances as [speech] acts is immediate and abstract, and having to do with features of interaction and context as well as of grammar". In other words, the meaning of a speech act is conveyed by a combination of factors. These include paralinguistic features such as intonation, as well as the position of the speech act in an exchange and the social relationship of the interlocutors.

4.4.1.2 SPEAKING Framework

Hymes developed an etic (i.e., universal, not culture-specific) framework to guide the analysis of communicative patterns in a culture. The framework has eight components denoted by the mnemonic term SPEAKING:

- S – the setting;
- P – the participants;
- E – the end purpose of an event;
- A – the acts that make up an event;
- K – the key, or tone, in which communication is enacted;
- I – the instrumentalities, or channels of communication;
- N – the norms of interaction and interpretation;
- G – the genre.

Duranti and Goodwin (1992) observed that, compared with speech act theory, this framework allows a fuller analysis of the context of communication. It explicitly deals with the setting (both spatial and temporal) and the various roles that participants may adopt (i.e., addressor, speaker, addressee or hearer/audience). As noted by Coulthard (1985), it is not uncommon for participants to make frequent and rapid role changes. In pilot-ATC radiotelephony, a typical speech situation involves a controller (in the role of speaker) transmitting a message to a particular flight crew (addressee) while other crews (audience) listen on the same radio frequency. Then the flight crew (as a speaker) responds to the message while the controller (addressee) and other crews (audience) listen. And so the communication continues with other aircraft. Additionally, a controller may sometimes change role from speaker to addressor in the middle of a transmission in order to read out a pre-scripted message such as a weather warning.

4.4.1.3 Personal Address & Silence

Other important concepts in EOC include personal address and silence, both of which are subject to rules that vary depending on culture and context. Personal address denotes the expressions used by speakers to refer to self and other. These include first names versus family names, nicknames, honorifics and occupational titles such as "Captain". Silence, or the absence of speech, is particularly relevant to the sterile cockpit rule in commercial aviation. As mentioned in Section 2.3, this rule prohibits crews from engaging in non-essential speech when flying below 10,000 feet. Hisam and Hampton (1996) suggested that there may be differing interpretations of the sterile cockpit rule in different cultures.

4.4.1.4 Communicative Competence

As discussed in Section 2.1.1, Hymes proposed the concept of communicative competence as a response to Chomsky's notion of linguistic competence (which is similar to Saussure's concept of langue). Native speaker-listeners acquire not only grammatical knowledge of a language but also learn how to use the language appropriately in their society so that "a child becomes able to accomplish a repertoire of speech acts, to take part in speech events, and to evaluate their accomplishment by others" (Hymes 1972a, p. 277). Likewise, non-native speakers must gain communicative competence in a foreign language, in order to be able to use the language effectively and appropriately.

4.4.1.5 Speech Community & Community of Practice

A fundamental notion within EOC is the speech community, defined by Coulthard (1985, p. 35) as "any group which shares both linguistic resources and rules for interaction and interpretation". While noting the usefulness of this concept, Coulthard stressed that it is an idealized notion due to the inherent difficulty in separating speakers into categories. Montgomery (1986) listed some attributes that members of a speech community share: a common language, ways of using language, reactions and attitudes to language, and social bonds. Montgomery noted that it is difficult to find actual communities meeting all these conditions. He suggested considering a speech community as including "not only the notion of verbal practices held in common, but also of tension and conflict between them" (Montgomery, 1986, p. 135).

Another concept that has been widely used in recent years is that of a community of practice, referring to "a set of people who share a purpose and pursue that purpose jointly in shared practices" (K. Tracy, 2009, p. 145). In the context of airline operations, Clark (2007, p. 8) identified the communities of practice of pilots and flight attendants as sets of people who work in close proximity but have "different discursive practices and speaking styles". Each of these communities can in turn be broken down into smaller communities of practice based on nationality, ethnic or regional culture, airline, and so on. Contrasting the community of practice paradigm with that of speech community, Clark (2007, p. 7) observed that social identity in a community of practice is not fixed "but is fluid, and constructed through shared practices, including discourse practices".

4.4.1.6 Code Switching

The members of a speech community or a community of practice may use multiple linguistic codes (i.e., languages, dialects, registers or styles) for communication. Code switching takes place when speakers alternate between different linguistic codes during a single interaction. This often occurs when members of different language communities interact. For example, an American pilot who contacts ATC in Colombia may use English interspersed with a few Spanish words such as "gracias" or "buenos noches". Another form of code switching takes place within a single speech community when the members switch between the different codes they share, such as dialects and registers. For example, a pilot may use standard phraseology in a transmission to ATC, then switch to plain English for intra-cockpit dialogue with other crew members.

Some researchers differentiate language shifting, or the switching between different languages, from style shifting, or the monolingual switching between different linguistic registers and dialects (Bullock & Toribio, 2009). There is further discussion of code switching in Section 2.7.

4.4.2 Limitations of Ethnography

The ethnographic method can provide insights into culture not captured by other research methods. It does this through a variety of data collection methods including participant observation, field notes, interviews and surveys. However, as Strauch (2010, p.

259) pointed out, this kind of study “is resource intensive, requires considerable expertise, and may be subject to observer variability”. In aviation the resource requirements include the need to gain access to flight decks, which for security reasons has been very difficult since the terrorist attacks of 2001. In addition, expertise is required in a variety of fields including piloting, human factors, anthropology, language and culture (Hutchins et al., 2002; Hutchins et al., 2006).

4.4.3 Applications to Aviation

Widespread use has been made of the technique of observing pilots at work during routine flights. However, this is rarely done within an ethnographic framework. Different flight crews participate in each observation, which typically lasts a few hours, and the aim is usually to collect quantitative data describing the performance of pilots. Sometimes flight deck observations are used to complement other data collection methods, such as large-scale surveys (see, for example, Helmreich & Merritt, 1998). In other cases, such as the Line Operations Safety Audit (LOSA) programme, flight deck observations are the only data collection method used. LOSA involves observers recording how pilots deal with threats and errors during actual flights. The LOSA programme is linked with CRM training and draws on the TEM safety taxonomy developed by Robert Helmreich’s human factors team at the University of Texas (ICAO, 2002).

One reason for ethnography not being widely used in aviation is that considerable resources are required, as mentioned above. Another reason is that aviation research has traditionally been dominated by quantitative methods, especially in the United States. In one notable study that utilised the ethnographic approach, Hutchins et al. (2006) examined the impact of culture on cockpit interaction at airlines in the Asia-Pacific region. Their study included observations of cockpit operations and simulator training as well as airline staff interviews. It identified specific differences in cockpit practice between airlines in different countries, illustrating a point made by Strauch (2010) that the ethnographic method can provide insights into culture not captured by other research methods. Section 4.9.5 has more information about this study.

Clark (2007) used ethnographic methods to investigate attitudes towards pilot-cabin crew communication in a study of flight attendant identity construction. Data collection included a survey, industry forum postings, and participant observation at an American airline. Clark used communication accommodation theory (CAT) to explain interactions between pilot and flight attendant communities of practice. She noted that some cabin crew accept the chain of command hierarchy that places them below pilots, but others exhibit non-accommodation by calling pilots "motorcoach drivers". Referring to the studies of Chute and Wiener (1995, 1996), she emphasised differences between the professional cultures of pilots and cabin crew: "The two groups have different histories, work rules, and unions; they are grouped in different departments in most airlines, and have different training programmes" (Clark, 2007, p. 24). The differences are compounded by a gender divide in many airlines, with pilots generally being male and flight attendants female.

4.5 Interdiscourse Communication

Interdiscourse communication is an approach to intercultural communication that was developed by the linguists Ron Scollon, Suzanne Wong Scollon and Rodney Jones, drawing heavily on Hymes's EOC. Two key concepts of interdiscourse communication are that people participate in discourse systems, and language is inherently ambiguous. The grammar of context framework was developed to facilitate the analysis of interdiscourse communication.

4.5.1 Key Concepts in Interdiscourse Communication

4.5.1.1 Discourse Systems

While acknowledging that the word *discourse* has numerous meanings, Scollon et al. (2012, p. 8) chose to define it in general terms as "the broad range of everything which can be said or talked about or symbolized within a particular, recognizable domain". Based on this definition, they explained the concept of a *discourse system* in terms of groups of people using different discourses: "Any group that has particular ways of thinking, treating other people, communicating and learning can be said to be participating in a particular discourse system." Such groups can be extremely large, as with the discourse system of international capitalism, or quite small, in the case of a family. Scollon et al. (2012, p. 9) contrasted this concept of a discourse system with that of a discourse community or a community of practice by emphasising that the former refers to "broader systems of communication in which members of communities participate". More emphasis is placed on shared systems of communication than on tightly defined boundaries to group membership.

A key assumption is that individuals may simultaneously participate in multiple discourse systems related to their nationality, region, ethnicity, gender, age, social class, profession, organization, and so on. As a result, social interaction between participants in different discourse systems, which is termed *interdiscourse communication* by Scollon et al. (2012), is a fundamental part of almost all communication. This allows for a more flexible and nuanced approach to intercultural communication than was taken in previous studies that, for example, focused solely on the effects of national culture. The discourse system approach may be applied to the analysis of communication patterns in small groups. In a discourse analysis study of small-group decision-making meetings, Aritz and Walker (2010, p. 25) noted that differences in discourse systems can "affect group performance and lead to different levels of leadership, team identity, relational conflict, and satisfaction among members of multinational teams".

4.5.1.2 The Ambiguity of Language

A further important assumption underlying this framework is that language is inherently ambiguous in that speakers and writers are never able to completely control how their words will be interpreted by listeners and readers. In other words, "meaning in language is jointly constructed by the participants in communication" (Scollon et al., 2012, p. 11). Ambiguity may exist at word-level, sentence-level or discourse-level. Participants in the same discourse system communicate on the basis of shared assumptions and knowledge. This allows them to deal with ambiguity by making inferences about what their interlocutors mean. In cases of interdiscourse communication, however, it may not be possible for participants to use inferences to cope with ambiguity because they do not have shared histories, backgrounds or experiences. Scollon et al. (2012, p. 16) summed up this line of reasoning as follows: "Two people from the same village and the same family are likely to make fewer mistakes in drawing inferences about what the other means than two people from different cities on different sides of the earth."

International civil aviation has developed into a global business with hundreds of thousands of operators from a large number of different countries and cultures. As a result, it is commonplace for pilots and air traffic controllers to be communicating with people who do not share the same assumptions and knowledge. This underscores the importance of using standard phraseology for pilot-ATC communications to reduce ambiguity.

4.5.2 Grammar of Context

As a tool to facilitate the analysis of interdiscourse communication, Scollon et al. (2012) proposed the grammar of context framework shown in Table 5. This framework is intended to provide a "common vocabulary" capable of embracing multiple aspects of context or culture. It was adapted from the EOC framework developed by Hymes.

Table 5: A grammar of context (Scollon et al., 2012, pp. 30-31).

SEVEN MAIN COMPONENTS FOR A GRAMMAR OF CONTEXT	
1. Scene	(a) setting (time, place, location, use of space), (b) purpose (function), (c) topic, (d) genre
2. Key	tone or mood
3. Participants	(a) who they are, (b) roles they take
4. Message form	(a) speaking, (b) writing, (c) silence, (d) other media (video, digital images, etc)
5. Sequence	(a) set agenda, (b) open agenda
6. Co-occurrence patterns	(a) marked, (b) unmarked
7. Manifestation	(a) tacit, (b) explicit

In their commentary on the grammar of context, Scollon et al. (2012) discussed concepts that may be incorporated from other strands of intercultural research. Within the "scene" component, for instance, the "setting" of an interaction includes the aspect of how participants view time, and may therefore be informed by the concepts of chronos and kairos time, drawing on the work of Hall (1990). Similarly, the different ways in which participants make use of space may draw on Hall's (1969) work on proxemics. In addition, Hall's (1969, 1990) concepts of monochronic versus polychronic time may inform the "purpose", "topic" and "genre" of the scene insofar as some participants prefer to work on one thing at a time while others prefer to engage in multiple activities. Significantly, Scollon et al. (2012) stressed that these concepts should not be considered characteristics of an entire group of people from a particular culture, but rather as characteristics of the particular events or situations in which people participate.

Other concepts discussed by Scollon et al. (2012) include face systems, kinship, and ingroups and outgroups. All of these may inform the identities, roles and relationships of participants. In this framework it is understood that the importance of the components shown in Table 5 varies depending on the speech situation. Different components are salient in different speech situations. For example, participant roles and the use of space may be more important in a courtroom than at a cocktail party.

4.5.3 Applications to Business Communication

The grammar of context framework does not appear to have been previously applied to aviation communications, but Pan, Scollon & Scollon (2002) described how it has been used to analyse professional communication in four typical business contexts. One study focused on business telephone calls and analysed three calls made by a Hong Kong IBM representative. The researchers concluded that the structure of the calls was influenced by many factors including: telephone technology, the nature of the situation, the relationship between the caller and his clients, and the monetary significance of the business they were discussing.

The telephone calls in this study were mainly in Cantonese but featured code mixing with English expressions. Pan et al. (2002, p. 47) related how focus group discussions were conducted with participants from Beijing who reacted strongly to the code switching. These participants thought that switching between Cantonese and English was acceptable for calls between Hong Kong people (i.e., an ingroup relationship), but not for calls involving mainland Chinese as it was annoying and might “create distance in interpersonal relationships” (i.e., ingroup versus outgroup). The researchers noted that practices acceptable in one context may create problems in another.

In their analysis of the phone calls, Pan et al. (2002, p. 49) mentioned politeness markers such as “please” and “thank you”. They observed that in Chinese these markers would be replaced by “prosodic factors such as tone of voice, intonation, or rate of speech, with appropriate pauses and other discursive features”. Another point of difference was self-identification. The authors noted two completely different situations in which Chinese people do not identify themselves on the telephone: firstly, when the callers are intimates; and secondly, when there is a low trust situation. That the same signal may be sent in two different situations may lead to ambiguity and possible misinterpretations.

4.5.4 Implications for Pilot-ATC Communication

There are parallels between the analysis of business telephone calls and pilot-ATC radiotelephony. Firstly, the participants in both contexts are in different locations using two-way mediated communication. However, multiple speakers are sharing the same radio frequency in the case of pilot-ATC communication. Each participant may send a message (in the role of a speaker), which can be heard not only by the intended recipient (addressee) but also by other participants (audience).

The message form in both cases is speaking through an electrical channel that only permits oral communication: telephone for the business calls and VHF radio for aviation. The absence of a visual channel means that gesture, posture and gaze information is not available. Since participants cannot see each other, there is a need for self-identification. For pilot-ATC radiotelephony this is realised through the use of designators identifying ATC facilities (e.g., “New York Approach” and “Kennedy Tower”) and call signs for individual aircraft (e.g., “Avianca zero five two”).

One significant difference between business calls and pilot-ATC radiotelephony relates to participant relationships. When an airliner enters a new sector of airspace, a pilot contacts the air traffic controller. It is likely that the pilot and controller have never spoken before, or at least they are unaware of having done so. This limits the amount of shared information available to them and further emphasises the importance of standardized procedures.

A second difference is that in pilot-ATC communication the sequence of speech acts is prescribed, as noted in the discussion of standard phraseology in Section 2.4.1. Furthermore, one radio frequency is often shared by many aircraft so there is pressure to keep messages short to avoid frequency congestion. As a result, pilot-ATC exchanges typically consist of only two or three turns. The time pressure in commercial aviation is echoed in the oft-repeated mantra that the goals of pilot-ATC radiotelephony are “clarity, conciseness and correctness” (e.g., ICAO, 2010, p. 5-5).

A further idiosyncrasy of radiotelephony communication is that only one speaker can transmit at a time. In the event of simultaneous transmissions, part or all of a message is liable to be blocked. However, the sender of the message may not be aware that blocking has occurred.

Table 6 uses the grammar of context framework to summarise key features of radiotelephony communication between airline flight crews and air traffic controllers. In

Chapter 7, this framework is applied to the analysis of pilot and controller language use in the crash of Avianca Flight 052. The analysis also makes use of components not included in Table 6, such as co-occurrence patterns that are marked. An example is a controller using an idiomatic expression instead of standard phraseology to request information about aircraft status. The framework may be applied to other aviation contexts, if appropriate adjustments are made to the components. For instance, in the case of a private pilot flying a light aircraft, there would be a single pilot participant rather than the captain and first officer shown in the table. Alternatively, a modern airline flight using datalink technology would include communications with a written message form.

Table 6: Grammar of context description of pilot-ATC radiotelephony.

COMPONENTS OF AIRLINE PILOT-ATC RADIOTELEPHONY	
1. Scene (setting)	• Pilots: seated in the cockpit of an aircraft moving through the air or taxiing/stationary on the ground
	• Controllers: stationary in ATC facilities on the ground
3. Participants	• One pilot (captain or first officer) communicates with a series of controllers while the other pilot controls the aircraft
	• Controllers are responsible for a sector of airspace and communicate with a series of aircraft flying through the sector
4. Message form	• Speaking through an electrical channel
5. Sequence	• Message sequence and format are prescribed by standard phraseology • Only one speaker can transmit at a time and messages should be short

4.6 Hofstede's Cultural Dimensions

Social psychologist Geert Hofstede investigated differences in national culture in a research programme starting in the 1960s. He applied factor analysis to data aggregated from surveys of 88,000 workers in more than 70 countries. Four cultural dimensions were identified and numerical values calculated for all countries on each dimension (Hofstede, 1983). The dimensions were: *power distance*, *individualism* versus *collectivism*, masculinity versus femininity, and *uncertainty avoidance*. Later studies identified two more dimensions: long-term orientation versus short-term normative orientation, and indulgence versus restraint (Hofstede, Hofstede & Minkov, 2010). Hofstede's research has concentrated on national cultural differences, although there was a study of organizational culture in Denmark and the Netherlands (Hofstede, Neuijen, Ohayv & Sanders, 1990).

4.6.1 Hofstede's Dimensions

Hofstede's cultural framework has been very influential in many fields. Nakata (2009) listed four reasons for its success:

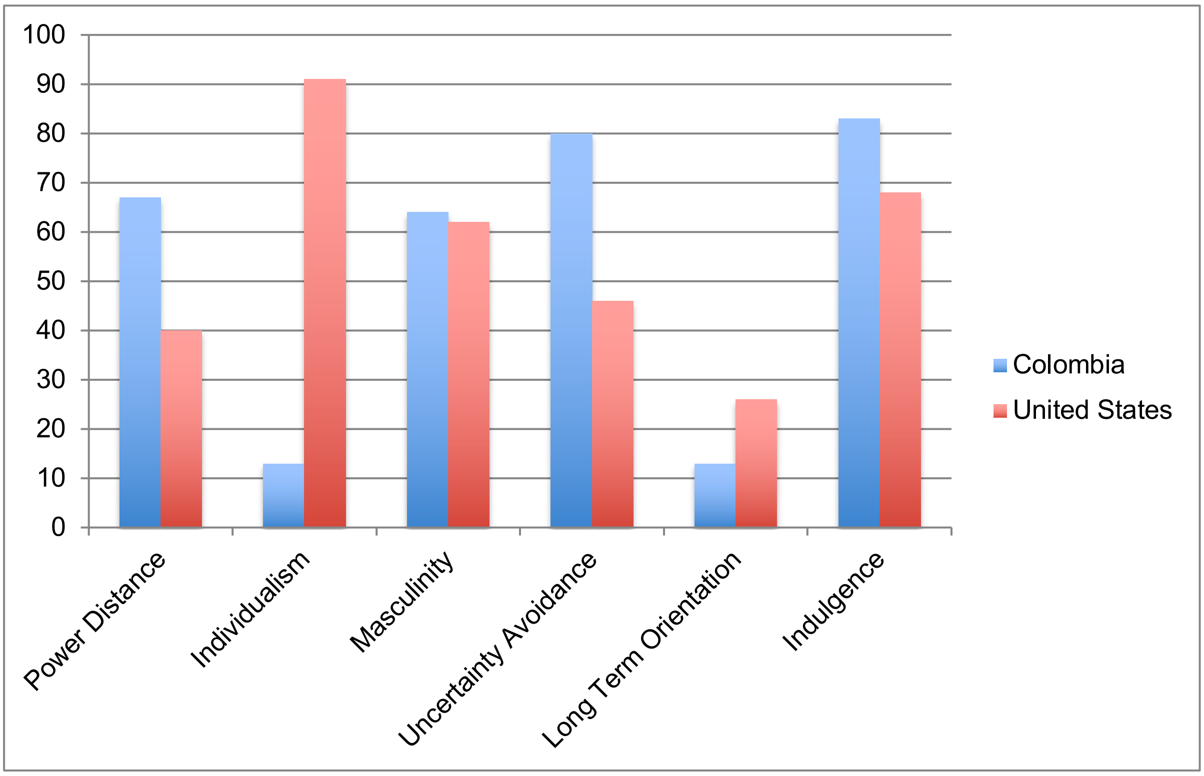
- the statistical analysis of a huge amount of survey data from a wide range of countries provided unprecedented insights into national culture;
- the cultural dimensions allow all national cultures to be described, not just some, which makes the framework suitable for a variety of research purposes;
- the framework has theoretical grounding in the work of anthropologists Florence Kluckhohn and Fred Strodtbeck as well as sociologist Talcott Parsons;
- the survey instruments generate standardized cultural scores, making them ideal for quantitative research in a way not possible for some other cultural frameworks.

Within aviation, Hofstede's tools and methodology were championed by the human factors team at the University of Texas and incorporated into airline CRM training. The following paragraphs discuss three of Hofstede's cultural dimensions that are especially relevant to commercial flight operations: power distance, individualism-collectivism, and uncertainty avoidance.

4.6.1.1 Power Distance

The dimension of power distance reflects the degree to which people in a society accept unequal power relationships. Subordinates in high power-distance cultures tend to accept autocratic power relations. By contrast, subordinates in low power-distance cultures tend to be more comfortable challenging the decision-making of those in power. Adler and Gundersen (2008, p. 55) suggested that employees in a low power-distance country may be afforded leeway "to bypass their bosses frequently in order to get their work done" but in a high power-distance country such behaviour is considered insubordination. Gudykunst et al. (1988, p. 47) commented that in a high power-distance society "superiors consider their subordinates to be different from themselves and vice versa". According to Hofstede's data, as shown in Figure 10, Colombia (with a score of 67) has a higher power distance than the United States (40).

Figure 10: Hofstede's cultural dimension scores for Colombia and the US (Hofstede, 2001).



4.6.1.2 Individualism-Collectivism

The individualism-collectivism dimension is a measure of the degree to which people in a society act as individuals rather than as members of cohesive groups. Adler and Gundersen (2008, p. 51) suggested that individualism is characterized by people who "focus primarily on taking care of themselves and their immediate families". Collectivism, by contrast, features "tight social networks" in which people "expect members of their particular in-groups to look after them, protect them, and give them security in exchange for their loyalty to the group". Hofstede's data showed a striking difference between the scores of the United States (91), ranked as one of the most individualistic countries in the world, and Colombia (13), one of the most collectivistic.

Gudykunst et al. (1988, p. 44) posited that Hofstede's individualism-collectivism dimension is isomorphic with Hall's concepts of low- and high-context. They inferred that "low- and high-context communication are the predominant forms of communication in individualistic and collectivistic cultures, respectively".

4.6.1.3 Uncertainty Avoidance

Uncertainty avoidance denotes the extent to which the members of a society feel threatened by uncertainty or ambiguity. In countries with a high uncertainty-avoidance score, people are less tolerant of uncertainty and ambiguity, and there is a corresponding need for formal rules as well as a rejection of deviant ideas and behaviour (Adler & Gundersen, 2008; Gudykunst et al., 1988). According to Hofstede, Colombia (80) has a significantly higher score for uncertainty-avoidance than the United States (46).

4.6.1.4 Hofstede's Country Clusters

Hofstede did some preliminary work on plotting the positions of countries on graphs combining pairs of cultural dimensions. For example, when power distance was plotted against individualism-collectivism, Hofstede (1983) derived five country clusters and one outlier. In this analysis, Colombia was in a large group of countries (including Peru, Salvador, Singapore and Indonesia) characterized by high power distance and low individualism. On the other hand, the United States was grouped with countries featuring low power distance and high individualism (e.g., Great Britain and Australia). This basic analysis of country clusters was later developed by other researchers such as Ronen and Shenkar, and also in the Global Leadership and Organizational Behavior Effectiveness (GLOBE) research project (Hodgetts et al., 2005).

4.6.2 Criticism of Hofstede's Model

The limitations of Hofstede's research have been widely documented outside of aviation. McSweeney (2002) challenged several of the underlying assumptions, such as using limited sets of survey respondents to represent national populations, and identifying cultural dimensions through the analysis of questionnaire responses. Analysing the political subtext of Hofstede's methodology, Ailon (2008) cautioned against an uncritical application of the dimensions to other cultures. Writing from a postcolonialist perspective, Fougere and Moulettes (2007, p. 2) argued that the discursive world constructed by

Hofstede is “characterized by a division between a ‘developed and modern’ side (mostly ‘Anglo-Germanic’ countries) and a ‘traditional and backward’ side (the rest)”.

In a study of multicultural work teams, Aritz and Walker (2010) raised further questions about Hofstede’s approach: whether his data may be reliably applied to countries not covered by the initial surveys (such as China); whether the data are applicable to other workforces or national populations, given that the participants were sales managers and engineers; and what insights the dimensions offer into everyday intercultural interactions, such as team decision-making.

Guirdham (2005) reported two main criticisms of Hofstede’s framework: it is static and it omits important values. She cited a comment by Tayeb as typical: “A country’s culture is too vibrant and complex an entity to be simplified and described only in terms of these dimensions” (Guirdham, 2005, p. 59). Similarly, Nakata (2009) and Brannen (2009) pointed out that static representations of culture, such as Hofstede’s value-based model, are not appropriate for describing a globalized world that is characterized by “the increasingly fluid nature of culture” (Nakata, 2009, p. 4).

Within aviation, Hofstede’s model was criticized by Hutchins et al. (2002) on numerous counts, which included: the absence of data regarding intra-country variability in the dimensions; the methodology used to determine the probes; the problem of translation effects in cross-cultural surveys; and the fundamental issue of how survey responses relate to cockpit operations.

Hofstede (1983, p. 78) responded to the charge that his studies did not capture variation within national populations:

> The national culture found is a kind of average pattern of beliefs and values, around which individuals in the country vary... In describing national cultures we refer to common elements within each nation, but we should not generalize to every individual within that nation.[28]

This note of caution has seemingly been overlooked by many aviation researchers. It is important to consider, though, when applying the results of Hofstede’s large-scale data collection to airline interactions that involve dyads, triads or small groups. Hofstede

[28] See also Hofstede (1994, p. 12): “All statements [about national culture] in this article should be seen as only ‘statistically’ true: they are common trends, but individuals may differ from them. Within each country there is a wide range of individuals, and this fact too should be taken into account in order to manage successfully.”

responded to other criticism with further surveys that included East Asian participants, and with investigations of organizational culture and cultural differences within a single country. Two new cultural dimensions were identified, but the underlying methodology remained unchanged (Hofstede et al., 2010).

4.6.3 Applications to Aviation

Hofstede's work has been very influential in aviation and has been described as the third leg of the "three-legged stool upon which broad, systematic-oriented aviation safety and efficiency endeavors rest" (Helmreich & Merritt, 1998, p. xvii).[29] In a series of studies using materials and methodology adapted from Hofstede, a team led by Robert Helmreich at the University of Texas conducted attitude surveys of airline crew in over 20 countries. Section 4.9.1 provides more details about this project, and Sections 4.9.2-4.9.4 describe other studies that used surveys based on Hofstede's work.

Helmreich (1994) also used Hofstede's cultural dimensions to analyse the actions of the Colombian flight crew in the Avianca Flight 052 accident. As noted previously, Colombia has a high power distance score. Helmreich posited that this made the first officer and flight engineer reluctant to suggest alternative courses of action to the captain. Furthermore, since Colombia is strongly collectivist, he suggested the Avianca crew were reluctant to declare an emergency and push ahead of other crews they perceived to also be in difficulty. Finally, Colombia scores highly in uncertainty avoidance and so Helmreich reasoned that the crew preferred to continue with the initial flight plan, rather than face the ambiguity of discussing possible alternate airports to which they could divert.

Hofstede's framework has been applied to numerous areas of aviation research, in testament to the appeal of its quantitative approach. Examples include: a comparison of accident rates in NATO air forces (Soeters & Boer, 2000); post-accident responses by Japanese and American airlines (Haruta & Hallahan, 2003); and cultural differences in risk mitigation in ATC operations (Surakitbanharn & Landry, 2017).

Finally, as mentioned in the discussion of Hall's concepts, Hofstede's framework has been used to raise pilot awareness about cultural issues. Dahlstrom and Heemstra (2009) reported on the use of Hofstede's dimensions during facilitated discussions for recently joined pilots at a large multi-cultural airline. This application, if not all of the

[29] The other legs of the stool were the SHELL model and Reason's accident causation model.

previous ones, is in line with the advice of Johnston (1993, p. 380), who said: “It would certainly appear reasonable to use Hofstede’s data as a point of departure, though a healthy regard as to its possible limitations would be prudent.”

4.7 Trompenaars’ Cultural Dimensions

During the 1980s and 1990s management consultant Fons Trompenaars conducted large-scale surveys of cultural diversity in companies operating in 50 countries. From these data, and drawing on the work of sociologist Talcott Parsons and anthropologists Florence Kluckhohn and Fred Strodtbeck, he developed a framework of seven cultural dimensions. This framework describes the relationships that people have with other people, time and the environment (Trompenaars & Hampden-Turner, 1997).

Like Hofstede’s work, Trompenaars’ research for the main part focused on differences in national culture. However, it did also address regional differences within a national culture, albeit in a limited way. One study investigated regional differences in South Africa, generating average scores for eight language/ethnic groups on six cultural dimensions. The results indicated significant cultural variations within the nation: for instance, English South Africans scored 72% on the individualism-communitarianism dimension compared with 22% for the Tsonga. In addition, a separate strand of the research described different kinds of organizational (or corporate) cultures: the family type, the Eiffel Tower type, the guided missile type, and the incubator type (Trompenaars & Hampden-Turner, 1997).

4.7.1 Trompenaars’ Dimensions

The seven cultural dimensions in Trompenaars’ framework are: universalism versus particularism, individualism versus communitarianism, neutral versus affective, specific versus diffuse, achievement versus ascription, sequential versus synchronic time, and inner- versus outer-directed. The following paragraphs discuss two of the dimensions that are relevant to airline operations.

4.7.1.1 Individualism-Communitarianism

Trompenaars’ individualism-communitarianism dimension is similar to (but not exactly the same as) Hofstede’s individualism-collectivism, with both measuring the extent to which people regard themselves as individuals or part of groups. Hodgetts et al., (2005) highlighted differences in the findings of the two researchers. In Hofstede's data, for example, Mexico and Argentina scored more highly for collectivism, but Trompenaars found them to be high in individualism. Given that Hofstede's data were collected much earlier, Hodgetts et al. (2005, p. 112) suggested that countries like Mexico and Argentina may have over time "moved from dominant collectivistic or communitarianistic cultural values to more individualist values".

To illustrate national differences in this dimension, Trompenaars and Hampden-Turner (1997) related the story of a "critical incident" in a factory run by an American multinational and staffed by Japanese workers. A serious error by a Japanese worker led to the loss of a production batch. After the work group accepted responsibility, the factory director – to the surprise of a Western investigator – did not try to punish or even identify the worker who caused the loss. The reason was that in Japanese culture the shame of letting the group down was considered punishment enough.

The above anecdote illustrates a reluctance of individuals in communitarian cultures to openly accept responsibility for errors, which impacts on two aspects of airline operations. Firstly, as part of airline CRM training, individual members of a flight crew are trained to assertively communicate problems, including errors. Secondly, as part of an effective safety culture, it is essential for employees to report errors in their organization. It is clear that attitudes to error vary significantly between cultures, which should be taken into account during training. This is of particular significance for multicultural airlines, where a range of nationalities interact on a daily basis.

4.7.1.2 Achievement-Ascription

The achievement-ascription dimension relates to the status of an individual within society. In achievement cultures (e.g. the United States) people are accorded status based on their work performance and recent accomplishments. By contrast, in ascription cultures (e.g. Japan or China) status is accorded based on age, kinship, gender, connections and educational record. Status is thus perceived differently in different cultures, which may affect leadership and communication on the flight deck.

The achievement-ascription dimension is especially relevant to CRM training, which makes the assumption that captains can learn how to establish an appropriate level of authority. Ginnett (1993) described three techniques that captains can use to set up effective teams on the flight deck:

- establish competence in the pre-flight briefing;
- disavow perfection in order to allow other crew members to take responsibility;
- engage the crew during the briefing and group formation process.

These techniques are based on NASA research with American flight crews. They may prove effective in achievement cultures but less so in ascription cultures where status, which is integral to a person's authority, is not related to work performance.

Another problem arises when there is a large difference between the status of the captain and junior officers. In this situation, a steep authority gradient may exist in the cockpit (Wiegmann & Shappell, 2003). This can hinder communication and decision making, and has been identified as a causal factor in accidents such as the 1977 runway collision at Tenerife. CRM programmes teach polite assertiveness techniques to help junior officers overcome the problem, but these may not be effective in ascription cultures where status derives from intrinsic characteristics such as age and gender.

4.7.1.3 Trompenaars' Country Clusters

As with Hofstede's results, Trompenaars' data may be readily analysed into country clusters. Hodgetts et al. (2005, p. 117) observed that there was "a great deal of similarity between the Trompenaars and the Ronen and Shenkar clusters". However, they also noted inconsistencies which might indicate that earlier cluster analyses (such as those of Ronen and Shenkar) were in need of revision.

4.7.2 Criticism of Trompenaars' Model

Trompenaars' use of survey data to identify cultural differences is open to similar criticisms to those levelled at Hofstede's work, but one point of difference is that business anecdotes were used by Trompenaars and Hampden-Turner (1997) to contextualize the dimensions in interpersonal interactions. Guirdham (2005) observed that while each of Trompenaars' dimensions is described as a continuum, in practice they are treated as dichotomies. Furthermore, the dimensions are not conceptually distinct, and Hofstede (1996) claimed that only two of them could be confirmed statistically. Furthermore, there is overlap between this and other cultural frameworks. As noted previously, Trompenaars' dimension of individualism-communitarianism is similar to individualism-collectivism in

Hofstede's system. Also, Trompenaars' specific-diffuse dimension corresponds closely to Hall's concept of high- and low-context.

4.7.3 Applications to Aviation

In contrast to Hofstede's research, there has only been a limited application of Trompenaar's dimensions to aviation. Nevertheless, the following studies are relevant to airline training and operations.

Firstly, Jing, Lu and Peng (2001) used Trompenaars' data in a correlational study of airline accident rates and attitudes to authority. The authors stated that no direct causal relation could be inferred between culture and accidents, but concluded that culture is "an indirect essential contributory factor in aircraft accidents" (Jing et al., 2001, p. 341). They found authoritarianism to be the most significant cultural variable. Strauch (2010, p. 254) cautioned that this and other studies of accident rates "are only suggestive of cultural effects on aviation" due to limitations in the generalizability of the initial survey data.

Secondly, Glover and Friedman (2014) outlined the application of Trompenaars' cultural dimensions to projects dealing with changes in organizational culture. One project involved the merger of a government-owned bank with a financial services company in the South Pacific. The researchers used a scenario-based method based on cultural dilemmas elicited during focus groups and interviews "to anticipate potential merger problems and to create appropriate change initiatives to smooth the transformation" (Glover & Friedman, 2014, p.89). This methodology could potentially be applied to the airline industry, which is characterized by regular mergers.[30] As noted by Sharma and Thomas (2015, p. 20), airline mergers and acquisitions are "loaded with difficulties", one of which is "the need of forming one coherent organisational culture".

Finally, Friedman et al. (2013) described a scenario-based programme for training military ground forces to deal with socio-cultural encounters (SCEs), or interactions between people with different cultural orientations. Each scenario presented a dilemma and four possible responses related to one of Trompenaars' dimensions. Although designed for

[30] Between 2000 and 2016 there were 17 mergers and acquisitions in the US airline industry alone. These included the takeovers of TWA and US Airways by American Airlines in 2001 and 2013 respectively, Northwest by Delta Air Lines in 2009, Continental by United Airlines in 2010, and AirTran Airways by Southwest Airlines in 2011 (Airlines for America, 2018).

military personnel, Friedman et al. (2013, p. 18) claimed that this approach is "applicable to any organizational and professional setting." One possibility for airline training would be to apply the methodology to flight scenarios such as those developed by Fischer and Orasanu (1999), which are described in Section 4.9.8.

4.8 Politeness & Face

Proponents of politeness theory, which dates back to the late 1970s, and face negotiation theory, which was introduced in the mid 1980s, contend they are universal theories that account for the role of politeness in social interactions. This section outlines the two theories and some criticisms levelled against them. It also discusses two research projects that applied politeness theory to the aviation context.

4.8.1 Politeness Theory & Face Negotiation Theory

The following paragraphs review key concepts in Brown and Levinson's influential politeness theory and Ting-Toomey's face negotiation theory.

4.8.1.1 Politeness Theory

Politeness theory was first formulated in 1978 by Penelope Brown and Stephen Levinson and presented as a set of universal concepts. A central concept is *face*, defined as "the projected image of one's self in a relational situation" (Ting-Toomey, 2012, p. 407). Brown and Levinson (1987) divided face into two components. *Positive face* relates to a person's desire that his or her self-image be appreciated and approved by others. *Negative face* is the desire for freedom to act and freedom from being imposed upon.

The theory describes acts that threaten a person's positive face or negative face. Examples of positive face threatening acts are expressions of disapproval, contradictions, disagreements and challenges. All of these may damage a listener's positive face. Negative face-threatening acts include orders, requests, suggestions, advice, reminders, threats and warnings. They may obstruct a listener's freedom of action. Brown and Levinson compiled a typology of face threatening acts that threaten the positive or negative face of speakers or hearers. The level of threat is also related to status relations between interlocutors and how well they know each other (Guirdham, 2005).

Politeness in communication is "the attempt by the speaker to minimise or reduce the threat to the hearer's face" (Guirdham, 2005, p. 101). Four main types of politeness strategy have been identified:

- Bald on-record – making no attempt to reduce the threat;
- Positive redress – minimizing the threat to a listener's positive face by, for instance, expressing approval or solidarity;
- Negative redress – minimizing the threat to the listener's negative face by expressing deference or a reluctance to impose;
- Off-record – using indirect strategies to mask the threat (Goldsmith, 2009).

To avoid good and bad connotations of the labels "positive" and "negative", and noting the range of terminology used in the sociolinguistic literature, Scollon et al. (2012) proposed alternative terms: *involvement* instead of positive redress/politeness, and *independence* in place of negative redress/politeness. By using these terms, Scollon et al. (2012, p. 49) wished to emphasise that "*both* aspects of face must be projected simultaneously in any communication". They also made the salient observation that miscommunications are liable to take place across the boundaries of discourse systems because members of one social group may not be familiar with the different face values of another group.

4.8.1.2 Face Negotiation Theory

Face negotiation theory, developed by Stella Ting-Toomey, draws on multiple sources: Brown and Levinson's politeness theory; Erving Goffman's study of facework; research by Harry Triandis on the distinction between collectivism and individualism; and Chinese concepts of face (Ting-Toomey, 2009, 2012). A key concept is *facework*, which Ting-Toomey (2012, p. 408) defined as "specific verbal and non-verbal messages that help to maintain and restore face loss, and to uphold and honor face gain".

Since it first appeared in the mid-1980s, Ting-Toomey has developed several versions of face negotiation theory with adjustments to the core assumptions and propositions. The theory's claim to be universal is reflected in the first core assumption: "people in all cultures try to maintain and negotiate face in all communication situations" (Ting-Toomey, 2009, p. 371). One of the fundamental ideas of face negotiation theory makes a connection to the frameworks of Hall, Hofstede and Trompenaars. It states that "people from collectivistic/high-context cultures are noticeably different in the way they manage face and conflict situations than people from individualistic/low-context cultures" (Ting-Toomey, 2012, p. 410).

4.8.2 Criticism of Politeness Theory & Face Negotiation Theory

While noting that a lot of research has supported politeness theory, Goldsmith (2009) also listed several criticisms. One concern is the lack of attention the theory pays to nonverbal communication. Another issue is that threats to a listener's face are emphasised at the expense of threats to a speaker's face. The main criticism, however, concerns the cross-cultural validity of the theory, with scholars pointing out there are national, ethnic and gender differences in the politeness strategies that people use (Guirdham, 2005).

Face negotiation theory, as originally conceived, was founded on the differing perceptions held by people from individualistic and collectivistic cultures. Ting-Toomey (2012) has, however, acknowledged deficiencies in the concepts of individualism and collectivism. Consequently, as a work in progress, face negotiation theory has in recent years switched its focus to the concept of self-construal, which is defined as: "self-image; the degree to which people conceive of themselves as relatively autonomous from, or connected to, others" (Ting-Toomey, 2012, p. 410).

4.8.3 Applications to Aviation

Concepts of politeness and face have not been widely applied in aviation, but two notable research projects have incorporated politeness theory. Firstly, Linde (1985) used transcripts from accident reports to investigate the role of mitigated speech in intra-cockpit communication at US airlines. Secondly, Fischer and Orasanu (1999) conducted studies of intra-cockpit communication strategies used by pilots to mitigate errors made by fellow pilots. These projects are described in Sections 4.9.7 and 4.9.8 respectively.

Additionally, it has been suggested that face was a causal factor in the 1977 crash of Japan Airlines Flight 8054 in Anchorage, Alaska. Strauch (2010) hypothesized that the first officer and flight engineer (who were both Japanese) were unwilling to threaten the face of the captain (who was American). Prior to takeoff, the Japanese crew members did not challenge the captain about his intoxicated condition or about icing on the airframe. The plane crashed shortly after takeoff with the loss of all five people on board.

The role of face in airline accidents and incidents would seem to have important explanatory potential, but so far this is an under-researched field. What is clear, though, is that misunderstandings are liable to occur when people from different cultures cannot interpret each others' face signals and behaviour.

4.9 Intercultural Communication Studies in Aviation

The final part of the literature review presents ten intercultural communication studies that have investigated the communication of pilots and ATC. These empirical studies draw on research described in all three areas of the literature review: language, risk and culture. As studies of intercultural communication, they owe a particular debt to research in the areas of language and culture. Within the latter there is a strong emphasis on Hofstede's work: four of the studies conducted large-scale surveys based at least partly on his methodology and test items. The rest of the studies used a range of methodologies including mixed methods (surveys, interviews and focus groups), ethnography, speech act coding and scenario-based analysis. Risk is implicit in any research into flight operations, but is not mentioned explicitly in most of these studies. One notable exception is the investigation by Fischer and Orasanu (1999) of intra-cockpit communication strategies in Section 4.9.8, which included the level of risk as one of the variables. Also, the IATA survey in Section 4.9.10 elicited responses about communication practices that are perceived as threats.

4.9.1 Attitudes of Airline Crews in Multiple Countries

Using test items and methodology adapted from Hofstede, a team led by Robert Helmreich at the University of Texas conducted a series of surveys of the attitudes of airline crew. The surveys involved more than 15,000 airline pilots and cabin attendants in over 20 countries, and were supplemented by observations and interviews (Helmreich & Merritt, 1998; Merritt, 2000). Two instruments were used for the surveys: the Cockpit Management Attitudes Questionnaire (CMAQ) and the Flight Management Attitudes Questionnaire (FMAQ). The CMAQ included questions about briefings, communication styles, decision making, crew coordination, authority, monitoring, fatigue and crew experience. Merritt and Helmreich (1996, p. 23) noted that this tool, having been "designed by American researchers and psychometrically refined for American pilots", was not suitable for detecting differences in national culture. In order to remedy this deficiency, they developed the FMAQ, which incorporated items from Hofstede's Work Values Survey and the CMAQ, as well as other questions designed to "capture Hofstede's dimensions within the aviation environment" (Merritt, 2000, p. 285).

This large-scale research project generated a range of findings. Using the FMAQ survey data, the researchers were able to replicate two of Hofstede's cultural dimensions: power distance and individualism-collectivism. There was also a weak correlation with uncertainty avoidance, but the masculinity-femininity dimension failed to replicate (Helmreich & Merritt, 1998). The research team concluded that "national culture exerts an influence on cockpit behavior over and above the professional culture of pilots" (Merritt, 2000, p. 283). It is important to note, though, that the replication study was based on a restricted set of responses: only airlines with a dominant national culture were used and all of the participants were male pilots of the same nationality as their airline.

Another notable finding from this project was that, for almost all countries studied, the pilot scores were higher for the power distance and individualism dimensions than the country scores originally reported by Hofstede (Helmreich & Merritt, 1998). In addition, hierarchical cluster analyses were conducted to discover which countries formed clusters. One of these analyses revealed a tight cluster of "Anglo countries" (including the United States, Australia and New Zealand) that were characterized by low scores for power distance and uncertainty avoidance combined with high individualism. A looser cluster included several countries in South America and Asia (such as Argentina, Taiwan, Brazil and Malaysia) that shared high power distance scores (Merritt, 2000).[31]

The main focus of the project was national culture, but the studies also provided insight into organizational and professional cultures. Illustrating how organizational culture varies between companies in the same industry and country, Helmreich and Merritt (1998) presented survey data from pilots at two US airlines. For one organizational climate item, 87% of pilots at one airline agreed that "Pilot morale is high", compared with only 3% at the second airline. Regarding perceptions of management, 84% of respondents at the first airline agreed that "Management never compromises safety for profit", compared with 12% at the other carrier. The data provided fewer insights into professional culture, but one

[31] Colombia was not included in these analyses. However, by way of comparison, Hofstede's original power distance scores for these countries were as follows: Argentina, 49; Taiwan, 58; Colombia, 67; Brazil, 69; and Malaysia, 104 (Hofstede, 2001).

noteworthy conclusion was that pilots (and also doctors) have unrealistic attitudes towards stressors. For example, a majority of pilots said that their decision making was as good in emergencies as in routine situations, and that personal problems did not affect their performance (Helmreich, 2000).

Many aviation researchers have been influenced by the studies conducted by the University of Texas Human Factors Research Project and by their use of Hofstede's tools and techniques. The project findings fed directly into airline CRM training programmes in the 1990s (Maurino & Murray, 2010).

4.9.2 Attitudes of Airline Pilots & Managers in Taiwan

In the 1990s, Professor Hung-Sying Jing surveyed approximately 1,000 pilots and managers at airlines in Taiwan, including a significant number of foreign pilots. He used a modified version of the FMAQ instrument developed by Helmreich (which was based in turn on Hofstede's dimensions). The results highlighted differences between Chinese and foreign pilots in attitudes to interpersonal relations and authority. Jing believed that these differences could not be adequately explained by uni-dimensional concepts such as power distance, and he therefore developed a framework to account for interpersonal relations and authority in Chinese culture (Jing & Batteau, 2015).

Drawing on research by the scholar Fei Xiao-Tung, Jing created a "differentiated order model" with four levels of intimacy: kin, acquaintance, fellow and alien. According to this model, Chinese pilots consider that: close family are kin; other Chinese pilots are acquaintances; other Chinese workers in the same company are fellows; and foreign workers in the same company are aliens. The structure is not fixed and individuals can change level, for example by marriage or a serious falling out. Jing added a description of the Chinese concept of authoritarianism, which is dominated by the father-son relationship, to this model of interpersonal relations.

The differentiated order model has been used to analyse accidents involving Asian airlines, such as the 1995 crash of a TransAsia Airways ATR72 aircraft in Taiwan. At the time of the accident, the first officer was pilot flying (PF) and the captain was pilot not flying (PNF). Immediately before the crash, the captain was talking to a cabin attendant in the cockpit, which distracted him from his duties of monitoring the aircraft status and communicating with ATC. In their analysis, Jing and Batteau (2015, p. 30) suggested that the captain regarded the cabin attendant as an acquaintance but considered the air traffic controller to be a stranger, adding that “Every Chinese person would be inclined by instinct to attend to a friend first, not the stranger”.[32]

Western pilots may consider such behaviour to be a blatant dereliction of duty, but Jing’s work highlights the impact that cultural factors can have on cockpit interactions and flight crew communications. Interestingly, it echoes Hall’s description of the emphasis placed by polychronic people on personal relations. Jing and Batteau also commented on ways in which cultural differences impact flight procedures. Chinese pilots are conditioned by the non-linear ideographic Chinese language and therefore have difficulty following sequential SOPs. The researchers see this as one manifestation of a systematic problem whereby Chinese pilots are not culturally programmed to use commercial aircraft or an air transport system that have both been largely designed by Westerners.

4.9.3 Attitudes of Airline Pilots in Norway

In Norway Mjøs (2004) conducted a survey of pilots at three airlines and received 242 usable responses. The variables included cultural indices (based on Hofstede’s four original dimensions), social climate, barriers to communication, and operational problems experienced in the previous year. This survey identified differences between the airlines. The pilots of one company, who were almost all from a military background, were more experienced and scored higher on power distance and masculinity. Furthermore, the pilots of all three airlines had higher mean scores for individuality and masculinity than the national scores reported by Hofstede, indicating that cultural dimensions for a professional group within a country may differ from national characteristics. This led Mjøs to caution against applying national cultural dimension data to research comparing aviation safety records in different countries.

4.9.4 Pilot Decision-Making in a Large Multicultural Airline

Scott (2013) conducted a mixed methods investigation of the influence of national culture on pilot decision-making on the flight deck. The study was conducted at a major

[32] The context of the accident was unusual: it occurred on New Year’s Eve; the plane was not carrying passengers; and the captain was junior to the first officer in terms of previous air force service. It underlines the importance, even in unusual circumstances, of following regulations such as the sterile cockpit rule, which prohibits non-essential speech below 10,000 feet.

airline in the Middle East that has a large, multicultural workforce. It included individual interviews, focus group interviews and a survey of pilot attitudes. A 40-item questionnaire was used for the survey, covering decision-making, culture, language and behaviour. Some questions were taken from previous studies by Hofstede (2001) and Helmreich and Merritt (2000). The survey of pilot attitudes produced 613 usable responses and 66 countries were represented.

Some of the survey findings related to specific aspects of language use on the flight deck. Approximately 60% of participants thought that communication problems occur as a result of culture, with pronunciation cited as an example. More than 70% of respondents reported that, when starting conversations with individuals from other countries, it sometimes took time to understand their English pronunciation. Scott (2013, p. 261) concluded that communication was a “major factor on the flight deck, especially if pilots were from different cultures”. In addition, the interview data indicated that “pilots from non-English speaking cultures often struggled with communications in an English-driven aviation world”, and it suggested that “pilots from Asia, the Far East, parts of Europe and South America sometimes did not have sufficient command of the English language” (Scott, 2013, p. 262).

In another interesting survey finding, echoing Dahlstrom and Heemstra (2009), more than 80% of participants said that pilot professional culture was for them a stronger influence on the flight deck than national culture. Just 18.5% of participants said that their national culture was not overridden by professional culture. Scott (2013, p. 259) noted that these pilots were “from areas that were of mostly of Islamic religion”, such as Algeria, Egypt, Malaysia, Pakistan and the United Arab Emirates (UAE).

4.9.5 Cockpit Communication in Airlines in the Asia-Pacific Region

Hutchins et al. (2006) carried out an ethnographic study that examined the impact of culture on cockpit communication and interaction at three airlines in the Asia-Pacific region. The study included flight deck and simulator observations, as well as interviews with airline personnel. An interesting aspect of this research is that it identified specific differences in cockpit practice between airlines in different countries. These differences included how checklists and charts were actually used. However, since only a limited number of airlines were studied it is not clear to what extent the variation was due to national culture as opposed to organizational culture. For instance, Japanese pilots in the study annotated their charts whereas pilots from New Zealand were not allowed to do so, but it is possible that other New Zealand airlines permit chart annotation. As mentioned before, difficulties posed by this form of research include the need to gain access to flight decks and the requirement for expertise in a range of fields such as piloting, human factors, anthropology, language and culture.

4.9.6 Communication between Korean ATC & Foreign Pilots

Kim and Elder (2009, 2015) reported on a mixed methods research project that examined the construct of radiotelephony communication in the Korean aviation context. Data collection took place between 2007 and 2009. Data were collected using a variety of methods: observations of ATC centres, audio recordings of radio communications between Korean ATC and foreign pilots, surveys of Korean pilots and controllers, and interviews and focus groups with Korean pilots and controllers.

Although not explicitly addressing national culture, this research project has significant implications for intercultural communication between pilots and controllers from different countries. One clear finding was that participants did not accept that limited English proficiency of non-native speakers was a main contributing factor to accidents. Instead they believed it was “one of a complex array of factors contributing to problems in radiotelephony communication” (Kim & Elder, 2009, p. 23.2). The authors also described communication problems exhibited by native and non-native English speakers. Problems of NESs included: non-adherence to standard phraseology, excessive use of plain English, a range of accents and expressions, and a fast rate of speech. The main problem for NNSs was first language (L1) interference with accents, although there was a tendency for some proficient English speakers to overuse plain English (Kim, 2013; Kim & Elder, 2009).

Kim and Elder (2009, p. 23.14) concluded that “communication in the aviation context is a complex matter and that responsibilities for its success (or failure) are shared across participants, regardless of their language background”. In order to promote greater communicative responsibility by all pilots and controllers, they advocated thinking of aviation English in terms of a lingua franca. Drawing on English as a lingua franca (ELF) research, they recommended training for both NESs and NNSs in specific communicative strategies such as simplifying speech, avoiding redundant information, and paraphrasing problematic utterances.

4.9.7 Use of Mitigated Speech by Airline Crews in the USA

Linde (1985) drew on Brown and Levinson's politeness theory to investigate the use of *mitigated speech* in intra-cockpit communications. This was part of a larger study that used speech act coding to analyse transcript data from eight accidents involving American airlines in the 1970s and 1980s (Goguen, Linde & Murphy, 1986). A mitigated form of speech was defined by Linde (1985, p. 4) as "one which expresses a given propositional content in such a way as to avoid giving offense". The main thrust of the research concerned how the use of mitigated speech varied with social status (e.g., captain versus first officer) or operational context (e.g., emergencies or other in-flight problems). Linde developed a scale for quantifying mitigation, which a group of airline pilots and non-aviation analysts applied to the transcripts.

Some of the findings related to national and professional cultures. Firstly, the results suggested that regional dialects within the United States might be associated with significant differences in the use of mitigated speech. In other words, there was empirical evidence, albeit limited, for variation within a national culture. Secondly, there were systematic differences in the rhetorical conventions of pilots compared with non-aviation analysts. Linde (1985, pp. 9-10) cited examples of indirect requests using "want", such as "You want me to fly it Bob?" Such expressions were considered less mitigated by the pilots than by the non-aviation analysts. Linde inferred that within pilot professional culture this strategy had become conventionalized to the point that its social force was direct, while it was interpreted as indirect and mitigated within the academic professional culture of the analysts.

Linde (1985, p. 8) concluded that "the use of indirect speech acts for mitigation is extremely complex", and she emphasised the importance of understanding the context in which communications are situated.

4.9.8 Intra-Cockpit Communication Strategies in the USA & Europe

Fischer and Orasanu (1999) reported on a series of studies of the intra-cockpit communication strategies that are used by pilots to mitigate errors made by other pilots. Participants were given different flight scenarios in which either the captain or first officer had made an error. They were asked what request they would make to resolve the problem. The studies examined the effect of two variables on the communications: (1) the level of risk inherent in the scenario, and (2) the level of face-threat involved in resolving the error.

One study investigated the influence of national culture on communication strategies by comparing pilots from the USA and three European countries. The number of participants was 533, of whom 249 were captains and the remainder first officers.

The findings indicated that for captains, both American and European, the preferred communication strategy was to give a command, while first officers preferred using hints. The status difference between captains and first officers in the US was more pronounced. Compared with their American counterparts, European captains were more likely to give hints and European first officers were more likely to issue commands. This finding was unexpected and at odds with previous research on attitudes towards leadership. The authors suggested it was due to differences in methodology between their scenario-based studies and earlier research, such as that reported by Merritt (2000), which used surveys to elicit pilot attitudes (Fischer, 2000; Fischer & Orasanu, 1999).

4.9.9 Characteristics of ATC Radiotelephony in Malaysia

Mohd (2007) carried out a study of ATC radiotelephony in Malaysia. Two methods were used for data collection: (1) a survey of air traffic controllers with 188 respondents, and (2) recording of 73 hours of ATC audio. This study is valuable for the information it provided about RT communication in a location where air traffic controllers are not native speakers of English.

The survey of controllers collected extensive demographic data. This included information about: English language proficiency test results, aviation English and ATC communication training, problems in RT practices, and communication-related safety occurrences. One interesting finding was that the use of English varied depending on the ATC working environment. Among terminal approach radar controllers, 70% reported that English was their most frequently used daily language. For tower controllers, the figure was only 28%.

The ATC audio data were transcribed and then coded using the Aviation Topic and Speech Act Taxonomy (ATSAT). Analysis of the ATC recordings revealed a very low level of code switching from English to other languages. Overall, about 0.2% of the total number of words were non-English. These words were all greetings and courtesies, such as “selamat pagi” (“good morning” in Malay).

4.9.10 Use of Phraseology by Pilots & Air Traffic Controllers

The International Air Transport Association (IATA) conducted a worldwide survey to investigate safety threats related to communication with a narrow focus on the use of standard phraseology. Separate questionnaires were devised for pilots and air traffic controllers. A total of 2,070 responses were collected from pilots (86% of whom operated international flights) and 568 from controllers. Since there was a lack of responses from countries in which English is not the main language, Russian and Chinese versions of the pilot questionnaire were also distributed. The survey was carried out in collaboration with the International Federation of Air Line Pilots' Associations (IFALPA) and International Federation of Air Traffic Controllers' Associations (IFATCA).

The findings were published as a report in 2011. The study concluded that the use of non-standard phraseology was "a major obstacle" to effective communications between ATC and pilots (IATA, 2011, p. 53). A high rate of speech and lack of harmonization were other factors that increased the risk of communication errors. One problem with the survey was ambiguity in the expression "non-standard phraseology". For example, question 9 in the pilot survey asked, "Is there an airport(s) where ICAO standard phraseology is not used? If yes, please specify airport code(s)". The report noted that Paris Charles de Gaulle Airport was the most common response "but in almost all cases it was because of the use of both English and a local language in Pilot communication and not specifically for non-standard phraseology" (IATA, 2011, pp. 17-18).

Although the focus of the study was on phraseology, respondents made numerous comments about plain language. The following factors were reported as contributing to pilot-ATC communication errors: use of plain English instead of phraseology, use of slang, and ambiguity in plain language. These findings reinforce the discussion in Section 2.4.3 about the difficulty of separating standard phraseology from plain language. Other factors found to "compromise human communication" included pronunciation problems of NNSs, accents, and NNS-NNS communication (i.e., code switching between English and other languages) (IATA, 2011, p. 53).

The IATA phraseology study provides a useful model for the construction and delivery of an online survey of pilots. It was designed to be completed in a short time (10 minutes) but allowed respondents to enter detailed information about specific procedures or practices that they perceive to be a threat.

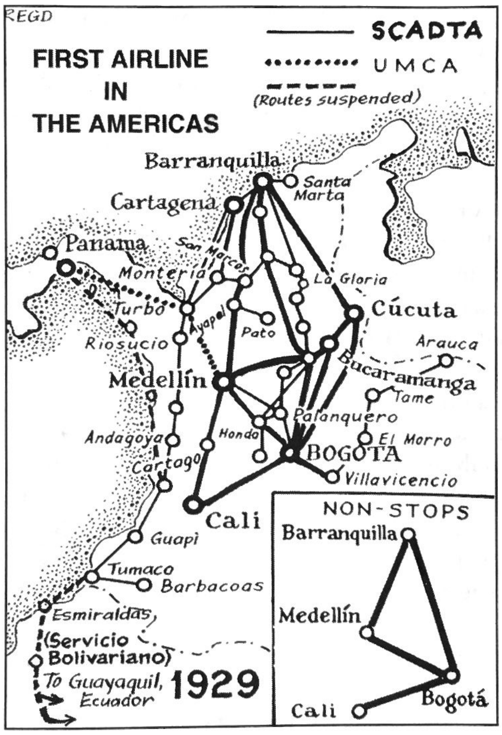
CHAPTER 5: The Crash of Avianca Flight 052

This chapter lays out the context of Avianca Flight 052, which crashed near Cove Neck, New York, on 25th January 1990. The Avianca 052 crash was one of the accidents cited by ICAO to justify the language proficiency programme. It is the focus of the Stage Two analysis in Chapters 6-8. This chapter presents multiple layers of context for the crash. It draws on information from 25 books and documents included in the literature review database, as well as a search of New York Times newspaper articles. First, I outline significant events in the history of Avianca that informed its organizational culture prior to the accident. Certain key events are highlighted in a timeline of the history of the airline. Second, I present details of the Avianca 052 flight crew and a synopsis of the flight. Then I list significant events in the history of the airline that have taken place since the accident. Finally, I outline representations of the Avianca 052 crash that have been made in various media, including the official accident report and a TV documentary.

5.1 History of Avianca until 1990

Avianca is the national airline of Colombia. It claims to be the oldest airline in the Americas and, after KLM, the second oldest airline in the world. Its lineage traces back to 1919 when Sociedad Colombo Alemana de Transporte Aéreo, SCADTA, was founded with aircraft and technical support from Germany. In 1940, SCADTA merged with another Colombian airline, SACO, to form Aerovías Nacionales de Colombia S.A., otherwise known as AVIANCA (see Figure 11).

Figure 11: 1929 route map of SCADTA. Reprinted from *Airlines of the jet age: A history* (p. 5), by R. E. G. Davies, 2011, Washington, D. C.: Smithsonian Institution Scholarly Press. Copyright 2011 by the Smithsonian Institution. Reprinted with permission.



The Colombian SCADTA was the ancestor of today's AVIANCA, which can thus claim to be America's oldest airline.

Following the Second World War, steps were taken to consolidate the position of Avianca as the dominant airline in Colombia and later as the dominant airline in South America (Davies, 2011; Avianca, 2020):

- international services were launched to the United States and Europe in 1946;
- a regular service to New York started in 1949;

- Avianca transported the Colombian delegation to the Melbourne Olympics in 1956;
- jet aircraft (including the Boeing 707) were introduced in 1960;
- domestic rival Sociedad Aeronautica de Medellin, SAM, was acquired in 1963;
- Avianca became the first Latin American airline to operate the Boeing 747 wide body jet in 1976.

The ambition of Avianca is encapsulated in a long-running slogan that proclaims it to be "first airline of the Americas". The slogan is ambiguous: it may denote the popularity of the airline (i.e., first choice of passengers), the high quality of service (i.e., first class), best on-time performance (i.e., first arriving aircraft) or the pioneering spirit of Avianca (e.g., first South American airline to use the B747). It may also refer to the company's long history, as with the catchline of an advertisement posted in New York Magazine: "First airline of the Americas...second oldest in the world" (Avianca, 1981, p. 25).

Although initially set up with German aircraft and support, Avianca has had strong financial and operational ties with the United States for most of its history. One example is the substantial shareholding that Pan American Airways held in the company for several decades after World War Two. Another is the mainly American fleet of aircraft operated by Avianca from its merger in 1940 until the end of the century. The close relationship was epitomized by the airline's inaugural jet service, which flew from Bogota to New York in 1960 using a Boeing 707 leased from Pan American Airways.[33]

At the start of the 1980s, Avianca opened the Puente Aéreo Terminal (Air Bridge Terminal) at El Dorado International Airport in Bogota to handle domestic traffic and international flights to the United States. As shown in Table 7, the rest of that decade was tragically marked by three major accidents in which more than 400 people died. The first accident was the controlled flight into terrain of Flight 011 near Madrid, Spain, in 1983 (CIAIAC, n.d.). The second was the controlled flight into terrain of Flight 410 shortly after takeoff at Cúcuta, Colombia, in 1988 (CAD, 1996b). The third was the mid-air explosion of Flight 203 while climbing away from El Dorado International Airport in Bogota, Columbia, in 1989.[34]

[33] Three decades later Avianca Flight 052 flew the same route using the same type of aircraft.

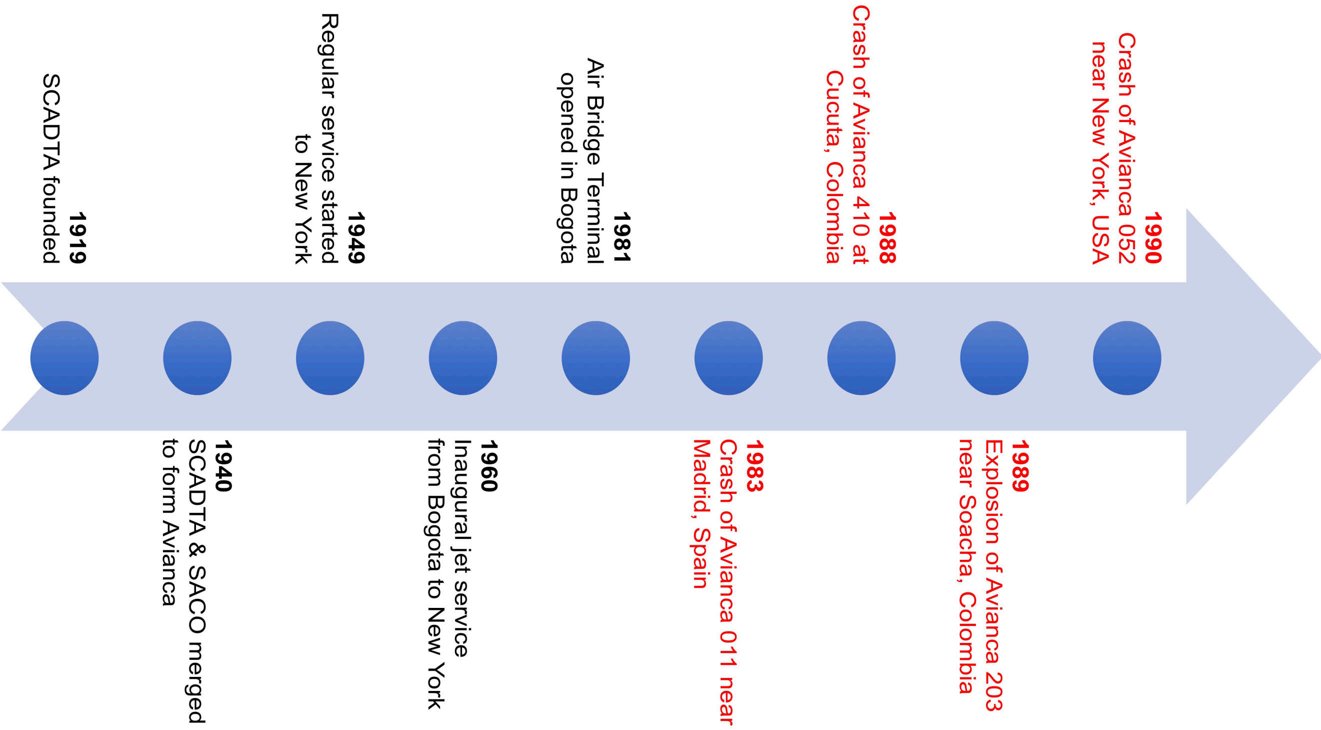
[34] No accident report is available for the Avianca Flight 203 accident, but it is referred to in the NTSB report for the crash of TWA Flight 800 (NTSB, 2000a).

Table 7: Avianca accidents in the 1980s.

DATE	FLIGHT NUMBER	LOCATION	ACCIDENT TYPE	AIRCRAFT TYPE	FATALITIES
27th Nov 1983	Avianca Flight 011	Madrid, Spain	Controlled flight into terrain	Boeing 747-200	181
17th Mar 1988	Avianca Flight 410	Cúcuta Colombia	Controlled flight into terrain	Boeing 727	143
27th Nov 1989	Avianca Flight 203	Soacha, Colombia	Bomb explosion	Boeing 727	110

Avianca was still recovering from the three accidents that it suffered in the 1980s when the crash of Flight 052 occurred on 25th January 1990, as indicated by the timeline in Figure 12.

Figure 12: Timeline of key events in the history of Avianca (1919-1990).



5.2 The Crew of Avianca Flight 052

The flight crew of Avianca 052 consisted of the captain, first officer and flight engineer. The 51-year-old captain was a very experienced pilot, with no record of previous accidents, and was also a pilot in the Columbian Air Force Reserve. The 45-year-old flight engineer was likewise very experienced, and had accumulated more than 3,000 flight hours in Boeing 707 aircraft. By contrast, as Helmreich (1994, p. 280) noted, the young first officer was "inexperienced overall and particularly in the B-707". He was 28 years old and had a total flight time of 1,837 hours, with just 64 hours in this aircraft type. Table 8 gives details of the flight experience of the crew members.

The Avianca captain had previously flown on international flights with the first officer, and also with the flight engineer, but this was the first time that all three flew together as a crew. Citing NTSB research, Helmreich and Merritt (1998, p. 12) observed that "a disproportionate percentage of accidents happen to crews who are flying together for the first time".

Table 8: Flight experience of the Avianca 052 crew (NTSB, 1991).

	CAPTAIN	FIRST OFFICER	FLIGHT ENGINEER
Age	51	28	45
Flight hours (total)	16,787	1,837	10,134
Flight hours (B707)	1,534	64	3,077
Flight hours (night flying)	2,435	408	2,986
Flight hours (B707 night flying)	478	13	1,062
Flights to NY 1989-1990 (total)	14	13	7
Flights to NY 1989-1990 (B707)	14	5	5

5.3 Synopsis of the Avianca 052 Accident

On 25th January 1990, Avianca Flight 052 was scheduled to fly from El Dorado International Airport in Bogota, Colombia, to John F. Kennedy International Airport (JFK) in New York. The crew departed from Bogota at 13:10 EST on the first leg, which was a 54-minute flight to Medellin. After a brief refuelling stop, the aircraft took off at 15:08 bound for New York. As the plane reached the north-eastern United States it encountered adverse weather conditions. Air traffic controllers instructed the plane to enter holding patterns on three separate occasions. The holding delays lasted a total of 77 minutes, which meant the flight time from Medellin to New York was much longer than the planned time of 4 hours 40 minutes.[35]

The Avianca first officer was responsible for communication with ATC. At 20:46, during the third holding period, he notified ATC they could only hold for about five more minutes and could not reach their alternate airport in Boston because they were running out of fuel. The aircraft finally descended towards JFK and attempted to land. However, the pilots encountered wind shear and executed a missed approach at 21:23. They attempted to return for a second approach, but lost power in all four engines due to fuel exhaustion.

Figure 13: Section of fuselage at the Avianca 052 crash site in Cove Neck, New York. Public domain image from FAA (n.d.).

[35] According to an Avianca captain interviewed after the crash, holding delays for JFK were normally "a maximum of 20 to 30 minutes" (Cushman, 1990).

At approximately 21:34 Avianca Flight 052 crashed at Cove Neck, Long Island (see Figure 13). Of 158 passengers and crew on board the plane, 73 died as a result of the crash. The fatalities included all the crew with the exception of one flight attendant.

5.4 History of Avianca since 1990

Avianca launched a fleet renewal at the start of the 1990s to replace its ageing Boeing 707, 727 and 747 jets. These aircraft types had been involved in the four accidents that occurred between 1983 and 1990. The airline continued to suffer problems as the decade unfolded. With airline deregulation in Colombia in 1991, Avianca's share of the domestic market fell from 61% in 1990 to 41% in 1997 (Davies, 2011). After the 2001 terrorist attacks in New York, the company faced further struggles due to the collapse of international tourism. It filed for Chapter 11 bankruptcy in 2004.

The company relaunched itself in 2005 under a new name which reflected its desire to be the preeminent airline on the continent: Aerovías del Continente Americano S.A. It began another fleet renewal in 2007 by ordering Airbus A320 and A330 jets. A merger with TACA, the national airline of El Salvador, was completed in 2013. New direct routes to Europe were opened with the launching of Bogota-London and Bogota-Munich services in 2014 and 2018 respectively. Avianca was named the Best Airline in South America in the Skytrax World Airline Awards for 2017 and 2018. The 2019 annual report celebrated the company's 100th anniversary by proclaiming it would "continue connecting the world with Latin America for 100 more years" (Avianca, 2020, p. 2).

The expansion of the relaunched company had come at a cost. By 2019 Avianca had built up a debt of $7.3 billion. The following year the airline was hit heavily by the worldwide reduction in air traffic resulting from the Covid-19 pandemic, and it again filed for Chapter 11 bankruptcy in May 2020 (Rochabrun, Kumar & Bocanegra, 2020).

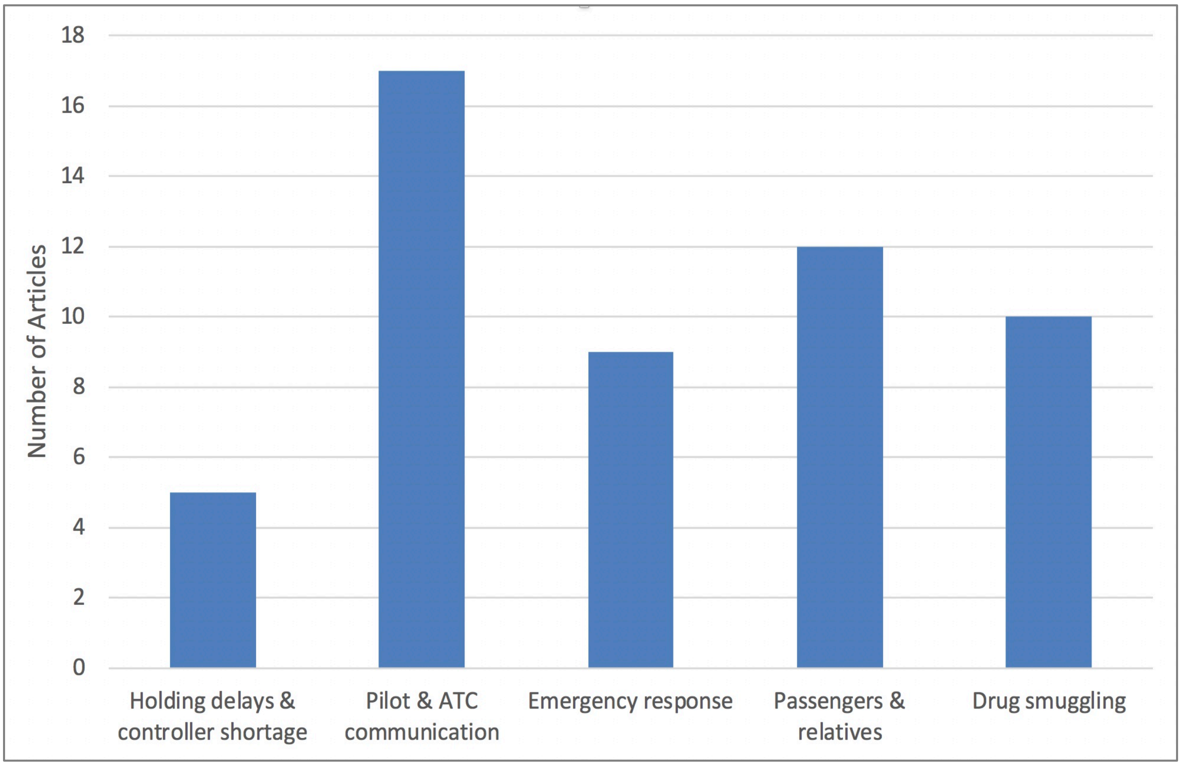
5.5 Representations of the Avianca 052 Accident

Since the crash of Avianca Flight 052, many analyses and representations have appeared in diverse media. Newspaper articles appeared in the days following the crash. The NTSB accident report was released in 1991, and further analyses were published in subsequent years by the Flight Safety Foundation and Robert Helmreich at the University of Texas. A TV documentary about the Avianca 052 accident was broadcast in 2005 and journalist Malcolm Gladwell wrote about it in a 2008 book titled “Outliers: The Story of Success”. The following paragraphs report key points and limitations of each of these representations of the accident.

5.5.1 Articles in the New York Times

During the 1980s, only ten New York Times articles mentioned the three Avianca accidents that took place in 1983, 1988 and 1989. In the week after the crash of Avianca Flight 052, there were 25 reports about the accident. By 2018, the New York Times had published 82 articles about Avianca Flight 052. Amongst these, 51 items focused on the Avianca 052 crash while the others mentioned it briefly in the context of other accidents. Figure 14 shows the most common themes in the articles that focused on Avianca 052. The great majority of these articles (over 90%) were published in 1990.

Figure 14: Most common themes in NY Times articles about Avianca 052 (1990-2018).



Communication involving pilots and air traffic controllers was the most common theme. There were many stories about passengers and relatives, including lawsuits filed against the FAA and Avianca, and compensation paid by the airline. Drug smuggling was discussed in a significant number of articles, especially after two of the passengers were found to have been transporting cocaine. The response of the emergency services was widely covered, particularly communication problems and the difficulty in accessing the crash site. Finally, five articles covered problems in the ATC system: the increased risk caused by holding delays and the shortage of air traffic controllers.[36]

5.5.2 NTSB Accident Report

The National Transportation and Safety Board (NTSB) investigated the Avianca accident and published its report in April 1991. The investigation was complex and the report ran to 295 pages. It contained a detailed description of fuel calculations for the flight and extensive listings of flight crew and ATC communication. The probable cause of the accident was found to be "the failure of the flightcrew 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" (NTSB, 1991, p. 76). The following contributory factors were also listed:

- the flight crew failed to use an airline operational control dispatch system;
- the FAA traffic flow management was inadequate;
- there was a lack of standardized, understandable terminology for minimum and emergency fuel states;
- the first approach to JFK was hindered by wind shear, crew fatigue and crew stress.

The NTSB report did *not* include several sets of potentially significant information. Firstly, the aircraft's flight data recorder (FDR) was inoperative because the recording foil had been taped down. Therefore airspeed data, which could have shed light on the severity of wind shear encountered in the first approach, was not available. Secondly, there were no toxicological test results for the air traffic controllers. The remains of the flight crew were tested (and found to be negative) for alcohol and drugs. The controllers who handled the final stages of Flight 052 were also tested, but the FAA did not provide the results to the NTSB investigation, nor did it permit separate testing of the controllers. Thirdly, the FAA Central Flow Control Facility (CFCF) ran traffic management programs to control the flow

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[36] The controller shortage was a legacy of President Reagan firing more than 11,000 air traffic controllers following the 1981 ATC strike.

of aircraft. At the end of each traffic management shift a Verification and Analysis Report was usually available, but on 25th January 1990 "a report for the JFK program was not retrievable because of computer problems" (NTSB 1991, p. 45).

There was disagreement about the contents of the report amongst the NTSB staff responsible for compiling it. Two members added dissenting comments:

- Jim Burnett criticised the report for not adequately addressing the "substandard service" provided by the ATC system;
- Christopher Hart objected to the finding about a "lack of standardized understandable terminology" and stated the Avianca flight crew should have used the existing terms "Mayday" or "Emergency" (NTSB 1991, p. 79).

The Administrative Department of Civil Aeronautics (DAAC) in Colombia challenged the report's findings. Noting the lack of time they had to respond, the DAAC said the actions of the ATC system should have been more rigorously examined, especially with regard to information provided to the crew and the way that delays were handled.

5.5.3 Flight Safety Foundation Analysis

In 1992, the Flight Safety Foundation (FSF) published an analysis of the Avianca 052 accident by Captain Thomas Duke, an experienced ex-airline and military pilot who had worked for the NTSB. The FSF report noted evidence from the CVR transcript that the aircraft was being flown manually and the Avianca captain was fatigued. The analysis included a reconstruction of the flight detailing the fuel situation for each stage between Medellin, in Colombia, and JFK Airport, in New York. The reconstruction ended with the following comments:

> This accident reflects the combination of multiple events that eventually become overwhelming and result in a disaster. There was a long string of air-ground miscommunications and unverified misunderstandings, poor flight planning decisions, poor crew coordination, poor company dispatch and avionics support procedures and rules, worse than forecast weather and an unexpected number of delays. The result was extreme crew stress and fatigue that led to inadequate communications and a poorly executed approach and missed approach circuit ... and ultimately fuel exhaustion. (Duke, 1992, p. 6)

The FSF report stated that, because the Avianca flight crew did not survive the accident, the events that took place in the cockpit and at ATC facilities on the ground may never be completely understood.

5.5.4 "Anatomy of a System Accident" Analysis

Psychologist Robert Helmreich produced a widely-cited analysis incorporating information from post-crash litigation between Avianca and the US government. The analysis utilised several methodologies including Reason's (1990) concepts of active and latent failures, and the crew performance model developed by Helmreich and Foushee (1993). It did not explicitly mention corporate culture or organizational culture, but found that "latent failures in the organization – including training, operational procedures and manuals, crew pairing, dispatch, and maintenance – created a window of opportunity for an accident to occur" (Helmreich, 1994, p. 281). This was therefore a *system accident*.

Helmreich hypothesised that the actions of the Avianca crew could be explained using Hofstede's cultural dimensions of individualism-collectivism, uncertainty avoidance and power distance. He acknowledged that the hypothesis was unprovable, but concluded cultural factors probably played a significant role in the accident:

> It seems likely that national culture may have contributed to inflexible decision making, that weak leadership may have been exacerbated by a normative reluctance to question that leadership, and that the need to maintain group harmony may have inhibited crewmembers from presenting their concerns and suggestions. Finally, mistaken cultural assumptions arising from the interaction of two vastly different national cultures may have prevented effective use of the air traffic system. (Helmreich, 1994, pp. 282-283)

Strauch (2010, p. 255), in a paper about accidents in sociotechnical systems, was critical of Helmreich's hypothesis. He posited that alternative explanations, which did not involve cultural factors, could have accounted for the actions of the Avianca crew:

> Although the pilots' communication errors may have been influenced by cultural influences, other explanations, such as the crew's unfamiliarity with U.S. dispatch offices, a reluctance to divert to an airport with which the airline did not have prearranged fueling and passenger handling procedures, and poor "airmanship" skills in

their inability to relate expected holding times to anticipated fuel needs, could also account for their performance errors.

Ragan (2007, p. 59), by contrast, maintained that the communication of the Avianca first officer was affected by cultural factors. He suggested two reasons why controllers did not realise the severity of the Avianca fuel problem: the first officer did not use the word "emergency" in his communications; and he continued "speaking indirectly, non-aggressively, and politely despite the desperate urgency of the situation".

5.5.5 "Missing over New York" TV Documentary

A 47-minute TV documentary recounting the story of Avianca 052 was broadcast on 27th February 2005 in Season 2 of the "Mayday" series.[37] The opening sequence states: "This is a true story. The reconstruction contains certain composite characters, and the dialogue has been adapted from actual recordings." (Jorgensen, 2005). The documentary gives no details about the changes that have been made. These changes include:

- Language change – the Avianca flight crew talked to each other in Spanish, but in the documentary they use English;
- Omniscient narrator – the actual crew did not know an accident was going to happen, but the documentary narrator gives a commentary explaining what will happen as the drama unfolds (e.g., "Flight 52 is about to crash somewhere over New York");
- Omission of utterances – many utterances in the CVR transcript are omitted in the documentary dialogue (e.g., dialogue lasting 4 minutes 20 seconds in the transcript is reduced to a 20-second sequence in the documentary);
- Re-ordering of utterances – some utterances have been cut and pasted from different points in the CVR transcript to make a new dialogue in the documentary;
- Paralinguistics – the CVR transcript gives no indication of anger or rapid speech, but the captain in the documentary speaks rapidly in an angry, raised voice;
- Paraphrase – key messages from the CVR transcript are reproduced using different words in the documentary (e.g., the original ATC message "I'm gunna have to spin you" is changed to "I'd like you to make a right 360 degree turn").

[37] "Mayday" is a Canadian documentary series produced by Cineflix. In other countries it is known as "Air Crash Investigation", "Air Emergency" or "Air Disasters".

5.5.6 "Outliers" Bestselling Book

The book "Outliers: The Story of Success" by popular journalist Malcolm Gladwell contained a lengthy account of the Avianca 052 accident. The discussion touched on pilot workload, mitigated speech and Hofstede's cultural dimensions, especially power distance. Drawing on the analysis by Helmreich (1994), Gladwell's main argument was that cultural factors prevented the Colombian first officer from clearly informing American air traffic controllers about the aircraft's fuel problem.

The book presented a dramatic and oversimplified version of the dialogue that took place within the Avianca cockpit. The author's argument is weakened by the following mistakes and omissions:

- Condition of the plane – Gladwell (2008, p. 186) stated, "There was nothing wrong with the aircraft." As Helmreich (1994, p. 271) pointed out, the autopilot system was not working (which necessitated hand flying), the FDR was inoperative and there was "a decaying cardboard box inside one of the fuel tanks".
- Silence in the cockpit – The book noted repeated periods of silence in the Avianca cockpit, and claimed no one said anything for five minutes before engine number four flamed out. The CVR transcript shows there were 40 utterances by the Avianca crew during this period.
- First officer's feelings – Gladwell (2008, p. 208) repeated a mistake from Helmreich's paper by attributing the utterance "The guy is angry" to the first officer in order to strengthen his argument about cultural influences. The CVR transcript indicates that this utterance was made by the flight engineer, not the first officer.

CHAPTER 6: Methodology

This chapter outlines the methodology for the dissertation, which is divided into two parts: Stage One and Stage Two. In Stage One, I investigate the relevance of past accidents to contemporary civil aviation, focusing on the four accidents cited by ICAO in Document 9835. In Stage Two, I examine the communication problems that contributed to one of these accidents: the 1990 fuel exhaustion crash of Avianca Flight 052. Each of the stages has four research questions (RQs). Multiple methods are employed in the study, including a survey of current airline pilots, a series of semi-structured interviews with a key informant (KI), and linguistic analysis of pilot-ATC communications. In addition, this chapter introduces the Aviation Communication Toolkit (ACT), a glossary that I have created to facilitate the analysis of language use in accidents. The structure of the chapter is shown below.

6.1 STAGE ONE: Past Accidents Cited by ICAO

- 6.1.1 Research Questions A-D
- 6.1.2 Survey of Pilots' Attitudes to Past Accidents
- 6.1.3 Semi-Structured Pilot Interviews

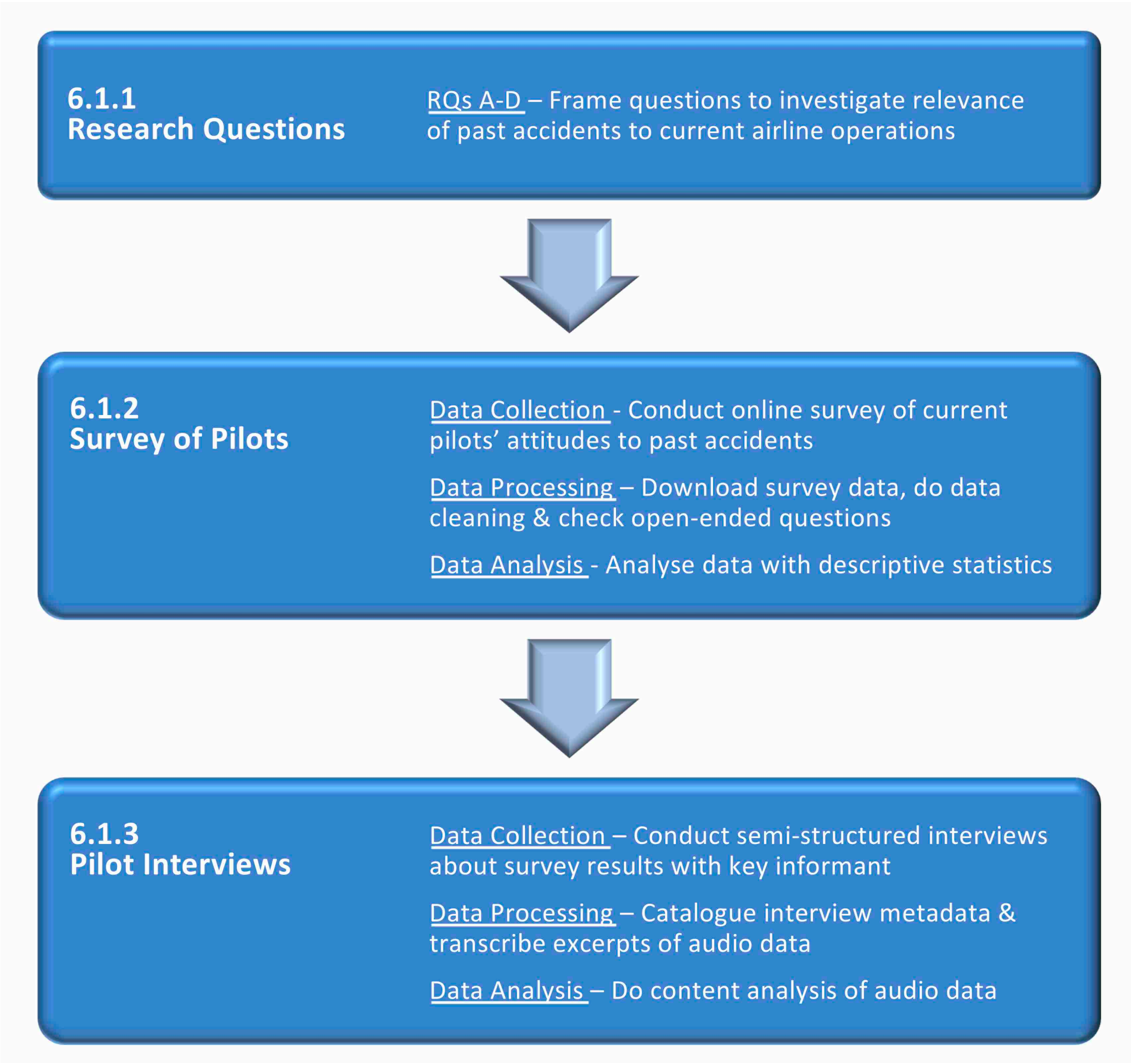
6.2 STAGE TWO: Analysis of the Avianca 052 Accident

- 6.2.1 Research Questions E-H
- 6.2.2 An Aviation Communication Toolkit
- 6.2.3 Analysis of Language Use in the Accident

6.1 STAGE ONE – Past Accidents Cited by ICAO

The first stage of the analysis investigates the relevance of past accidents to current airline operations. I adopted a mixed methods approach using a sequential explanatory design (Creswell & Plano Clark, 2007). In the first phase, a survey was conducted to gather quantitative data about the attitudes of airline pilots. In the second phase, follow-up interviews were held with one participant to examine the survey results in detail and collect qualitative data. The methodology is outlined in Figure 15. Stage One is framed by the question: *How relevant are the accidents cited by ICAO to current airline operations?*

Figure 15: Outline of Methodology Stage One.



As discussed in Chapter 1, a number of airline accidents have been cited by the International Civil Aviation Organization (ICAO) as canonical cases that triggered radical changes in civil aviation operations and training. Specifically, these cases led to ICAO launching its language proficiency programme, which was developed in the early 2000s and finally implemented in 2011.

During the course of this project, I spoke with a number of experienced pilots and researchers who questioned the relevance of past accidents to current airline operations. One observation was that accidents which happened several decades ago are no longer relevant due to the amount of time that has passed. Another comment was that measures had been taken after specific accidents to ensure that similar events would not happen again. Following the 1977 Tenerife runway collision, for example, ICAO made changes to standard phraseology and procedures (ICAO, 2010).

In order to address this question and investigate the relevance of past accidents, I conducted a survey of current airline pilots with follow-up interviews. The methodology for this stage is described in the sections that follow.

6.1.1 Research Questions A-D

Four accidents are referred to in Document 9835, which is the official guide to the ICAO language proficiency programme. In each case it is noted that "insufficient English language proficiency on the part of the flight crew or a controller" was a contributory factor (ICAO, 2010, p. 1-1). The four accidents were:

- 1977 Tenerife – runway collision in the Canary Islands, Spain;
- 1990 Cove Neck – fuel exhaustion crash at Cove Neck, New York, USA;
- 1995 Cali – controlled flight into terrain (CFIT) near Cali, Colombia;
- 1996 New Delhi – mid-air collision over Charkhi Dadri, near New Delhi, India.

I drew up four research questions to investigate airline pilots' awareness of, and attitudes towards, these accidents. The research questions were used to design the survey and guide the interviews. The questions were:

- RQ A – Is studying past airline accidents important for improving airline safety?
- RQ B – Which of the accidents cited by ICAO have pilots heard of?
- RQ C – What are pilots' sources of information about these accidents?
- RQ D – Did insufficient English proficiency of pilots and/or air traffic controllers play a contributing role in these accidents?

6.1.2 Survey of Pilots' Attitudes to Past Accidents

This section outlines the survey that I conducted to investigate the attitudes of current airline pilots to past accidents. The survey explored: respondents' awareness of, and attitudes towards, the four accidents cited in ICAO Document 9835; their sources of information about the accidents; and the role played by the English proficiency of pilots and air traffic controllers in the accidents.

6.1.2.1 Data Collection

Using the SurveyMonkey online survey tool, I created a 31-item questionnaire based on the research questions. Human factors (HF) experts and training captains at a major Middle East airline were consulted during the design process. On their advice, the survey was designed to be completed in a short time (i.e., 10-15 minutes). Three applied linguists were also consulted to ensure that the question items were rigorous. Appendix 7 contains a full listing of the questionnaire items.

The questionnaire is divided into three sections: introduction, questions about each of the four accidents in turn, and background questions. It contains a mixture of question types: 5-scale Likert items, yes/no closed items, and multiple choice questions. There is only one item in the first section:

- Q1 – Studying past airline accidents is important for improving current airline safety. [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

The second section has five items that are repeated for each of the four accidents. The questionnaire design uses page skip logic so that, if respondents answer "No" to the first question about an accident, they are not asked further questions about that accident. The items for one accident (1977 Tenerife) are as follows:

- Q2 – On 27th March 1977, there was a runway collision between KLM Flight 4805 and Pan Am Flight 1736 at Los Rodeos Airport on the island of Tenerife. Have you heard of the 1977 Tenerife accident?
  [Yes / No]
- Q3 – Where did you hear about the 1977 Tenerife accident? (You can select more than one answer.)
  [Accident report / Another pilot / Book / Company training / IATA publication / ICAO publication / Internet / Magazine or newspaper article / TV documentary / TV or radio news / Other (please specify)]

- <u>Q4</u> – The 1977 Tenerife accident is relevant to current airline operations.
  [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
- <u>Q5</u> – Insufficient English proficiency of pilots played a contributing role in the 1977 Tenerife accident.
  [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
- <u>Q6</u> – Insufficient English proficiency of air traffic controllers played a contributing role in the 1977 Tenerife accident.
  [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

The final section includes ten questions relating to demographics. These questions ask respondents about their: rank, training appointments, flight hours, age, gender, airline, nationality (or nationalities), native language(s), other languages known and ICAO language proficiency level.

The questionnaire was distributed via the internet to UK-based pilots through two discussion forums operated by the British Airline Pilots Association (BALPA). One of the forums is for all BALPA members and the other is for British Airways pilots only. These are closed forums where members (i.e., airline pilots) discuss professional issues.

6.1.2.2 Survey Demographics

The survey was open on the BALPA discussion forums for two months (April-May 2018) and there were 92 respondents. Four outlier respondents spent less than one minute on the survey and only completed two questions. The remaining respondents answered questions about the four accidents, and 74 participants completed all sections including the demographic questions. A sample survey response from one de-identified participant (respondent #23) is reproduced in Appendix 8.

All of the respondents were airline pilots. A majority were captains and most had a large number of flight hours. In terms of gender and nationality, there was a narrow range of backgrounds: almost all participants were male and the great majority were British. Nearly all the respondents were native English speakers, with a handful of native speakers of other European languages. There were five maximal bilinguals (English-Danish, English-Dutch, English-German, English-Irish and English-Welsh). Below is a summary of the demographic information:

- <u>Rank</u> – 60.8% of respondents were captains and 39.2% were first officers (n=74);

- Training appointments – 23.0% were technical trainers and 2.7% were human factors trainers (n=74);[38]
- Flight hours – 59.5% had 10,000+ flight hours and 18.9% had less than 5,000 flight hours (n=74);
- Age – 21.6% were older than 55, 25.7% were 46-55, 31.1% were 36-45, and 21.6% were 35 or younger (n=74);
- Gender – 97.3% were male and 2.7% were female (n=74);
- Airline – a significant number of respondents worked at British Airways (32 pilots); the other airlines were Thomson Airways (17), Virgin Atlantic (5), easyJet (4), Norwegian (2), Air Berlin (1), Qatar (1), flybe (1) and Jet2.com (1) (n=64);[39]
- Nationality – 87.8% of respondents were British; other nationalities were Dutch (4.1%), Irish (2.7%), Danish (1.4%), German (1.4%), Scottish (1.4%) and Welsh (1.4%) (n=74);
- Native languages – 97.3% of respondents were native English speakers; there were also native speakers of Dutch (4.1%), Danish (1.4%), German (1.4%), Irish (1.4%) and Welsh (1.4%) (n=74);
- Other languages – the most common other languages were French (24 pilots), German (16 pilots) and Spanish (4 pilots) (n=39).

6.1.2.3 Data Processing

After the survey had been open for two months, I downloaded the data from the SurveyMonkey account as a single Excel file. This file contained all the responses as well as metadata including the dates and times at which participants started and completed the survey. In addition to the downloaded data, the SurveyMonkey system allows results to be displayed as: a summary for each item; trends in the responses for items by day, week or month; and responses of individual participants. I exported summaries for several items in the form of bar charts and tables. The summaries indicated the number of participants who answered or skipped each question.

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[38] Technical training involves the skills and knowledge required to fly an aircraft. Human factors training covers domains such as communication, decision making and stress management.

[39] On the advice of airline captains that I consulted while creating the questionnaire, this question was made optional due to the reluctance of some pilots to disclose their company.

I checked the data for outlier respondents who had: completed the survey too quickly, given the same response repeatedly, or entered nonsensical responses. Then the data were coded in preparation for the statistical analysis. Data cells in the Excel file were colour-coded so that survey items matched the four research questions: items relating to RQ A were coloured yellow; RQ B items were green; RQ C were blue; and RQ D were grey. Numerical coding of the responses for the yes/no closed items and the 5-scale Likert items was done as follows:

- Yes/no items – Yes / No => 1 / 0
- 5-scale Likert items – Strongly agree / Agree / No opinion / Disagree / Strongly disagree => 5 / 4 / 3 / 2 / 1

Most of the questionnaire items were closed questions, but several multiple choice questions included an open-ended "Other (please specify)" option. I manually checked the responses for these items using the question summaries and adjusted the data as necessary. For example, Q22 asked respondents whether their rank was "Captain", "First officer" or "Other". One participant had used the "Other" option to enter "Senior First Officer", which I coded as "First officer".

6.1.2.4 Data Analysis

The survey of airline pilots generated quantitative data which were analysed using descriptive statistics. The four research questions (RQs A-D) were used to structure the analysis. The correspondence between RQs A-D and the items on the survey questionnaire was as follows:

- RQ A: learning from past accidents – this question was addressed by Q1 and also, for each individual accident, by Q4, Q9, Q14 and Q19 (all 5-scale Likert items);
- RQ B: pilots' awareness of past accidents – this question was addressed by Q2, Q7, Q12 and Q17 (all yes/no closed items);
- RQ C: sources of information – this question was addressed by Q3, Q8, Q13 and Q18 (multiple choice items with one free response "Other" option);
- RQ D: insufficient English proficiency – Q5, Q10, Q15 and Q20 addressed the English proficiency of pilots, while Q6, Q11, Q16 and Q21 addressed that of air traffic controllers (all 5-scale Likert items).

6.1.3 Semi-Structured Pilot Interviews

In accordance with the sequential explanatory mixed methods design, after the online survey had been completed I conducted a series of interviews with one of the survey participants. The purpose of the interviews was to discuss the survey results in detail and collect qualitative data that might offer an explanation for any significant or surprising results from the survey.

6.1.3.1 Data Collection

One of the pilots who participated in the survey was selected as a key informant (KI) for the interviews. The KI has been an airline captain since 2006. There were several reasons for selecting this participant:

- his considerable experience of international airline flying;
- his interest in communication problems on the flight deck;
- an ability to articulate his experiences and observations;
- a willingness to participate in an extended series of interviews;
- his availability for interview on a regular basis.

This captain met the criteria that were laid out by the anthropologist Marc-Adélard Tremblay for an “ideal informant” in terms of his role in the community, knowledge, willingness, communicability and impartiality. Moreover, his close interest in the professional behaviour of other pilots and aviation workers, and his ability to observe critically and make inferences about their behaviour mark him out as a “natural observer” (Tremblay, 1989).

I adopted a semi-structured approach for the interviews because this provided flexibility and allowed for extended probing of the survey results. For instance, it offered an opportunity to explore how the KI characterized the four accidents, and to discuss related experiences from his own flying career. I was also able to probe the sources of information that airline pilots use to learn about accidents. Drawbacks of semi-structured interviews include the significant amount of time and effort they take, and the requirement for interviewer sophistication (Adams, 2015). These disadvantages were outweighed by the increased depth that the qualitative interview data added to the quantitative data from the survey.

When the captain’s flying schedule allowed, some of the interviews took place face-to-face during layovers in Tokyo. Others were conducted online using the FaceTime and Zoom video call systems. All of the interviews were recorded with the KI's consent. A mixture of closed- and open-ended questions were used to guide the interviews, as shown in Appendix 9. Additional questions were asked in response to topics that came up in the course of the discussions. The questions used to guide the interviews were divided into the following two sections:

- Past accidents – RQs A-D plus follow-up questions to elicit more information about the reasons for the KI's responses, his attitudes to the accidents, and related personal experiences;
- Background questions – the same demographic questions that were used in the airline pilot survey.

6.1.3.2 Biographical Data for Key Informant (KI)

The KI is a native English speaker and his nationality is British. He has been a captain at a major European airline since 2006. He was 51 years old at the start of the interviews, and had accrued approximately 15,000 flight hours.

A series of 13 semi-structured interviews were conducted with the KI between August 2019 and June 2020. We discussed the survey questions and results in five of the interviews (#5-9). In the remaining interviews we discussed the ACT glossary, which is outlined in Section 6.2. Appendix 10 has details of the interviews including a summary of their content.

6.1.3.3 Data Processing

A MacBook Pro laptop computer was used to record each of the interviews in an audio M4A format. Following each interview, I listened to the recording and logged the following metadata: the interview date, format (face-to-face or online), recording length, questions asked, and points to follow up on in subsequent interviews. The audio quality was poor for some of the face-to-face meetings. I used Audacity audio editing software to remove background noise from these recordings. In addition, I transcribed excerpts of the audio that were especially pertinent to the analysis.

6.1.3.4 Data Analysis

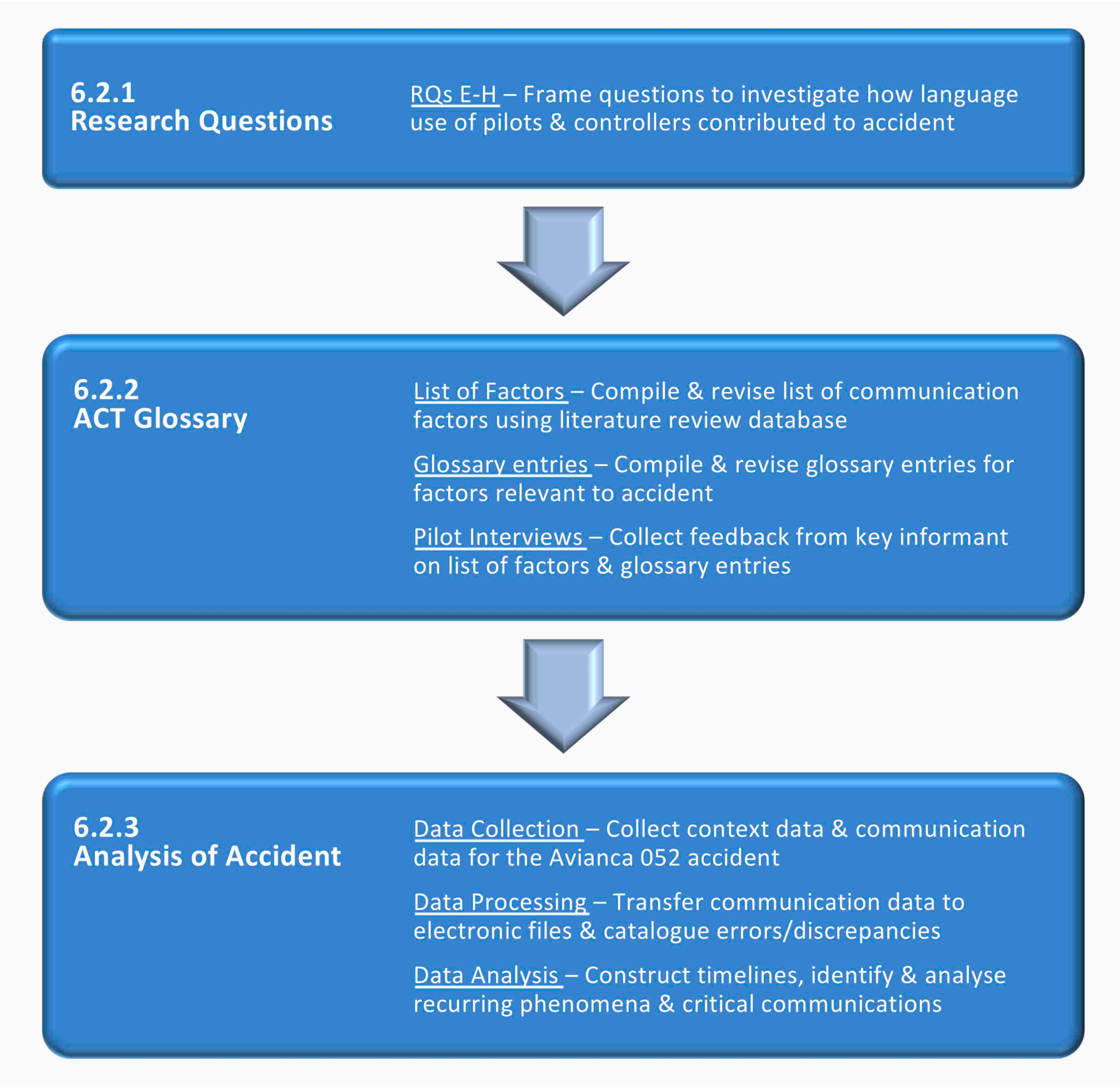
The interviews gathered qualitative data relating to the four research questions (RQs A-D), as indicated in Appendix 9. I listened to each interview recording several times and conducted manual content analysis, coding the data within the framework of the research questions. The correspondence between RQs A-D and the interview questions was as follows:

- RQ A: learning from past accidents – this question was addressed by Q1-2;
- RQ B: pilots' awareness of past accidents – this question was addressed by Q3-6;
- RQ C: sources of information – this question was addressed by Q7-9;
- RQ D: insufficient English proficiency – this question was addressed by Q10.

6.2 STAGE TWO – Analysis of the Avianca 052 Accident

The second stage of the analysis examines the communication problems which occurred in one of the accidents that was featured in the survey and cited by ICAO. The accident is the 1990 crash of Avianca Flight 052 at Cove Neck, New York. To facilitate the analysis, I used the literature review database to create a glossary of communication factors: the Aviation Communication Toolkit (ACT). The methodology for Stage Two is outlined in Figure 16. This stage is framed by the question: *How did the language use of pilots and controllers contribute to the Avianca 052 accident?*

Figure 16: Outline of Methodology Stage Two.



As discussed in Section 1.6, there were two main reasons for selecting the Avianca Flight 052 accident. Firstly, several issues relating to the communication of pilots and ATC were left unresolved following publication of the official report by the NTSB. Secondly, the Avianca 052 crash has not been analysed as thoroughly as some of the other accidents cited by ICAO (i.e., the 1977 Tenerife and 1995 Cali accidents).

6.2.1 Research Questions E-H

I formulated four research questions to guide the analysis of language use in the accident. The questions were derived from Document 9835, the official guide to the ICAO language proficiency programme. As noted previously, Document 9835 indirectly refers to four accidents that involved communication problems: Tenerife, 1977; Cove Neck, 1990; Cali, 1995; and New Delhi, 1996. The document states that in each case "insufficient English language proficiency on the part of the flight crew or a controller had played a contributing role in the chain of events leading to the accident" (ICAO, 2010).

Document 9835 does not include any analysis of the four accidents. It simply states three ways in which language use can contribute to accidents and incidents:

1. "incorrect use of standardized phraseologies";
2. "lack of plain language proficiency";
3. "the use of more than one language in the same airspace" (ICAO 2010, p. 1-1).

The document also notes that the language performance of individuals may be affected by other factors such as "levels of attention, mood, stress, verbal working memory and verbal processing abilities" (ICAO 2010, p. 2-3).

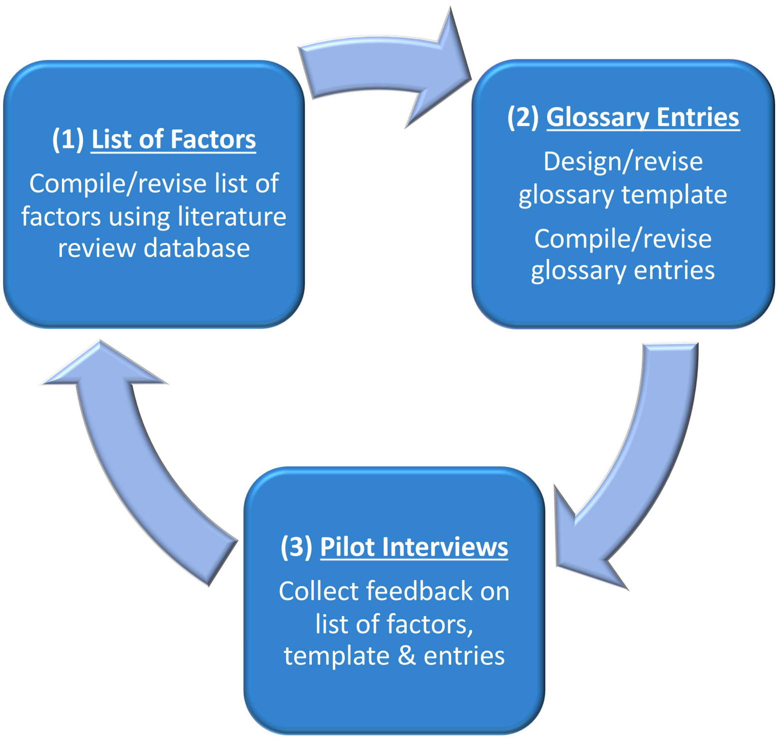
Based on the propositions put forward in Document 9835, I framed the following research questions to guide the analysis of the Avianca 052 accident:

- RQ E – Did the incorrect use of standard phraseology by pilots and/or air traffic controllers contribute to the accident?
- RQ F – Did a lack of plain language proficiency of pilots and/or air traffic controllers contribute to the accident?
- RQ G – Did the use of more than one language in the same airspace by pilots and/or air traffic controllers contribute to the accident?
- RQ H – Did the influence of other factors on the language use of pilots and/or air traffic controllers contribute to the accident?

6.2.2 An Aviation Communication Toolkit

In order to facilitate the analysis of language use in the accident, I first compiled a glossary of communication factors: the Aviation Communication Toolkit (ACT). The ACT glossary lists core terms relating to the communication of pilots and controllers. The terms are defined and explained using examples taken from accident and incident reports. The glossary is essentially a *communication toolkit* that provides specialist information for the analysis of *communication breakdowns*. Figure 17 shows the 3-part cyclical process used to construct the glossary. The process drew on the literature review database and involved another set of semi-structured interviews with the KI.

Figure 17: Process for compiling the ACT glossary.



6.2.2.1 List of Factors

ICAO Document 9835 contains multiple references to the risk of "communication breakdown". This catch-all phrase is used in aviation to cover a myriad of communication problems. Illustrating its ubiquity, NASA's ASRS incident database lists more than 18,700 incidents which involved communication breakdowns (ASRS, n.d.). Although valuable as a general construct, communication breakdown does not explain specific communication processes (Cookson, 2017a). In the ACT glossary, this construct is broken into discrete communication factors. The factors can then be used to analyse the processes by which communication broke down in specific accidents and incidents.

The first step in compiling the ACT glossary was to draw up an initial list of communication factors using the literature review database. This list was progressively modified based on feedback from the KI interviews, and the factors were divided into categories (e.g., the workplace, the radio, and ways of speaking). Some of the factors are small-scale features of speech (e.g., repetition). Others are larger-scale phenomena that impact not only communication but also other aspects of flight operations (e.g., fatigue and startle effect).

6.2.2.2 Glossary Entries

In the second part of the process shown in Figure 17, I designed a template for the glossary entries. I then used the literature review database to create entries for individual communication factors. The entries draw on information from a range of fields including applied linguistics, sociolinguistics, cognitive psychology, social psychology, aviation human factors and accident investigation. Each entry describes one factor associated with communication problems that pilots and air traffic controllers may experience. The entries include the following elements:

- Meaning – a concise definition of the factor;
- Communication risk – the risk posed by the factor expressed as a factual conditional sentence based on the "findings as to risk" format described in Section 3.8;
- Language indicator – specific instances of language symptomatic of the factor;
- Accidents & incidents – events in which this was a contributory factor;
- Further reading – sources with more detailed information.

In addition, most entries have a short dialogue illustrating the factor. The dialogues are authentic interactions, taken from accident and incident reports, which show the actual language use of pilots and controllers. Some dialogues feature an exchange that was a critical communication in an accident or incident.

6.2.2.3 Pilot Interviews

The third part of the process involved further semi-structured interviews with the KI. The purpose of the interviews was to collect feedback on: (1) the list of factors, (2) the glossary entry template, and (3) individual glossary entries. The procedure used for data collection, processing and analysis was the same as outlined in Section 6.1.3. Once again the interviews were recorded with the KI's consent. The following questions guided the discussion in the interviews, with additional questions being asked as necessary:

- Q1 – What do you think about the template for glossary entries?
  (Comment on its usefulness, usability, format and content.)
- Q2 – What do you think about the list of communication factors?
  (Suggest changes you think should be made to the list, such as additions, deletions and revisions. Also, indicate the factors most relevant to your work.)
- Q3 – What do you think about the individual glossary entries?
  (Suggest any changes you think should be made, for example, to improve the readability of an entry or to rectify omissions. Also, describe any experiences you have had related to an entry.)

The cycle shown in Figure 17 was repeated after each interview. I revised both the list of factors and the glossary entries based on the interview feedback, and then conducted another interview. The process continued until the ACT glossary was robust enough for the analysis of the Avianca 052 accident.

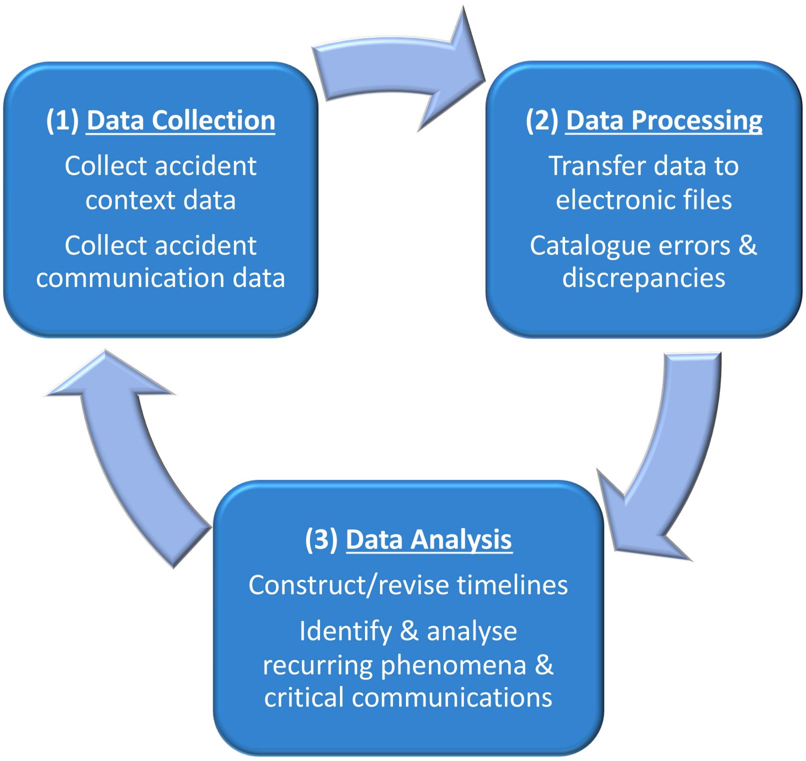
6.2.3 Analysis of Language Use in the Accident

The aim of this study is to analyse the language use of pilots in the *context* in which it occurs. The aim follows the principles of ethnography of communication (EOC) and interdiscourse communication for analysing speech and interaction in the context in which it emerges, as outlined in Sections 4.4 and 4.5. Furthermore, the study recognises that the context is not limited to the setting of an interaction and the roles of participants. It also includes other layers, for example organizational influences, which may be spatially or temporally distant from an accident. The two case studies that were described in Section 3.3, the 1981 Binghampton chemical fire and the 1986 Challenger space shuttle explosion, highlight the importance of understanding the organizational context in which decisions are made.

This study is in line with contemporary approaches to the analysis of accidents in high-risk complex systems, such as Reason's Swiss Cheese model, the Human Factors Analysis and Classification System (HFACS), and the Man-Technology-Organisation (MTO) model. These approaches acknowledge that accidents are invariably the result of the co-incidence of multiple factors that are operating at various levels, from the acts of individuals to the influence of organizational culture or regulations (Wiegmann & Shappell, 2003; Reason, Hollnagel & Paries, 2006).

The following paragraphs describe the methodology for analysing the language use of pilots in the Avianca 052 accident. Figure 18 depicts the 3-part iterative process that was followed. This process allowed timelines to be constructed for the accident. Then I was able to identify and analyse the recurring communication phenomena of interest and the critical communications.

Figure 18: Process for analysing language use in the accident.



6.2.3.1 Data Collection

Two sets of data were collected about the Avianca 052 accident: data relating to the accident context, and data relating to the communication of pilots and air traffic controllers during the flight.

The first set of data relates to the accident context. These data are multi-layered. They include the airline history, details of its organizational culture, the aircraft condition, the condition of the pilots and controllers, and the history of the Avianca 052 flight. Data were obtained from the NTSB accident report and from other documents in the literature review database. In addition, I conducted a search of articles in the New York Times. This newspaper was selected because the crash site was in New York and the articles are readily accessible online. ProQuest databases were searched for the period 1950 to 2018 with the search term “Avianca AND accident”, source type “newspaper” and publication title “New York Times”.

The second set of data concerns communication between the pilots and controllers. As is standard procedure after an accident, the NTSB investigation into the Avianca 052 crash examined two types of audio recordings: (1) cockpit communications recorded by the Avianca CVR, and (2) pilot-controller communications recorded at relevant ATC facilities. The NTSB is prohibited from releasing CVR recordings under US law, but can publish excerpts of transcripts considered relevant to an investigation (see Appendix 11). I submitted requests for information to the NTSB in an attempt to gain access to all or part of the audio recordings, but these requests were not successful.[40]

For the analysis of language use I used the eight transcripts of CVR and ATC audio recordings in the accident report.[41] Appendix 12 has a summary of the transcripts, which total 184 pages. The transcripts are a written representation of oral communications that took place on the day of the accident. They include communications between ATC units on the ground, between controllers and multiple aircraft, and amongst the Avianca flight crew. They cover different periods of time, some of which overlap. As a result, certain exchanges are in two transcripts. For instance, many transmissions between the Avianca crew and the controllers are recorded in both the CVR and ATC transcripts.

6.2.3.2 Data Processing

For the context data, the newspaper search of articles about Avianca accidents in the New York Times yielded 100 results. Irrelevant articles were removed manually, which left 92 items. A summary of these was downloaded as an Excel file. To code the

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[40] I sent a request via the NTSB Request for Information Product website on 16th April 2017 but received no reply. I subsequently made multiple attempts to submit Freedom of Information Act (FOIA) requests via the NTSB website between 2017 and 2020. These attempts were unsuccessful due to repeated technical issues (e.g., “Secure Connection Failed” errors).

[41] Previous studies have analysed pilot and controller communication using CVR transcript data from accident reports. See, for example, Driscoll (2002) and Nitayaphorn (2009).

articles, I used the ProQuest database subject codes as a base and made manual revisions as necessary. Since the ProQuest codes are broad categories (e.g., "accidents and safety"), many revisions involved adding detail (e.g., specifying whether the article was about the "emergency response" or "interviews with survivors"). Also, the ProQuest coding was not always thorough, for instance it identified some, but not all, of the articles about drug smuggling.

For the communication data, I downloaded the Avianca 052 accident report as a PDF file from the NTSB website. I then transferred the transcript data to Word and Excel files to facilitate the analysis. Two problems emerged during this process. Firstly, the PDF file transcripts contained numerous typographical errors: for example, "**n**aintain" instead of "**m**aintain", and "**X**vianca" for "**A**vianca". I made corrections to obvious mistakes, which are indicated by footnotes in Chapter 7. Errors may have been introduced in the initial typing of the accident report. Or they might have occurred when the report was scanned using optical character recognition (OCR) software to make a PDF version. I contacted the NTSB about the errors and asked if a hard copy of the report was available. Unfortunately I was unable to obtain any further information.[42] The second problem that emerged relates to pilot-controller exchanges that are in both the CVR and ATC transcripts. There are many discrepancies between the different versions of these exchanges. Where relevant, footnotes in Chapter 7 detail the discrepancies.

6.2.3.3 Data Analysis

As indicated in Figure 18, the data analysis consists of the following elements: constructing timelines for the accident, identifying the recurring phenomena of interest and the critical communications, and then analysing the recurring phenomena and critical communications.

A timeline is a representation of the key events, processes and communications that are relevant to an accident. Two timelines were constructed for the Avianca 052 accident based on the context data and the communication data. Together they covered a period from years to seconds preceding the crash. The construction of the timelines was informed by two principles outlined by Dekker (2006). Firstly, the air transport system is complex

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[42] I contacted the NTSB Request for Information Product website on 28th April 2017. They sent the following response: "What do you mean by 'scanning errors'? We do not have any hard copies of this publication." I then sent details of the errors, but did not receive a reply.

and nonlinear. Events or decisions may have unforeseen consequences years after they take place. Secondly, it is recognized that the CVR and ATC recordings are only "partial data traces" which represent the human behaviour that occurred as the accident unfolded. The data traces should not be mistaken for actual human behavior.

To investigate the communication data I drew on the conversation analysis (CA) tool developed by Nevile (2006) for the Australian Transport Safety Bureau (ATSB) (see Section 2.6.2). The method that was adopted for this study was novel in several regards: Nevile's CA methodology was applied to pilot-ATC communications, not intracockpit communications; it was applied to written transcripts, not audio data; and it was used in conjunction with the grammar of context and the ACT glossary.

The communication data were first examined using the technique of unmotivated looking, in which there is no specific focus or intention. Then the data were examined using motivated looking, which is informed by knowledge about the context, such as the conclusions and dissenting statements in the NTSB accident report. These two techniques were used to identify the following features:

- <u>Recurring phenomena</u> – "communication phenomena of special interest that recur over the whole recording";
- <u>Critical communications</u> – "key periods of interaction for close analysis", which are considered to be contributory to the accident (Nevile, 2006, pp. 19-20).

The linguistic analysis of both the recurring communication phenomena and the critical communications was based on a tripod of methodologies: (1) the CA techniques outlined in Section 2.6, (2) the grammar of context framework described in Section 4.5, and (3) the ACT glossary introduced in Section 6.2.2. The rationale for using multiple approaches was that by examining the same event from different angles it is possible to clarify both expected and unexpected findings. The layering of information provides a richer explanation of the causal processes at work during the accident.

After the first round of analysis was complete, I repeated the cycle depicted in Figure 18. Additional data were collected as necessary, the timelines were revised, and further analysis carried out on the recurring phenomena and critical communications. The cycle was continued until the analysis produced a comprehensive account of the language use of pilots in the Avianca 052 accident.

CHAPTER 7: Findings

In this chapter, the results of the study are presented in two parts: Stage One and Stage Two. Stage One examines the relevance of past airline accidents to current flight operations and addresses RQs A-D. In this section, I report the results from: (1) the survey of pilots' attitudes to past accidents cited by ICAO, and (2) the follow-up interviews with the KI. Stage Two focuses on one accident, the crash of Avianca Flight 052, and addresses RQs E-H. This section starts with a report on the Aviation Communication Toolkit (ACT) glossary. Then I present the findings of the analysis of language use in the Avianca 052 accident, which identified three recurring communication phenomena of interest and six critical communications. The structure of the chapter is shown below.

7.1 STAGE ONE – The Relevance of Past Accidents

- 7.1.1 RQ A – The Importance of Past Accidents
- 7.1.2 RQ B – Pilots' Awareness of Past Accidents
- 7.1.3 RQ C – Sources of Information
- 7.1.4 RQ D – Insufficient English Proficiency

7.2 STAGE TWO – Language Use in the Avianca 052 Accident

- 7.2.1 The ACT Glossary
- 7.2.2 RQs E-H & Communication Factors
- 7.2.3 Recurring Phenomena in the Avianca 052 Accident
- 7.2.4 Critical Communications in the Avianca 052 Accident

7.1 STAGE ONE – The Relevance of Past Accidents

In Stage One, I report the findings from the online survey of pilot attitudes and the KI interviews. The survey and interviews examined the relevance of past accidents cited by ICAO to current airline operations. They specifically addressed the four accidents that were referenced in Document 9835:

- the 1977 runway collision at Tenerife in the Canary Islands;
- the 1990 fuel exhaustion crash at Cove Neck, near New York;
- the 1995 controlled flight into terrain (CFIT) near Cali, Colombia;
- the 1996 mid-air collision near New Delhi.

The survey and interview findings are presented for each of the four research questions (RQ A-D) in the paragraphs that follow.

7.1.1 RQ A – The Importance of Past Accidents

7.1.1.1 Survey Results

The first survey item asked whether studying past airline accidents is important for improving current airline safety. The respondents overwhelmingly think that studying past accidents *is* important:

- Past accidents – 91.3% of respondents strongly agree, and 98.9% agree or strongly agree (n=92).

The respondents were also asked whether each of the four accidents cited by ICAO is relevant to current airline operations. For three of the accidents, more than 95% believe they are still relevant. For the 1996 New Delhi crash, the figure is slightly under 80%:

- 1977 Tenerife – 96.6% of respondents agree/strongly agree (n=88);
- 1990 Cove Neck – 96.5% of respondents agree/strongly agree (n=57);
- 1995 Cali – 95.2% of respondents agree/strongly agree (n=63);
- 1996 New Delhi – 79.2% of respondents agree/strongly agree (n=24).

7.1.1.2 Interview Results

For the KI, studying past accidents is "very important" and is part of an ongoing process of reflection and self-awareness. This process helps him to recognise mistakes that he has made in the past, and how they potentially might have led to an incident or accident.

It also allows him to identify what caused the mistakes, and how he can preventing them happening again in future:

> I think when you're able to sit and read someone's report on an accident or an incident and say to yourself, you know I've actually done that, I've made that mistake myself and it hasn't led to deaths, but it does make you reflect on perhaps why you personally had made that mistake and what you might do to avoid repeating it. But you don't even have an awareness of the potential of your own error until you read about how the same error or a similar error has led to an accident. (Interview 5)

During the interviews, he cited other airline accidents that he had learned specific lessons from. These included the 1972 Staines, 1989 Kegworth, 2009 Colgan Air and 2016 Dubai accidents. He noted the value of such accidents being referenced in human factors courses to illustrate specific hazards and training points.

7.1.2 RQ B – Pilots' Awareness of Past Accidents

7.1.2.1 Survey Results

Respondents were asked if they have heard of the four accidents referred to in Document 9835. All participants know of the 1977 Tenerife collision. A substantial majority have heard of the 1990 Cove Neck and 1995 Cali crashes. However, less than one-third of the pilots surveyed have heard of the 1996 New Delhi accident:

- 1977 Tenerife – 100% have heard of the accident (n=92);
- 1990 Cove Neck – 70.1% have heard of the accident (n=87);
- 1995 Cali – 78.1% have heard of the accident (n=82);
- 1996 New Delhi – 32.1% have heard of the accident (n=78).

7.1.2.2 Interview Results

The KI has heard of all four of the accidents. He provided descriptions in his own words of key features of the accidents, as shown in Table 9. The KI remarked several times that the accidents involved multiple causal factors. Nevertheless, each description focuses on a single issue he considers to be the most salient for that particular accident.

Table 9: Key informant's descriptions of four accidents cited by ICAO.

ACCIDENT	KEY FEATURES OF ACCIDENT (ALL QUOTES FROM INTERVIEW 5; EMPHASIS ADDED)
1977 Tenerife	"In my head it's primarily a command gradient issue… There are all sorts of things going on. I suppose operating in an unfamiliar airfield in bad weather is part of it, and then the communication difficulties between ATC and the Dutch crew, but… it's always struck me that one as a command gradient thing primarily."
1990 Cove Neck	"It would never have happened... if they were all using English as their first language and therefore able to not have to code switch, I suspect that the message would have got across better, or it would have been recognized that it hadn't got across from the aircraft to the ground controller. That seems a much more clear-cut language barrier based accident."
1995 Cali	"That to me looks like a breakdown of procedures on the flight deck coupled with becoming too focused with your FMC [flight management computer] and programming that and insufficient situational awareness of where you are in terms of the surrounding terrain and the MSA [minimum safe altitude]… looks like a failure to follow procedures accident."
1996 New Delhi	"They were cleared to 15 [thousand feet] and they descended to 14, well you can do that in your first language quite easily… Even in English, where everyone's speaking English, it's possible to do it. So again I don't see language as being the main [issue]. If I had to put that [accident] in a box I'd say that's a procedural error."

The KI also described various experiences from his career that the four accidents reminded him of. The recollections were triggered by one aspect of an accident, which was not always the issue highlighted in Table 9. The recollections included the following stories (all from Interview 6):

- 1977 Tenerife – the KI noted that one of the factors in this accident was KLM Flight 4805 starting its takeoff roll before receiving takeoff clearance; this reminded him of an occasion when he landed at Verona Airport without receiving landing clearance due to distraction and excessive workload;

- 1990 Cove Neck – Avianca Flight 052 crashed due to fuel exhaustion; this brought to mind cockpit briefings he had made in situations “where the amount of fuel predicted to be left onboard is moving away from the comfortable level”;
- 1995 Cali – the crew of American Airlines Flight 965 ignored warning cues to continue their approach to Cali;[43] this reminded the KI of a simulator check ride that he failed when a mistuned radio aid led to snowballing workload within the cockpit; he commented that “it’s really hard to recognise that a situation has got away from you, cos you go from everything is fine, all under control, to everything’s gone right out the window really really quickly, and your capacity bucket fills really fast”;
- 1996 New Delhi – this accident involved a mid-air collision; it triggered a detailed description of TCAS (traffic collision avoidance system) training that the KI had experienced.

7.1.3 RQ C – Sources of Information

7.1.3.1 Survey Results

The respondents were asked where they heard about each of the accidents. This was a multiple choice question for which respondents could select more than one response. There were 11 options including an open “Other (please specify)” comment box.

For three of the accidents, TV documentaries are the most common information source. For the other accident (1995 Cali), company training is the most common and TV documentaries are second. The most common sources are as follows:

- 1977 Tenerife – TV documentary (76.1%), company training (61.4%) and accident report (50.0%) (n=88);
- 1990 Cove Neck – TV documentary (50.9%), accident report (33.3%) and company training (33.3%) (n=57);
- 1995 Cali – company training (66.7%), TV documentary (47.6%) and accident report (46.0%) (n=63);
- 1996 New Delhi – TV documentary (54.2%), accident report (45.8%) and internet (45.8%) (n=24).

[43] This is an example of *plan continuation bias*, an unconscious cognitive bias to persist with the original plan even though conditions are changing (Dismukes et al., 2007).

Many respondents report multiple sources of information per accident. If the results are aggregated for all four accidents, 67.7% of respondents cite more than one source of information. Among respondents who include TV documentaries, the figure rises to 84.9% citing more than one source, with 68.3% citing three sources or more.

7.1.3.2 Interview Results

During the interviews with the KI, I asked where he learned about each of the four accidents. In Interview 5, he reported the following sources:

- 1977 Tenerife – company training (HF course), TV documentaries, magazine articles and news articles; he noted "Of the four [accidents] that's the one that's had the widest coverage, and I'd say I've probably seen that in most media sources, and most of those boxes to tick [in the survey] I could probably have ticked."
- 1990 Cove Neck – company training (HF course);
- 1995 Cali – company training (HF course) and probably also a TV documentary;
- 1996 New Delhi – contemporary news reports and company training (for the TCAS system).

In Interview 8, the KI spoke at length about TV documentaries that depict airline accidents. He noted the value of using a "four-minute extract" or "90-second Youtube clip" from a documentary to reinforce a learning point during training. However, he also commented that the primary purpose of documentaries is entertainment: "I doubt many documentaries are made as a learning tool, even if some of them are used as a learning tool in human factors courses and what have you, they are not made with that intent, they're made to entertain."

In recent years there has been a significant change in the viewing habits of the KI. Ten years ago he watched TV documentaries. Since then "the delivery of media has changed in the household" with the advent of Netflix and Amazon Prime. As a result, he no longer watches this genre of programme. He suspects this change might be reflected across the pilot population, and notes the importance of Youtube and Netflix products for his children's generation. He summarises: "There's been a huge change in our viewing habits in the last three or four years."

The KI related how TV documentaries influenced the way he responded during one particular incident when he was a first officer. He had watched a documentary series with an opening sequence that featured alert sounds from a ground proximity warning system

(GPWS).[44] As a professional pilot, he recognised that the audio was not a genuine warning, but was instead the sound made by a GPWS device being tested: "Terrain terrain whoop whoop pull up pull up". Nevertheless, the sequence left a strong impression on him. Some months later he was flying through an intense rainstorm, during the approach to Verona Airport in Italy, when a GPWS warning was triggered:

> It freaked me out. I was freaked out anyway but the message I had subconsciously got from this documentary series was: when you hear that noise, you're going to crash.

Prior to the warning going off, there had been a lot of noise and distraction in the cockpit environment, but both pilots had felt in control of the situation:

> The impact of the raindrops on the cockpit was making communication quite difficult as well. So there was a disorientation from the amount of noise on the flight deck. The [Boeing] 737 wipers were (a) useless and (b) incredibly noisy. So the wipers are banging around, the noise of the rain was disorientating and distracting, but we still felt everything was fine. And then we get this [GPWS] warning indicating everything is not fine any more, exactly as implied by the documentary that I'd watched some time in the previous 6 months, 12 months.

After a brief discussion, the pilots continued the flight without further mishap and the plane landed safely. It turned out that the density of the rain had triggered a false GPWS warning. This incident illustrates how quickly a normal cockpit situation can deteriorate. As the KI notes about the documentary opening sequence: "They have suddenly gone from thinking everything is fine, to suddenly everything is not fine any more. And that's exactly what we had on this approach [to Verona]."

In addition, the KI discussed two electronic sources that provide him with information about accidents. One source is Wikipedia, which for general purposes he considers "as right at it needs to be" although the information is "incomplete". Another source is the internal system used by his airline for sending safety notices to pilots' iPads. During his career, this system has replaced paper notices. He noted two problems with electronic notices. First, they are in competition with other applications installed on the

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[44] GPWS is an electronic system that alerts pilots if an aircraft is in immediate danger of flying into the ground or an obstacle.

device: “The iPad is a great distraction. There’s always something else to do on your iPad rather than open up a safety publication.” Second, the ease with which electronic bulletins can be generated has led to an increase in their quantity: “You just get swamped with it, to the point of ignoring them.”

7.1.4 RQ D – Insufficient English Proficiency

7.1.4.1 Survey Results

Respondents were asked if insufficient English proficiency of pilots played a contributing role in each accident. For three of the accidents, a majority of respondents think that it did play a contributing role. The exception is the 1995 Cali crash, for which less than 13% agree, and almost 50% disagree or strongly disagree:

- 1977 Tenerife – 59.1% agree/strongly agree, and 19.3% disagree/strongly disagree (n=88);
- 1990 Cove Neck – 66.7% agree/strongly agree, and 7.0% disagree/strongly disagree (n=57);
- 1995 Cali – 12.7% agree/strongly agree, and 47.6% disagree/strongly disagree (n=63);
- 1996 New Delhi – 58.3% agree/strongly agree, and 8.3% disagree/strongly disagree (n=24).

Finally, the respondents were asked whether insufficient English proficiency of air traffic controllers was a contributing factor in each accident. The strongest agreement is for the 1977 Tenerife accident, with two thirds agreeing and only 10% disagreeing:

- 1977 Tenerife – 67.0% agree/strongly agree, and 10.2% disagree/strongly disagree (n=88);
- 1990 Cove Neck – 29.8% agree/strongly agree, and 36.8% disagree/strongly disagree (n=57);
- 1995 Cali – 33.3% agree/strongly agree, and 31.7% disagree/strongly disagree (n=63);
- 1996 New Delhi – 50.0% agree/strongly agree, and 16.7% disagree/strongly disagree (n=24).

Therefore, only for the 1977 Tenerife accident do most respondents believe English proficiency was a problem on the part of *both* pilots and controllers. In the case of the 1995

Cali accident, by contrast, just a small proportion of respondents (a third or less) think that the English proficiency of pilots *or* controllers was a contributory factor.

7.1.4.2 Interview Results

In discussing the role played by English proficiency in the four accidents, the KI draws on his own flying experiences. He acknowledges that his responses are influenced by attitudes he holds towards particular national or regional groups. Regarding the English proficiency of pilots, he believes that this is "less likely to have been a factor" in the 1977 Tenerife collision, but suspects it "played quite a big part" in the 1990 Avianca accident. He does not have an opinion about the two other accidents.

The 1977 Tenerife accident involved a collision between a KLM aircraft (with a Dutch crew) and a Pan Am aircraft (with an American crew). In discussing this accident, the KI cites his experiences flying with Dutch pilots. He expresses a highly favourable evaluation of their English proficiency, although he acknowledges that this has no direct bearing on the crew involved in the accident:

> The Dutch pilots I've flown with, and of course this doesn't translate directly to how good that Dutch [KLM] captain was, or that Dutch [KLM] crew was, or how proficient they were, the Dutch that I have flown with, they probably have better English than many English people do. (Interview 9)

Finally, concerning the English proficiency of controllers, the KI thinks it "could easily have played a part" in the 1995 Cali accident. He has no opinion about the other accidents. The Cali accident involved the controlled flight into terrain (CFIT) of an American Airlines aircraft in western Colombia. The KI's response about this accident is prefaced by comments about his experiences flying in South America. In these comments, he expresses a negative evaluation of the English proficiency of some air traffic controllers in that region:

> I've encountered some of the most difficult ATC communication [when flying] in South America. I have been to Columbia once, a long time ago, and I don't recall a problem on that trip, but certainly going down to Brazil is not without its problems with communication. (Interview 9)

7.2 STAGE TWO – Language Use in the Avianca 052 Accident

Stage Two presents findings from the analysis of the Avianca Flight 052 accident. First I report on the Aviation Communication Toolkit (ACT) glossary that I compiled to facilitate the language use analysis. Then I explain how RQs E-H are addressed in the analysis. The remaining parts of the chapter detail the analysis of pilot and controller language use in the accident. Three recurring communication phenomena of interest and six critical communications are identified. These were key components in the process of communication breakdown before the crash. They are analysed using three methodologies: CA techniques, the grammar of context framework, and the ACT glossary.

7.2.1 The ACT Glossary

The ACT glossary defines key concepts related to the communication of pilots and controllers. On one level it functions as a coding system for diagnosing communication problems in airline accidents and incidents. At a deeper level, it allows for the analysis of the process by which a communication breakdown occurs.

In this section, I report on the list of communication factors assembled for the glossary, the entries that were created, and stories of intercultural communication told by the KI that relate to particular factors. The glossary was compiled using the 3-part cyclical process shown in Figure 17 in Chapter 6. An essential part of the process was collecting feedback from the KI during the semi-structured interviews. In addition, I received input from pilots, controllers, regulators and HF researchers during three presentations I gave at international conferences (Cookson 2017a, 2017b, 2020).

7.2.1.1 List of Factors

The initial list of communication factors was assembled using the literature review database, drawing heavily on accident and incident reports. The list was revised based on feedback from the pilot interviews. For instance, headphone quality was added to the list at the suggestion of the KI. Appendix 13 shows the final list of 68 factors. To make the list manageable, the factors were grouped into categories. These were revised several times to make the labels and groupings clearer. The final categories are as follows:

- <u>The workplace</u> – e.g., noise;
- <u>The body</u> – e.g., fatigue;

- The radio – e.g., blocked transmission;
- Interacting with people – e.g., call sign confusion;
- Ways of speaking – e.g., code switching;
- Words and grammar – e.g., idiom.

During the pilot interviews, it became clear that the KI was more familiar with some communication factors than others. Many concepts were familiar because they are an integral part of flight operations (e.g, the factors in the workplace or radio categories) or they are discussed in HF training courses (e.g., authority gradient, expectation bias and the factors in the body category). Other concepts were not familiar. These included several factors in the categories of interacting with people (e.g., community of practice, diffusion of responsibility and speech community) and ways of speaking (e.g., accommodation, avoidance and first language influence). The unfamiliarity of some concepts underscores the importance of including clear definitions in the glossary.

We discussed certain factors at length across multiple interviews. Appendix 10 shows the factors discussed in the interviews, with those featuring three or more times highlighted in bold. It was evident that the KI considers some factors to be more salient than others. I therefore asked him to rank the factors in terms of the risk they pose to communication. According to his ranking, the most important factors are: distraction, fatigue, blocked transmission, message complexity, message length and stuck microphone. However, he adds the following caveat:

> …all of those things are based on me as a level 6 [ICAO scale] fluent speaker that doesn't often end up with non-level-6-native-Brits in the seat next to me. So other people from other communities will view many of those [factors] very differently. (Interview 13)

7.2.1.2 Glossary Entries

The initial template for the glossary entries was drawn up incorporating input from a sociolinguist and HF researchers. A series of improvements were made to the template design based on feedback from the KI interviews. For example, revisions were made to the headings used for each section of the entry (e.g., meaning and communication risk) to make them easier to understand. The final format can be seen in the sample entry for one of the communication factors shown in Figure 19.

Figure 19: ACT glossary entry for "Call Sign Confusion".

CALL SIGN CONFUSION

Meaning A speaker says a call sign incorrectly or a listener mishears a call sign. Confusion is more likely if speakers abbreviate call signs or aircraft with similar call signs are on the same radio frequency.

Communication risk If call sign confusion occurs: the intended recipient of a transmission might not act on a clearance; the wrong aircraft may change flight level, heading or radio frequency; and resolving confusion may add to the workload of pilots and controllers.

Language indicator In the dialogue below, the controller uses **an incorrect call sign**. This is followed by **correction**. **A similar call sign** and **similar numbers** in previous transmissions may have contributed to the confusion.

Dialogue Tower controller at JFK Airport, New York, speaking with Avianca flight 052, TWA flight 801 and Avensa flight 520 on January 25, 1990. Language: English.[8]

TIME (UTC)	SPEAKER	SPEECH
0221:07	TWR	**Avianca zero five two** heavy can you increase your airspeed one zero knots at all
0221:11	AVA052	Yes we're doing it
0221:12	TWR	Yeah ah thanks
0221:30	TWR	TW eight oh one you're gaining on the heavy seven oh seven turn left heading of ah – one **five zero** and maintain ah – **two** thousand
0221:38	TWA801	Okay TWA eight oh one heavy a left to one **five zero** maintain **two** thousand
0221:49	TWR	**Avianca zero five two** cross two two right taxi straight ahead now --- correction taxi right ah – right on the outer ground one two one point niner
0222:02	TWR	**Correction Avensa five twenty** cross two two right taxi right on the outer ground point nine
0222:06	AVE520	Cross two two right right on the outer and one two one point niner five two zero

Accidents & incidents This was a factor in:

- 1991 crash of Nigeria Airways 2120 in Jeddah, Saudi Arabia (FSF, 1993)
- 1991 runway collision of USAir 1493 and SkyWest 5569 in Los Angeles, USA (NTSB, 1991b)
- 1997 CFIT of Garuda Indonesia 152 in North Sumatra, Indonesia (KNKT, 2004)
- 2017 loss of separation between Sichuan 603 and China Southern 6068 over Yangon, Myanmar (MAIB, 2017)

Further reading Monan (1983) discusses call sign problems in the US. Cardosi, Falzarano and Han (1998) report on pilot-ATC communication errors including the problem of similar call signs on the same frequency. CAP 704 is a study of call sign confusion reports in the UK (CAA, 2000).

Related factors ABBREVIATION, AMBIGUITY, DISTRACTION, EXPECTATION BIAS, FATIGUE, MICROPHONE CLIPPING, NUMBER TRANSPOSITION, WORKLOAD

Many of the glossary entries contain a dialogue box. The dialogues are excerpts of the actual language use of pilots and controllers which include the communication factor. In the dialogue shown in Figure 19, a tower controller (TWR) says an incorrect call sign ("Avianca zero five two" at 0221:49) and then gives a correction ("Avensa five twenty" at 0222:02). The dialogues are taken from transcripts in accident and incident reports. In the original reports, various transcription conventions are used to express times, abbreviations, translated text and cockpit sounds. A standardized format was developed for the glossary dialogues to make them easier to read.

After I had created individual glossary entries, I collected feedback on them in the interviews. Numerous revisions were made to the content of the entries based on feedback from the KI. The most common changes were as follows:

- Meaning – making definitions easier to understand and/or more comprehensive;
- Communication risk – defining risks more accurately;
- Dialogue – making the dialogues easier to read;
- Related factors – adding extra related factors.

To illustrate the process of revision, the initial version of the entry for call sign confusion focused on productive errors made by speakers. In Figure 19, this corresponds to the first part of the meaning: "A speaker says a call sign incorrectly". After discussions with the KI in interviews 3 and 4, I modified the entry so that it also included receptive errors made by listeners: "or a listener mishears a call sign". In addition, distraction and expectation bias were added to the related factors at the end of the entry.

A significant proportion of the KI's comments concerned the risk that certain factors posed to communication. Based on these comments, I made substantial changes to the communication risk section for the following factors: blocked transmission, call sign confusion, expletive, first language influence, message length, number transposition, repetition and style shifting.

Appendix 14 contains glossary entries for 21 communication factors. All of these factors are relevant to the crash of Avianca Flight 052. The entries are used in the analysis of language use in the accident that follows in Sections 7.2.3 and 7.2.4.

7.2.1.3 Stories of Intercultural Communication

During the interviews, the KI related stories about his communication experiences with pilots, controllers and other personnel in numerous countries. In Appendix 10, the topics covered in the stories are indicated by interview keywords (e.g., ATC in Japan/UK, level of controller experience). Some stories describe a specific incident; others are an amalgam of multiple experiences. Each story was triggered by discussion of a particular communication factor. Here are some examples:

- Accent – the difficulty that British pilots have understanding the accents of Russian controllers;
- Call sign confusion – a Japanese controller used the wrong call sign several times for a British aircraft descending to Haneda International Airport;
- Code switching – French controllers switching between English and French when speaking to aircraft in busy airspace;
- Face – a Hong Kong Chinese pilot who was training in the UK maintained he understood ATC instructions despite attempting to land on a closed section of runway;
- Plain language – pilots using plain language to speak to tug drivers at airports in the UK and China;
- Pronunciation – the difficulty that British pilots have pronouncing place names when overflying Russia;
- Pronunciation – a British flight crew were not able to understand a key word in a message from a Japanese controller during the approach to Haneda International Airport in Tokyo;
- Rate of speech – the high rate of speech of controllers in India;
- Speech community – differences in informal norms for saying call signs between controllers in Canada and the US.

An interesting theme to emerge during the interviews is the suggestion that some factors are more likely to occur in certain countries or regions of the world. For instance, the KI stated that he often heard code switching in France, or encountered controllers with a high rate of speech in India. In the following excerpt, he outlines a specific risk posed by code switching:

> For some reason, France, the local traffic... even in TMAs [terminal manoeuvring areas] and airways traffic they [controllers] will still talk to some of the French traffic in French... It's quite frustrating. You can easily imagine a scenario where in poor visibility someone is cleared to land, contradicting your clearance to line up and take

off, but they've been cleared to land in a foreign language and you as you line up, if the transmission had been made in English, you'd pick it up and you'd hold position, but if the incorrect clearance to land is made in a foreign language, you're doomed. (Interview 4)[45]

Some of the KI's stories illustrate how factors combine to increase the risk of communication problems. In the following example, the interaction of workload and rate of speech leads to the situation worsening:

> It tends to happen where there is a high workload in the first place, so a high rate of speech causes communication difficulties, [and it] just increases everyone's workload. And in certain countries, India being the one that most obviously springs to my mind, when the controller's workload is going up, his speech rate tends to go up, which just exacerbates the entire rate of speech issue. (Interview 3)

One way for pilots to mitigate risks is to discuss possible threats during briefings. When flying to Asia, the KI and his crew often discuss threats related to communication problems as they start the descent to their destination:

> Usually into Asia one of the first comments anyone makes is communication difficulties causing controlled flight into terrain or mid-air collision. And so as part of our process to avoid, trap and mitigate threats we talk about how to avoid the threat of a communication problem becoming a bigger problem and that is to do with resolving ambiguity. And that's sometimes easier said than done. (Interview 2)

The latter excerpt was part of a discussion about ambiguity. It led to a talk about two other factors: the limited English vocabulary of some controllers in China, and the pronunciation of controllers in Japan. This discussion, and the previous excerpt about the interaction of workload and rate of speech, aptly illustrate how interconnected the factors are in actual language use.

[45] Code switching was identified as a causal factor in the 2000 runway collision in Paris and the 2001 runway collision in Milan (BEA, 2001; ANSV, 2004).

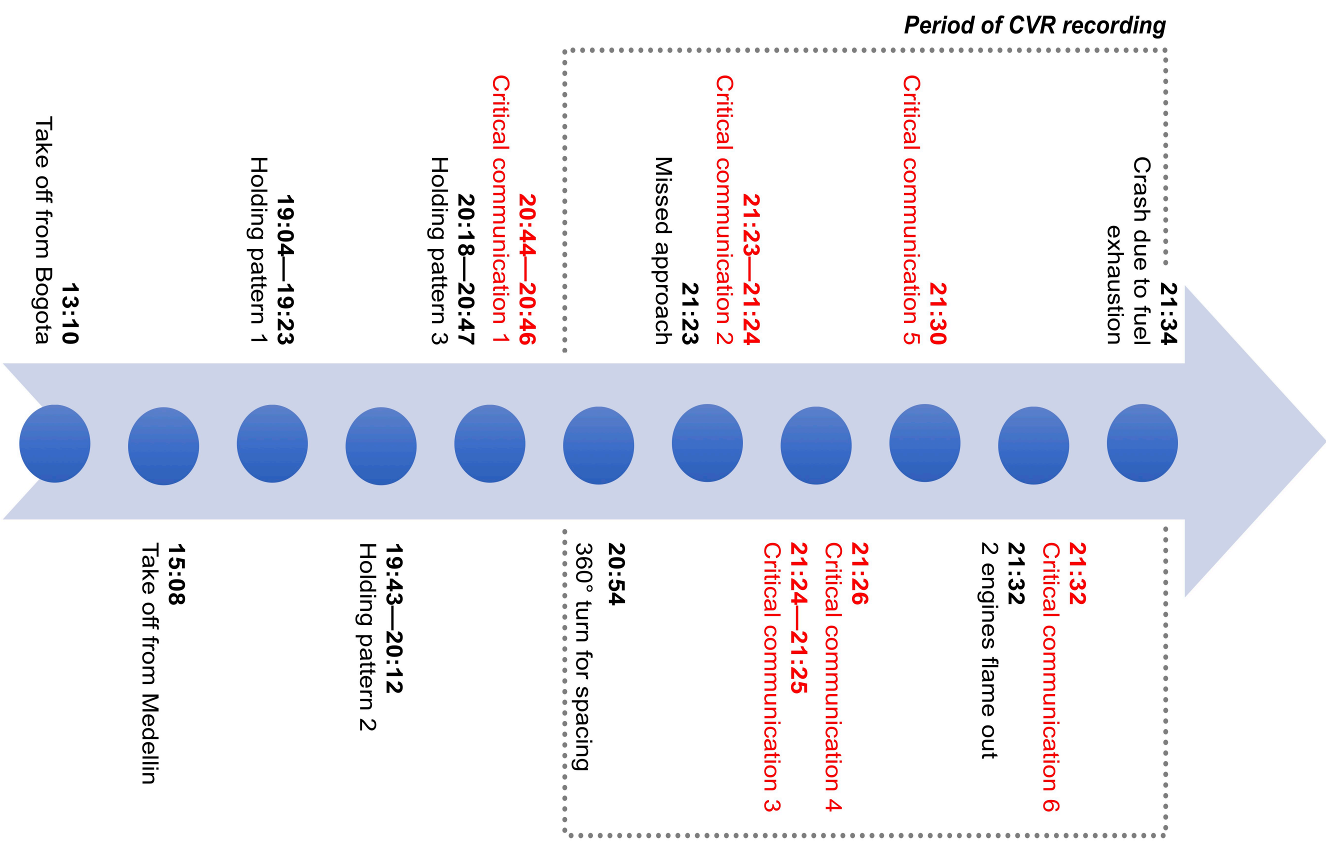
7.2.2 RQs E-H & Communication Factors

As explained in Section 6.2.1, the research questions for Stage Two (RQs E-H) were derived from Document 9835, the official guide to the ICAO language proficiency programme. During the analysis of the Avianca 052 accident, it was evident that multiple research questions were interwoven in each of the transcript excerpts examined. Therefore, for clarity, the findings are presented in two parts: Section 7.2.3 addresses the recurring communication phenomena, and Section 7.2.4 reports on critical communications.

The analysis draws on CA techniques, the grammar of context framework and the ACT glossary. When communication factors from the ACT glossary are first cited in a section, they are highlighted (e.g., idiom). Glossary entries for the factors are reproduced in Appendix 14. The correspondence between RQs E-H and the factors is as follows:

- RQ E – this question addresses standard phraseology;
- RQ F – this question addresses plain language;
- RQ G – this question addresses code switching;
- RQ H – this question addresses the remaining factors.

Figure 20: Timeline of Avianca Flight 052 on 25th January 1990. All times are EST.



The timeline in Figure 20 shows key events during the flight of Avianca 052 on 25th January 1990. Both parts of the accident analysis use data from the CVR and ATC transcripts in the NTSB report. As noted in Section 3.8.1, CVR devices have a limited recording duration. For the Avianca 052 accident, the CVR recording only covered the final 40 minutes of the flight, from 20:53 to 21:34 EST, as shown on the timeline.

7.2.3 Recurring Phenomena in the Avianca 052 Accident

In this part of the analysis, the CA technique of unmotivated looking was used to identify three communication phenomena that recurred throughout the transcripts:

- Repetition – the Avianca captain repeatedly requested confirmation of the same item of information (Section 7.2.3.1);
- Code switching – the Avianca first officer frequently switched languages and registers during dialogue with ATC and other crew members (Section 7.2.3.2);
- Style shifting – the final vector (FV) controller alternated between different language styles depending on the pilot he was addressing (Sections 7.2.3.3 and 7.2.3.4).

The following sections present the results for each of these communication phenomena.

7.2.3.1 Repetition: Language Use of the Avianca Captain

Analysis of the transcript data revealed a recurring phenomenon of interest in the communication of the Avianca captain. Following an ATC message containing numerical information, the captain would repeatedly request confirmation of the information. This pattern of repetition recurred throughout the CVR transcript. It is illustrated by the excerpt shown in Table 10.

There are four speakers in the excerpt: the New York CAMRN approach controller (APP), the Avianca captain, the first officer (FO) and the flight engineer (FE). The crew of Avianca 052 (AVA052) were seated in the cockpit of their aircraft, which was flying at an altitude of 7,000 feet. The captain was flying the plane and the first officer was responsible for radio communication with ATC. The APP controller was in the New York TRACON ATC facility and was responsible for the aircraft flying through his sector of airspace (see Appendix 15). During this period the controller contacted three other planes, but those transmissions were not included in the CVR transcript.

Table 10: Excerpt from AVA052 CVR recording (20:54-20:56).

TIME	SPEAKER	CONTENT [46]
20:54:40	APP (radio)	Avianca zero five two turn right right turn heading two two zero I'm gunna have to spin you sir
20:54:45	FO (radio)	okay heading two two zero avianca zero five two
20:54:49	Captain	*dos veinte*[47] [two twenty]
20:54:50	FO	*dos veinte* [two twenty]
20:55:07	Captain	*cuanto* [how much]
	FO	*dos veinte* [two twenty]
20:55:08	Captain	*dos veinte* [two twenty]
20:55:09	FO	*dos veinte si senor* [two twenty sir]
20:55:54	APP (radio)	Avianca zero five two traffic in your turn twelve thirty five miles eastbound at six thousand
20:55:59	Captain	no contact – *ah si ahi esta* [no contact - - okay we have it]
20:56:00	FO (radio)	Avianca we have the traffic in sight thank you
20:56:05	FE	[unintelligible]
20:56:07	Captain	*seis mil* [six thousand]
20:56:13	Captain	*dos veinte no* [two twenty no]
20:56:14	FO	*dos veinte* [two twenty]

The dialogue is in two languages. English was used for radio transmissions and the Colombian crew of the Avianca aircraft talked to each other in Spanish. In Table 10 the Spanish speech is shown in italics, followed by the English translation from the transcript

[46] There are discrepancies between the radio transmissions in the CVR and ATC 3 transcripts. The ATC 3 transcript has the words "I'm **going to** have to spin you sir" at 20:54:40, and "thirty **and** five miles" at 20:55:**52**. It also has an extra transmission by the controller at 20:56:01: "Roger".

[47] In the CVR transcript this line is "doe veinte". I changed it to "**dos** veinte" on the assumption it was a typographical or scanning error.

in brackets. At 20:54:40, the controller instructed AVA052 to make a 360-degree turn for spacing. The instruction is marked because it was realised in a familiar key and the controller used plain language with pronouns, colloquialism and an idiom: "**I'm gunna** have **to spin you** sir".

The first officer read back the instruction to the controller at 20:54:45 ("heading two two zero"). Then code switching occurred at 20:54:49 as the captain said the heading in Spanish ("dos veinte"). From this point until the end of the excerpt, there were seven instances of repetition of the heading by the captain and first officer. Including the question from the captain at 20:55:07 ("cuanto"), the pilots produced eight utterances to confirm a single item of information: the heading of 220° given by the controller. These utterances took the form of a series of question-answer adjacency pairs. In each pair of utterances, the captain asked for confirmation of the heading (e.g., "dos veinte" at 20:55:08) and the first officer answered ("dos veinte si senor").

The repetition shown in Table 10 occurred near the start of the period covered by the CVR. The pattern recurs throughout the CVR transcript. There are seven occasions where the captain repeatedly asked for confirmation of a heading change following an ATC message: confirming the seven items of information took a total of 35 utterances. There are two other occasions where he similarly requested confirmation of airspeed or wind information: these involved a further 17 utterances.

The Table 10 excerpt also provides evidence regarding the English proficiency of the Avianca captain. It is clear that he was monitoring radio transmissions (which were in English) because he responded to both messages before the first officer could translate them. At 20:54:49, the captain translated the new heading directly after the first officer's read-back, and at 20:55:59 he searched for and located the other aircraft ("the traffic") immediately after the transmission from the approach controller.

7.2.3.2 Code Switching: Language Use of the Avianca First Officer

The second recurring phenomenon of interest was code switching involving the Avianca first officer. This continued throughout the CVR transcript and had presumably been present for most, if not all, of the flight. It is illustrated by a two-minute segment of communication which is reproduced in Appendix 16. The segment is a composite made using data from the CVR, ATC 3 and ATC 4 transcripts. It shows all the communication that the first officer engaged in, or could hear, from 21:02 to 21:04 EST. This allows us to examine how the Avianca crew integrated radio messages (in English) with intracockpit dialogue (in Spanish).

The segment chosen is one minute either side of AVA052 entering a new sector of airspace. There are multiple participants in the dialogue, including two controllers and the crew members of six aircraft, as detailed in Appendix 16. There are also non-speaking participants who are not addressed in the dialogue but overhear it because they are in the same region of airspace and share a common radio frequency. At the start of the segment the Avianca first officer was in contact with the New York CAMRN approach controller (APP). Then the aircraft entered a new sector and was handed over to the final vector (FV) controller. The change in radio frequency for the new sector resulted in a change in the participants that the first officer was interacting with.

The Avianca first officer was responsible for talking with ATC and therefore had to monitor radio transmissions as well as listen to dialogue within the cockpit. Pilots of five other aircraft were communicating with the controllers during this segment. The Avianca first officer could listen to these exchanges for so-called "party line" information about, for example, weather conditions, runways and traffic flow.

During the two-minute period, there were 21 instances of code switching between English and Spanish. These were not evenly distributed: there were only four instances in the first half of the segment compared with 17 in the second half. This discrepancy was probably partly due to a two-minute ATIS broadcast that was playing until 21:02:31, with information about weather and runways at JFK International Airport. It was also partly due to the plane entering a new airspace sector halfway through the segment. Throughout the CVR transcript there is an uneven distribution of code switching. Bursts of intense switching between English and Spanish are interspersed with periods in which it was infrequent.

Most code switching in the segment was intersentential. Some instances were the result of routine flight tasks. As shown in Appendix 16, a six-turn exchange between the captain and first officer (in Spanish) starting at 21:02:29 was interrupted at 21:02:38 by a message from the approach controller (in English) instructing the crew to contact Kennedy Tower. Also, following radio exchanges (in English), the captain requested (in Spanish) that heading information be repeated at 21:02:59, and the first officer directly translated information (into Spanish) for the captain at 21:03:18.

Several instances of intrasentential code switching occurred near the end of the segment when the flight engineer inserted technical English phrases (e.g., "go around procedure") into a Spanish-language briefing at 21:03:56. The captain had difficulty understanding one of the phrases ("nose up attitude"), so the first officer repeated it in English followed by a Spanish translation at 21:04:10.

In addition, there were instances of code switching between standard phraseology and plain language. Much of this was intersentential code switching that coincided with the switching between English and Spanish because the radio communications (in English) featured a lot of phraseology while the intracockpit dialogue (almost all in Spanish) was mainly plain language. For example, after a standard phraseology read-back from the Avianca first officer to the controller at 21:02:29, the captain said "eh Ave Maria pues" ("eh Hail Mary then"). This colloquialism from the captain triggered a plain language exchange between him and the first officer.

Another instance occurred as AVA052 was about to change sector. The approach controller signalled the closure of communications in the first sector by sending a standard phraseology message at 21:02:38 telling the aircraft the new radio frequency. The first officer read back the frequency at 21:02:42. The controller repeated the instruction in a transmission marked by its message length at 21:02:44. In this message he switched codes to insert a 42-token plain language warning about wind shear (starting "and before you go..."). The insert is marked by the use of complete sentence structures with plain language features that are omitted in standard phraseology: a copula verb ("is"), articles ("a" and "an"), a subject pronoun ("it"), and prepositions ("on", "at" and "by"). It may be inferred that the insert represents a change of mode from spoken phraseology to spoken written speech. In other words, the controller changed roles from speaker (at the start of the transmission) to addressor (as he read out a pre-scripted wind shear warning). At the end of the message he changed back to speaker again when he repeated the frequency and added a plain language phatic expression ("good night").[48]

Communication was very dense during the two-minute segment in Appendix 16. There were 41 turns in slightly more than two minutes, which equates to approximately one turn every three seconds. In addition, the ATIS broadcast was playing in the cockpit until 21:02:31. Intracockpit dialogue accounted for 46% of the turns. All three members of the Avianca flight crew participated: the captain and flight engineer had six turns each and the first officer had seven. The mean turn length in the intracockpit dialogue was 5.32

[48] The ATC 3 transcript shows the approach controller gave similar wind shear warnings to other aircraft at 20:53:55, 20:56:15, 21:04:00 and 21:07:05.

tokens. The captain's utterances were very short, with a mean length of only 2.83 tokens. The longest turn (24 tokens) was spoken by the flight engineer as he read aloud part of the go around procedure for a low fuel situation at 21:03:56.

Radio transmissions accounted for 54% of the turns in the segment, with eight different speakers. The approach controller had six turns while the FV controller and the Avianca first officer had five each. The other pilots only spoke once or twice. The mean turn length was longer for radio messages (12.45 tokens) than for intracockpit utterances, the longest turn (53 tokens) being the last transmission from the approach controller to Avianca 052 at 21:02:44 in which he warned about wind shear.

A final point about this segment concerns the translation of Spanish dialogue. During the analysis it became clear that there were discrepancies in the English translation provided in the CVR transcript. For example, the Spanish words "es", "uno" and "un" in the utterance at 21:03:46 were not translated into English. I therefore asked a bilingual English-Spanish speaker to make a new translation of the Spanish dialogue in the segment. The new version is shown in Appendix 17. There are a considerable number of differences between the two versions, highlighting shortcomings in the English translation that was provided in the NTSB report. The following are some of the inaccuracies in the English translation in the CVR transcript:

- 21:02:37: extra "feet" added at the end of the utterance;
- 21:03:46: "es", "uno" and "un" not translated; only one "con" translated;
- 21:03:56: "alteraciones" translated as "accelerations" instead of "changes";
- 21:04:10: extra "hold" added at the end of the utterance.

7.2.3.3 Style Shifting 1: Language Use of the FV Controller with AAL692

The final recurring phenomenon of interest to be identified in the transcripts was style shifting by air traffic controllers. The style shifting is illustrated by examining the radio communication of the final vector (FV) controller as he dealt with 11 aircraft during a 20-minute period of activity from 20:58 to 21:18 EST.[49] This section of the analysis uses the ATC 4 transcript from the NTSB accident report, which was transcribed from audio recorded at the New York TRACON ATC facility.

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[49] In the ATC transcripts, all times are expressed as UTC. For the analysis I converted them to EST, which was the time zone for JFK. EST is five hours behind UTC.

The FV controller was 33 years old (see Appendix 15 for more details). He was responsible for guiding aircraft through his sector before handing them over to the tower controller for landing at JFK International Airport. During this 20-minute period, seven of the 11 aircraft were operated by American companies: American Airlines, Pan Am, TWA and US Airways. They had flight crews who were native English speakers (NESs). The remaining four aircraft were from France, Israel and South America, with crews who were largely or completely non-native speakers (NNSs) of English.

Adverse weather conditions were causing considerable congestion and delays in the air transport system. As a result two aircraft in the sector were running critically low on fuel: American Airlines Flight 692 (AAL692) and Avianca Flight 052 (AVA052). The American Airlines jet was ahead of the Avianca plane. Both planes were being handled by the same controller and were experiencing the same non-routine situation: a fuel shortage problem. This section of the analysis focuses on the language use of the FV controller as he handled AAL692 during its flight through the sector. The next section focuses on the language use of the controller as he handled AVA052.

No information is available about the crew of AAL692. The aircraft had left the previous sector at 20:42 and it is reasonable to assume it contacted the FV controller soon after. However, the ATC 4 transcript does not begin until 20:58, and therefore it does not include the initial contact (and possibly some subsequent communication). There are 11 exchanges between the controller and this American Airlines aircraft in the transcript. The first exchange is shown in Table 11.

The exchange is marked both in terms of its length and also the sequence of the speech acts. There were seven turns, whereas the other exchanges between this aircraft and controller had only two or three turns. By comparison, all except one exchange between the FV controller and Avianca 052 consisted of two turns. One reason for the length of the Table 11 exchange is that two separate interactions ran together without a break. The first was a three-turn pilot-controller-pilot exchange, starting at 20:59:17, in which the pilot expressed dissatisfaction with the assigned altitude. This was immediately followed by a controller-pilot-controller-pilot exchange, from 20:59:29, in which the controller gave an instruction to climb.

The pilot did not adhere to standard phraseology in his use of numbers for the aircraft call sign. He said “six **ninety**-two” at 20:59:26 and 20:59:36 as opposed to the standard “six niner two”. He did this consistently throughout the other exchanges in this transcript, whenever he gave the call sign. In addition, at the start of the first utterance in

Table 11 there was a partial call sign ("**Ø** Ninety two" at 20:59:17) indicating that microphone clipping might have occurred.

Table 11: Exchange 1 between AAL692 and FV controller (20:59).

TIME	SPEAKER	CONTENT
20:59:17	AAL692 (radio)	Ninety two very unhappy at two thousand feet
20:59:20	FV (radio)	American six ninety two New York I understand maintain two thousand fly heading one uh one four zero for now
20:59:26	AAL692 (radio)	Okay one forty at two thousand American six ninety two
20:59:29	FV (radio)	American six ninety two climb and maintain three thousand you're number five I'll make sure you get a lot of room there
20:59:36	AAL692 (radio)	Maintain three thousand you say three thousand American six ninety two
20:59:39	FV (radio)	Affirmative sir
20:59:40	Unknown	Alright

Similarly, the controller used the same non-standard call sign in this and all other exchanges with AAL692. In transmissions to other American aircraft during the 20-minute period, he used similar non-standard number contractions that combined the final two digits of the call sign (e.g., U.S. Air Flight 117 became "US Air one **seventeen**"). The one exception was Trans World Airlines Flight 801. The contraction pattern was not possible because of the zero in the middle position, so he either said "TWA eight zero one heavy" or "TWA eight oh one heavy".

For the call signs of non-American aircraft, the controller adopted two different approaches. For Avianca Flight 052 and Air France Flight 26 he followed standard phraseology in reading out the digits individually. However, in all five exchanges with Avensa Flight 520, he used the non-standard phrase "Avensa five **twenty**". Possibly this was to avoid confusion with the similar-sounding Avianca Flight 052. The controller also used non-standard numbers for El Al Flight 842. At first he mistakenly called it "El Al eight **fifty** two heavy", perhaps due to interference from an altitude ("five thousand") and the call-sign in the next transmission ("Avianca zero five two heavy"). Subsequently he referred to the aircraft as "El Al eight **forty** two heavy".

At 20:59:26 in Table 11, the pilot also read back the heading using a non-standard contraction ("one **forty**" instead of "one four zero"). In later exchanges, the pilot read back some headings with numbers in the correct format but in other cases used non-standard contractions (e.g., Table 19 at 21:09:59). The key of some of the plain language used by the pilot is marked as familiar speech: "very unhappy" at 20:59:17, "Okay" at 20:59:26, "you say" at 20:59:36, and "Alright" at 20:59:40. None of these expressions were used by other speakers during this period. As a further note, the source of the final transmission ("Alright") is designated as unknown in the transcript but, given the timing and content, it is reasonable to assume it was the American Airlines pilot.

The plain language used by the controller is marked as it featured pronouns and colloquialism, and was in a helpful key: "**I understand**" at 20:59:20, and "**I'll make sure you** get a lot of room there" at 20:59:29. In two subsequent transmissions to this aircraft the controller again used the word "understand" (Table 13 at 21:02:08 and Table 17 at 21:06:18). He did not use it with other flights. The controller was deferential to the pilot, addressing him as "sir" at 20:59:39 in Table 11. During the 20-minute period, the address "sir" was used five times by the controller and two times by pilots.

In the next exchange, shown in Table 12, the controller issued a new heading instruction to the American Airlines aircraft. In his read-back at 21:01:47, the pilot added the preposition "to" before the heading, which is non-standard and introduces ambiguity due to possible confusion with the homophone "two". In later heading changes, the pilot inserted "to" on two further occasions (Table 16 at 21:05:23 and Table 19 at 21:09:59). During this period, two other American aircraft did likewise (TWA Flight 801 and American Airlines Flight 40) but none of the non-American flights did so.

Table 12: Exchange 2 between AAL692 and FV controller (21:01).

TIME	SPEAKER	CONTENT
21:01:42	FV (radio)	American six ninety two turn left heading zero six zero
21:01:47	AAL692 (radio)	Left to zero six zero american six ninety two

In the dialogue in Table 13, the AAL692 pilot used plain language at 21:02:00 to notify the controller of his aircraft's fuel problem: "I want to advise you we're at minimum fuel". He did not declare an emergency but instead warned one was imminent: "we're uh about uh twelve or fourteen minutes from declaring an emergency". The function of this transmission was to share information predicting a future problematic event. It is not clear whether the pilot had previously notified the controller about the fuel problem.

Once again, the controller's speech in this and the following exchange is marked. He used plain language that featured pronouns and colloquialisms in a helpful key: "**I understand**" and "**you're** number four with **me**" at 21:02:08 in Table 13; and "**I'm** going to take **you** another eight miles where **you** are then turn **ya** to the final" at 21:02:36 in Table 14.

Table 13: Exchange 3 between AAL692 and FV controller (21:02).

TIME	SPEAKER	CONTENT
21:02:00	AAL692 (radio)	American six ninety two I want to advise you we're at minimum fuel uh we're uh about uh twelve or fourteen minutes from declaring an emergency
21:02:08	FV (radio)	I understand uh you're number four with me sir
21:02:11	Unknown	Ok

Table 14: Exchange 4 between AAL692 and FV controller (21:02).

TIME	SPEAKER	CONTENT
21:02:36	FV (radio)	American six ninety two I'm going to take you another eight miles where you are then turn ya to the final
21:02:42	Unknown	Roger

The exchange in Table 13 was closed with a non-standard transmission (again assumed to be the AAL692 pilot) in a casual key: "Ok" at 21:02:11. Similarly, the final transmission in Table 14 (also assumed to be from the same pilot) acknowledged receipt of the message ("Roger" at 21:02:42) but did not confirm the content.

Crucially, Avianca Flight 052 had not yet entered the sector at this time. As a result the Avianca crew were not tuned to the radio frequency and were unable to hear the Table 13 exchange in which the American Airlines pilot described his fuel problem.

The next two exchanges had the same structure and function, with the controller issuing new headings. However, the pilot read back the information in different ways. In Table 15, the pilot repeated the heading correctly but there is omission of the word "left" (at 21:04:36). In Table 16, by contrast, his read-back is marked by the insertion of the preposition "to" and the use of a non-standard heading contraction ("two **seventy**" instead of "two seven zero" at 21:05:23).

Table 15: Exchange 5 between AAL692 and FV controller (21:04).

TIME	SPEAKER	CONTENT
21:04:33	FV (radio)	American six ninety two turn left heading three two zero
21:04:36	AAL692 (radio)	Three two zero American six ninety two

Table 16: Exchange 6 between AAL692 and FV controller (21:05).

TIME	SPEAKER	CONTENT
21:05:20	FV (radio)	American six ninety two turn left heading of two seven zero
21:05:23	AAL692 (radio)	Left to two seventy American six ninety two

The exchange in Table 17 is marked by the controller using plain language to request information about the status of the American Airlines aircraft. The request was realised in a familiar key using colloquial speech including an idiomatic phrasal verb: "how are we **making out**" at 21:06:12. This was the only such inquiry made by the controller during the 20-minute period. In similar fashion, the pilot's response is marked by the use of plain language using colloquial speech with the idiom "that's it" to mean "that's all we have" at 21:06:15. This exchange is also marked by the controller's use of the first person plural pronoun "we" (at 21:06:12). Previously he had only used singular pronoun forms: "I", "me", "you" and "ya" (in Tables 11, 13 and 14).

Having joined the radio frequency at 21:03:07, the crew of Avianca Flight 052 could have heard the Table 17 exchange about the fuel problem of the American Airlines aircraft. This exchange was initiated by the controller, not by the pilot. The inexperienced Avianca first officer might have assumed that the controller, having checked the fuel status of AAL692, was going to do the same for his aircraft. To reiterate, the Avianca first officer had not been able to hear the earlier exchanges in Tables 11 and 13 that were initiated by the American Airlines pilot.

Table 17: Exchange 7 between AAL692 and FV controller (21:06).

TIME	SPEAKER	CONTENT
21:06:12	FV (radio)	American six ninety two how are we making out
21:06:15	AAL692 (radio)	We got enough fuel for the approach and landing and that's it
21:06:18	FV (radio)	Ok understand

In Table 18, the controller requested that the American Airlines aircraft fly at 160 knots. The pilot's response is marked because he did not read back the speed, but simply acknowledged receiving the message ("roger" at 21:08:20). The controller issued speed instructions to five other aircraft during this period, all of which read back the speed: Pan Am Flight 474, Avensa Flight 520, Avianca Flight 052, TWA Flight 80 and American Airlines Flight 40.

Table 18: Exchange 8 between AAL692 and FV controller (21:08).

TIME	SPEAKER	CONTENT
21:08:16	FV (radio)	American six ninety two speed one six zero if practical
21:08:20	AAL692 (radio)	American six ninety two roger

In the Table 19 exchange, the controller's transmission at 21:09:50 is marked by the message length. It included a heading change, position information, an altitude instruction and clearance for the final approach to Runway 22L. The pilot's read-back of the new heading was again non-standard: he inserted the preposition "to" and contracted the heading ("two **ten**" as opposed to "two one zero" at 21:09:59).

Table 19: Exchange 9 between AAL692 and FV controller (21:09).

TIME	SPEAKER	CONTENT
21:09:50	FV (radio)	American six ninety two turn left heading two one zero you're one three miles from outer marker maintain two thousand till established localizer cleared ILS two two left
21:09:59	AAL692 (radio)	Turning to two ten uh two thousand feet cleared the ILS two two left American uh six ninety two

In the exchange in Table 20, the controller gave information at 21:10:48 about the separation between AAL692 and the preceding aircraft (a Boeing "seven two seven"). The transcript shows no request for information. The FV controller gave similar, albeit simpler, information on one other occasion, following a request from US Airways Flight 117.

Table 20: Exchange 10 between AAL692 and FV controller (21:10).

TIME	SPEAKER	CONTENT
21:10:46	Unknown	Blocked
21:10:48	FV (radio)	American six ninety two you're six miles behind a seven two seven compatible speed
21:10:53	Unknown	Thank you

The source of the transmission "Blocked" at 21:10:46 in Table 20 is designated "unknown" in the transcript. Presumably one of the pilots in the sector was signalling a blocked transmission.[50] It is possible that the American Airlines pilot requested separation information, but his message was garbled or blocked due to simultaneous transmissions. The source of the message at 21:10:53 is also designated “unknown” in the transcript. It is reasonable to assume the speaker was the American Airlines pilot closing the exchange with a polite, non-standard expression: “Thank you”.

Table 21 shows the final exchange between the FV controller and AAL692 before the aircraft left the sector. At 21:12:01, the controller instructed the American Airlines pilot to contact Kennedy Tower and gave him the new radio frequency. He finished with the phatic expression “good evening”, signalling the imminent departure of the aircraft. This transmission is marked by the insertion of a deferential expression following the call sign: “again thank you for your cooperation”. During the 20-minute period, the controller gave this type of final instruction to seven aircraft. In only one other case did he insert an expression of gratitude, appending “thanks for your help” to a transmission to Pan Am Flight 474.

Table 21: Exchange 11 between AAL692 and FV controller (21:12).

TIME	SPEAKER	CONTENT
21:12:01	FV (radio)	American six ninety two again thank you for your cooperation contact Kennedy Tower one one niner point one good evening
21:12:07	AAL692 (radio)	Teen one American six ninety two [unintelligible]

The final message from the AAL692 pilot to the FV controller seems to feature microphone clipping of a non-standard number contraction: “**Ø teen** one” instead of the standard “one one niner point one” at 21:12:07. The ending of the transmission was unintelligible to the transcriber.

[50] Simultaneous transmissions block all or part of a message. The CAA Radiotelephony Manual advises pilots or controllers to “draw attention to the situation using the word ‘blocked’” (CAA, 2015, p. 2-31).

7.2.3.4 Style Shifting 2: Language Use of the FV Controller with AVA052

This section examines the language use of the FV controller as he handled Avianca Flight 052 (AVA052). The 28-year old first officer was handling radio communications for the Avianca aircraft. This section of the analysis is based on the ATC 4 transcript and the Avianca CVR transcript. Discrepancies between the transcripts are detailed in footnotes. The CVR transcript is a partial transcription of the audio recording: it includes all of the intracockpit dialogue but not all radio communications. From the start of the recording until 21:15:19 only radio transmissions involving AVA052 were transcribed. After this time, all radio transmissions in the sector were included.

AVA052 left the previous sector at 21:03 and contacted the FV controller at 21:03:07, which was after the initial contact of AAL692. This meant that the Avianca crew did not hear the AAL692 pilot report his fuel problem in the transmission shown in Table 13. There are ten exchanges between the FV controller and AVA052 in the transcript, five of which are reproduced in this section.

The first exchange is shown in Table 22. The controller signalled the aircraft's entry to the sector with the plain language phatic expression "good evening" at 21:03:11. He welcomed four other aircraft with the same expression in the 20-minute period: Trans World Airlines Flight 801, American Airlines Flight 40, El Al Flight 842 and American Airlines Flight 4.

Table 22: Exchange 1 between AVA052 and FV controller (21:03).

TIME	SPEAKER	CONTENT
21:03:07	AVA052 (radio)	New York approach Avianca zero five uh two leveling five thousand
21:03:11	FV (radio)	Avianca zero five two heavy New York approach good evening fly heading of zero six zero [51]
21:03:16	AVA052 (radio)	Zero six zero Avianca zero five two heavy [52]

[51] In the CVR transcript "heading of' is changed to "heading".

[52] In the CVR transcript "Zero six zero" is changed to "heading zero six zero".

The pilot identified his aircraft as “Avianca zero five uh two” at 21:03:07, with omission of the word “heavy”. The controller corrected the call sign to “Avianca zero five two **heavy**” 21:03:11 and the pilot accepted the correction in his read-back at 21:03:16. The Avianca pilot adhered to standard phraseology and used the correct call sign in all subsequent exchanges. The transcript recorded a similar contact with El Al Flight 842 in which the pilot omitted the “heavy” designation and was corrected by the controller. The El Al pilot continued to omit the word “heavy” in this and subsequent exchanges.

In the next three exchanges, the controller issued instructions to change heading. Both the controller and the Avianca pilot adhered to standard phraseology. Table 23 shows the first of the exchanges. After each heading instruction, the pilot’s read-back included the words “Left heading” (as shown at 21:05:16). This is consistent with other exchanges in the transcript. The words “Left heading” or “Heading” were used by all the non-American aircraft: Air France Flight 26, Avensa Flight 520, Avianca Flight 052 and El Al Flight 842. None of the seven American aircraft used the word “heading” in their read-backs; they instead said “left” or “left to”, or simply read back the numbers.

Table 23: Exchange 2 between AVA052 and FV controller (21:05).

TIME	SPEAKER	CONTENT
21:05:12	FV (radio)	Avianca zero five two heavy turn left heading three six zero
21:05:16	AVA052 (radio)	Left heading three six zero Avianca zero five two heavy

Table 24: Exchange 3 between AVA052 and FV controller (21:08).

TIME	SPEAKER	CONTENT
21:08:34	FV (radio)	Avianca zero five two heavy descend and maintain uh descend and maintain three thousand
21:08:40	AVA052 (radio)	Descend and maintain three thousand Avianca zero five two heavy [53]

[53] The ATC 4 transcript has the words “**n**aintain” and “**X**vianca” in this line. I corrected them to “**m**aintain” and “**A**vianca” on the assumption that they were typographical or scanning errors.

In the exchange in Table 24, the controller issued an instruction to change altitude. He made a self-initiated repair at 21:08:34, signalled by the hesitation token “uh”, with a partial repeat (of the phrase “descend and maintain”) before completing the utterance.

In the next exchange, the controller issued a further heading change instruction. Then he gave another heading change instruction to bring the aircraft in line with the localizer beam, as shown in the Table 25 excerpt.

Table 25: Exchange 4 between AVA052 and FV controller (21:10).

TIME	SPEAKER	CONTENT
21:10:26	FV (radio)	Avianca zero five two heavy turn left heading two five zero intercept the localizer
21:10:31	AVA052 (radio)	Heading two five zero intercept the localizer Avianca zero five two heavy

The pilot omitted “left” from the read-back at 21:10:31 in Table 25. The reason may have been because he had to process a more complex instruction (including “intercept the localizer”) than the previous four heading changes (e.g., Table 23). This is consistent with other instances involving non-American crews during the 20-minute period: Avensa Flight 520 and El Al Flight 842 both used “Left heading” in read-backs of simple heading change instructions, but Air France Flight 26, Avensa Flight 520 and El Al Flight 842 simply said “Heading” when the instruction was more complex.

In the next two exchanges, the controller first gave AVA052 clearance for the final approach, and then requested that the aircraft fly at 160 knots in order to maintain spacing during the approach.

The final exchange between AVA052 and the FV controller is shown in Table 26. At 21:15:08 the controller instructed the pilot to contact Kennedy Tower and gave him the new frequency. The controller ended his message with the phatic expression “good day”, signalling the aircraft’s departure from the sector. The controller also used “good day” when two other non-American aircraft departed: Air France Flight 26 and Avensa Flight 520. He used “good evening” when three American aircraft departed: Pan Am Commuter Flight 793, Pan Am Flight 474 and American Airlines Flight 692. In the case of U.S. Air

Flight 117, the controller first used "good day" then added "good night" in response to the pilot's use of that expression.

Table 26: Exchange 5 between AVA052 and FV controller (21:15).

TIME	SPEAKER	CONTENT
21:15:08	FV (radio)	Avianca zero five two heavy contact Kennedy Tower one one niner point one good day
21:15:12	AVA052 (radio)	One one niner point one so long

At 21:15:12 the Avianca pilot read back the new frequency ("One one niner point one"). He ended with a colloquialism: the phatic expression "so long". Compared with the transmissions of other crews in the transcript, this is marked as a familiar key.[54] During the 20-minute period, most aircraft responded with more formal expressions: Air France Flight 26 used "good day", U.S. Air Flight 117 said "good night", Pan Am Commuter Flight 793 and Avensa Flight 520 said "good night sir", Pan Am Flight 474 did not use any phatic expression, and for American Airlines Flight 692 the ending was unintelligible.

The exchange shown in Table 26 was the last communication between AVA052 and the FV controller before the aircraft's first approach. They later resumed contact after the missed approach.

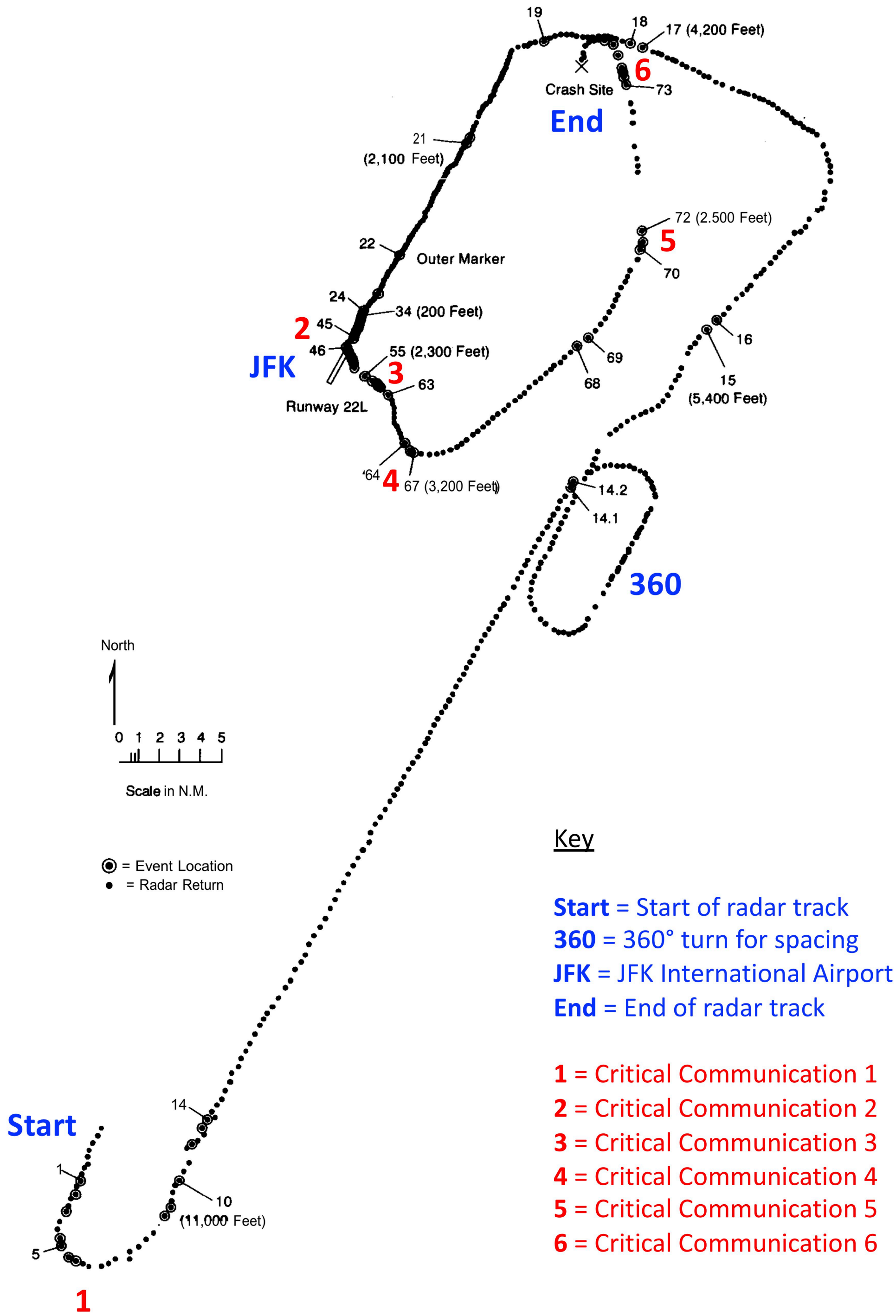
7.2.4 Critical Communications in the Avianca 052 Accident

Using the CA techniques of unmotivated and motivated looking, I identified six critical communications in the flight of Avianca 052. Each of the critical communications included one or more transmissions relating to the fuel situation of the Avianca aircraft. These key periods of interaction are represented by excerpts of dialogue from the CVR and ATC transcripts. The excerpts were closely analysed using CA techniques, the grammar of context framework and the ACT glossary. The critical communications are highlighted in

[54] According to the CVR transcript, the Avianca first officer also said "so long" twice when leaving the CAMRN sector at 21:02:42 and 21:02:56. Only the first is recorded in the ATC 3 transcript.

red on the Figure 20 timeline. As indicated on the timeline, the first critical communication was not covered by the CVR recording. Figure 21 shows approximate locations where the critical communications occurred on a radar track of the final stage of the flight.

Figure 21: Radar track of the final stage of Avianca Flight 052. Adapted from a public domain image in NTSB (1991, p. 3).



7.2.4.1 Critical Communication 1

The first critical communication occurred while AVA052 was waiting in the third holding pattern. The aircraft was flying an oval-shaped course at an altitude of 11,000 feet at the CAMRN intersection, 39 nautical miles south of JFK. The communication involved the Avianca first officer and the R67 controller in the New York ARTCC control center. Table 27 shows an excerpt of radio dialogue taken from the ATC 1 transcript. The CVR transcript does not cover this period because of the 40-minute recording limit. As a result, the excerpt does not include any intracockpit dialogue (which would have featured code switching). The radio communication could have been overheard by the Avianca captain and flight engineer, and also by other pilots in the same airspace.

Immediately prior to the excerpt, the first officer requested an estimate of when AVA052 would get a clearance to proceed to the next sector. This was five minutes after they had been told to expect clearance, and 26 minutes after they had entered the holding pattern. The first officer's word choice was polite, formal and deferential (twice saying "Thank you" and addressing the controller as "sir"). The controller responded in a helpful key ("ah might be able to get you in right now") and instructed them to stand by.

After a gap of about two seconds,[55] the controller sent the first message shown in Table 27. It instructed AVA052 to continue holding indefinitely. The transmission is marked by message length. It contained two sub-messages, each starting with the aircraft call sign ("Avianca zero five two"). The first sub-message relayed information about clearance to leave the sector. It was realised in plain language using an idiom: "ah we just **got off the line** its ah indefinite hold at this time". The second sub-message was an instruction in standard phraseology for the aircraft to hold. The Avianca first officer read back the instruction at 20:44:23 and the controller acknowledged the read-back.

Following a gap of approximately 9 seconds, the next exchange started at 20:44:43. The controller gave a response to the first officer's earlier request for an estimate by saying "expect further clearance time zero two zero five". The time corresponded to 21:05 EST, which meant the aircraft would be holding for a further 20 minutes. The first officer read back the time at 20:44:50. His transmission was problematic in several regards. After the read-back, he included an appended message: "ahhhh well I think we need priority we're passing". Also, the end of the message was unintelligible, possibly due to a blocked

[55] The lengths of gaps cannot be determined accurately because the transcripts do not show the end times of utterances.

transmission. Moreover, the message did not provide information about the status of the aircraft, and ambiguity was introduced through the underdetermined word "priority".

Table 27: Excerpt involving AVA052 and R67 controller (20:44-20:46).

TIME	SPEAKER	CONTENT
20:44:09	R67 (radio)	Avianca zero five two[56] ah we just got off the line its ah indefinite hold at this time Avianca zero five two turn left heading zero nine zero join the Deer Park two twenty one radial hold at CAMRN maintain one one thousand.
20:44:23	FO (radio)	Ok Avianca zero five two heavy turning left zero nine zero to join ah two two one Deer Park radial and holding CAMRN.
20:44:32	R67 (radio)	Avianca zero five two roger.
20:44:43	R67 (radio)	Avianca zero five two heavy expect further clearance time zero two zero five .
20:44:50	FO (radio)	Zero two zero five ahhhh well I think we need priority we're passing [unintelligible].
20:44:58	R67 (radio)	Avianca zero five two heavy roger how long can you hold and ah what is your alternate
20:45:03	FO (radio)	Ok stand by on that.
…	…	…
20:45:59	FO (radio)	Kennedy Avianca zero five two heavy.
20:46:01	R67 (radio)	Avianca zero five two heavy go ahead.
20:46:03	FO (radio)	Yes sir ah we'll be able to hold about five minutes thats all we can do.
20:46:08	R67 (radio)	Avianca zero five two heavy roger what is your alternate?
20:46:13	FO (radio)	Ah we said Boston but ah it is ah full of traffic I think.
20:46:20	R67 (radio)	Avianca zero five two say again your alternate airport.
20:46:24	FO (radio)	It was Boston but we we can't do it now we, we, don't, we run out of fuel now.
20:46:29	R67 (radio)	Avianca zero five two ah just stand by.
20:46:32	FO (radio)	Thank you.

[56] The ATC 1 transcript has "tvo", which I changed to "two". This excerpt had 22 similar errors.

The controller expressed repair at 20:44:58 as he asked two questions about the aircraft's status that were realised in plain language: "how long can you hold and ah what is your alternate". At 20:45:03 the first officer gave a dispreferred response by instructing the controller to stand by.

The R67 controller then communicated with three other aircraft (not shown in Table 27). The Avianca first officer contacted him again at 20:45:59. This was the start of an exchange marked by its length: nine turns. At 20:46:03 the first officer used plain language with colloquialism to respond to the first question the controller had asked earlier: "**we'll** be able to hold about five minutes **thats** all we can do". At 20:46:08 the controller repeated the second question about the alternate airport. The pilot used plain language including pronouns to give an answer ("Ah **we** said Boston") with an ambiguous appended message ("but ah **it** is ah full of traffic **I** think"). At 20:46:20 the controller told him to repeat the alternate airport. The first officer accepted by repeating the answer ("It was Boston") but again appended an ambiguous message with repetition and an idiom ("but **we we** can't do it now **we, we**, don't, **we run out** of fuel now"). The controller instructed AVA052 to stand by, and the first officer closed the exchange 20:46:32 with a polite phatic expression ("Thank you").

Following the excerpt shown in Table 27, there was a pause of about 14 seconds. Then the controller contacted AVA052 to give them clearance for the next sector and the new radio frequency. The problem of leaving the third holding pattern had been resolved successfully. This may have led the first officer to assume that the controller had received and understood all three messages concerning the fuel problem: "we need priority" at 20:44:50, "we'll be able to hold about five minutes thats all we can do" at 20:46:03, and "we run out of fuel now" at 20:46:24. Actually, the accident report indicated that a handoff controller (H67) overheard the second message and telephoned the next ATC sector. The phone call lasted from 20:46:24 to 20:46:44, so the H67 controller was unable to hear the third message. He passed on one piece of information to the controller in the next sector: "Avianca zero five two just coming on CAMRN **can only do five more minutes in the hold**" (NTSB, 1991, p. 6).

In summary, during this critical communication the Avianca first officer notified the R67 controller about the aircraft's fuel problem, saying "we need priority" and "we run out of fuel now". The messages were sent more than 45 minutes before the crash. The H67 controller informed the next sector that AVA052 could hold for five minutes. He did not mention "priority" and he did not hear the fuel message due to the distraction of the phone call. It is likely that the first officer mistakenly assumed all his messages were passed on to the next controller, but we cannot know for sure. Our ability to make sense of the decisions and communication during this period is severely limited by the absence of CVR data.

7.2.4.2 Critical Communication 2

In the next sector the Avianca crew were instructed by the APP controller at 20:54:40 to make a 360-degree turn for spacing, as discussed in Section 7.2.3.1. Duke (1992) noted that this manoeuvre used up between six and eight minutes of their remaining flight time. AVA052 was then handed off to the FV controller and given "a long 15-mile final approach leg" to JFK. The aircraft was being flown manually and during the final approach to the airport it experienced wind shear. The CVR indicates 15 GPWS warnings telling the crew to pull up or signalling deviations from the glide slope. The NTSB report commented that the crew experienced a high level of stress during the approach.

After an instruction from the captain, the first officer notified the tower controller (TWR) that the aircraft was executing a missed approach. The controller acknowledged the message, and issued a new altitude and heading at 21:23:39. This is the first message in the Table 28 excerpt, which is based on the CVR and ATC 6 transcripts.

Immediately following the controller's message, there was code switching from English to Spanish as the captain gave information about the aircraft's status ("we don't have fue-") at 21:23:43. His statement was incomplete; the transcripts do not indicate if there was overlapping speech.

The Avianca first officer relayed the new altitude and heading to the other crew members at 21:23:45. He spoke in Spanish with intrasentential code switching to English for the heading ("one eight zero"). The first officer then switched to English to give the read-back response to the controller at 21:23:48. There was a self-initiated repair of the altitude read-back ("climb and maintain **one – two** thousand"), perhaps due to interference from the last English phrase he had spoken ("**one** eight zero").

From 21:23:54 the three crew engaged in six turns of talk about the configuration of the aircraft and difficulty in locating the runway. This exchange featured repetition: the expressions "flaps twenty five" and "I didn't see it" were each repeated three times.[57]

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[57] The CVR transcript shows the first officer and flight engineer saying "I didn't see it" in English, but presumably their intracockpit talk was actually in Spanish.

Table 28: Excerpt involving AVA052 and TWR controller (21:23-21:24).

TIME	SPEAKER	CONTENT
21:23:39	TWR (radio)	Avianca zero five two heavy roger ah climb and maintain two thousand turn left heading one eight zero
21:23:43	Captain	*no tenemos comb-* [we don't have fue-]
21:23:45	FO	*mantener dos mil pies* one eight zero *en el rumbo* [maintain two thousand feet one eight zero on the heading]
21:23:48	FO (radio)	climb and maintain one – two thousand one eight zero on the heading
21:23:54	Captain	flaps *venticinco* [flaps twenty five]
21:23:54	FO	*dos mil pies* [two thousand feet]
	FE	flaps *venticinco* [flaps twenty five]
21:24:00	Captain	flaps *venticinco yo no se que paso con la pista oye no la vi* [58] [I don't know what happened with the runway I didn't see it]
	FE	I didn't see it[59]
	FO	I didn't see it
21:24:04	TWR (radio)	Avianca zero five two you are making a left turn correct sir[60]
21:24:06	Captain	*digale que estamos en emergencia* [tell them we are in emergency]
	FE	*dos mil pies* [two thousand feet]
		[sound of altitude alert chime]
21:24:08	FO (radio)	that's right to one eight zero on the heading and ah we'll try once again we're running out of fuel
21:24:14		[sound of trim in motion horn]
21:24:15	TWR (radio)	Okay

At 21:24:04 there was a message from the TWR controller asking whether the aircraft was turning as instructed. The controller's question was realised in plain language

[58] The first two words of this line are not in the English translation in the CVR transcript.

[59] There is no Spanish for this line and the next line in the CVR transcript.

[60] There are some differences in the ATC 6 transcript: "**the** left turn" at 21:24:04, the time 21:24:08 changed to 21:24:**07**, and the time 21:24:15 changed to 21:24:**13**.

as a statement: “you are making a left turn correct sir”. Immediately following the controller’s message, at 21:24:06, there was another instance of English-Spanish code switching as the captain instructed the first officer to declare an emergency (“tell them we are in emergency”). There may have been overlapping speech as the flight engineer changed topic to say the aircraft had reached the assigned altitude (“two thousand feet”) and an altitude alert sounded. Then the first officer switched to English and responded to the controller’s question at 21:24:08. He confirmed the new heading (“that’s right to one eight zero on the heading”). He also included an appended message that was realised in plain language with colloquialism and had two sub-messages. The first sub-message said the crew would try to land again (“and ah we’ll try once again”). The second sub-message relayed the information from the captain and included an idiom: “we’re **running out of** fuel ”. The second sub-message was possibly influenced by the captain’s utterance at 21:23:43 (“we don’t have fue-”). There was avoidance of the word “emergency” which the captain used in his instruction at 21:24:06. The controller responded at 21:24:15 with a minimal acknowledgement (“okay”) that introduced ambiguity. It was not clear from this response whether the controller was accepting the read-back of the heading, either of the sub-messages, or the entire transmission.

To summarise the second critical communication, the TWR controller contacted AVA052 twice during this excerpt. Both times the captain initiated a turn before the first officer could respond to the controller. On both occasions, the first officer engaged in code switching as he listened to (and, in the first case, spoke to) the captain, then responded to the controller. His second response to the controller (at 21:24:08) was problematic. The important information from the captain was buried in a sub-message inside an appended message. Moreover, the first officer avoided the word “emergency”. Possibly he did not clearly hear the captain’s second utterance due to overlapping speech. He paraphrased the captain’s earlier utterance (“we don’t have fue-”) by saying “we’re running out of fuel”. The TWR controller responding with an ambiguous minimal acknowledgement (“okay”).

Following this excerpt, the captain again instructed the first officer to declare an emergency. The captain said this *during* a long transmission from the TWR controller about wind shear to another aircraft. As Duke (1992) suggested, the wind shear message might have been a distraction that prevented the first officer from fully attending to the captain’s instruction. The captain then asked, “did you tell him”. The first officer replied, “yes sir” and “I already advised him”. The CVR data thus indicate that the first officer thought he had notified the TWR controller about the fuel problem. However, AVA052 subsequently received vectors for another long final approach.

7.2.4.3 Critical Communication 3

After the missed first approach, the TWR controller handed AVA052 off to the FV approach controller without passing on information about the aircraft running out of fuel. The first officer contacted the FV controller at 21:24:55. This is the start of the excerpt shown in Table 29, which is taken from the CVR and ATC 4 transcripts. Previously the FV controller had handled AVA052 before the missed approach, from 21:03 to 21:15. (See the analysis in Section 7.2.3.4.)

In the first transmission in Table 29, the first officer notified the FV controller about the missed approach and reported the aircraft's altitude. This message was realised in plain language with pronouns, colloquialism, repetition and a hesitation marker: "**we** just **missed** a **missed** approach and **ah we're** maintaining two thousand and five on th-". Then there was code switching in the cockpit as the flight engineer and captain confirmed the flap setting. The FV controller responded with an acknowledgement and a new altitude at 21:25:07.[61] For this message the controller used standard phraseology with a plain language phatic expression ("good evening"), just as he had previously done when AVA052 entered the sector at 21:03. (See Table 22.)

Immediately after the controller's message, at 21:25:08, there was code switching from English to Spanish as the captain gave an instruction to the first officer: "advise him we don't have fuel". The first officer switched to English to give the read-back response to the controller at 21:25:10. He relayed the information from the captain in an appended message realised in plain language with a hesitation marker and an idiom: "and **ah** we're **running out of** fuel sir". It was the same message that the first officer had sent to the TWR controller at 21:24:08 (in Table 28), except he addressed the FV controller deferentially as "sir". The controller responded at 21:25:12 with a minimal acknowledgement ("okay") and a new heading instruction. The controller's acknowledgement introduced ambiguity. It was not clear whether he was accepting the read-back of the altitude, the appended message, or both. The first officer read back the heading and repeated the altitude at 21:25:15. This

[61] This time is 21:25:**02** in the ATC 4 transcript, which is significantly different. Considering the times of other transmissions, it is probable that the ATC 4 transcript time is more accurate.

transmission was marked by the omission of the aircraft call sign and the non-standard insertion of "to" before the altitude.

Table 29: Excerpt involving AVA052 and FV controller (21:24-21:25).

TIME	SPEAKER	CONTENT
21:24:55	FO (radio)	approach Avianca zero five ah two heavy we just missed a missed approach and ah we're maintaining two thousand and five on th-[62]
21:24:58	FE	flaps *catorce* [flaps fourteen]
21:25:00	Captain	flaps *catorce* [flaps fourteen]
21:25:07	FV (radio)[63]	Avianca zero five two heavy New York good evening climb and maintain three thousand
21:25:08	Captain	*digale que no tenemos combustible* [advise him we don't have fuel]
21:25:10	FO (radio)	climb and maintain three thousand and ah we're running out of fuel sir
21:25:12	FV (radio)	okay fly heading zero eight zero
21:25:15	FO (radio)	flying heading zero eight zero climb to three thousand
21:25:19	FO	*tres mil pies por favor* [three thousand feet please]
21:25:19	FV (radio)	TWA eight zero one heavy turn left heading zero four zero
21:25:20	Captain	*cero que ochenta* [what zero eighty]
	FO	*ciento ochenta* [hundred and eighty]
21:25:22	Captain	Ah
21:25:22	TWA801 (radio)[64]	zero four zero TWA eight oh one heavy
	FO	*ciento ochenta* [hundred and eighty]

[62] There are some differences in the ATC 4 transcript: this line ends "two thousand **one** five **(unintelligible)**"; 21:25:12 begins "okay **ah** fly"; and 21:25:15 begins "**right** heading". Several transmission times also differ, most notably 21:25:07 which is changed to 21:25:**02**.

[63] The FV controller (FV) is misidentified as the CAMRN controller (APP) in the CVR transcript.

[64] TWA801 is misidentified as the tower controller (TWR) at 2125:22 in the CVR transcript.

At 21:25:19 the Avianca first officer switched to Spanish and relayed the altitude instruction to the captain. A two-turn question-answer exchange took place between the captain and first officer at 21:25:20. The captain said the heading correctly but asked for confirmation ("what zero eighty"). The first officer responded with an *incorrect* heading ("hundred and eighty"). At 21:25:22 there was another two-turn exchange in which the first officer again said the incorrect heading. Several factors may have contributed to his error. Firstly, the first officer may have inadvertently recalled the heading they received after the missed approach (in Table 28 at 21:23:39). Secondly, there might have been interference from radio transmissions at 21:25:19 and 21:25:22 involving a TWA aircraft with a call sign that had the same digits as the incorrect heading ("eight zero one"). The first officer repeated the incorrect heading five times and was not corrected by the other crew members, possibly indicating fatigue. The incorrect heading took AVA052 further away from the airport.

In summary, the third critical communication involved the recurrence of previous patterns. After the FV controller contacted AVA052 at 21:25:07, the captain initiated a turn before the first officer could respond. The first officer engaged in code switching as he listened to the captain and then responded to the controller. The first officer's response to the controller at 21:25:10 was problematic. He transmitted important information from the captain in an appended message. This was compounded by the controller responding with an ambiguous acknowledgement ("okay").

Following this excerpt, the captain again checked if the first officer had sent a message about the fuel problem ("did you already advise that we don't have fuel"). The first officer replied that he had ("yes sir I already advise him"), and then he repeated the incorrect heading. The CVR data indicate that the first officer thought he had told the FV controller about the fuel problem situation.

7.2.4.4 Critical Communication 4

The next contact from the FV controller to AVA052 occurred at 21:26:27. It is the first transmission in the excerpt shown in Table 30, which is taken from the CVR and ATC 4 transcripts. The controller used standard phraseology to issue a new heading ("zero seven zero"). The first officer read back the heading correctly at 21:26:31. He then engaged in code switching to relay the heading in Spanish to the other crew members.

Table 30: Excerpt involving AVA052 and FV controller (21:26).

TIME	SPEAKER	CONTENT
21:26:27	FV (radio)[65]	Avianca zero five two heavy turn left heading zero seven zero
21:26:31	FO (radio)	heading zero seven zero Avianca zero five two heavy
21:26:34	FO	*cero siete cero* [zero seven zero]
21:26:35	FV (radio)	and Avianca zero five two heavy ah I'm gunna bring you about fifteen miles north east and then turn you back onto the approach is that fine with you and your fuel[66]
21:26:43	FO (radio)	I guess so thank you very much
21:26:46	Captain	*que dice* [what did he say]
	FE[67]	*el man se calento* [the guy is angry]
21:26:47	FO	*quince millas para volvernos a meter en el localizador* [fifteen miles in order to get back to the localizer]

At 21:26:35 the controller sent a transmission to AVA052 that was marked by the message length. It consisted of two sub-messages and, after the aircraft call sign, it was realised in plain language. The first sub-message gave information about the approach and included colloquialism: "ah **I'm gunna** bring you about fifteen miles north east and then turn you back onto the approach". The second sub-message was a question: "is that fine with you and your fuel". At 21:26:43 the first officer gave a preferred response to the controller's question using plain language: "I guess so". He closed the exchange with a polite, non-standard expression: "thank you very much". There was another instance of code switching as the captain asked for a translation at 21:26:46: "what did he say". It is apparent that the captain did *not* understand this message from the FV controller. At 21:26:47 the first officer responded to the captain by relaying the information about the approach in Spanish. As Helmreich (1994) noted, the first officer did not consult the

[65] The FV controller (FV) is misidentified as the CAMRN approach controller (APP) in this section of the CVR transcript.

[66] There are some differences in the ATC 4 transcript: "I'm **going to** bring you" and "back **on for** the approach". Also, the radio transmission times in this excerpt all differ by 1 or 2 seconds.

[67] Helmreich (1994) and Gladwell (2008) mistakenly attributed this utterance to the first officer.

captain about the approach, and the subject was not discussed by the crew members. Meanwhile the flight engineer had made a comment about the FV controller: “the guy is angry”. The transcripts do not contain any paralinguistic information. However, the flight engineer’s remark indicates that he, and possibly the first officer, *perceived* anger in the controller’s speech. This perception may have made the first officer reluctant to cause trouble and influenced his response to the controller at 21:26:43.

This critical communication differs from the previous ones because for the first time a controller inquired about the fuel problem.[68] Presumably the FV controller had understood the fuel message sent at 21:25:10 (in Table 29). However, his transmission at 21:26:35 was problematic. It was in colloquial plain language and had two sub-messages. Moreover, at least one of the Avianca crew thought it was delivered in an angry key. The transmission included a question (“is that fine with you and your fuel”) to which the first officer gave a preferred response (“I guess so”). He did not consult the captain.

After this excerpt, the FV controller contacted other aircraft and the Avianca crew members talked about details of the approach. During the intracockpit talk, the new heading was correctly repeated five times (“zero seven zero”) and incorrectly once (“zero ninety” by the captain). The repetition of the heading might be evidence of fatigue and also of surprise that the aircraft was still being directed away from the airport.

7.2.4.5 Critical Communication 5

The Avianca aircraft received vectors for a long approach, just as with the first approach. At 21:29:11, the Avianca first officer contacted the FV controller to request a turn on to the final approach: “ah can you give us a final now Avianca zero five two heavy”.[69] The controller responded by issuing a small heading change to 040 degrees, keeping the aircraft on course for a long 15-mile final leg. A minute later the controller contacted TWA Flight 801 (TWA801). This is the first line of the excerpt in Table 31, which is from the CVR and ATC 4 transcripts.

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[68] The only other message from ATC about the Avianca fuel problem was at 21:34:00, when the FV controller asked, “Avianca zero five two you have uh you have enough fuel to make it to the airport”. At 21:33:24 the CVR had stopped recording and the crash occurred shortly after.

[69] The ATC 4 transcript has “**when** can you give us” and gives the time as 21:29:**19**.

Table 31: Exchange involving AVA052 and FV controller (21:30).

TIME	SPEAKER	CONTENT
21:30:14	FV[70] (radio)	TWA eight zero one heavy turn left heading two five zero you're one five miles from outer marker maintain two thousand until established on the localizer cleared for ILS two two left[71]
21:30:21	FO (radio)	Avianca zero five two heavy left turn two five zero and ah we're cleared for ILS[72]
21:30:25	Captain	*que rumbo digame* [what heading tell me]
21:30:26	FV (radio)	okay two called Trans World eight oh one you were cleared for the approach
21:30:27	FO	*dos cinco cero* [two five zero]
21:30:30	TWA801 (radio)	Affirmative TWA eight oh one we got it we're out of three for two
21:30:32	FO	*dos cinco cero en el rumbo* [two five zero in the heading]
21:30:32	FV (radio)	Avianca fifty two climb and maintain three thousand
21:30:33		[sound of landing gear warning horn]
21:30:36	FO (radio)	ah negative sir we just running out of fuel we okay three thousand now okay
21:30:39	Captain	*no no tres tres mil tres mil* [no no three three thousand three thousand]
21:30:44	FV (radio)	okay turn left heading three one zero sir
21:30:47	FO (radio)	three one zero Avianca zero five two

The FV controller's message at 21:30:14 instructed TWA801 to turn on to the final approach. The transmission is marked by the message length. It included a heading change, position information, an altitude instruction and clearance for the approach to Runway 22L. This was the message that the Avianca first officer was waiting for and had requested

[70] The FV controller (FV) is misidentified as the CAMRN approach controller (APP) in this section of the CVR transcript.

[71] There are some differences in the ATC 4 transcript: "on localizer" in this line; "climb maintain" at 21:30:32; and "**we we're** just running out of" and "now **we could**" at 21:30:36. Also, several radio transmission times differ by 1-4 seconds.

[72] This entire message is marked unintelligible in the ATC 4 transcript, so presumably was blocked.

one minute previously. Although the controller had correctly said the call sign for another aircraft ("TWA eight zero one heavy"), the Avianca first officer responded to the message at 21:30:21, reading back the heading and acknowledging the approach clearance. It was an instance of call sign confusion.

The first officer's message at 21:30:21 was unintelligible to the controller, probably because of a blocked transmission. It is likely that the TWA801 pilot transmitted at the same time as AVA052. The first officer would have been unaware of the blocked message. He was immediately engaged in code switching as the captain asked for the new heading at 21:30:25 ("what heading tell me"). The first officer relayed the heading to the captain at 21:30:27 ("two five zero") and repeated it at 21:30:32.

While the captain and first officer were talking in Spanish, the FV controller sent another message to TWA801 at 21:30:26. This message used plain language to express repair: "Trans World eight oh one you were cleared for the approach". TWA801 responded at 21:30:30, using idiom and colloquialism to accept the clearance ("we got it") and acknowledge the altitude instruction ("we're out of three for two"). In the Avianca cockpit, there was probably a significant amount of overlapping between the intracockpit dialogue (in Spanish) and the radio transmissions (in English). We cannot know for sure because the transcripts do not indicate utterance end times. It is clear that the first officer did not realise he had accepted a clearance meant for another aircraft, because he repeated the heading at 21:30:32 after the controller's second message to TWA801. It may be surmised that the first officer did not understand the meaning of the radio exchange between the controller and TWA801 due to distraction by his dialogue with the captain.

Several factors might have contributed to the first officer accepting a message that was intended for TWA801: pilot expectation, message length, workload and fatigue. As noted by Cardosi, Falzarano and Han (1998), these are all factors that may contribute to pilots accepting a clearance intended for another aircraft. It is also possible that there was interference from the heading ("two five zero"), which had the same digits as the Avianca call sign ("zero five two").

It seems that the captain understood the altitude instruction given by the controller at 21:30:14 and started to descend. At 21:30:32, the controller instructed AVA052 to climb back to its previously assigned altitude ("climb and maintain three thousand"). The first officer responded at 21:30:36 with a transmission that is difficult to understand. The first part of the transmission was a dispreferred response to the altitude instruction: "ah negative sir". Then there was an appended message with two sub-messages. The first sub-message repeated the idiomatic fuel message (“we just running out of fuel”) that he had previously sent to the TWR controller (at 21:24:08 in Table 28) and the FV controller (at 21:25:10 in Table 29). The second sub-message seems to accept the altitude instruction and implies the aircraft had by this time returned to three thousand feet (“we okay three thousand now okay”). The transmission featured ambiguity and omission of the aircraft’s call sign.

Code switching took place in the cockpit 21:30:39 as the captain declared in Spanish: “no no three three thousand three thousand”. The captain’s lexical repetition may have expressed fatigue, disbelief or despair. The controller responded to the first officer’s transmission with a minimal acknowledgement (“okay”) and a new heading instruction at 21:30:44. Then the first officer read back the heading (“three one zero”) and included the call sign at 21:30:47.

In summary, this critical communication involved the recurrence of two features from the second and third critical communications: the first officer used an appended message to send the same information as before about the aircraft’s status (“we’re running out of fuel”); and the controller responded with an ambiguous minimal acknowledgement (“okay”). In addition, there is further evidence of a deterioration in the first officer’s performance. In the third critical communication he had relayed an incorrect heading to the captain. In this critical communication he had multiple problems: call sign confusion, a blocked transmission, accepting a heading intended for another aircraft, and the confused message he sent at 21:30:36: “ah negative sir we just running out of fuel we okay three thousand now okay”.

7.2.4.6 Critical Communication 6

Following the previous excerpt, the first officer twice relayed the heading (“three one zero”) to the captain in Spanish. At 21:30:55 the FV controller issued a new heading of 360 degrees, taking the aircraft further away from JFK. The controller explained: “okay and you're number two for the approach I just have to give you enough room so you make it without ah having to come out again”. At 21:32:08 the controller gave another heading change to 330 degrees. Then the flight engineer reported that one of the engines had flamed out. This is the first line of the excerpt in Table 32, which is from the CVR and ATC 4 transcripts.

At 21:32:39 the flight engineer reported the flame out of engine number four: the outermost engine on the starboard wing had lost power due to fuel starvation. The captain acknowledged the flame out at 21:32:42. One second later the flight engineer reported the other starboard engine flaming out ("flame out on engine number three"). At 21:32:49 the captain declared: "show me the runway". The aircraft was more than 20 nautical miles from JFK. Also at 21:32:49, there was code switching in the cockpit as the first officer contacted the FV controller. This transmission used plain language to report the status of the aircraft: "we just ah lost two engines and ah we need priority please".

Table 32: Exchange involving AVA052 and FV controller (21:32).

TIME	SPEAKER	CONTENT
21:32:39	FE	*se apagaron--se apago el motor cuatro* [flame out flame out on engine number four]
21:32:41		[sound of momemtary power interruption to the CVR]
21:32:42	Captain	*se apago* [flame out on it]
21:32:43	FE	*se apago el motor tres essential en* number one--*e1 dos--en el uno* [flame out on engine number three essential on number two on number one]
21:32:49	Captain	*muestreme la pista* [show me the runway]
21:32:49	FO (radio)	Avianca zero five two we just ah lost two engines and ah we need priority please[73]
21:32:54	FV (radio)[74]	Avianca zero five two turn left heading two five zero intercept the localizer
21:32:56		[sound of engine spooling down]
21:32:57	FO	*dos cinco cero* [two five zero]
21:32:59	FO (radio)	Roger

The first officer began his transmission at 21:32:49 with the aircraft's call sign, which he could produce as a well-rehearsed prefabricated chunk ("Avianca zero five two"). The transmission had two sub-messages. The first sub-message included a

[73] There are some differences in the ATC 4 transcript: "and we need" in this line; and the times of the radio transmissions differ by 1-2 seconds.

[74] The FV controller (FV) is misidentified as the CAMRN approach controller (APP) in this section of the CVR transcript.

disfluency marked by the hesitation token “ah” as the first officer formed a message he most likely had never spoken before: “we just **ah** lost two engines”. There was another hesitation marker in the second sub-message as the first officer retrieved from memory an expression he had used in the first critical communication: “and **ah** we need priority”. (See Table 27 at 20:44:50.) This non-standard request was delivered in a deferential key with the addition of the politeness marker “please”.

The controller responded at 21:32:54 with an instruction to turn to a new heading. This was the same instruction that the first officer had mistakenly accepted a few minutes earlier (at 21:30:14 in Table 31) except there was omission of the altitude instruction and the clearance. The first officer relayed the new heading (“two five zero”) to the crew in Spanish at 21:32:57. Then he responded to the controller in English at 21:32:59 with a minimal acknowledgement (“roger”). In this message he did not read back the heading or include the call sign. The minimal response of the first officer was marked. He had used “roger” once before in response to a tower controller instruction at 21:15:32, but had included the aircraft call sign.

Following this excerpt, the captain and first officer had a seven-turn exchange about the instrument landing system (ILS). The controller sent another message to AVA052 at 21:33:04, which included the altitude instruction and clearance for a final approach. The first officer acknowledged the message by saying “roger Avianca”. Less than one minute later the aircraft crashed approximately 16 miles from the airport.

CHAPTER 8: Making Sense of Past Accidents

This chapter discusses the results of Stage One and Stage Two of the analysis with reference to the literature review. Some findings from previous studies are confirmed while other findings are challenged. The first part of the chapter discusses the results of Stage One. It considers the relevance of past accidents, and how pilots are able to learn lessons from past accidents that improve the safety of contemporary aviation. The second part of the chapter discusses the results of the Stage Two analysis of language use in the Avianca 052 accident. Based on the recurring phenomena and critical communications that were identified, a narrative is constructed for the process by which communication broke down amongst Avianca flight crew and air traffic controllers. Finally, there is a discussion of the limitations to the transcript data in the NTSB accident report. The structure of the chapter is shown below.

8.1 STAGE ONE – Learning from Past Accidents

In this part of the chapter I discuss the results of the survey and the KI interviews concerning the relevance of past accidents to current airline operations. The results of both the survey and the interviews underline how different the four accidents cited in Document 9835 were. Each was a complex accident with multiple causal factors, and we should be wary about making sweeping generalisations concering their causes.

The following sections address each of the research questions (RQ A-D) in turn. The first section discusses the relevance of past accidents and the process by which pilots learn from them. The second section considers how some accidents become iconic, and the implications for aviation safety. Then I discuss information sources that pilots use to learn about accidents, in particular TV documentaries. The final section addresses the English proficiency of pilots and controllers, and language attitudes towards speakers from other countries or regions.

8.1.1 RQ A – The Process of Learning from the Past

The first research question (RQ A) asked whether studying past airline accidents is important for improving safety. The survey participants overwhelmingly think so. Almost 99% of respondents agree that studying past accidents is important, with more than 91% expressing strong agreement. Furthermore, over 95% agree that three of the accidents cited by ICAO are relevant to current airline operations. The exception is the 1996 New Delhi collision, which is considered relevant by slightly less than 80% of respondents.

The KI agrees that learning about past accidents is very important. The follow-up interviews provide insight into how he integrates information about accidents into his professional practice as an airline captain. The accident information enables him to reflect on his own mistakes. It allows him to: become aware of the possible consequences of a particular mistake; understand the causal process that led to it; and figure out how to avoid repeating it. This process of reflection is a method of risk mitigation. In Interview 6, the KI related the story of a mistake he had made due to distraction and workload when landing at Verona Airport without landing clearance from ATC. On that occasion the aircraft landed safely, but, by his own admission, on another day he may not have been so lucky. He drew a connection between this story and the 1977 Tenerife accident in which one of the causal factors was an aircraft starting its takeoff roll before the crew received takeoff clearance. The Tenerife disaster made him understand that his landing at Verona could have had a worse outcome, and it gave him a heightened appreciation of the importance of landing and takeoff clearances.

The KI discussed other accidents in addition to the four cited in the survey. Some of the accidents were recent and had a direct bearing on his work. For instance, the 2016 runway impact of Emirates Flight 521 at Dubai, UAE, involved a Boeing 777-300 aircraft, which is the type that the KI currently flies. Other accidents were older but still relevant, such as the 1989 crash of British Midland Flight 92 at Kegworth in the UK. The lesson he learned from the Kegworth disaster was that careless vocabulary selection can result in ambiguity. In that accident there was confusion about whether the “left” or “right” engine was on fire, and the pilots ended up shutting down the wrong engine. To avoid ambiguity the KI’s airline now trains crew to use the words “port” and “starboard”.

A theme that emerged from the interviews was that accidents which occurred a long time ago may involve factors that still remain critical to aviation safety. In 1990, Avianca Flight 052 crashed due to fuel exhaustion near New York and the accident report questioned the English language proficiency of the crew. In 2016, LaMia Flight 2933 crashed due to fuel exhaustion in Colombia and the investigation found that neither pilot held a valid English language proficiency licence. Fuel management and communication ability remain critical issues. Understanding the causal processes that led to both of these accidents can help prevent similar disasters from occurring in the future.

8.1.2 RQ B – Iconic Accidents

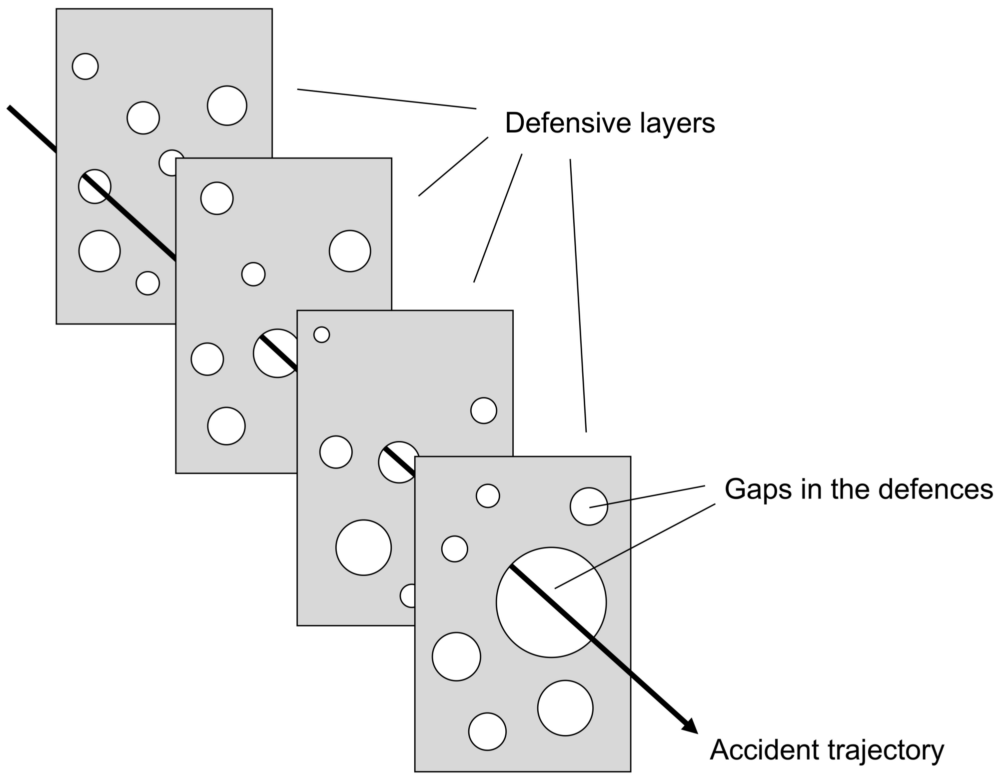
The second research question (RQ B) asked whether pilots have heard of the four accidents cited by ICAO. There was considerable variation in the survey responses. Less than one-third have heard of the 1996 New Delhi accident, compared with 100% for the 1977 Tenerife collision and more than 70% for the other two accidents.

Several reasons may be put forward to explain the disparity in these figures. Firstly, it is unsurprising that all respondents know of the 1977 Tenerife collision. It is the airline accident with the greatest number of fatalities in history and has thus been the subject of numerous news articles, books and TV programmes, with titles such as “The Deadliest Plane Crash” and “Crash of the Century”. Furthermore, airline non-technical skills training programmes often feature the 1977 Tenerife and 1995 Cali accidents, and to a lesser extent 1990 Cove Neck. Technical publications in English (including accident reports) are readily available for these three accidents, but not for the 1996 New Delhi collision. There is no accident report in the public domain for the latter accident, just a two-page accident summary and a one-page operations circular (DGAC, n.d., 1999). The lack of awareness about the 1996 New Delhi disaster may explain why fewer respondents consider this accident relevant to current operations (see RQ A).

The KI has heard of all four accidents and he was able to provide descriptions of their key features (see Table 9). Each of his descriptions highlights a single issue that he considers to be the most salient for that particular accident (e.g., authority gradient for the 1977 Tenerife collision). In Interview 5, he stated that the crash of Avianca 052 was the only one of the four that he thought was a "clear-cut language barrier based accident".

Although the KI highlighted one factor for each accident, he acknowledged they all involved multiple factors. He explained this in terms of the *Swiss cheese model*. Developed by Reason (1990), this accident causation model visualizes the defences of a system as layers. Separate layers may represent unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. Gaps, or weaknesses, in defences are depicted as holes in the layers, as shown in Figure 22.

Figure 22: The Swiss cheese model of accident causation. Adapted from Maurino, Reason, Johnston and Lee (1995, p. 25).



For a layer that represents unsafe acts, a gap might be caused by a pilot initiating takeoff before receiving takeoff clearance. The gaps continually change position and size. If gaps in all the layers are aligned, an accident trajectory can pass through the defences, like a skewer through the holes in slices of Swiss cheese. When this happens, an accident results. In Interview 8, the KI suggested that, in each of the accidents cited by ICAO, one layer had a *large* gap with “a greater potential to influence the outcome”. The large gap corresponds to the issue he considers most salient for the accident.

The KI also described experiences from his own career that the four accidents reminded him of. His descriptions of the accidents, and the recollections they triggered from his flying and training experiences, indicate that these are iconic accidents which serve a valuable purpose in providing context for training. They help pilots to remember important lessons and thereby improve flight safety. For the KI, the 1995 Cali accident emphasises the importance of following standard operating procedures, while the 1996 New Delhi collision highlights the value of TCAS.

8.1.3 RQ C – TV Documentaries & Other Information Sources

The next research question (RQ C) asked where pilots found out about the four accidents. The survey results indicate that TV documentaries are the most common source of information for three accidents: 1977 Tenerife, 1990 Cove Neck and 1996 New Delhi. Company training is also important, being the most common information source for the 1995 Cali crash and significant for two others. In addition, accident reports are prominent, being the second or third most important sources for all four accidents.

Many features of TV documentaries make them attractive sources of information. They are visual, aural and dramatic, with movement, spoken language and sound effects. They may be watched in a short time (i.e., a maximum of 40-50 minutes). Moreover, they present accidents in a personal style that foregrounds individuality and personality. The potency of documentaries is illustrated by the KI’s story about a GPWS warning being triggered by a rainstorm on the approach to Verona Airport. He was “freaked out” by the warning because the opening sequence of a documentary had imprinted in his mind the message: “when you hear that noise, you’re going to crash” (Interview 8).

As noted in Section 5.5.5, there are limitations to documentaries as sources of information about accidents. The limitations include: the selective use of accident report transcripts, with some dialogues being re-ordered or re-written; the speech of NNSs being translated into English; and the use of an omniscient narrator who knows an accident will happen although the actual participants did not have this awareness (i.e., hindsight bias[75]). Given these limitations, it is reassuring that TV documentaries are typically not the only source of information for pilots in the survey. Compared with all respondents, those citing TV documentaries as an information source are more likely to cite two or more sources. However, this suggests the need for further research to investigate how pilots integrate accident information that comes from multiple sources. It is also important for instructors who use excerpts from TV documentaries during airline training to be cognisant of their shortcomings and to use them in conjunction with other sources of information, such as accident reports.

The KI commented on the value of using short extracts from documentaries during pilot training. However, he noted that the main purpose of documentaries is entertainment; they are not created as learning tools. The KI used to watch TV documentaries but no longer does so due to changes in the delivery of media. He suspects that the change in his viewing habits might be reflected in the wider pilot population. This echoes discussions that have become commonplace in recent years at aviation conferences (e.g., AHFE, ISAP, RAeS Flight Operations Group) about changes in the viewing habits and learning styles of pilot trainees compared with the trainers' generation.

8.1.4 RQ D – English Proficiency & Language Attitudes

The final research question for Stage One (RQ D) asked whether the insufficient English proficiency of pilots and/or air traffic controllers contributed to the four accidents. In the case of the English proficiency of pilots, a majority of the survey respondents think that it played a contributing role in three of the accidents: 1977 Tenerife, 1990 Cove Neck and 1996 New Delhi. The exception is the 1995 Cali crash, for which less than 13% agree. For the English proficiency of air traffic controllers, a majority think it played a role only in the 1977 Tenerife runway collision. For the 1996 New Delhi mid-air collision, 50% of respondents agree, and for the other accidents the proportion was one third or less.

Combining the results, only in case of the 1977 Tenerife accident do the survey respondents perceive English proficiency to have been a problem for both the pilots and

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[75] *Hindsight bias* refers to the distortion of a person's evaluation of a situation when that person knows the outcome of the situation (Dismukes et al., 2007).

controllers. This is consistent with the accident reports, which found that the contributory factors included the inadequate language used by one of the KLM pilots (CIAIAC, 1978) and the difficulty in understanding taxi instructions given by the ground controller (Roitsch et al., 1978).

The 1995 Cali accident stands out because only a small proportion of respondents (a third or less) think that insufficient English proficiency of the pilots or controllers was a contributory factor. It seems that the pilots surveyed, like the KI, do not consider this to be primarily a language accident. Instead they might consider it to be an instance of cockpit procedures breaking down, as the KI suggested. Another possibility is that they consider it to be an automation accident, illustrating the hazards associated with the introduction of new technology and unexpected failure modes into the cockpit. Such reasoning would be consistent with the findings of the Colombian accident report, which cited the flight crew's "uso inadecuado de automatizacion" ("inadequate use of automation") in its listing of the probable cause (CAD, 1996a, p. 68).

The KI acknowledges that his responses to the survey questions about English proficiency were influenced by attitudes he holds towards certain national or regional groups. For instance, he has a very favourable evaluation of the English proficiency of Dutch pilots, in contrast to his poor evaluation of the English proficiency of air traffic controllers in South America. It is possible that the responses of survey respondents were similarly influenced by their attitudes. The language attitudes of pilot and controllers is an under-researched area. To address this deficiency, one suggestion for future research is to conduct a matched-guise experiment that is designed to elicit the attitudes of pilots and air traffic controllers towards particular nationalities.

8.2 STAGE TWO – Making Sense of the Avianca 052 Accident

Avianca Flight 052 crashed as the result of the complex interplay of numerous causal factors. In recent decades it has become a key tenet of accident analysis that airline accidents do not usually have a single cause, but instead result from the co-incidence of multiple factors (Dismukes et al., 2007). The NTSB report listed 24 findings and outlined several contributory factors. These were distilled down to two key points: "the probable cause of this accident was the failure of the flightcrew 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" (NTSB, 1991, p. 76).

This dissertation attempts to make sense of how communication broke down between the pilots and controllers during the Avianca 052 accident. The discussion of the Stage Two results is divided into four sections. The first section considers the significance of the three recurring phenomena of interest that were analysed in Chapter 7. The second section addresses the six critical communications that were identified, and reconstructs the process by which communication breakdown took place. The next section addresses the research questions (RQs E-H) and discusses communication factors that contributed to the accident. The final section concerns limitations to the transcript data provided in the NTSB accident report. Key factors from the ACT glossary are highlighted (e.g., fatigue).

8.2.1 Recurring Phenomena – Captain, First Officer & Controller

The analysis of the language use of pilots and controllers in Section 7.2.3 identified three recurring communication phenomena of interest. Firstly, on multiple occasions the Avianca captain repeatedly requested confirmation of an item of information following a message from ATC. Secondly, the Avianca first officer frequently switched languages and registers in his dialogue with ATC and the other flight crew members. Thirdly, the final vector (FV) controller alternated between different language varieties depending on the pilot he was contacting. The significance of these three recurring phenomena is discussed in the following paragraphs.

8.2.1.1 Repetition of the Avianca Captain

According to the NTSB report for the Avianca 052 accident, the CVR evidence indicated that the captain "did not hear or understand the ATC communications" and it was likely that "his limited command of the English language prevented him from effectively monitoring the content of the transmission" (NTSB, 1991, p. 58). The analysis of the CVR excerpt in Section 7.2.3.1 contradicts this finding. The captain *was* able to understand the messages from the approach controller about a new heading and another aircraft before they had been translated by the first officer. His comprehension of ATC messages can also be observed at a number of other points in the CVR transcript.

In the Table 10 excerpt in Chapter 7, the captain repeated the heading information four times. One reason for the repetition may have been surprise. The Avianca aircraft was running low on fuel and needed to land as soon as possible. Instead, they were given an instruction to make a 360-degree turn for spacing. The Colombian DAAC stated that this effectively put the aircraft in "a racetrack holding pattern", even though it had entered the TRACON airspace where no holding delays were expected (NTSB, 19991, p. 283). Thus, in this excerpt the captain's repetition of the new heading may have been an expression of surprise that the aircraft was being directed *away* from the airport.

Another possible reason for the repetition is fatigue. The NTSB report indicated that the aircraft was flown manually from Medellin in Colombia due to problems with the autopilot. As time passed and the fuel situation worsened, this led to increasing fatigue and stress. The main body of the report cited "nine distinct incidents of the captain asking for instructions to be repeated" as evidence of fatigue and stress (NTSB, 1991, p. 67). The report's conclusion, however, downplayed the effect of fatigue by noting only that it may have adversely affected the pilot's performance in flying the first approach.

There are multiple effects associated with fatigue, several of which may impact communication: diminished ability to picture the overall situation, difficulty in allocating attentional resources, degraded accuracy and timing, difficulty in integrating information, acceptance of lower standards of performance, impaired reasoning, deterioration in attitude and mood, inconsistent performance, waning attention, and involuntary lapses into sleep (Caldwell & Caldwell, 2003). Fatigue has been cited as a contributory factor in many accidents and incidents. It can be difficult, though, to establish a causal relation between fatigue and specific outcomes. As a consequence, accident reports frequently include general statements to the effect that "pilot performance was likely impaired by fatigue" (see, for example, NTSB, 2000b, 2011, 2014).

The analysis in Section 7.2.3.1 found a pattern of repetition by the captain that recurred throughout the CVR. Although he was able to translate ATC messages into Spanish, he had difficulty integrating the information. Moreover, if he was surprised by the

ATC instruction for a 360-degree turn for spacing, he did not articulate this clearly and did not question the instruction. The captain seems to have been preoccupied with flying the aircraft, and his communication was limited to finding out or confirming just the items of information he thought necessary to land the plane. This all indicates that the captain was suffering from fatigue during the last 40 minutes of the flight.

Helmreich (1994, pp. 275, 279) described the Avianca captain's behaviour as "reactive" rather than "proactive", and concluded that his failure to discuss possible contingencies or inform the other crew members about his overall intentions indicated inadequate leadership. Fatigue may have contributed to the captain's reactive behaviour. Regarding his communication, Duke (1992, p. 4) noted that the CVR data "contained ample evidence of fatigue and stress". The analysis in this dissertation supports the hypothesis that the captain's language use was affected by fatigue.

The analysis highlights a significant limitation of the accident data. If a longer CVR recording (e.g., two hours or more) were available, it would be possible to test the fatigue hypothesis. We would expect to see an increase in the captain's use of repetition as the flight progressed (i.e., as the captain became more fatigued). However, in accordance with the regulations in effect at the time, the recording only covered the final 40 minutes of the flight. The absence of cockpit audio data from earlier in the flight illustrates the value of longer CVR recording times for accident investigations.[76]

8.2.1.2 Code Switching of the Avianca First Officer

A two-minute segment of communication involving the Avianca first officer was analysed in Section 7.2.3.2. As expected, the segment contained code switching between English and Spanish, and also between standard phraseology and plain language. There were 21 instances of English-Spanish code switching, 81% of them occurring in the second half of the segment. The intensity of the code switching imposed a substantial cognitive burden on the first officer, increasing his workload as he monitored and participated in communications both on the radio and in the cockpit.

The first officer's primary responsibility was handling radio communications, but he also took on an additional role as an interpreter for the captain. This was perhaps due to the repeated requests for confirmation of information that the captain had previously made.

[76] Modern passenger aircraft typically carry CVRs that record for two hours. In 2021, 25-hour CVR devices are due to be introduced (see Cookson, 2019a).

For instance, midway through the segment the first officer translated a heading instruction into Spanish after receiving it from the FV controller. Subsequently he provided a Spanish translation of the English phrase “nose up attitude” on behalf of the flight engineer when the captain could not understand part of a briefing.

In his analysis of the accident, Helmreich (1994, p. 275) stated that: “Overall, the total amount of communication within the cockpit was very low”. This statement needs to be qualified. Firstly, Helmreich’s analysis was based on the CVR data and was therefore limited to the final 40 minutes of the flight; the total flight time was 6 hours 26 minutes. Secondly, there were periods when communication in the Avianca cockpit was high, and other times when it was low. Communication was dense in the two-minute segment shown in Appendix 16. Even though there was an ATIS information broadcast playing for the first 30 seconds, there were still 41 turns, 46% of which were intracockpit dialogue. All three Avianca crew members participated, but the captain’s mean turn length (2.83 tokens) was noticeably shorter than that of the crew as a whole (5.32 tokens). This is further evidence that the captain was experiencing fatigue and was focusing his attentional resources on controlling the aircraft.

Helmreich (1994, pp. 274-275) compared the amount of communication in the Avianca cockpit with other accidents “where the crew’s performance was deemed to be exemplary by the NTSB”. He cited two accidents: the 1989 explosive decompression of United Airlines Flight 811, and the 1989 uncontained engine failure of United Airlines Flight 232. Both accidents involved American flight crews and American controllers. In other words, all participants were speaking their first language: English. In addition the flight crews for these accidents were highly experienced.[77] The context of the Avianca 052 accident was very different: there was a steep experience gradient within the cockpit, and the NNS flight crew were interacting with NES controllers. The analysis of code switching in this dissertation highlights the extra communication burden that NNS crews face when flying through airspace in which English is the common language. This underlines the importance of taking into account the language background of participants and details of the accident context when undertaking comparative studies of accidents.

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[77] The three members of the United Flight 811 crew had accumulated about 28,000, 14,500 and 20,000 flight hours (NTSB, 1992). The four crew members flying United Flight 232 each had between 15,000 and 30,000 hours (NTSB, 1990). By contrast, as noted in Table 8, the Avianca first officer had a total of 1,837 flight hours.

The analysis of code switching in Section 7.2.3.2 brought to light shortcomings in the English translation provided in the CVR transcript in the NTSB report. Some of the differences identified in Appendix 17 are relevant to the accident. The non-translation of "es" at 21:03:46 is of particular significance as it changes the meaning of the utterance. In the new translation, "it's" is an example of anaphoric pronominal reference, pointing back to a previous utterance. It indicates that, at this point in the dialogue, the flight engineer was *resuming* a briefing he had started earlier. There are no other related utterances made by the flight engineer prior to this in the CVR transcript, so the implication is that the flight engineer began the briefing *prior* to the start of the CVR recording at 20:53. If that is the case, it would undermine the assertion by Helmreich (1994, p. 274) that "there was no discussion of actions to be taken in the event of encountering reported wind shear". This again suggests that only having a 40-minute CVR recording for this accident was a major limitation for the NTSB investigation as intracockpit dialogue relevant to the crash seems to have taken place before the start of the audio record.

8.2.1.3 Style Shifting of the FV Controller

The third recurring communication phenomenon to be identified was style shifting by the FV controller. Radio exchanges were examined between the controller and two aircraft that were both running critically low on fuel. Section 7.2.3.3 revealed distinctive patterns in the language use of the pilot of American Airlines Flight 692 (AAL692). The analysis also highlighted features of the language variety used by the FV controller when he was handling this American aircraft.

The pilot of AAL692 did not adhere to standard phraseology. He repeatedly used a non-standard call sign ("six ninety-two"). On several occasions he seems to have avoided using the call sign at the end of an exchange, instead saying a single word (e.g., "Alright"), but this cannot be confirmed because the transcript designated the speaker as unknown. He sometimes used non-standard contractions for headings (e.g., "two seventy") and at other times used the correct format (e.g., "three two zero"). He showed a tendency to insert "to" before a heading, which is non-standard. When requested to fly at 160 knots he did not read back the speed, as other pilots did, but simply acknowledged receiving the message. The pilot exhibited a marked tendency to use plain language in terms of vocabulary selection (e.g., "very unhappy", "you say"). As was to be expected, he displayed a high level of spoken English proficiency when sharing information about the fuel problem and anticipating an emergency: “we’re uh about uh twelve or fourteen minutes from declaring an emergency”. He similarly demonstrated a high level of listening comprehension by responding fluently and without hesitation to the controller’s idiomatic inquiry about the status of his aircraft (“how are we making out”). Finally, there were two instances of microphone clipping, which might indicate poor radio technique.

No data are available about the background of the AAL692 pilot, but his proactive, non-standard manner (e.g., “very unhappy at two thousand feet”) and the deference that was shown by the controller imply experience and possibly seniority. He did not adhere to standard phraseology, but was able to use the plain language resources at his disposal to negotiate the earliest possible landing for his plane. As noted in Section 2.6.2, pilots sometimes embellish prescribed wordings in order to do important interactional work, such as communicating an understanding of the current situation. Nevile (2004) observed that linguistic improvisation during routine operations can help pilots develop a resource for dealing with emergency situations for which there are no prescribed wordings.

The FV controller used non-standard language when contacting AAL692, and consistently used the same non-standard call sign as the pilot (“six ninety two”). He repeated this pattern elsewhere, using the same form of contraction for the call signs of all the American aircraft except for Trans World Airlines Flight 801, whose number could not be shortened in this way. The controller used a significant amount of plain language to deal with the fuel problem of AAL692. This included colloquialisms and complete sentences (e.g., “I’m going to take you another eight miles where you are then turn ya to the final”). Several messages from the controller were delivered in a reassuring or helpful key not found in exchanges with other aircraft (e.g., “I’ll make sure you get a lot of room there”). The controller also used some communicative functions with AAL692 that he did not use with other pilots. One example occurred when he inquired about the fuel status using an idiomatic phrasal verb (“how are we making out”). In addition, the deferential language in the controller’s final message to the American Airlines pilot (“again thank you for your cooperation”) was one of only two occasions when he used expressions of gratitude, and showed a more formal word selection than the other instance (when he said “thanks for your help” to a Pan Am flight).

A subtle change took place in the plain language used by the FV controller as he communicated with AAL692. For the first few exchanges he used *singular* pronoun forms only (e.g., “**I** understand uh **you**’re number four with **me** sir”). However, in the middle of the exchanges, he switched to the first person *plural* to check the aircraft status by saying “how are **we** making out”. This was echoed in the pilot’s response: “**We** got enough fuel for the approach and landing and that’s it”. Thereafter, the controller reverted to only using singular forms (e.g., “**you**’re one three miles from outer marker”). As shown by Nevile (2004), pilots may use singular first or second person pronouns to invoke an individual identity, contrasted with the use of plural first person pronouns to invoke a shared identity. A similar process may have been operating between the FV controller and the AAL692 pilot. At first the pilot was assertive and initiated two exchanges. The controller was reactive, quickly issuing an instruction to climb after the pilot said he was “very unhappy at two thousand feet”. In the subsequent exchanges the controller reestablished control by explaining the action he would take and giving routine heading instructions. He then used the first person plural pronoun, “we”, to check the aircraft’s status, signalling a willingness to present the emergency as a shared problem. Finally, the controller reverted to singular pronoun forms, reasserting his individual identity, but he continued to communicate in a helpful and deferential key.

The language variety used by the first officer of Avianca 052 differed significantly from that of the AAL692 pilot, even though the two aircraft were on the same course and both facing a fuel emergency. The exchanges in Section 7.2.3.4 show the first officer adhering to standard phraseology and not using plain language. He used the correct call sign for every exchange after the initial contact (when he omitted the designation “heavy”) and consistently used phraseology to read back ATC instructions. The instructions were routine messages about heading changes, an altitude change, clearance for the approach and a speed request. Such was the first officer’s adherence to phraseology that the phatic expression he used on leaving the sector (“so long”) stands out as overly familiar.

The FV controller used a completely different language variety when speaking with AVA052 compared with AAL692. He consistently used standard phraseology, mirroring the Avianca first officer’s use of phraseology. He always said the Avianca call sign in standard format. There were just two minor instances of plain language, one at the start of the communications and one at the end. During the first exchange, the controller signalled the entry of the Avianca aircraft to the sector with the phatic expression “good evening”. He used the same expression with the other aircraft entering the sector during this period. In the final exchange with AVA052, the controller used the expression “good day”. He used this expression with two other non-American aircraft that departed the sector, but used “good evening” with three out of four American aircraft.

Why did the first officer *not* notify the FV controller about his aircraft's fuel situation during this period, as the AAL692 pilot had done? There may have been several factors influencing him. Firstly, the parallel communication with ATC and his fellow crew members, which involved a lot of code switching, was imposing a considerable burden on his linguistic resources. As a non-native speaker, it was less cognitively demanding for him to produce routine phraseology than it was to produce a novel message in plain English explaining the fuel problem. Furthermore, he was an inexperienced pilot, particularly in terms of flying a Boeing 707 at night. It is likely that he had no previous experience of this kind of emergency or exposure to the language needed to resolve it. After entering the sector, he heard the FV controller inquire about the fuel status of AAL692. He did not hear the two earlier messages the American pilot transmitted about the fuel problem. Besides, he believed that the previous controller had passed on his messages about the Avianca fuel situation. It may therefore have seemed reasonable to wait for the FV controller to initiate a fuel status check. These factors are consistent with the suggestion by Helmreich (1994) that the communicative goal of the first officer was to cause no extra problems for ATC on a busy night. By not creating more problems, he may have reasoned that his flight (and others) would be handled as quickly as possible.

The lack of an explicit warning from the Avianca first officer, combined with the routine nature and phraseology of his messages, gave no indication to the controller that AVA052 had an incipient fuel emergency. As noted by Allen and Guy (1989, p. 54) the use of routine communication in a crisis increases risk as it "deludes and diverts those who are most responsible from recognizing the danger and verbalizing the needed direction to avert failure".

The analysis in Chapter 7 showed the distinct language varieties used by the pilots of AAL692 and AVA052 as they tried to negotiate the fuel problems that their aircraft were facing. It also highlighted style shifting by the FV controller as he alternated between separate language varieties depending on the pilot he was contacting. This finding is significant. Standard phraseology is intended to ensure that the same language is used with all pilots. However, the analysis found evidence of systematic variation in the actual language use of a controller during a crucial stage of the accident flight.

The controller deployed different language varieties depending on the context. For Avianca 052, perhaps concerned about the English proficiency of NNS pilots, the variety consisted almost entirely of standard phraseology. With AAL692, both participants were NESs so the controller used fluent, non-standard (and sometimes colloquial) language to achieve effective and efficient communication. There are understandable reasons for this type of style shifting. As Liddicoat (2007, p. 6) noted, “listeners are motivated to hear a turn that is designed for them”. A controller may use recipient design, for example, by using the same form of call sign as the pilot (e.g., standard format for the Avianca first officer but non-standard for the American Airlines pilot). Accommodation makes sense as a controller strategy to ensure that pilots hear messages intended for them. Another reason for using a non-standard variety with the American pilot is to establish a shared identity. This invokes shared knowledge and assumptions, which are otherwise scarce in pilot-ATC communication. Such non-standard language use between NESs might be considered appropriate to the immediate needs of the interlocutors. However, this practice increases the risk of a communication barrier between NESs and NNSs. It may inhibit some NNS pilots from using plain language when they need to, and NNS pilots listening on the same radio frequency may not understand the exchanges.

8.2.2 Critical Communications – The Process of Breakdown

This section discusses six critical communications that were identified in the final stage of the flight of Avianca 052. It is divided into two parts. The first part presents a narrative of the process by which communication breakdown occurred. It highlights key messages that were transmitted and factors that mitigated their effectiveness. The second part discusses a series of opportunities where the accident could have been prevented. Reasons for these opportunities not being taken are proposed, and the roles played by the main participants in the communication breakdown are discussed.

8.2.2.1 Narrative of a Communication Breakdown

In the first critical communication, the Avianca first officer notified the R67 air traffic controller about the aircraft’s fuel problem more than 45 minutes before the crash occurred. In three messages sent between 20:44 and 20:46, the first officer said “I think **we need priority**”, “we’ll be able to hold about five minutes” and “**we run out of fuel now**” (Table 27). The H67 controller phoned the next sector controller to inform him about one of the messages: AVA052 could hold for five minutes. The H67 controller did not mention “priority” and he did not hear the “we run out of fuel now” message due to the distraction of the phone conversation. It is probable that the first officer mistakenly assumed all three messages were passed on to the next controller.

In the next sector, AVA052 was instructed to make a 360-degree turn for spacing by the APP controller at 20:54. This used up between six and eight minutes of flight time and reduced the fuel reserve. The aircraft was then handed off to the FV controller and given a long final approach leg to JFK.

The Avianca captain was flying the aircraft manually. During the final approach it experienced wind shear. There were 15 GPWS warnings and the NTSB report noted that the crew experienced a high level of stress during the approach. The aircraft executed a missed approach at 21:23 and the first officer notified the TWR controller.

In the second critical communication, the TWR controller contacted AVA052 twice and on both occasions the captain spoke in Spanish before the first officer could respond to the controller. On the first occasion the captain said “we don’t have fue-”, and the second time he said “tell them we are in emergency” (Table 28). It is possible that the first officer did not clearly hear the captain’s second utterance. There may have been overlapping speech between this utterance (in Spanish), the second radio message (in English) and an utterance from the first engineer (in Spanish), as well as an altitude alert sounding. In addition, the first officer was having to process a question from the controller (in English), not just a routine instruction. The first officer responded to the controller at 21:24:08 and notified him of the fuel problem by saying “**we’re running out of fuel**”. This was a paraphrase of the captain’s first utterance, and a repetition of a message the first officer had sent in the first critical communication. It was buried in a sub-message inside an appended message. There was ambiguity in the controller’ response as he gave a minimal acknowledgement: “okay”.

The captain again instructed the first officer to declare an emergency. Once more there may have been overlapping speech in the cockpit: the captain spoke (in Spanish) in the middle of a long transmission from the controller (in English) about wind shear to another aircraft. As Duke (1992) suggested, the radio message about wind shear might have been a distraction that prevented the first officer from clearly hearing the captain’s instruction. The captain then asked, “did you tell him”, and the first officer replied, “yes sir” and “I already advised him”. The first officer thought he had told the TWR controller about the fuel problem. However, the TWR controller did not pass on information about the fuel problem when he handed AVA052 off to the FV approach controller.

In the third critical communication, the FV controller contacted AVA052 with an altitude instruction. The captain initiated a turn before the first officer could respond, saying “advise him we don’t have fuel” (Table 29). The first officer responded to the controller at 21:25:10 and notified him of the fuel problem by saying "**we're running out of fuel sir**". This notification was in an appended message. The FV controller responded with an ambiguous acknowledgement ("okay") and an instruction for a new heading ("fly heading zero eight zero"). The first officer subsequently told the captain an incorrect heading ("hundred and eighty").

The captain again checked if the first officer had sent a message about the aircraft's fuel problem. The first officer replied that he had ("yes sir I already advise him"), and then repeated the incorrect heading. The first officer thought he had told the FV controller about the fuel problem.

In the fourth critical communication, for the first time there was an inquiry from ATC about the fuel problem. At 21:26:35 the FV controller sent a message about the final approach, which ended with the question: "is that fine with you and your fuel" (Table 30). This inquiry indicates that the FV controller had understood the fuel message previously sent by the first officer at 21:25:10. The controller's transmission used plain language with colloquialism and had two sub-messages. The captain did not understand the transmission, and the flight engineer thought it was delivered in an angry key. The first officer gave a polite preferred response to the controller: "I guess so thank you very much". He did not consult the captain.

The Avianca crew received vectors for a long approach, just as they had for the first approach. At 21:29:11, the Avianca first officer contacted the FV controller to request a turn on to the final approach: "ah can you give us a final now Avianca zero five two heavy". The controller responded by issuing a small heading change to 040 degrees, which kept the aircraft on course for a long 15-mile final leg.

In the fifth critical communication, the FV controller contacted TWA Flight 801 (TWA801) with an instruction to turn on to the final approach. There was an instance of call sign confusion and probably also blocked transmission as the Avianca first officer responded to this message at 21:30:21 (Table 31). The controller repeated the instruction to TWA801, but the first officer probably did not hear this clearly because at the same time he was responding to a question from the captain about the heading. The controller then gave an altitude instruction to AVA052. The first officer responded with a confused message at 21:30:36: "ah negative sir **we just running out of fuel** we okay three thousand now okay". This was the fourth time he had sent the same message about the fuel problem ("we're running out of fuel"). The controller responded with an ambiguous minimal acknowledgement ("okay") and a new heading instruction.

At 21:30:55 the FV controller issued a new heading of 360 degrees, taking the Avianca aircraft further away from JFK. The controller explained: “okay and you're number two for the approach I just have to give you enough room so you make it without ah having to come out again”. At 21:32:08 the controller gave AVA052 another heading change to 330 degrees.

In the final critical communication, the flight engineer told the other crew members at 21:32:39 that one of the four engines had flamed out (Table 32). Seconds later he said another engine had flamed out. At 21:32:49 the first officer contacted the FV controller: “Avianca zero five two we just ah lost two engines and ah **we need priority** please”. In this message the first officer repeated an expression that he had used in the first critical communication (“we need priority”). The controller responded by issuing a new heading instruction. The first officer relayed the new heading (“two five zero”) to the captain and then responded to the controller with a minimal acknowledgement (“roger”).

At 21:33:04 the FV controller sent another message with an altitude instruction and clearance for the final approach. The first officer acknowledged the message by saying “roger Avianca”. Less than one minute later the aircraft crashed approximately 16 miles from JFK International Airport.

8.2.2.2 Opportunities to Prevent the Accident

During the final stage of the flight of Avianca 052, the first officer twice told a controller “we need priority” and four times he sent a message saying “we’re running out of fuel”. Before the crash occurred, the controllers sent one message to inquire about the Avianca fuel problem: “is that fine with you and your fuel”. The following paragraphs discuss the language choices made by the participants, especially the Avianca first officer, and the opportunities that existed for preventing the accident.

The first officer used the expression “we’re running out of fuel” four times. He said it once to the R67 controller (Table 27), once to the TWR controller (Table 28) and twice to the FV controller (Tables 29 and 31). The expression was most likely prompted by the captain saying in Spanish “we don’t have fue-” and “advise him we don’t have fuel” (Tables 28 and 29). After using the expression in the first critical communication, the first officer may have evaluated it positively because the Avianca aircraft promptly received clearance to leave the holding pattern and enter the next sector. The first officer did not know that this had happened as a result of another message (“we’ll be able to hold about five minutes”). Furthermore, the expression “we’re running out of fuel” was a chunk that could be readily retrieved from memory and spoken under conditions of time pressure and stress. It was less cognitively demanding and time consuming to produce than the message sent by the AAL692 pilot: “I want to advise you we’re at minimum fuel uh we’re uh about uh twelve or fourteen minutes from declaring an emergency”. It was also simpler and shorter than the alternative suggested in the accident report: “Did you receive our low fuel call to NY Center, we said that we no longer have enough fuel to make it to our alternate?” (NTSB, 1991, p. 64).

The NTSB report stated that the Avianca crew should have realised they were receiving routine handling when given a 360-degree turn for spacing at 20:54, and that they could have declared an emergency at that time. Then, or subsequently, they could have used standard phraseology to declare an emergency. By sending a “MAYDAY” message, they could have signalled distress and the need for immediate assistance. Alternatively, they could have sent a “PAN PAN” message to signal urgency. The flight crew did not use either of the phrases. This is one of the key lessons for all current and future pilots to take from the Avianca 052 accident.

Another option was for the Avianca flight crew to communicate the fuel problem using the word “emergency” in a non-standard message. The accident report suggested that they could have said “we are declaring an emergency” (NTSB, 1991, p. 64). The Avianca crew did not do this. The investigation found there was a total communication breakdown amongst the crew because the captain twice said “tell them we are in emergency” but the first officer failed to pass on the messages to ATC. This dissertation builds on the analysis by Duke (1992) to offer an explanation for the failure of the first officer to convey these crucial messages: the distraction of overlapping cockpit speech and radio messages may have prevented him from hearing the word “emergency” both times.

On two occasions the first officer used the expression “we need priority”, once to the R67 controller (Table 27) and once to the FV controller (Table 32). Following the accident, there was much debate about the first officer’s word choice. According to the testimony of another Avianca captain, training provided by Boeing gave the impression that “the words priority and emergency conveyed the same meaning to air traffic control” (NTSB, 1991, p. 63). The accident report noted that Boeing had issued a bulletin in 1980 to all Boeing 707 operators advising “priority handling from ATC should be requested” during operations with very low fuel quantities (NTSB, 1991, p. 28). This advice was at odds with the statements of controllers questioned during the investigation. They stated that the word "priority" did not require a specific response from ATC, and that flight crews should only use the terms "MAYDAY", "PAN PAN" or "emergency" to declare a fuel emergency. It is evident that the Avianca pilots and the air traffic controllers had different interpretations of the word "priority". This ambiguity was instrumental in the divergent situational awareness that developed between the Avianca first officer, who thought he had notified ATC of the fuel problem, and the controllers, who continued to handle the flight routinely.

In its conclusion, the NTSB report declared: "The controllers' actions in response to AVA052's requests were proper and responsive to a request for priority handling" (NTSB, 1991, p. 75). However, within the report there is evidence that some controllers shared the same interpretation of the word "priority" as the Avianca pilots. The following section indicates that certain flights *did* receive "priority handling", in this case due to a sick passenger:

> At 1640, the CFCF advised N90 of an aircraft inbound to JFK that needed a 'priority' landing because of a sick passenger. At 1643, ZNY asked ZOB if the pilot had requested priority handling because of the holding for JFK. ZNY stated, 'I want to make sure that if we are going to run him priority that he is declaring a priority handling.' ZOB confirmed that the pilot was indeed requesting priority because of the sick passenger. (NTSB, 1991, p. 158, emphasis added)

The Avianca first officer probably assumed that the controllers had understood the messages in which he said "we need priority" and "we're running out of fuel". The prompt release of the aircraft from the third holding pattern would have reinforced the assumption. However, it is possible that the controllers did not fully comprehend some of the messages. The first officer used an appended message in four of the critical communications (Tables 27, 28, 29 and 31). This increased the risk of key information being ignored. The TWR and FV controllers gave an ambiguous response ("okay"), which made it unclear which parts of the transmissions they had understood.

As Avianca 052 proceeded through the sectors, the controllers did not forward information about the fuel problem. Only the message about being able to hold for five minutes was passed on (Table 27). The first officer was unaware that the other messages were not communicated between controllers. One of the NTSB members who compiled the report, Jim Burnett, attached a dissenting comment about the inadequate ATC service that was provided. He noted that: "The JFK tower local controller failed to forward to the N90

FV controller the remark by the flightcrew concerning their fuel situation" (NTSB 1991, p. 78). This was crucial: it was just after the missed first approach and there was still a chance for the aircraft to have reached the airport if it had been given direct vectors.

Noting that the first officer twice asked for "priority" and four times advised ATC that the plane was low on fuel, Krause (2003, pp. 106-107) stated that "it would seem reasonable and logical" for the controllers to have asked for clarification. The first officer may have been waiting for a controller to make an inquiry about the fuel problem in the period before the first approach. As noted in Section 8.2.1.3, the first officer had heard the FV controller inquire about the fuel status of AAL692 at 21:06: "American six ninety two how are we making out" (Table 17). He had not heard the earlier transmissions initiated by the AAL692 pilot. He believed (mistakenly) that his messages about the fuel problem had been relayed to the FV controller, and he thought the controller was giving them priority handling. The CVR shows a discussion amongst the Avianca crew at 21:09 in which the first officer said "they are giving us priority". In fact the Avianca aircraft was not receiving priority handling, and the FV controller was instead devoting his attention to expediting the landing of the American Airlines plane.

This analysis highlights the complex and stochastic nature of the Avianca 052 accident. It occurred as a result of the co-incidence of numerous causal factors. Disaster might have been averted: if the H67 handoff controller had not been on the phone when the first officer said "we run out of fuel now"; if AVA052 had entered the FV controller's airspace two minutes earlier so that the first officer could hear the AAL692 pilot negotiate his fuel problem; or if there had been no distraction on either occasion when the captain said "tell them we are in emergency".

The analysis has attempted to peel away the layers of complexity to reveal the process by which communication broke down. The aim is not to apportion blame. The Avianca captain's behaviour was reactive, not proactive; it is clear that he was suffering from fatigue. The first officer was inexperienced; he struggled to manage the increasing workload and stress. The controllers did not communicate effectively with each other as they tried to operate within an overloaded air traffic system. The actions and non-actions of all of the participants contributed to a progressive breakdown in communications that prevented the fuel emergency of Avianca 052 from being communicated to ATC.

8.2.3 RQs E-H – Factors that Contributed to the Accident

This section sums up the findings from the analysis of recurring phenomena and critical communications in terms of the four research questions for Stage Two (RQs E-H). It discusses the numerous communication factors that contributed to this accident.

8.2.3.1 RQ E – Use of Standard Phraseology

The first research question for Stage Two (RQ E) asked whether the incorrect use of standard phraseology by the pilots or air traffic controllers contributed to the accident. As noted in Section 8.2.2.2, the accident could have been prevented if the Avianca first officer had used the standard phraseology terms "MAYDAY" or "PAN PAN" to notify ATC of the fuel emergency. He could have done this at any time. However, the first officer was young and inexperienced. Additionally, he came from Colombia, which, as Helmreich (1994) observed, has a high score on the Hofstede cultural dimension of power distance and a very low score for individualism (see Figure 10). It is unlikely that the first officer would have declared an emergency unless the captain instructed him to do so. After the missed first approach, the captain twice said "tell them we are in emergency". The analysis of the second critical communication indicates that on both occasions the first officer may not have heard the word "emergency" due to the distraction of other cockpit speech and radio messages.

There was another way in which the first officer's use of phraseology may have contributed to the accident. As noted in the discussion of style shifting in Section 8.2.1.3, the first officer strictly adhered to standard phraseology in his exchanges with the FV controller before the first approach. The routine nature and phraseology of his messages, combined with the absence of an explicit warning, gave no indication to the controller of the seriousness of the fuel problem. As Ragan (2007, p. 59) commented, "the first officer shows a certain facility in speaking indirectly, non-aggressively, and politely despite the desperate urgency of the situation". The continued routine transmissions increased risk by masking the crisis that was developing inside the Avianca aircraft.

8.2.3.2 RQ F – Plain Language Proficiency

The second research question (RQ F) asked whether a lack of plain language proficiency of the pilots or air traffic controllers contributed to the accident. The Avianca first officer was handling radio communication with ATC. Helmreich (1994, p. 272) stated that he had "excellent, unaccented English". However, this analysis shows a deterioration in the effectiveness of the first officer's communication during the final stage of the flight. It is hypothesised that his language use was progressively affected by increasing workload and stress. As a coping mechanism, the first officer used simple English expressions. He repeatedly used the expressions "we're running out of fuel" (four times) and "we need priority" (twice). He did not attempt a message as complex as that sent by the AAL692 pilot. He also used these simple expressions in appended messages, which increased the risk that they would be ignored. In addition, the first officer made significant errors that were not repaired. In the third critical communication he passed on an incorrect heading to the captain (Table 29). In the fifth critical communication there was call sign confusion as he mistakenly accepted a clearance intended for another aircraft (Table 31).

The analysis did not find evidence that the English proficiency of the Avianca captain directly contributed to the accident. The captain was flying the aircraft; he was not responsible for ATC communication. It is clear that he understood some of the radio transmissions, but he did not understand the inquiry from the FV controller about the fuel situation in the fourth critical communication (Table 30). That was a lengthy non-standard message delivered in colloquial English with two sub-messages. At the time the captain was most likely suffering from fatigue and experiencing a high level of workload and stress. These factors would have made it difficult for him to understand the controller's message as he manually flew the aircraft away from the missed approach. Fatigue and workload may have contributed to the poor timing of his messages to the first officer, and prevented him from managing their communication more effectively.

As for the controllers, the analysis identified style shifting by one of the controllers as a recurring phenomenon. The FV controller used non-standard call signs with American aircraft, and a significant amount of plain language when dealing with the fuel problem of AAL692. This made it easier for the AAL692 pilot to use plain language to negotiate a solution to his aircraft's fuel problem. The controller's language use towards AAL692 was exemplified by the idiomatic inquiry that he sent: "American six ninety two how are we making out" (Table 17). By contrast, the controller consistently used standard phraseology with Avianca 052 in the period before the first approach, which may have made it more difficult for the first officer to use plain language when he needed to. The controller finally inquired about the Avianca fuel situation in the fourth critical communication. His message was delivered in an angry tone, not a reassuring or helpful key: "and Avianca zero five two heavy ah I'm gunna bring you about fifteen miles north east and then turn you back onto the approach is that fine with you and your fuel" (Table 30).

8.2.3.3 RQ G – Use of More than One Language

The next research question (RQ G) asked whether the use of more than one language in the same airspace by the pilots or air traffic controllers contributed to the accident. Code switching between different languages during radio communication did not contribute to the accident. However, as discussed in Section 8.2.1.2, the first officer had to engage in frequent code switching between English and Spanish as he integrated the radio and cockpit communication. This imposed a substantial cognitive load, which may have impaired his ability to communicate effectively, especially when the level of flight crew stress was increasing late in the flight. Specifically, the cognitive load imposed by code switching may have made it difficult for the first officer to create novel English messages. Instead he repeatedly used simple expressions (e.g., "we're running out of fuel"). Thus, code switching in the cockpit may have contributed indirectly to a deterioration in the first officer's ability to communicate effectively on the radio.

8.2.3.4 RQ H – Influence of Other Factors

The final research question (RQ H) asked whether the influence of other factors on the language use of the pilots or air traffic controllers contributed to the accident. The analysis of recurring phenomena and critical communications identified numerous factors that contributed to the crash of Avianca 052. The factors were: accommodation, ambiguity, appended message, avoidance, blocked transmission, call sign confusion, code switching, colloquialism, distraction, fatigue, idiom, message length, microphone clipping, omission, phrasal verb, plain language, repetition, standard phraseology, stress, style shifting and workload. Entries from the ACT glossary for these factors are reproduced in Appendix 14. Some of the factors played a minor role in this accident; others were more significant. One example of a significant factor was the distraction of a telephone conversation that meant the H67 controller did not hear the first officer's message "we run out of fuel now" (Table 27). Another example was the first officer's repeated use of an appended message to send information about the aircraft's fuel situation (Tables 27, 28, 29 and 31).

8.2.4 NTSB Report – Limitations of the Transcripts

This section discusses limitations of the CVR and ATC transcript data from the Avianca 052 accident. It is divided into two parts. The first part discusses shortcomings in the transcripts, and presents a protocol for transcribing CVR and ATC audio that addresses the shortcomings. The second part discusses the limited duration of the CVR recording, and the impact it had on the NTSB investigation and this analysis.

8.2.4.1 Shortcomings of CVR & ATC Transcripts in the NTSB Report

Audio recordings provide a record of spoken communications and, in the case of the CVR, oral alerts and other sounds on an aircraft's flight deck. They do not provide a record of non-verbal communication. In other words, audio recordings do not contain any information about hand gestures, including pointing at displays, or facial gestures. Nor do they provide information about what pilots were looking at as they spoke. In recognition of the limitations, Dekker (2006, p. 97) characterized CVR and ATC recordings as "partial data traces" and cautioned against mistaking them for actual human behaviour. He made the observation that these partial data traces point "to a world that was unfolding around the practitioners at the time, to tasks, goals, perceptions, intentions, thoughts, and actions that have since evaporated".

In a study of US airline accidents that drew heavily on NTSB reports, Dismukes et al. (2007, p. 8) noted that the process of "transcribing the recording inherently requires varying degrees of interpretation". The subjective nature of transcribing is well understood in conversation analysis (CA), in which the construction of detailed transcriptions plays an essential role. Liddicoat (2007, p. 9) commented that transcripts "re-present" events and "are in every case subjective representations of the talk in which the transcriber has made decisions about what features of talk to include or exclude from the transcription".

For airline accident investigations, the process of transcribing involves a significant loss of detail because the transcription conventions are much simpler than those used in conversation analysis. For instance, accident report transcripts usually do not indicate the precise timing of pauses and overlaps, and they do not include information about speech delivery characteristics such as rising or falling intonation. Having information about overlaps and prosody would have benefited the Avianca 052 analysis. It would have confirmed whether overlapping speech affected the first officer's ability to hear the two crucial instructions from the captain ("tell them we are in emergency" in Table 28) and whether the FV controller's inquiry was delivered in an angry tone ("is that fine with you and your fuel" in Table 30).

There were a number of specific problems in the transcripts, which are detailed in the footnotes in Chapter 7. The shortcomings in the CVR and ATC data record for the Avianca 052 accident make it difficult for researchers to analyse this accident and learn lessons from it. These problems therefore hinder attempts to improve aviation safety. The shortcomings include:

- Typographical errors – spelling mistakes and the inaccurate labelling of speakers (e.g., tower controller and CAMRN approach controller instead of final vector controller and TWA801 in Table 29);
- Omitted start times – some utterance start times are not included in the transcripts (e.g., see the utterances of the FE in the excerpt in Appendix 16);
- Discrepancies between transcripts – dialogues that are in more than one transcript have different utterance start times, word omissions and different words (e.g., "now okay" instead of "now we could" in Table 31);
- Translation inaccuracies – see Appendix 17 for inaccuracies in the translation of Spanish dialogue into English.

Guidance for dealing with CVR data during an accident investigation is provided in an NTSB publication titled "Cockpit Voice Recorder Handbook for Aviation Accident Investigations". Regarding the procedure that should be followed for transcribing audio data, this publication simply states: "The transcript is punctuated and formatted to standard NTSB transcript style." (NTSB, 2016, p. 7). In order to address shortcomings in transcripts from the Avianca 052 accident and other accidents, I created a transcription protocol for transcribing CVR and ATC audio. This simple protocol, which features cross-checking of transcriptions, is included in Appendix 18.

8.2.4.2 Duration of the CVR Recording

In 1990, at the time of the Avianca 052 accident, large passenger aircraft were required to carry a CVR that could record for 30 minutes. Currently, most airliners are equipped with either 30-minute or 2-hour CVR devices. In recent years there have been numerous accident and incident investigations in which relevant CVR data could not be retrieved (Cookson, 2019a). As a result, ICAO and the European Union are introducing new requirements. As of 1st January 2021, newly-manufactured transport aircraft with a maximum certificated take-off mass (MCTOM) of over 27,000 kg must be equipped with 25-hour CVRs (EU, 2015).

The following extract from NTSB Safety Recommendation Report ASR-18-04 underscores the importance of CVR data for accident investigation:

> CVRs are among the most valuable tools used for accident investigation. Information such as flight crew verbalizations of intentions and coordination, as well as pilots' awareness of the state of the aircraft and cockpit information, allows investigators to more comprehensively assess accident/incident factors. These factors include flight crews' procedural compliance, distraction, decision-making, workload, fatigue, and situational awareness. Ultimately, CVRs provide unique information with which the NTSB can conduct more thorough investigations to more effectively target safety recommendations. (NTSB, 2018, p. 1)

The length of the Avianca 052 CVR audio recording was 40 minutes 15 seconds. The CVR transcript provided valuable data for this analysis. However, the analysis was constrained in three ways by the CVR duration being limited to only 40 minutes:

1. No CVR data are available for the first critical communication, when Avianca 052 was in a holding pattern and the first messages were sent about the fuel problem;
2. There is evidence that a briefing for a low fuel situation go around started earlier than 20:53 but this cannot be verified because the CVR data are not available;
3. It is not possible to test the fatigue hypothesis to see if there was an increase in the captain's use of repetition as the flight progressed.

The Avianca Flight 052 accident is a powerful argument for extending the duration of CVR devices. This analysis has highlighted the potential benefits of such a change to accident investigation. In particular, the third point above represents an important area that is currently under-researched but which could be significantly impacted by the introduction of extended duration CVRs: the effect of fatigue on the language use of pilots.

CHAPTER 9: Conclusion

The first page of this dissertation shows three quotes related to the three areas of the literature review: language, risk and culture. All three quotes have a bearing on the findings of the study. Firstly, this is an examination of aviation English. It investigates how standard phraseology and plain language are interwoven in the actual language use of pilots and controllers, and also the ways in which NNS pilots integrate English with other languages. Secondly, the project examines the interplay of risk and communication. The ACT glossary has been created to raise awareness of the risks associated with particular communication factors. Finally, the study explores the role played by culture in pilot-ATC communications. This includes the national culture of participants (e.g., language attitudes based on a speaker's nationality), organizational culture (e.g., Avianca or the FAA) and professional culture (e.g., airline pilots or air traffic controllers).

The dissertation has been written in response to the ICAO language proficiency programme. This chapter presents the main findings and implications in four sections. The first section contains a reassessment of the crash of Avianca Flight 052, one of the four accidents referenced in ICAO Document 9835. The reassessment is based on the Stage Two analysis of language use and it attempts to make sense of how communication broke down between the pilots and controllers. The second section draws on both Stage One and Stage Two to discuss the implications of the study for two areas of aviation: flight crew training and accident investigation. The third section presents a framework for analysing the language use of pilots in accidents. The framework was developed from the analysis of the Avianca 052 accident. The final section of the chapter reflects on limitations of three elements of the study: the survey of pilot attitudes, the semi-structured interviews with the KI, and the Avianca 052 analysis.

9.1 Reassessing the Avianca 052 Accident

Cobb and Primo (2003, p. 10) observed that airplane crashes are "easily simplified, personalized and symbolized". They therefore lend themselves to being reduced to short, dramatic news stories. This process could be observed in the aftermath of the Avianca 052 accident. On the next day, newspapers across America carried headlines such as:

- "'A MIRACLE' ANYONE SURVIVED" (Seattle Times, Washington)
- "Plane 'just went down'" (Providence Journal, Rhode Island)
- "Jet crashes in N.Y. fog: 'worst thing you ever saw'" (St. Petersburg Times, Florida)

One year later, a large amount of information about the flight became available when the report of the NTSB investigation was published. Nevertheless, the same process of simplification, personalization and symbolization was evident in media coverage of the accident report, even in aviation publications. Flight International magazine condensed the findings of the 295-page NTSB document to a single paragraph with the headline "CREW FAILED". The article declared "there was '...such poor flight crew performance' that any air traffic control shortcomings were irrelevent [sic]" (Flight International, 1991). The accident was reduced to a simple narrative of foreign pilots failing to communicate a fuel emergency. The reality was much more complex.

To make sense of the Avianca 052 accident, it is necessary to try to understand how the flight crew and controllers experienced events as they unfolded. We must bear in mind that the participants did not know an accident would happen. In other words, it is important to avoid hindsight bias (Dekker, 2007). The pilots and controllers were moving along the Figure 20 timeline, not knowing that the flight would end in tragedy at 21:34 EST. Their lack of awareness of impending disaster is summed up by a comment from the Avianca first officer shortly after the aircraft entered the FV controller's airspace. At 21:07 he said to his colleagues, "this means that we'll have hamburger tonight" (NTSB, 1991, p. 97). As we look back on the events after 30 years have passed, we have the benefit of numerous representations of the accident. In addition to newspaper articles and the NTSB report, there have been books, documentaries, and analyses by pilots and human factors experts. These representations should be regarded critically, and we need to remain mindful of their limitations when reassessing the accident.

Stage Two of this study examined the communication problems that occurred during the Avianca 052 flight. The accident did not hinge on a simple misunderstanding between a pilot and a controller. Nor was it mainly due to the limited English proficiency of NNS pilots. There was a communication breakdown that involved three members of the Avianca crew, five controllers and numerous other pilots flying through the same airspace. Section 8.2.2 describes the process by which communication broke down. As the Avianca fuel situation worsened, the first officer tried to inform ATC of the problem in a series of transmissions. He twice sent a message saying "we need priority" and on four occasions radioed "we're running out of fuel". However, the meaning that he intended to convey in these messages was masked by the following factors:

- Intelligibility – in the first critical communication one of the messages about the fuel problem was partially garbled;
- Plain language – the first officer used idiomatic plain language which mitigated the force of his communication (i.e., "running out of fuel");
- Standard phraseology – he did not declare an emergency using terminology that the controllers would respond to (i.e., MAYDAY, PAN PAN or emergency);
- Appended messages – he sent the information as appended messages which increased the risk of controllers not hearing it and not acting on it;
- Routine messages – the ongoing routine messages from the first officer reinforced the impression that the aircraft was *not* in an emergency situation.

The first officer assumed that controllers were passing his messages on to the next sector, and that the Avianca aircraft was receiving priority handling. Just one message was passed on, and the plane did not receive priority handling. After the missed approach, the captain twice gave an instruction to declare an emergency. The first officer most likely did not hear these instructions clearly. He did not declare a fuel emergency.

From the end of the third holding pattern, there was a steady deterioration in the condition of the Avianca aircraft. Over the course of 45 minutes it progressively worsened from a non-routine low fuel situation into a fuel emergency. No sudden, obvious change in aircraft condition occurred that might have signalled to the inexperienced first officer the need to declare an emergency. Initially, the first officer seems to have been waiting for ATC to inquire about the fuel problem, as he had heard the FV controller do for another flight (AAL692). Crucially, the first officer had not heard the earlier transmissions initiated by the American Airlines pilot. The inquiry from ATC eventually came after the missed first approach and it was apparently delivered in an angry tone. A dangerous gap had by now developed between the situational awareness of the first officer (who thought he had notified ATC about the fuel problem) and the controllers (who continued to handle the flight routinely). This gap finally disappeared at 21:32 in the sixth critical communication when the first officer radioed "we just ah lost two engines and ah we need priority please". The controller gave an instruction to turn on to the final approach, but it was too late to save the flight.

This analysis of the Avianca 052 accident highlights some factors that were noted in previous studies, but not accorded much significance. Firstly, it provides evidence from the captain's language use that he was suffering from fatigue. This was mentioned in the body of the NTSB report but downplayed in the conclusion, which stated only that fatigue may have adversely affected his handling of the first approach. Secondly, the analysis highlights the steep experience gradient in the Avianca cockpit between the captain and young first officer. Helmreich (1994) noted the inexperience of the first officer, but did not consider how it limited the support he could give the captain in flying the aircraft, or how it affected his ability to manage ATC communication. Thirdly, the analysis of the second critical communication indicates that the first officer may not have clearly heard either of the instructions from the captain to declare an emergency. This develops the suggestion by Duke (1992) that the distraction of a wind shear radio message prevented the first officer from hearing the second instruction.

In addition, the analysis identifies other factors that played a significant role in the accident, but were not considered in previous studies. The first of these is code switching by the first officer, which imposed an extra cognitive burden as the stress and workload increased late in the flight. The second factor is the style shifting of the FV controller, which facilitated the use of plain language by the AAL692 pilot but reinforced the use of routine phraseology by the Avianca first officer. A final factor that was analysed for the first time is the first officer's repeated use of appended messages, which increased the risk of important information being ignored by controllers.

Previous research has pointed out problems associated with the overuse of plain language by NES pilots, including verbosity, colloquialisms and rapid rate of speech (Kim & Elder, 2009; Kim, 2013). Another phenomenon was identified in this study: the use of colloquial plain language by NESs to negotiate preferential outcomes. Section 7.2.3.3 explained how AAL692 received priority handling after the pilot told the controller "very unhappy at two thousand feet" and "uh we're uh about uh twelve or fourteen minutes from declaring an emergency". The American Airlines pilot used colloquial English to warn of a potential fuel emergency. The controller responded by drawing on his own plain language resources to ensure AAL692 proceeded quickly to a safe landing. It was not an isolated case. Pan Am Flight 224 was given clearance to leave the holding pattern at CAMRN a few minutes after the pilot had told the R67 controller “Ah ah roger ahhh about another fifteen minutes then zero one ah three zero that’s the limit for us ah well have to divert on it” (NTSB, 1991, p. 165). It is not possible to say whether preferential treatment given to other planes increased the delays experienced by Avianca Flight 052. However, it is clear that some American pilots *did* receive “priority handling” without declaring an emergency. Those pilots demonstrated a high level of sociolinguistic competence in managing social relationships with controllers. Such sociolinguistic competence requires a high level of English proficiency and also considerable experience of flight operations.

The purpose of this analysis is not to apportion blame. None of the participants wanted an accident to occur. The crash of Avianca Flight 052 was a complex accident that involved numerous causal factors. This analysis is an attempt to understand the process by which communication broke down between the pilots and controllers so we can prevent similar events from happening again. By learning from the problems of the past, we are better equipped to make the future safer.

9.2 Implications for Pilot Training & Accident Investigation

During the course of this project, I have been struck by the contrast between the experienced KI and the young Avianca first officer. The KI explained in the interviews how he learns from past accidents and the mistakes of others. This ongoing process of learning has helped him to develop into an experienced captain. Tragically, the Avianca first officer had not yet had the chance to learn such lessons when Flight 052 crashed. One overall conclusion to be drawn from this study is that the process of learning from past accidents is a vital element in the development of successful airline pilots. In addition, the study has a number of implications in two areas of civil aviation: (1) flight crew training, and (2) accident investigation.

The first implication for flight crew training is that the Stage Two analysis provides a reassessment of the Avianca 052 accident. The narrative of communication breakdown presented in Section 8.2.2.1 is significant because it is the first applied linguistic analysis of the process by which communication broke down during this accident. The findings may be used in training workshops to inform flight crew (or air traffic controllers) about the communication risks associated with factors such as appended message or distraction. The analysis serves as a stark reminder of the vital role played by standard phraseology in providing a common language for pilots and controllers around the world. Furthermore, it clearly demonstrates how interwoven standard phraseology and plain language are in the actual language use of pilots and controllers (see Section 2.4.3).

The second implication for training concerns information about past accidents. The Stage One survey respondents overwhelmingly agree that studying accidents is important for improving airline safety. However, TV documentaries are their most common source of information, which is problematic because documentaries offer simplified representations of accidents, as noted in Section 7.2.2.5. It is therefore recommended that multiple sources of information be used in training workshops, and clear context be provided when using excerpts from documentaries.

The final implication for training involves the ACT glossary, which was applied to the analysis of the Avianca 052 accident and is reproduced in part in Appendix 14. The ACT glossary could be used during the recurrent training of pilots to raise awareness of the risks that certain factors pose to communication. A simple format for a training workshop is as follows: (1) a trainer presents one communication factor from the glossary; (2) pilots discuss any experiences they have had related to the factor; and (3) they discuss ways in which specific problems could be mitigated.

This study also has implications for accident investigation. Firstly, the analysis of language use in the Avianca 052 accident underscores the value of extended duration CVR devices. The analysis was impeded in three ways by the short length of the Avianca CVR recording: (1) the analysis of the first critical communication was restricted; (2) it was not possible to determine when the briefing for a low fuel go around began; and (3) the fatigue hypothesis could not be tested. Similar problems have been reported in numerous accident and incident investigations over recent years, and CVR duration has become an important issue in contemporary civil aviation. As noted in Section 8.2.4.2, ICAO and the European Union intend to introduce requirements for 25-hour CVRs on large, newly-manufactured transport aircraft from 2021.

Secondly, the study highlights the importance of accurate and detailed transcripts. Appendix 18 contains a simple protocol for transcribing CVR and ATC audio data. It has been designed to avoid the shortcomings found in the transcripts compiled for the NTSB investigation of the Avianca 052 accident. The protocol has three stages: compiling broad transcripts of all audio data, cross-checking the broad transcripts, and compiling narrow transcripts of critical communications. It is proposed that the CA transcription procedure only be applied to critical communications.

Finally, there is an epistemological aspect to this project. The conclusion of the NSTB report for the Avianca 052 crash indicated a probable cause of the accident and a list of contributory factors. However, it made no mention of significant limitations to the data available for the investigation. As noted in Section 5.5.2, the following information was not included in the report: data from the FDR device, toxicological test results for the air traffic controllers, and the FAA traffic management report for the night of the accident. There were also limitations to the transcript data, as described in Section 8.2.4. The current study demonstrates that it is not always possible to provide definite explanations for how and why an accident occurred. There are limits to our knowledge. This is in line with the sentiment expressed by Duke (1992) that we may never completely understand the events that took place in the Avianca 052 cockpit and at ATC facilities on the ground.

9.3 A Framework for Analysing Pilot Language Use in Accidents

A novel framework has been developed during this study based on the analysis of language use in the Avianca 052 accident. It includes a robust procedure for transcribing audio data, and a suite of methodologies for analysing segments of communication that are identified as being of interest. The methodologies may be used to analyse both recurring communication phenomena and also key periods of interaction. The framework could be applied to all of the accidents cited by ICAO (see Table 2) as well as any other accidents or incidents that involve communication breakdowns.

The framework essentially consists of a 3-part iterative process, which is shown in Figure 23. The first step is to collect the context and communication data for an accident. Context data include information about the airline history, organizational culture, aircraft condition, condition of pilots and controllers, and the history of the flight. Communication data include audio data from the CVR and ATC recordings.[78] If available, pilot interview recordings may also be included. The second step is to compile transcripts from the data. Broad transcripts are made of all audio data using the transcription protocol in Appendix 18. Narrow transcripts are made of critical communications using the conversation analysis procedure. The third step is data analysis. Timelines are constructed for the accident. Then

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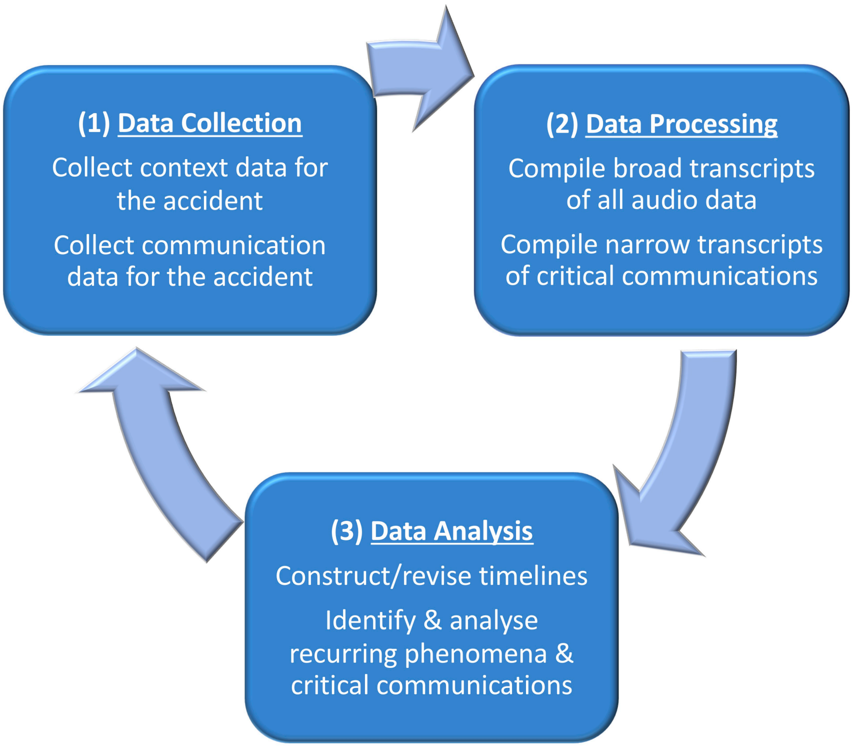
[78] Cockpit video recording systems, or airborne image recorders (AIR), might in future provide valuable additional data. Airlines are not currently required to install them, but there have been calls for their introduction (NTSB, 2000c; ICAO, 2012).

recurring phenomena of interest and critical communications are identified, and they are analysed. The three steps of the cycle depicted in Figure 23 are repeated until the analysis has produced a comprehensive account of the process of communication breakdown and the role it played in the accident.

Figure 23: Framework for analysing language use in an airline accident.



In the third step of the process, the analysis of recurring phenomena and critical communications draws on three methodologies: conversation analysis (CA) techniques, the grammar of context framework, and the ACT glossary. One key feature of the framework is that it includes CA techniques. These allow interactions to be examined as they unfold, utterance by utterance. Whenever we investigate an accident, we are by definition looking back in time with knowledge of the negative outcome. The CA approach is a defence against hindsight bias. It helps investigators to make sense of how participants perceived their situation as the events unfolded, and it provides insights into the decisions they made. Another important feature is that the grammar of context framework allows a full analysis of the context of communication, including the setting and various roles adopted by the participants. It embraces multiple aspects of culture through the assumption that people participate in multiple discourse systems related to nationality, gender, age, profession or organization, and so on. The third key feature of the framework is the ACT glossary. This provides a toolkit of core concepts relating to the communication of pilots and air traffic controllers, which facilitates the analysis of communication breakdowns.

9.4 Limitations of the Study

The final section of the conclusion reflects on the limitations of this study in three areas: the online survey of pilots' attitudes to past accidents, the semi-structured interviews with the KI, and the analysis of language use in the Avianca 052 accident.

Firstly, the scale of the survey was limited (n=92) and the participants were drawn from a narrow range of backgrounds: they were 100% native English speakers, 97% male and 88% British. Furthermore, in order to make the survey simple and quick to use, the questionnaire mainly consisted of closed-ended question types. The limited number of survey participants was partially offset by the fact that all the respondents were airline pilots. This was a result of the questionnaire being distributed through closed forums operated by BALPA. Despite the survey's limitations, interesting results were generated about the attitudes of pilots towards studying past accidents and the sources from which they gather accident information.

The second limitation concerned the semi-structured pilot interviews. Only one pilot participated in the interviews, which meant that the results were inevitably affected by bias. To minimise this problem, the KI was carefully selected using the criteria laid out by anthropologist Marc-Adélard Tremblay for an "ideal informant". Since there was only one KI, I was able to conduct a long series of in-depth discussions. This, and the flexibility afforded by the semi-structured interview approach, allowed us to follow particular themes and revisit them as the need arose. For instance, the KI was able to describe in detail how he integrates accident information into his professional practice as an airline captain. The KI's process of reflection is a method of risk mitigation, which involves him incorporating lessons learned from accidents such as the 1977 Tenerife runway collision into his daily work of flying airplanes.

The third limitation of the study was the lack of audio data for the analysis of language use in the Avianca 052 accident. It is sometimes possible to obtain partial ATC recordings for an accident, but the NTSB is prohibited under US law from releasing CVR recordings (see Appendix 11). This is unfortunate because, as explained in Section 8.2.4.2, CVR data provide unique information about the interaction, communication and decision making of pilots within the cockpit. I tried unsuccessfully to gain access to audio data for the Avianca 052 accident. In the absence of audio data, I decided to use the CVR and ATC transcript data from the NTSB accident report. Previous studies have conducted similar analyses of transcripts from other accidents (Linde, 1985; Driscoll, 2002; Nitayaphorn, 2009). One benefit of focusing the analysis on the transcript data was that it brought to light numerous shortcomings in these data, as detailed in Section 8.2.4.1. This led me to create the transcription protocol for CVR and ATC audio data, which is reproduced in Appendix 18.

LIST OF ABBREVIATIONS & ACRONYMS

AAIB	=	Air Accidents Investigation Branch (accident investigation agency in the UK)
AAIB	=	Aircraft Accident Investigation Bureau (accident investigation agency in Switzerland, Büro für Flugunfalluntersuchungen)
ACARS	=	Aircraft Communications Addressing and Reporting System (a data link system for transmitting messages between aircraft and ground stations)
AHFE	=	Applied Human Factors and Ergonomics (annual conference)
AIM	=	Aeronautical Information Manual (a guide to basic flight information and ATC procedures in the USA and Canada)
AIR	=	airborne image recorder
ALARP	=	as low as reasonably practicable
ANSV	=	Agenzia Nazionale per la Sicurezza del Volo (National Agency for the Safety of Flight, Italy)
ARTCC	=	air route traffic control centre (an ATC facility controlling aircraft in the en route flight phase in a particular volume of airspace)
ASRS	=	Aviation Safety Reporting System (a NASA system for aviation personnel to voluntarily submit incident reports)
ASSIB	=	and still stay in business
ATC	=	air traffic control
ATIS	=	automatic terminal information service (a recorded broadcast of essential aeronautical information for the airport area)
ATQP	=	alternative training and qualification programme
ATSAT	=	aviation topic and speech act taxonomy (a taxonomy for coding pilot-ATC RT messages)
ATSB	=	Australian Transport Safety Bureau (accident investigation agency in Australia)
BALPA	=	British Airline Pilots Association
BASIS	=	British Airways Safety Information System (a safety reporting system established by British Airways)

BEA	=	Bureau Enquêtes-Accidents (Bureau of Enquiry and Analysis for Civil Aviation Safety, France)
BTS	=	Bureau of Transportation Statistics (part of the United States Department of Transportation)
CA	=	conversation analysis
CAA	=	Civil Aviation Authority (agency regulating civil aviation in the UK)
CAD	=	Civil Aviation Department (agency regulating civil aviation in Colombia)
CAT	=	communication accommodation theory
CEO	=	chief executive officer
CFCF	=	Central Flow Control Facility (an FAA facility to manage traffic)
CFIT	=	controlled flight into terrain
CHIRP	=	Confidential Human Factors Incident Reporting Programme (a confidential safety reporting system in the UK)
CIAIAC	=	Comisión de Investigación de Accidentes e Incidentes de Aviación Civil (Civil Aviation Accidents and Incidents Investigation Commission, Spain)
CMAQ	=	cockpit management attitudes questionnaire
CPDL	=	controller-pilot data link
CPDLC	=	controller-pilot data link communications
CRM	=	crew resource management (an airline training methodology)
CVR	=	cockpit voice recorder
CWT	=	centre wing (fuel) tank
DAAC	=	Departamento Administrativo de Aeronáutica Civil (Civil Aviation Department in Colombia)
DGAC	=	Director General of Civil Aviation (in India)
EGP	=	English for general purposes
ELF	=	English as a lingua franca
EOC	=	ethnography of communication
EPA	=	Environmental Protection Agency (an agency of the federal government of the United States)
ESL	=	English as a second language
ESP	=	English for special/specific purposes

EST	=	Eastern Standard Time (5 hours behind UTC)
FAA	=	Federal Aviation Administration (agency regulating civil aviation in the USA)
FBO	=	fixed-base operator (a company providing aeronautical services, such as fueling, parking and rental, at an airport)
FDR	=	flight data recorder
FE	=	flight engineer
FL	=	flight level
FMAQ	=	flight management attitudes questionnaire
FMC	=	flight management computer
FO	=	first officer
FOIA	=	Freedom of Information Act
FOQA	=	flight operations quality assurance system
FRMS	=	fatigue risk management system
FSF	=	Flight Safety Foundation (a US non-profit safety organization)
FV	=	final vector (controller)
GA	=	general aviation
GLOBE	=	Global Leadership and Organizational Behavior Effectiveness (cultural research project)
GPWS	=	ground proximity warning system
HERA	=	Human Error in Air Traffic Management (a Eurocontrol project)
HF	=	human factors
HFACS	=	Human Factors Analysis and Classification System (a human factors taxonomy)
IAEA	=	International Atomic Energy Agency
IATA	=	International Air Transport Association (an association of airlines)
ICAEA	=	International Civil Aviation English Association
ICAO	=	International Civil Aviation Organization (a United Nations agency)
IFALPA	=	International Federation of Air Line Pilots' Associations
IFATCA	=	International Federation of Air Traffic Controllers' Associations
ILS	=	instrument landing system (a precision runway approach aid)
INSAG	=	International Nuclear Safety Advisory Group (IAEA advisory group)
ISAP	=	International Symposium on Aviation Psychology

IT	=	information technology
JFK	=	John F. Kennedy (International Airport in New York)
KI	=	key informant
KNKT	=	Komite Nasional Keselamatan Transportasi (National Transportation Safety Committee, Indonesia)
L1	=	first language or mother tongue
L2	=	second language or foreign language
LGP	=	language for general purposes
LOSA	=	line operations safety audit
LPRs	=	language proficiency requirements
LSP	=	language for special/specific purposes
MCTOM	=	maximum certificated take-off mass
MSA	=	minimum safe altitude
MTO	=	man-technology-organisation (a human factors model developed in Sweden for the nuclear power industry)
NASA	=	National Aeronautics and Space Administration (agency responsible for the civilian space programme in the USA as well as aeronautics and aerospace research)
NES	=	native English speaker
NNS	=	non-native speaker
NOTAM	=	notice to airmen (a notice that alerts pilots about hazards)
NTSB	=	National Transportation Safety Board (accident investigation agency in the USA)
OCR	=	optical character recognition
PA	=	public address
PANS	=	Procedures for Air Navigation Services (instruments used by ICAO)
PF	=	pilot flying (the pilot controlling an aircraft in a two-person crew)
PIC	=	pilot in command (the captain, in the case of an airline crew)
PM	=	pilot monitoring (the pilot monitoring aircraft status in a two-person flight crew; also known as pilot not flying, PNF)
PNF	=	pilot not flying (the pilot who is monitoring aircraft status in a two-person flight crew; also known as pilot monitoring, PM)
PRA	=	probabilistic risk assessment

PRICESG	=	Proficiency Requirements In Common English Study Group (ICAO study group)
RAeS	=	Royal Aeronautical Society (professional institution in the UK)
RPK	=	revenue passenger kilometres
RT	=	radiotelephony
RTF	=	radiotelephony
SARPs	=	Standards and Recommended Practices (instruments used by ICAO)
SARS	=	severe acute respiratory syndrome
SCE	=	socio-cultural encounter
SCT	=	speech codes theory
SLA	=	second language acquisition
SOP	=	standard operating procedure
SHEL	=	Software Hardware Environment Liveware (a human factors model; also referred to as SHELL)
SMS	=	safety management system
SUPPs	=	Regional Supplementary Procedures (instruments used by ICAO)
TCAS	=	traffic collision avoidance system
TEM	=	Threat and Error Management (a human factors model)
TMA	=	terminal manoeuvring area (controlled airspace around a major airport with a high volume of traffic)
TRACON	=	terminal radar approach control (an ATC facility that controls aircraft movement in the vicinity of a large airport)
TSB	=	Transportation Safety Board (accident investigation agency in Canada)
UAE	=	United Arab Emirates
UAS	=	unmanned aircraft system
UTC	=	Coordinated Universal Time[79]
VFR	=	visual flight rules
VHF	=	very high frequency
VIP	=	very important person

[79] Coordinated Universal Time (CUT), corresponding to Greenwich Mean Time, is the common time standard around the world. In French, it is called “Temps Universel Coordonné” (TUC). The abbreviation UTC is used to minimize confusion.

GLOSSARY OF AVIATION TERMS

accident	=	an occurrence during a flight in which a person suffers a fatal or serious injury due to the operation of the aircraft, or the aircraft is severely damaged
aileron	=	a flight control surface on the outer part of the wing that controls an aircraft's roll motion
Airspeak	=	a special language used for pilot-ATC communications
alternate airport	=	an airport identified in the flight plan for landing at if it is not possible to land at the intended destination
cabin crew	=	the personnel who look after passengers during a flight
call sign	=	a group of alphanumeric characters that identify an aircraft
captain	=	the senior pilot in a flight crew who is responsible for the aircraft's operation and safety
checklist	=	a tool which helps pilots to perform a series of actions correctly
cockpit voice recorder	=	a "black box" that records flight crew conversations and other cockpit sounds
controlled airspace	=	airspace of defined dimensions in which ATC service is provided (includes classes A, B, C, D and E)
controlled flight into terrain	=	a type of accident in which an airworthy aircraft, under pilot control, is unintentionally flown into terrain, water or an obstacle
crosswind	=	a wind that has a significant component perpendicular to the direction of travel
data link	=	a system for transmitting text messages between pilots and air traffic controllers
deregulation	=	the reduction or removal of rules and regulations in an industry (which for airlines started with the Airline Deregulation Act of 1978 in the USA)

elevator	=	a flight control surface on the horizontal part of the tail that controls an aircraft's pitch motion
fatigue	=	a state of tiredness resulting from prolonged excessive work and/or sleep deprivation
first officer	=	the second pilot in a flight crew (also called co-pilot)
flag carrier	=	an airline that is/was government owned and receives preferential rights in the country where it is registered
flight controls	=	movable surfaces (e.g., elevators, ailerons) on an aircraft's wings and tail that control its flight attitude
flight crew	=	the personnel who operate an aircraft during a flight; the captain, first officer and (in older aircraft) flight engineer
flight data recorder	=	a "black box" that records performance data from engines and other aircraft systems
flight deck	=	cockpit
flight level	=	a pressure altitude measured in 100-feet units
general aviation	=	civil aviation operations except those involving revenue passenger or cargo flights
glide slope	=	a beam providing vertical guidance on final approach
go-around	=	an aborted landing of an aircraft on final approach
heavy	=	a category of aircraft weighing more than 136,000 kg that require extra spacing due to wake turbulence
holding pattern	=	an oval-shaped pattern that aircraft fly at a specified location while waiting for clearance to proceed
incident	=	an occurrence during a flight, other than an accident, which affects safety
knot	=	a measure of speed which equals 1 nautical mile per hour, or 1.85 km/hr
listening watch	=	pilots listening to radio communications between ATC and other aircraft (also called party line)
localizer	=	part of an instrument landing system (ILS) which provides horizontal guidance to aircraft
missed approach	=	a procedure followed by a pilot when an approach cannot be continued to a successful landing

nautical mile	=	a measure of distance which equals 1,852 metres
party line	=	pilots listening to radio communications between ATC and other aircraft (also called listening watch)
plain language	=	language used in pilot-ATC communications that is not standard phraseology
port	=	the left side of an aircraft when facing forward
read-back	=	a pilot repeats a message or part of a message in order to confirm correct reception
runway excursion	=	an aircraft veering off the side or end of a runway during takeoff or landing
runway incursion	=	the unauthorized presence of an aircraft, vehicle or person on a runway
situational awareness	=	identifying and understanding critical information about the environment as it relates to the mission
standard phraseology	=	a standardized set of words, phrases and conventions used in routine pilot-ATC communications
starboard	=	the right side of an aircraft when facing forward
sterile cockpit rule	=	a regulation requiring pilots to refrain from non-essential activities during critical phases of flight
stress	=	a state of physical, mental or emotional strain due to an external or internal stimulus
turbine-powered	=	powered by jet or turboprop engines
uncontrolled airspace	=	airspace in which ATC service is not necessary or cannot be provided (includes classes F and G)
vector	=	a heading given to an aircraft by ATC
wake turbulence	=	turbulence that forms behind an aircraft as it moves through the air; may be hazardous, especially during takeoff and landing
weight and balance sheet	=	a document that records the distribution of weight in an aircraft and shows the centre of gravity
wind shear	=	a sudden change in wind speed or direction; may be horizontal or vertical or a mixture of both

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APPENDIX 1: ICAO Level 4 Descriptors

The ICAO language proficiency rating scale has six assessment criteria and six proficiency levels. The levels range from Level 1 (called "Pre-elementary") to Level 6 ("Expert"). Pilots and air traffic controllers involved in international flight operations are required to achieve Level 4 ("Operational"). They are evaluated on all six assessment criteria and the lowest evaluation determines the overall level. Therefore, to obtain a Level 4 rating, they must demonstrate Level 4 proficiency (or higher) for all six assessment criteria. The table below shows the descriptors and explanations for Level 4, reproduced from Document 9835 (ICAO, 2010, pp. 4-9–4-14).[80]

ASSESSMENT CRITERION	LEVEL 4 DESCRIPTOR	LEVEL 4 EXPLANATION
Pronunciation	Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation, but only sometimes interfere with ease of understanding.	Operational Level 4 speakers demonstrate a marked accent, or localized regional variety of English. Occasionally, a proficient listener may have to pay close attention to understand or may have to clarify something from time to time. Operational Level 4 is certainly not a perfect level of proficiency; it is the minimum level of proficiency determined to be safe for air traffic control communications. While it is not an Expert level, it is important to keep in mind that pronunciation plays the critical role in aiding comprehension between two non-native speakers of English.
Structure	Basic grammatical structures and sentence patterns are used creatively and are usually	Operational Level 4 speakers have good command of basic grammatical structures. They do not merely have a memorized set of words or phrases on which they rely but have sufficient

[80] Document 9835 contains the rating scale with descriptors and explanations for each level. In Annex 1 the rating scale shows only the descriptors (in Attachment A to Appendix 1).

	well controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning.	command of basic grammar to create new meaning as appropriate. They demonstrate local errors and infrequent global errors and communication is effective overall. Level 4 speakers will not usually attempt complex structures, and when they do, quite a lot of errors would be expected resulting in less effective communication.
Vocabulary	Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances.	An Operational Level 4 speaker will likely not have a well-developed sensitivity to register. A speaker at this level will usually be able to manage communication on work-related topics, but may sometimes need clarification. When faced with a communication breakdown, an Operational Level 4 speaker can paraphrase and negotiate meaning so that the message is understood. The ability to paraphrase includes appropriate choices of simple vocabulary and considerate use of speech rate and pronunciation.
Fluency	Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting.	Speech rate at this level may be slowed by the requirements of language processing, but remains fairly constant and does not negatively affect the speaker's involvement in communication. The speaker has the possibility of speaking a little faster than the ICAO recommended rate of 100 words per minute if the situation requires (Annex 10, Volume II, 5.2.1.5.3 b).
Comprehension	Comprehension is mostly accurate on common, concrete and work-related	As with all Operational Level 4 descriptors, comprehension is not expected to be perfectly accurate in all instances. However, pilots or air

	topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies.	traffic controllers will need to have strategies available which allow them to ultimately comprehend the unexpected or unusual communication. Unmarked or complex textual relations are occasionally misunderstood or missed. The descriptor of Operational Level 4 under "Interactions" clarifies the need for clarification strategies. Failure to understand a clearly communicated unexpected communication, even after seeking clarification, should result in the assignment of a lower proficiency level assessment.
Interactions	Responses are usually immediate, appropriate and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming or clarifying.	A pilot or air traffic controller who does not understand an unexpected communication must be able to communicate that fact. It is much safer to query a communication, to clarify, or even to simply acknowledge that one does not understand rather than to allow silence to mistakenly represent comprehension. At Operational Level 4, it is acceptable that comprehension is not perfect 100 per cent of the time when dealing with unexpected situations, but Level 4 speakers need to be skilled at checking, seeking confirmation, or clarifying a situation or communication.

APPENDIX 2: Accidents Cited by ICAO

The following seven aviation accidents, which all involved communication problems, were cited during a workshop at the ICAO Asia and Pacific Office (Lamy, 2008). Four of the accidents (numbers 2-5) are also referred to in ICAO Document 9835 (ICAO, 2010).

#	DATE & LOCATION	ACCIDENT TYPE & FATALITIES	FLIGHT NUMBER(S)	L1 OF PILOTS	L1 OF ATC
1	10th Sep 1976 Zagreb, former Yugoslavia	Mid-air collision 176	(1) Inex Adria Airways Flight 550 (2) British Airways Flight 476	(1) Serbo-Croatian (2) English	Serbo-Croatian[81]
2	27th Mar 1977 Tenerife, Canary Islands, Spain	Runway collision 583	(1) KLM Flight 4805 (2) Pan Am Flight 1736	(1) Dutch (2) English	Spanish
3	25th Jan 1990 Cove Neck, New York, USA	Fuel exhaustion 73	Avianca Flight 052	Spanish	English
4	20th Dec 1995 Buga, Valle del Cauca, near Cali, Colombia	Controlled flight into terrain 160	American Airlines Flight 965	English	Spanish
5	12th Nov 1996 Charkhi Dadri, near New Delhi, India	Mid-air collision 349	(1) Saudi Arabian Airlines Flight 763 (2) Kazakhstan Airlines Flight 1907	(1) Arabic (2) Kazakh	Hindi

[81] In their analysis of the 1976 Zagreb accident, Weston and Hurst (1982, p. ix) stated that “there is no such language as Serbo Croat or... Serbo-Croatian” but went on to use these terms because they occurred widely in source documents. I have used the term Serbo-Croatian on the premise that it is a pluricentric language. In so doing, I acknowledge the longstanding political and linguistic controversy over the status of Serbo-Croatian and the need to be sensitive to nomenclature about languages.

6	25th May 2000 Charles de Gaulle Airport, Paris, France	Runway collision 1	(1) Streamline Aviation Flight 200 (2) Air Liberté Flight 8807	(1) English (2) French	French
7	8th Oct 2001 Milano Linate Airport, Milan, Italy	Runway collision 118	(1) Scandinavian Airlines Flight 686 (2) private Cessna 525 Citation	(1) Swedish (2) German	Italian

APPENDIX 3: Sample Database Record

The table below shows a sample record from the database I compiled during the literature review. The database has 606 records including documents, technical manuals, accident reports, journal papers and books. The record below is a journal paper about the Avianca 052 accident. For brevity, only the notes for pages 265-269 of the paper are shown below.

FIELD	CONTENTS FOR THIS RECORD
Title	Anatomy of a System Accident: The Crash of Avianca Flight 052
Author	Helmreich, R. L.
Publisher	International Journal of Aviation Psychology, 4(3), 265-284
Year	1994
Amount Read	All
APA Reference	Helmreich, R. L. (1994). Anatomy of a system accident: The crash of Avianca flight 052. *International Journal of Aviation Psychology, 4*(3), 265-284.
Notes	Pages 265-266, limitations of the accident report: “The NTSB report on the Avianca Flight 052 (AV502) accident pinpointed a number of factors (including crew performance) that contributed to the crash (NTSB, 1991a). However, a number of additional pieces of information were uncovered in the course of litigation between the airline and the U.S. Government.” Page 266, methodologies used in this analysis: “Our article approaches the accident from a system and group perspective and utilizes several different methodologies to attempt to explain the multiple causal factors at play on the night of January 25, 1990. The analysis was guided by Reason’s (1990) notions of latent failures and resident pathogens in complex systems.” [In addition to Reason’s concepts, the analysis uses the crew performance model developed by Helmreich and Foushee (1993), which was adapted from McGrath’s (1964) model.] Page 269, landing checklist not completed correctly: “The CVR transcript indicates that the crew did not complete the B-707 Normal Checklist for Landing correctly.”

APPENDIX 4: Features of Standard Phraseology

The following table lists key features of standard phraseology to show how it differs from natural language. For each feature, there is an example of phraseology and a natural language equivalent. The listing is intended to be illustrative, not exhaustive. For some examples many equivalent natural language expressions are possible. Detailed descriptions of standard phraseology are provided in ICAO publications (ICAO, 2007a, 2007b, 2007c) as well as documents produced by national aviation authorities (e.g., CAA, 2015).

FEATURE	STANDARD PHRASEOLOGY EXAMPLE	NATURAL LANGUAGE EQUIVALENT
Pronunciation of numbers	"3" is pronounced |**tri**:|	"3" is pronounced |**θri**:|
Pronunciation of alphabet	"G" is pronounced |**gɒlf**|	"G" is pronounced |**ʤi**:|
Limited lexicon	Less than 1,000 words, one of which is "**climb**" with no synonyms	More than 100,000 words,[82] with many synonyms such as "climb", "ascend", "rise", "gain altitude", "move up", "soar"
Univocal vocabulary	"**level**" (as in "report your level") is a generic term for the altitude or flight level of an aircraft in flight	"level" can be a noun, adjective or verb; as a noun, it can mean a horizontal plane, a position on a scale, a measuring instrument, or a flat tract of land
Deletion of subject pronouns	"**Ø** cleared for takeoff"	"**you** are cleared for takeoff"
Deletion of auxiliary verbs	"**Ø** cleared for takeoff"	"you **are** cleared for takeoff"

[82] Crystal, D. (2003, p. 123) pointed out the difficulty of estimating the size of the English language and the lexicon of individual speakers. He noted that a medium-sized dictionary has about 100,000 entries.

Deletion of prepositions	"climb **Ø** flight level 280"	"climb **to** flight level 280"
Deletion of determiners	"request **Ø** departure information"	"I'd like to request **the** departure information"
Passive voice	"**cleared** to land"	"I give you permission to land"
Imperative forms	"**climb** flight level 280"	"I'd like you to climb to flight level 280"
Nominalizations	"**airspeed loss** 20 knots"	"we have lost 20 knots of airspeed"

APPENDIX 5: Accident/Error Models & Taxonomies

The table below shows five models and taxonomies that have been developed for accident investigation or error analysis in aviation.

NAME	MODEL / TAXONOMY	COMMENTS
ADREP (Accident / Incident Data Reporting System)	Taxonomy	• Used for classifying accident & incident data • System collects data about accidents & incidents • Operated by ICAO
ASRS (Aviation Safety Reporting System)	Taxonomy	• Used for classifying hazards & errors • Voluntary incident reporting system • Operated by NASA on behalf of the FAA
HFACS (Human Factors Analysis and Classification System)	Taxonomy	• Used for classifying threats & analysing accident causal factors • Based on Reason's (1990) accident causation model • 4 defensive layers (unsafe acts / preconditions for unsafe acts / unsafe supervision / organizational influences)
SHEL (Software Hardware Environment Liveware)	Model	• Used for analysing sources of risk • Also known as SHELL • Emphasises human interactions with other system components
TEM (Threat and Error Management)	Model & taxonomy	• Used for classifying threats & errors • Based on Reason's (1990) accident causation model • Terminology derived from pilots' language

APPENDIX 6: “Findings as to Risk” in TSB Reports

The table below lists a selection of “findings as to risk” related to communication issues. They are taken from Transportation Safety Board of Canada (TSB) reports released between 2015 and 2017. The table shows the dates of the accidents or incidents, locations, investigation report numbers and findings. Each report contains a number of findings as to risk (from 2 to 14), but only those related to communication are reproduced below. A range of people were involved in the communications referred to, not only pilots but also air traffic controllers, cabin crew and passengers.

DATE	LOCATION	REPORT NO. (REFERENCE)	FINDINGS AS TO RISK (RELATED TO COMMUNICATION)
22nd December 2012	Sanikiluaq, Nunavut	A12Q0216 (TSB, 2015a)	13. If non-compliant practices are not identified, reported, and dealt with by a company’s safety management system, there is a risk that they will not be addressed in a timely manner.
5th June 2014	Ottawa International Airport, Ottawa	A14H0002 (TSB, 2015b)	1. If air traffic control uses non-standard phraseology, there is a risk of inconsistencies and miscommunication between air traffic control and the pilot.
5th September 2014	London, Ontario, 53nm W	A14O0165 (TSB, 2016)	3. If cockpit voice recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.
24th February 2015	Sault Ste. Marie, Ontario	A15O0015 (TSB, 2017c)	3. If crews do not report unstable approaches and operators do not conduct flight data monitoring but rely only on safety management system reports to determine the frequency of unstable approaches, there is a risk that these issues will persist and contribute to an accident.
29th March 2015	Halifax / Stanfield	A15H0002 (TSB, 2017b)	1. If aircraft cockpit voice recorder installations do not have an independent power supply,

	International Airport Halifax		additional, potentially valuable information will not be available for an investigation. 8. If there is a complete loss of electrical and battery power and the passenger address system does not have an independent emergency power supply, the passenger address system will be inoperable, and the initial command to evacuate or to convey other emergency instructions may be delayed, putting the safety of passengers and crew at risk. 10. If passengers do not pay attention to the pre-departure safety briefings or review the safety-features cards, they may be unprepared to react appropriately in an accident, increasing their risk of injury or death.
30th December 2015	Anchorage, Alaska, 85 nm ENE	A15F0165 (TSB, 2017e)	6. If seat belt announcements do not contain sufficient detailed information on anticipated turbulence, then there is a risk that passengers will not immediately comply and maintain compliance with an instruction to fasten seat belts. 7. If safety announcements made by cabin crew do not use language that conveys the expectation of compliance, there is a risk that passengers will perceive these announcements to be less authoritative, which may result in non-compliance. 8. If passenger safety briefings lack information on the effects turbulence can have on individual passengers, their possessions, and on others, then there is a risk that it will reduce the probability of seat belt use.
30th January 2016	Toronto / Lester B. Pearson	A16O0016 (TSB, 2017d)	1. If air traffic controllers are not required to use standard phraseology that reinforces the need to hold short of a departure runway, there is an

	International Airport, Ontario		increased risk of miscommunication leading to runway incursions. 2. If plain-language phraseology used by air traffic controllers is not explicit, there is a risk of miscommunication between air traffic control and flight crews.
25th May 2016	Boston, MA, United States, 97 nm WNW	A16O0066 (TSB, 2017a)	4. If flight crews become aware of a situation that may jeopardize safety, but do not declare an emergency with air traffic control, then there is an increased risk that should the situation worsen, the flight will still be airborne due to a lack of priority handling, or that it will land without emergency services standing by.

APPENDIX 7: Survey Questionnaire

This questionnaire investigated pilots' attitudes to four accidents cited by ICAO. The 31 items are listed in the table below. The questionnaire was designed so that, if respondents answered "No" to the initial question about an accident, they were not asked any more questions about that accident. Questions 27 and 30 were optional.

ITEMS IN PILOT QUESTIONNAIRE
INTRODUCTION
Q1. Studying past airline accidents is important for improving current airline safety. [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
1977 TENERIFE ACCIDENT
Q2. On 27th March 1977, there was a runway collision between KLM Flight 4805 and Pan Am Flight 1736 at Los Rodeos Airport on the island of Tenerife. Have you heard of the 1977 Tenerife accident? [Yes / No]
Q3. Where did you hear about the 1977 Tenerife accident? (You can select more than one answer.) [Accident report / Another pilot / Book / Company training / IATA publication / ICAO publication / Internet / Magazine or newspaper article / TV documentary / TV or radio news / Other (please specify)]
Q4. The 1977 Tenerife accident is relevant to current airline operations. [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
Q5. Insufficient English proficiency of pilots played a contributing role in the 1977 Tenerife accident. [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
Q6. Insufficient English proficiency of air traffic controllers played a contributing role in the 1977 Tenerife accident. [Strongly agree / Agree / No opinion / Disagree / Strongly disagree]
1990 COVE NECK ACCIDENT
Q7. On 25th January 1990, Avianca Airlines Flight 052 crashed due to fuel exhaustion at Cove Neck, near to John F. Kennedy International Airport (JFK) in New York. Have you heard of the 1990 Cove Neck accident?

[Yes / No]

Q8. Where did you hear about the 1990 Cove Neck accident? (You can select more than one answer.)
[Accident report / Another pilot / Book / Company training / IATA publication / ICAO publication / Internet / Magazine or newspaper article / TV documentary / TV or radio news / Other (please specify)]

Q9. The 1990 Cove Neck accident is relevant to current airline operations.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q10. Insufficient English proficiency of pilots played a contributing role in the 1990 Cove Neck accident.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q11. Insufficient English proficiency of air traffic controllers played a contributing role in the 1990 Cove Neck accident.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

1995 CALI ACCIDENT

Q12. On 20th December 1995, American Airlines Flight 965 crashed into a mountain near Cali, Columbia. Have you heard of the 1995 Cali accident?
[Yes / No]

Q13. Where did you hear about the 1995 Cali accident? (You can select more than one answer.)
[Accident report / Another pilot / Book / Company training / IATA publication / ICAO publication / Internet / Magazine or newspaper article / TV documentary / TV or radio news / Other (please specify)]

Q14. The 1995 Cali accident is relevant to current airline operations.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q15. Insufficient English proficiency of pilots played a contributing role in the 1995 Cali accident.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q16. Insufficient English proficiency of air traffic controllers played a contributing role in the 1995 Cali accident.
[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

1996 NEW DELHI ACCIDENT

Q17. On 12th November 1996, there was a mid-air collision between Saudi Arabian Airlines Flight 763 and Kazakhstan Airlines Flight 1907 near New Delhi, India. Have you heard of the 1996 New Delhi accident?
[Yes / No]

Q18. Where did you hear about the 1996 New Delhi accident? (You can select more than one answer.)

[Accident report / Another pilot / Book / Company training / IATA publication / ICAO publication / Internet / Magazine or newspaper article / TV documentary / TV or radio news / Other (please specify)]

Q19. The 1996 New Delhi accident is relevant to current airline operations.

[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q20. Insufficient English proficiency of pilots played a contributing role in the 1996 New Delhi accident.

[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

Q21. Insufficient English proficiency of air traffic controllers played a contributing role in the 1996 New Delhi accident.

[Strongly agree / Agree / No opinion / Disagree / Strongly disagree]

BACKGROUND QUESTIONS

Q22. What is your rank?

[Captain / First officer / Other (please specify)]

Q23. Which training appointments do you hold?

[Technical trainer / Non-technical or human factors trainer / None / Other (please specify)]

Q24. How many flight hours do you have?

[>15,000 / 10,000-15,000 / 5,000-10,000 / 1,000-5,000 / <1,000]

Q25. How old are you?

[>55 / 46-55 / 36-45 / 25-35 / <25]

Q26. What is your gender?

[Male / Female / Other]

Q27. Which airline do you work for?

[Drop-down menu]

Q28. What is your nationality (or nationalities)? (You can select more than one answer.)

[Drop-down menu]

Q29. What is your native language (or languages)? (You can select more than one answer.)

[Drop-down menu / Other (please specify)]

Q30. What other languages do you know? (You can select more than one answer.)

[Drop-down menu / Other (please specify)]

Q31. What is your ICAO language proficiency level?

[Level 6 (Expert) / Level 5 (Extended) / Level 4 (Operational) / Level 3 (Pre-Operational) / Level 2 (Elementary) / Level 1 (Pre-Elementary) / Not applicable]

APPENDIX 8: Sample Survey Response

There were 92 respondents to the survey of pilots' attitudes to past accidents. The table below shows the survey data for one of the respondents.

SURVEY DATA FOR RESPONDENT #23
START DATE/TIME
2018/04/10 12:24:13
END DATE/TIME
2018/04/10 12:30:07
INTRODUCTION
Q1. [Strongly agree]
1977 TENERIFE ACCIDENT
Q2. [Yes]
Q3. [Another pilot / Company training / ICAO publication / Internet / TV documentary]
Q4. [Strongly agree]
Q5. [Disagree]
Q6. [Disagree]
1990 COVE NECK ACCIDENT
Q7. [Yes]
Q8. [Magazine or newspaper article]
Q9. [Strongly agree]
Q10. [Agree]
Q11. [Agree]
1995 CALI ACCIDENT
Q12. [Yes]
Q13. [Company training / Magazine or newspaper article]
Q14. [Strongly agree]
Q15. [No opinion]
Q16. [Agree]

1996 NEW DELHI ACCIDENT

Q17. [Yes]

Q18. [Company training / Magazine or newspaper article]

Q19. [Strongly agree]

Q20. [Disagree]

Q21. [Disagree]

BACKGROUND QUESTIONS

Q22. [Captain]

Q23. [None]

Q24. [>15,000]

Q25. [>55]

Q26. [Male]

Q27. [British Airways]

Q28. [British]

Q29. [English]

Q30. [-]

Q31. [Level 6 (Expert)]

APPENDIX 9: Airline Pilot Interview Guide

The table below lists the questions that were used to guide the airline pilot interviews. The questions were divided into two sections. The first section addressed past accidents: it included items based on the four research questions (RQs A-D) and follow-up questions designed to probe issues raised by the survey in more detail. The second section covered background questions: it consisted of the demographic questions from the survey.

PILOT INTERVIEW GUIDE
PAST ACCIDENTS
Q1. [RQ A] Is studying past airline accidents important for improving airline safety?
Q2. Why (not)?
Q3. [RQ B] Which of the accidents cited by ICAO had you heard of?
Q4. For any of these accidents, give a brief description that captures the key features of the accident.
Q5. Do these accidents remind you of any experiences from your flying career?
Q6. If so, describe the experiences.
Q7. [RQ C] What were your main sources of information about these accidents?
Q8. Do you watch TV documentaries about accidents?
Q9. What are the pros and cons of TV documentaries as sources of information about accidents?
Q10. [RQ D] Did insufficient English proficiency of pilots and/or air traffic controllers play a contributing role in these accidents?
BACKGROUND QUESTIONS
Q11. What is your rank?
Q12. Which training appointments do you hold (e.g., technical trainer, non-technical trainer)?
Q13. How many flight hours do you have?
Q14. How old are you?
Q15. What is your gender?
Q16. Which airline do you work for?
Q17. What is your nationality (or nationalities)?
Q18. What is your native language (or languages)?
Q19. What other languages do you know?
Q20. What is your ICAO language proficiency level?

APPENDIX 10: Airline Pilot Interview Log

A series of semi-structured interviews were conducted with the key informant (KI) between August 2019 and June 2020. The 13 interviews lasted 10 hours 13 minutes in total. All were recorded with the KI's consent. The table below shows the format of each interview, the recording length and the topics covered. The interviews addressed the following main areas:

- Survey of pilots – from Stage One of the analysis;
- ACT glossary – from Stage Two of the analysis.

Some interviews addressed one area and others covered both. For each interview covering the pilot survey, the questions that guided the discussion are listed below. For interviews addressing the ACT glossary, there is a list of factors discussed. Factors featuring in three or more interviews are highlighted in bold. Keywords show other important topics.

#	FORMAT & LENGTH	CONTENT OF INTERVIEW
1	Face-to-face 17 minutes	ACT glossary • Communication factors – ambiguity, **call sign confusion**, **pronunciation**, intelligibility • Keywords – ATC in Japan/UK, level of controller experience, pattern matching, terrain, traffic
2	Face-to-face 23 minutes	ACT glossary • Communication factors – accent, **headphone quality**, **pronunciation**, **message length**, rate of speech, sarcasm, vocabulary, **workload** • Keywords – ATC in China/India/Japan/Russia, capacity bucket, control of emotions, ideal controller, place names, threat categories
3	Face-to-face 23 minutes	ACT glossary • Glossary entry template • Communication factors – **call sign confusion**, **distraction**, **pronunciation**, rate of speech, stress, **workload** • Keywords –ATC in India, bad controllers, good controllers

4	Face-to-face 51 minutes	<u>ACT glossary</u> • List of factors • Glossary entry template • Communication factors – **authority gradient**, avoidance**,** **call sign confusion**, **code switching**, **community of practice**, diffusion of responsibility, **distraction**, **headphone quality**, hearing loss, in-group bias, interlanguage, sarcasm, **standard phraseology** • Keywords –1972 Staines accident, ATC in China/France/ Japan/Russia/Spain/South America, ground crew in China/UK
5	Video call 34 minutes	<u>Survey of pilots</u> • Q1, Q2, Q3, Q4, Q7 from Appendix 8 <u>ACT glossary</u> • Communication factors – **authority gradient**, **code switching**
6	Video call 37 minutes	<u>Survey of pilots</u> • Q5, Q6 from Appendix 8 <u>ACT glossary</u> • Communication factors – **authority gradient**, **distraction**, **workload** • Keywords – ageing, capacity bucket, departure from routine, plan continuation bias
7	Video call 36 minutes	<u>Survey of pilots</u> • Q4 from Appendix 8 • Keywords – terminology for emergencies
8	Video call 1 hour 24 minutes	<u>Survey of pilots</u> • Q4, Q5, Q7, Q8, Q9 from Appendix 8 <u>ACT glossary</u> • Communication factors – **community of practice**, **distraction, headphone quality**, noise • Keywords – 1989 Kegworth accident, ageing, electronic safety notices, Swiss cheese model

9	Video call 1 hour 9 minutes	<u>Survey of pilots</u> • Q10-20 from Appendix 8 <u>ACT glossary</u> • Communication factors – abbreviation, ambiguity, colloquialism, **community of practice**, fatigue, intelligibility, plain language, **standard phraseology**, startle effect, stress, vocabulary • Keywords – 1989 Kegworth accident, ATC in Brazil/China/ Japan, Dutch pilots, language attitudes, Swiss cheese model
10	Video call 33 minutes	<u>ACT glossary</u> • Communication factors – **distraction**, fatigue, sterile cockpit • Keywords –2009 Colgan Air accident, hotspot, cockpit door
11	Video call 14 minutes	<u>ACT glossary</u> • Communication factors – **distraction** • Keywords – 2016 Dubai accident, go around, training
12	Video call 1 hour 32 minutes	<u>ACT glossary</u> • Communication factors – appended message, blocked transmission, **code switching**, colloquialism, **distraction**, idiom, **message length**, microphone clipping • Keywords – 1990 Avianca accident, ATC in UK/US, critical communications, CVR/ATC transcripts, frequency congestion, pilot-controller communication loop, ranking of communication factors, pronouns, wind shear
13	Video call 1 hour 40 minutes	<u>ACT glossary</u> • Communication factors – accommodation, blocked transmission, courtesy bias, expletive, face, first language influence, information bias, **message length**, number transposition, omission, phrasal verb, repetition, speech community, **standard phraseology**, style shifting, • Keywords – 1972 Staines accident, 1989 Kegworth accident, ATC in Canada/France/UK, Hong Kong Chinese pilot, language attitudes, ranking of communication factors, RT procedure, short term memory

APPENDIX 11: U.S. Code for CVR Data

United States law restricts the release of CVR data. The NTSB is basically prohibited from releasing transcripts or recordings, but an exception allows the release of any part of a transcript that the NTSB deems relevant to a safety investigation. There is no exception allowing the release of audio recordings. This section of the law is reproduced in the table below (49 U.S. Code § 1114), where "the Board" refers to the National Transportation Safety Board (NTSB).[83]

49 U.S. CODE § 1114 – DISCLOSURE, AVAILABILITY, AND USE OF INFORMATION
(c) COCKPIT RECORDINGS AND TRANSCRIPTS.—(1) The Board may not disclose publicly any part of a cockpit voice or video recorder recording or transcript of oral communications by and between flight crew members and ground stations related to an accident or incident investigated by the Board. However, the Board shall make public any part of a transcript or any written depiction of visual information the Board decides is relevant to the accident or incident— (A) if the Board holds a public hearing on the accident or incident, at the time of the hearing; or (B) if the Board does not hold a public hearing, at the time a majority of the other factual reports on the accident or incident are placed in the public docket. (2) This subsection does not prevent the Board from referring at any time to cockpit voice or video recorder information in making safety recommendations.

[83] This section of the law was revised to restrict release of CVR data following the 1988 crash of Delta Air Lines Flight 1141. The NTSB investigation found this accident to have been partially caused by "the Captain and First Officer's inadequate cockpit discipline" which led to the aircraft taking off without flaps and slats set correctly. The CVR transcript in the accident report indicated there was a substantial amount of "non-pertinent conversation between the flight crew and a flight attendent [sic]" (NTSB, 1989b).

APPENDIX 12: Transcripts for Avianca 052 Accident

The table below gives basic information about the CVR and ATC transcripts that were included in the accident report for the Avianca Flight 052 crash (NTSB, 1991). For clarity, the ATC transcripts below have been numbered (1-7), but they are not numbered in the NTSB report.

TRANSCRIPT	NTSB REPORT	TIME	PARTICIPANTS
CVR	Pages 82-151	20:53:09-21:33:24 EST	3 Avianca flight crew + 3 controllers (in NY TRACON & JFK Tower) + 10 other aircraft
ATC 1	Pages 162-181	01:04-01:53 UTC (20:04-20:53 EST)	2 controllers (in NY ARTCC & NY TRACON) + 8 aircraft [84]
ATC 2	Pages 182-198	01:04-01:53 UTC (20:04-20:53 EST)	6 controllers (in NY ARTCC, NY TRACON & Washington ARTCC)
ATC 3	Pages 199-215	01:42-02:08 UTC (20:42-21:08 EST)	3 controllers (in NY TRACON, NY ARTCC & 1 other) + 9 aircraft
ATC 4	Pages 216-239	01:58-02:38 UTC (20:58-21:38 EST)	1 controller (in NY TRACON) + 14 aircraft
ATC 5	Pages 240-244	02:16-02:38 UTC (21:16-21:38 EST)	2 controllers (in NY TRACON & JFK Tower)
ATC 6	Pages 245-262	02:10-02:40 UTC (21:10-21:40 EST)	2 controllers (in NY TRACON & JFK Tower) + 11 aircraft
ATC 7	Pages 263-275	02:10-02:43 UTC (21:10-21:43 EST)	3 controllers (in NY TRACON & JFK Tower) + 10 aircraft + national weather service

[84] In the NTSB report, the first page of this transcript lists five controllers (in the NY ARTCC, NY TRACON and Washington ARTCC facilities) but only two actually featured in the transcript.

APPENDIX 13: List of Communication Factors

The table below shows the full list of 68 factors compiled for the ACT glossary. Glossary entries have been created for the 30 factors marked with an asterisk (*).

LIST OF COMMUNICATION FACTORS		
THE WORKPLACE		
- Distraction *	- Noise *	- Time pressure
- Headphone quality	- Temperature	- Workload *
THE BODY		
- Fatigue *	- Illness	- Startle effect *
- Hearing loss	- Medication	- Stress *
THE RADIO		
- Appended message *	- Message complexity	- Stuck microphone
- Blocked transmission *	- Message length *	
- Frequency change	- Microphone clipping *	
INTERACTING WITH PEOPLE		
- Authority gradient *	- Expectation bias	- Overhear
- Call sign confusion *	- Face	- Speech community
- Community of practice	- Groupthink	- Sterile cockpit *
- Comprehension	- Information bias	- Stigmatization
- Courtesy bias	- In-group bias	
- Diffusion of responsibility	- Intelligibility	
WAYS OF SPEAKING		
- Accent	- Hesitation	- Pronunciation *
- Accommodation *	- Misfire	- Rate of speech *
- Ambiguity *	- Multiple negation	- Repair
- Avoidance *	- Non-speaking	- Repetition *
- Code switching *	- Number transposition *	- Sarcasm
- First language influence *	- Omission *	- Style shifting *
- Fluency	- Politeness	

WORDS & GRAMMAR

Abbreviation	Idiom *	Plain language *
Colloquialism *	Interlanguage	Standard phraseology *
Expletive *	Jargon	Vocabulary
Grammar	Loanword	
Homophone	Phrasal verb *	

APPENDIX 14: ACT Glossary Entries

Selected entries from the ACT glossary are reproduced on the following pages. Only those factors used in the analysis of language use in the Avianca 052 accident are included. The factors are listed below.

- Accommodation
- Ambiguity
- Appended Message
- Avoidance
- Blocked Transmission
- Call Sign Confusion
- Code Switching
- Colloquialism
- Distraction
- Fatigue
- Idiom
- Message length
- Microphone clipping
- Omission
- Phrasal verb
- Plain Language
- Repetition
- Standard Phraseology
- Stress
- Style Shifting
- Workload

ACCOMMODATION

Meaning An individual adjusts their speech according to the language of another participant in a conversation. Accommodation may take the form of *convergence* (moving towards the language of another) or *divergence* (moving away). It can involve many aspects of language (eg: vocabulary, grammar, pronunciation, accent, dialect or rate of speech).

Communication risk If a speaker uses a language variety (eg: dialect or jargon) not shared by a listener, the listener may not be able to understand.

Language indicator In the dialogue below, the controller and pilot of one aircraft use **standard phraseology** when saying call sign numbers. By contrast, the controller and pilots of two other aircraft use **non-standard number abbreviations**. This is convergence, as the controller matches the form of call sign used by each pilot.

Dialogue Final vector (FV) controller speaking with American Airlines flight 692, Avianca flight 052 and American Airlines flight 40 near New York on January 25, 1990. Language: English.[1]

TIME (UTC)	SPEAKER	SPEECH
0208:16	FV	American **six ninety two** speed one six zero if practical
0208:20	AAL692	American **six ninety two** roger
0208:34	FV	Avianca **zero five two** heavy descend and maintain uh descend and maintain three thousand
0208:40	AVA052	Descend and maintain three thousand Avianca **zero five two** heavy
0209:18	FV	American **forty** heavy turn left heading three one zero
0209:20	AAL40	Left three one zero American **forty** heavy
0209:43	FV	Avianca **zero five two** heavy turn left heading two seven zero
0209:47	AVA052	Left heading two seven zero Avianca **zero five two** heavy

Further reading Giles (2009) gives an overview of accommodation theory, and suggests that effective accommodation is a fundamental part of communicative competence. Studies in English as a lingua franca (ELF) highlight the value of accommodation strategies in facilitating communication involving NNSs (Kim & Elder, 2009; Lee, 2013; Estival, Farris & Molesworth, 2016). Both forms of accommodation, convergence and divergence, can be understood as constituting an act of identity (Trudgill, 1992; Clark, 2007).

Related factors ABBREVIATION, ACCENT, CODE SWITCHING, COLLOQUIALISM, IDIOM, INTELLIGIBILITY, JARGON, PLAIN LANGUAGE, RATE OF SPEECH, STANDARD PHRASEOLOGY, STYLE SHIFTING

AMBIGUITY

Meaning A word, phrase or sentence has more than one interpretation.

Communication risk If the speech of a pilot or controller is ambiguous, listeners may not understand the intended meaning.

Language indicator In the dialogue below, the pilot reports his aircraft's position by referring to **an unofficial taxiway marking**. The controller instructs the aircraft to stop at **an ambiguous position**. The controller is referring to a position on taxiway R5, but the aircraft is actually on taxiway R6.

Dialogue Cessna 525A Citation (registration D-IEVX) speaking with ground controller (GND) during pre-takeoff taxi at Linate Airport, Milan, on October 25, 2001. Language: English.[2]

TIME (UTC)	SPEAKER	SPEECH
0608:23	D-IEVX	Delta India Echo Victor Xray, is approaching **Sierra 4**.
0608:28	GND	Delta India Echo Victor Xray confirm your position?
0608:32	D-IEVX	Approaching the runway ... **Sierra 4**.
0608:36	GND	Delta Victor Xray, Roger maintain **the stop bar**, I'll call you back.
0608:40	D-IEVX	Roger Hold position.

Accidents & incidents This was a factor in:

- 1990 fuel exhaustion crash of Avianca 052 at Cove Neck, NY, USA (NTSB, 1991a)
- 2000 runway collision of Streamline Aviation 200 and Air Liberté 8807 in Paris, France (BEA, 2001)
- 2001 runway collision of SAS 686 and Cessna 525A Citation in Milan, Italy (ANSV, 2004; see **Dialogue**)
- 2014 loss of control of Air Asia 8501 in the Karimata Strait, Java Sea (KNKT, 2015)
- 2016 runway incursion involving Air Canada 726 and Air Canada 1259 at Toronto Pearson International Airport, Canada (TSB, 2017)

Further reading One of the purposes of standard phraseology is "to reduce the possibility for ambiguity" (ICAO, 2010, p. 5-5). By contrast, the flexibility of plain language, which allows pilots and controllers to describe new situations, inevitably involves ambiguity. There are many possible sources of ambiguity. Cushing (1994) gives examples in which ambiguity arises from: vocabulary items, idiomatic expressions, homophones (eg: "to" and "two"), pronouns, indefinite nouns (eg: "things"), acronyms, grammatical structures and omission. Garzone et al. (2010) discuss ambiguity in the 2001 runway collision at Linate Airport due to the use of deictic expressions (ie: words or phrases whose meaning is dependent on context, such as "here" or "that one"). Deictics are valuable because they allow efficient communication, but their inherent indeterminacy is problematic for RT communication.

Related factors ABBREVIATION, CALL SIGN CONFUSION, EXPECTATION BIAS, FIRST LANGUAGE INFLUENCE, IDIOM, MICROPHONE CLIPPING, OMISSION, PLAIN LANGUAGE, PRONUNCIATION, STANDARD PHRASEOLOGY, STARTLE EFFECT, VOCABULARY

APPENDED MESSAGE

Meaning A pilot or controller adds a phrase, clause or sentence to a transmission that already sounds complete.

Communication risk If a speaker adds an extra message to a transmission that sounds complete: the appended message may be ignored; there may be a blocked transmission; and resolving confusion may add to the workload of pilots and controllers.

Language indicator In the dialogue below, the controller **requests information**. The FO responds with **heading information** and **an appended message**.

Dialogue Tower controller and crew of Avianca flight 052 speaking after missed first approach at JFK Airport, New York, on January 25, 1990. Languages: English (controller and FO) and Spanish (captain and FE).[3]

TIME (EST)	SPEAKER	SPEECH	TRANSLATION	SOUNDS
2124:04	TWR (radio)	**Avianca zero five two you are making a left turn correct sir**		
2124:06	Captain	digale que estamos en emergencia	tell them we are in emergency	
	FE	dos mil pies	two thousand feet	Altitude alert chime
2124:08	FO (radio)	**that's right to one eight zero on the heading and ah we'll try once again** **we're running out of fuel**		
2124:14				Trim in motion horn
2124:15	TWR (radio)	okay		

Further reading Monan (1983) discusses the risk of adding an explanation to the end of a transmission that already seems to be complete. He labels this "dangling phraseology".[4]

Related factors BLOCKED MESSAGE, MESSAGE LENGTH

AVOIDANCE

Meaning A speaker avoids using certain words or grammatical structures, or avoids discussing particular topics.

Communication risk If a pilot or controller avoids certain words, structures or topics, listeners may not understand important information.

Language indicator In the dialogue below, the captain gives the FO **an instruction**. Then the FO transmits **a paraphrase** of the instruction which does *not* include **a pertinent word**.

Dialogue Tower controller and crew of Avianca flight 052 speaking after missed first approach at JFK Airport, New York, on January 25, 1990. Languages: English (controller and FO) and Spanish (captain and FE).[5]

TIME (EST)	SPEAKER	SPEECH	TRANSLATION	SOUNDS
2124:04	TWR (radio)	Avianca zero five two you are making a left turn correct sir		
2124:06	Captain	**digale que estamos en emergencia**	tell them we are in **emergency**	
	FE	dos mil pies	two thousand feet	Altitude alert chime
2124:08	FO (radio)	that's right to one eight zero on the heading and ah we'll try once again **we're running out of fuel**		
2124:14				Trim in motion horn
2124:15	TWR (radio)	okay		

Accidents & incidents This was a factor in:

- 1990 fuel exhaustion crash of Avianca 052 at Cove Neck, NY, USA (NTSB, 1991a; see **Dialogue**)
- 1995 CFIT of American Airlines 965 near Cali, Colombia (Aeronáutica Civil, 1996)[6]

Further reading Avoidance is a common communication strategy for second language learners. It may involve lexical, syntactic, phonological or topic avoidance (Brown, 2000). A learner may avoid particular grammatical structures in the L2 when they differ significantly from those in the L1. Topic avoidance can occur when a speaker lacks cultural knowledge or judges that a topic requires grammar or vocabulary they have not mastered in the L2 (Macaro, Vanderplank & Murphy, 2013).

Related factors GRAMMAR, OMISSION, PLAIN LANGUAGE, VOCABULARY

BLOCKED TRANSMISSION

Meaning Transmissions are degraded or blocked when speakers make overlapping or simultaneous radio transmissions on the same frequency.

Communication risk If two people make overlapping or simultaneous transmissions: listeners may hear a degraded message; listeners may not hear important information; senders may not be aware of the problem; and resolving confusion may add to the workload of pilots and controllers.

Language indicator In the dialogue below, overlapping transmissions lead to **a squealing sound**. Blocked transmissions may also be indicated by the absence of a pilot's readback or a controller's response.

Dialogue Pilots of KLM flight 4805 and Pan Am flight 1736 speaking with controller at Los Rodeos Airport, Tenerife, on March 27, 1977. Language: English.[7]

TIME (GMT)	SPEECH		
	KLM FO (radio to controller)	Controller (radio to KLM)	Pan Am Captain & FO (radio)
1706:09	eh Roger Sir we are cleared to eh the Papa beacon flight level nine zero right turn out zero four zero until intercepting the three two five. We are now (eh taking off)		
1706:18		Okay	
1706:19		———	~~No uh~~
1706:20		———	~~And (*) we're still~~
1706:21		~~Stand by for takeoff, I will call you~~	~~taxiing down the runway the~~
1706:22			clipper one seven three six

Accidents & incidents This was a factor in:

- 1977 runway collision of KLM 4805 and Pan Am 1736 in Tenerife, Canary Islands (CIAIAC, 1978; Roitsch, Babcock & Edmunds, 1978; see **Dialogue**)
- 2007 runway incursions at Auckland International Airport, NZ (TAIC, 2008)

Further reading FSF (2000) notes that if a message contains a long pause, another person may try to transmit and blocking might occur. EUROCONTROL (2006) suggests that using more than one language on the same radio frequency contributes to blocked transmissions since a listener who cannot understand when a message ends may transmit too soon.

Related factors APPENDED MESSAGE, CODE SWITCHING, STUCK MICROPHONE

CALL SIGN CONFUSION

Meaning A speaker says a call sign incorrectly or a listener mishears a call sign. Confusion is more likely if speakers abbreviate call signs or aircraft with similar call signs are on the same radio frequency.

Communication risk If call sign confusion occurs: the intended recipient of a transmission might not act on a clearance; the wrong aircraft may change flight level, heading or radio frequency; and resolving confusion may add to the workload of pilots and controllers.

Language indicator In the dialogue below, the controller uses **an incorrect call sign**. This is followed by **correction**. **A similar call sign** and **similar numbers** in previous transmissions may have contributed to the confusion.

Dialogue Tower controller at JFK Airport, New York, speaking with Avianca flight 052, TWA flight 801 and Avensa flight 520 on January 25, 1990. Language: English.[8]

TIME (UTC)	SPEAKER	SPEECH
0221:07	TWR	**Avianca zero five two** heavy can you increase your airspeed one zero knots at all
0221:11	AVA052	Yes we're doing it
0221:12	TWR	Yeah ah thanks
0221:30	TWR	TW eight oh one you're gaining on the heavy seven oh seven turn left heading of ah – one **five zero** and maintain ah – **two** thousand
0221:38	TWA801	Okay TWA eight oh one heavy a left to one **five zero** maintain **two** thousand
0221:49	TWR	**Avianca zero five two** cross two two right taxi straight ahead now --- correction taxi right ah – right on the outer ground one two one point niner
0222:02	TWR	**Correction Avensa five twenty** cross two two right taxi right on the outer ground point nine
0222:06	AVE520	Cross two two right right on the outer and one two one point niner five two zero

Accidents & incidents This was a factor in:

- 1991 crash of Nigeria Airways 2120 in Jeddah, Saudi Arabia (FSF, 1993)
- 1991 runway collision of USAir 1493 and SkyWest 5569 in Los Angeles, USA (NTSB, 1991b)
- 1997 CFIT of Garuda Indonesia 152 in North Sumatra, Indonesia (KNKT, 2004)
- 2017 loss of separation between Sichuan 603 and China Southern 6068 over Yangon, Myanmar (MAIB, 2017)

Further reading Monan (1983) discusses call sign problems in the US. Cardosi, Falzarano and Han (1998) report on pilot-ATC communication errors including the problem of similar call signs on the same frequency. CAP 704 is a study of call sign confusion reports in the UK (CAA, 2000).

Related factors ABBREVIATION, AMBIGUITY, DISTRACTION, EXPECTATION BIAS, FATIGUE, MICROPHONE CLIPPING, NUMBER TRANSPOSITION, WORKLOAD

CODE SWITCHING

Meaning A speaker alternates between different linguistic codes (eg: languages, dialects or registers) during a conversation. Code switching may be *intentional* or *unintentional*.

Communication risk If a pilot or controller switches between different languages or dialects, listeners may not understand important information.

Language indicator In the dialogue below, the controller **changes language** from English to Serbo-Croatian. This unintentional code switching is preceded by **hesitation**.

Dialogue Upper sector controller at Zagreb speaking with Inex Adria Airways flight JP550, on September 10, 1976. Languages: English (both speakers) and Serbo-Croatian (both speakers).[9]

TIME (GMT)	SPEAKER	SPEECH	TRANSLATION
1014:14	Controller	What is your present level?	
1014:17	JP550	327	
1014:22	Controller	**[Stuttering] ... e ... zadržite se za sada na toj visini i javite prolazak Zagreba**	…e… maintain now that level and report passing Zagreb
1014:27	JP550	Kojoj visini?	What level?

Accidents & incidents This was a factor in:

- 1976 mid-air collision of Inex Adria Airways 550 and British Airways 476 above Zagreb, former Yugoslavia (AAIB, 1977, 1982; see **Dialogue**)
- 2000 runway collision of Streamline Aviation 200 and Air Liberté 8807 in Paris, France (BEA, 2001)
- 2001 runway collision of SAS 686 and Cessna 525A Citation in Milan, Italy (ANSV, 2004)
- 2012 loss of separation between Bombardier BD-700 and NetJets Europe 599U near Ibiza, Spain (CIAIAC, 2014)
- 2018 take-off without clearance of Cessna 525A Citation at Reykjavik, Iceland (RNSA, 2019)

Further reading Intentional code switching includes a pilot speaking one language (eg: English) and adding a greeting in another language (eg: "buenos dias"). Unintentional code switching sometimes happens when a second language (L2) speaker is under time pressure or stress. In this case, the speaker may revert to their first language (L1) due to the high cognitive load required to speak the L2. Ganushchak and Schiller (2009) describe the effect of time pressure on code switching. Weston and Hurst (1982) discuss code switching in the 1976 mid-air collision over Zagreb.

Related factors ACCOMMODATION, BLOCKED TRANSMISSION, HESITATION, STRESS, STYLE SHIFTING, TIME PRESSURE

COLLOQUIALISM

Meaning An informal word or phrase that is used in casual conversation.

Communication risk If a pilot or controller uses colloquialisms, non-native speaker (NNS) listeners may not understand important information.

Language indicator In the dialogue below, the controller uses **colloquialisms** in an exchange of messages that are in **plain language**.

Dialogue Approach controller speaking with Evergreen International Airlines flight 102 near New York on January 25, 1990. Language: English.[10]

TIME (EST)	SPEAKER	SPEECH
2128:58	APP	**yeah that's fine ah I have a heavy jet seven ahead and he's about twenty knots slower that's due to the winds I'm gunna need you to slow twenty knots in three or four miles**
2129:09	ELA102	**okay sir**

Further reading Colloquial speech is appropriate in relaxed, informal contexts. Common colloquialisms in English include: contractions (eg: “that’s”), informal words or phrases (eg: “yeah”), omissions and expletives (Trask, 1999).

Related factors ACCOMMODATION, EXPLETIVE, IDIOM, OMISSION, PLAIN LANGUAGE, STYLE SHIFTING

DISTRACTION

Meaning Something diverts a person's attention from a desired area of focus. Distraction impacts many aspects of flight operations, not just communication. Distractions may be *external* (eg: conversations, electronic devices, phone calls) or *internal* (eg: daydreaming, fatigue, hunger).

Communication risk If a person or a group experiences a distraction, they may not hear or understand important information.

Language indicator In the dialogue below, the controller sends **repeated transmissions** to an aircraft but there is **no response (**due to distraction in the cockpit).

Dialogue En route controller trying to contact Northwest flight 188 during scheduled flight from San Diego to Minneapolis St. Paul, on October 21, 2009. Language: English.[11]

TIME (UTC)	SPEAKER	SPEECH
0024:16	Controller	**northwest one eighty eight contact minneapolis center one two four point eight seven** see ya ● ● ●
0024:25	Controller	**northwest one eighty eight contact minneapolis center one two four point eight seven** ● ● ●
0024:32	Controller	**northwest one eighty eight** radio check ● ● ●

Accidents & incidents This was a factor in:[12]

- 1974 crash of Eastern Airlines 212 at Charlotte, North Carolina, USA (NTSB, 1975)
- 1988 crash of Delta Airlines 1141 at Dallas-Fort Worth, USA (NTSB, 1989)
- 1991 runway collision of USAir 1493 and SkyWest 5569 in Los Angeles, USA (NTSB, 1991b)
- 2006 mid-air collision of Gol Transportes Aéreos 1907 and Embraer Legacy 600 over central Brazil (CENIPA, 2008)
- 2008 loss of control of Aeroflot-Nord 821 at Perm, Russia (IAC, 2009)
- 2009 destination overshoot by Northwest 188 over Minneapolis, USA (NTSB, 2009a; see **Dialogue**)

Further reading Loukopoulos, Dismukes and Barshi (2009) report on the requirements for pilots to manage multiple tasks concurrently. They differentiate between *distraction* (ongoing conditions that divert attention but do not have to be dealt with immediately) and *interruption* (discrete events that must be dealt with).

Related factors FATIGUE, NOISE, REPETITION, STERILE COCKPIT

FATIGUE

Meaning Extreme tiredness due to excessive work, sleep deprivation, or being out of sync with the body's circadian rhythms. Fatigue impacts many aspects of flight operations, not just communication.

Communication risk If someone is fatigued: they may not understand important information; their social interactions may decline; and there is a risk of micro-sleeps.

Language indicator In the dialogue below, there is **word and phrase repetition** by the crew and the captain shows **narrowing of attention**. Fatigue may also lead to slow reactions, reduced motivation, distraction, slips, mistakes, and abnormal mood swings.

Dialogue Flight crew of American International Airways flight 808 speaking during approach to US Naval Air Station, Guantanamo Bay, Cuba, on August 18, 1993. Language: English.[13]

TIME (EDT)	SPEAKER	SPEECH	SOUNDS
1653:28	Captain	**where's the strobe**?	
1653:29	FE	**right over there**.	
1653:31	Captain	**where**?	
1653:33	FO	**right inside there**, **right inside there**.	
1653:35	FE	you know, we're not getting' our airspeed back there.	
1653:37	Captain	**where's the strobe**?	
1653:37	FO	**right** down **there**.	
1653:41	Captain	I still don't see it.	
1653:42	FE	#, we're never goin' to make this.	
1653:43	Captain	huh.	
1653:45	Captain	**where** do you see **a strobe light**?	
1653:48	FO	**right over** here.	decrease in engine RPM
1653:49			altitude warning horn
1653:50	?	** alright.	
1653:51	Captain	gear, gear down, spoilers armed.	
1653:52	FE	gear down three green, spoilers flaps, check list.	
1653:55	?	there you go, **right there** lookin' good	
1653:57	Captain	**where's the strobe**?	

Accidents & incidents This was a factor in:[14]

- 1990 fuel exhaustion crash of Avianca 052 at Cove Neck, NY, USA (NTSB, 1991a)
- 1993 uncontrolled flight into terrain of American International Airways 808 at Guantanamo Bay, Cuba (NTSB, 1994; see **Dialogue**)
- 2009 loss of control of Colgan Air 3407 near Buffalo, USA (NTSB, 2010)

Further reading Caldwell and Caldwell (2003) give a comprehensive review of fatigue in aviation.

Related factors DISTRACTION, NOISE, REPETITION

IDIOM

Meaning A group of words whose meaning is different from the meaning of the individual words.

Communication risk If a pilot or controller uses idioms, non-native speaker (NNS) listeners may not understand important information.

Language indicator In the dialogue below, the controller uses **a colloquialism** and **an idiom** in a plain language explanation.

Dialogue New York approach controller speaking with Avianca flight 052 on January 25, 1990. Language: English.[15]

TIME (EST)	SPEAKER	SPEECH
2054:40	APP (radio)	Avianca zero five two turn right right turn heading two two zero **I'm gunna** have to **spin you** sir
2054:45	FO (radio)	okay heading two two zero avianca zero five two

Further reading Idioms can help native speakers to establish a relationship through the "playful use of language" (Mathews & Gill, 2008, p. 36). However, they are also a barrier to communication with non-native speakers. ICAO Document 9835 notes that the ability to use idiomatic expressions is an indicator of language proficiency, but recommends avoiding idioms in pilot-ATC communication because they are an "obstacle to intelligibility" (ICAO, 2010, p. 4-11).

Related factors COLLOQUIALISM, JARGON, PHRASAL VERB, PLAIN LANGUAGE, STANDARD PHRASEOLOGY

MESSAGE LENGTH

Meaning The number of syllables or the number of elements of information (eg: heading, altitude) in a radiotelephony (RT) message.

Communication risk If a message contains too many elements of information (ie: more than two or three depending on workload): listeners may not understand important information or may fail to retain it; and resolving confusion may add to the workload of pilots and controllers.

Language indicator In the dialogue below, the controller transmits **a long message** containing multiple elements of information.

Dialogue TWA flight 801 speaking with tower controller at JFK Airport, New York, on January 25, 1990. Language: English.[16]

TIME (UTC)	SPEAKER	SPEECH
0218:57	TWA801	Kennedy tower TWA eight zero one heavy is twelve point two on the DME
0219:00	TWR	**TWA eight oh one heavy Kennedy tower roger number three on the approach following heavy seven oh seven traffic ah four and a half miles ahead he's indicating ten knots less on the ground speed there's a wind shear reported loss * gain and loss of ten knots seven hundred feet to the surface by a DC-9 runway two two left RVR more than six thousand**
0219:18	TWA801	ah thank you sir

Further reading To reduce turn-taking time, a controller may transmit one long message rather than a few shorter ones. However, research indicates that pilot readback errors are more likely as controller message length increases (Morrow, Lee & Rodvold, 1993; Prinzo, Hendrix & Hendrix, 2006; Prinzo, Hendrix & Hendrix, 2009). Barshi and Farris (2013) recommend controllers limit each message to a maximum of three commands, or two when speaking to non-native speaker (NNS) pilots with low English proficiency. If pilot workload is high, they recommend a maximum of two commands with new information, or one for NNSs with low English proficiency. As Estival, Farris and Molesworth (2016) note, this may not always be practical given the efficiency demands of the air traffic system.

Related factors APPENDED MESSAGE, MESSAGE COMPLEXITY, PLAIN LANGUAGE, RATE OF SPEECH, WORKLOAD

MICROPHONE CLIPPING

Meaning Clipping occurs when an operator either starts speaking before activating the microphone, or deactivates it before finishing speaking.

Communication risk If a pilot or controller clips a message: listeners may not hear important information; and call sign confusion may occur.

Language indicator In the dialogue below, the controller twice instructs the Air Canada aircraft to go around, but both **transmissions are clipped**.

Dialogue Pilots of Air Canada flight 178 and tower controller speaking during final approach to Toronto Pearson International Airport on March 11, 2013. The captain was pilot monitoring (PM) and the FO was pilot flying (PF). Language: English.[17]

TIME (UTC)	SPEAKER	SPEECH	EGPWS WARNINGS
0338:57			Approaching minimums
0339:00	Pilot monitoring	Stable	
0339:01	Pilot flying	Roger	
0339:04			Minimums
0339:07	Pilot monitoring	Runway in sight	
0339:08	Pilot flying	Landing	
0339:12			Two hundred
0339:12	ATC	**ɛrkænə 178**, pull up and go around, sir	
0339:19	ATC	**178**, pull up and go around	
0339:23			Fifty
0339:26			Forty
0339:27			Thirty
0339:28			Twenty
0339:30			Ten

Accidents & incidents This was a factor in:

- 2013 runway incursion involving maintenance vehicle and Air Canada 178 at Toronto Pearson International Airport, Canada (TSB, 2014; see **Dialogue**)
- 2016 runway incursion involving Alliance Airlines 3201 and Jetstar Airbus A320 at Adelaide Airport, Australia (ATSB, 2016)

Further reading McMillan (1998) notes that pilots and controllers who are busy or in training are vulnerable to microphone clipping.

Related factors AMBIGUITY, CALL SIGN CONFUSION, EXPECTATION BIAS, INTELLIGIBILITY, RATE OF SPEECH

OMISSION

Meaning A speaker leaves out a word, phrase or clause. Omission is a common feature of spoken English.

Communication risk If a pilot or controller omits a key word, listeners may not understand important information. If a pilot or controller omits the airline identifier from a call sign, call sign confusion may result.

Language indicator In the short dialogues below, two controllers contact the same aircraft. The controllers say **the call sign** and the pilot responds saying **the call sign without the airline identifier** (ie: "Evergreen") each time.

Dialogues CAMRN and FV controllers speaking with Evergreen International Airlines flight 102 near New York on January 25, 1990. Language: English.[18]

TIME (UTC)	SPEAKER	SPEECH
0200:17	CAMRN	**Evergreen one zero two** you can expect a few delaying vectors turn left heading one five zero
0200:21	EIA102	One five zero **one zero two heavy**
0201:24	CAMRN	**Evergreen one zero two** reduce speed one eight zero
0201:27	EIA102	One eight zero **one zero two heavy**
0202:14	CAMRN	**Evergreen one zero two heavy** turn right heading two two zero
0202:18	EIA102	Two two zero **one zero two heavy**
0206:47	CAMRN	**Evergreen one zero two** descend and maintain seven thousand
0202:50	EIA102	Down to seven thousand **one zero two heavy**
0223:29	FV	**Evergreen one zero two heavy** turn left heading three three zero
0223:33	EIA102	Three three zero **one oh two heavy**
0225:41	FV	**Evergreen one zero two heavy** fly heading two seven zero
0225:44	EIA102	Two seven zero **one oh two heavy**

Accidents & incidents This was a factor in:

- 2010 collision with runway lights of Finnair 658M in Oslo, Norway (SIA, 2013)

Further reading 'Ellipsis' is the omission of part of a sentence whose meaning can be recovered from the context or from elsewhere in the text (Cook, 1989). Philps (1991, p. 123) notes "a pronounced tendency towards ellipsis" in standard phraseology. For example, the plain language phrase "CLIMB TO (flight level)" is modified by deleting the preposition to produce the phraseology "CLIMB (flight level)".

Related factors ABBREVIATION, AVOIDANCE, STANDARD PHRASEOLOGY

PHRASAL VERB

Meaning Two or three words (eg: verb+preposition or verb+adverb) that together form a single unit of meaning.

Communication risk If a pilot or controller uses phrasal verbs, NNS listeners may not understand important information.

Language indicator In the dialogue below, the controller requests information about the status of an aircraft using **plain language** including **a phrasal verb**.

Dialogue FV controller speaking with American Airlines flight 692 near New York on January 25, 1990. Language: English.[19]

TIME (UTC)	SPEAKER	SPEECH
0206:12	FV	American six ninety two **how are we making out**
0206:15	AAL692	We got enough fuel for the approach and landing and that's it
0206:18	FV	Ok understand

Further reading There are thousands of phrasal verbs (or 'multi-word verbs') in English, and they represent "one of the most distinctive features of English syntax" (Crystal, 2003, p. 212). They are usually taken for granted by NESs, but are a problem area for NNSs. A phrasal verb can have more than one meaning, and sometimes the meaning can be difficult to deduce from the constituent words (McCarthy & O'Dell, 2007). A few phrasal verbs are part of standard phraseology (eg: "stand by", "line up" and "take off") but the great majority are plain language.

Related factors IDIOM, INTELLIGIBILITY, PLAIN LANGUAGE, STANDARD PHRASEOLOGY

PLAIN LANGUAGE

Meaning Any language that pilots and controllers use which is *not* standard phraseology. Plain language is an essential part of pilot-ATC communication.[20]

Communication risk If a pilot or controller uses plain language instead of standard phraseology, some listeners may not understand and there may be frequency congestion. If non-native speakers (NNSs) have insufficient plain language proficiency, they may not be able to understand important information or communicate problems.

Language indicator The dialogue below shows some typical features of plain language: **colloquialisms**, **an ambiguous phrase**, **repetition of phrases** and **a long message**. Plain language may also include idioms and expletives.

Dialogue Approach controller speaking with Evergreen International Airlines flight 102 and Avianca flight 052 near New York on January 25, 1990. Language: English.[21]

TIME (EST)	SPEAKER	SPEECH
2128:42	ELA102	ah approach for Evergreen one oh two heavy is **one seven zero** **a good speed** **on final**
2128:47	APP	ah **what's it gunna be** in knots ah I don't know the MACH ah
2128:54	ELA102	ah yes sir a hundred and seventy knots **on final** for Evergreen **is that okay**
2128:58	APP	**yeah that's fine ah I have a heavy jet seven ahead and he's about twenty knots slower that's due to the winds** **I'm gunna need you to slow** **twenty knots in three or four miles**
2129:09	ELA102	okay sir
2129:11	AVA052	ah can you give us a final now Avianca zero five two heavy
2129:20	APP	Avianca zero five two affirmative sir turn left heading zero four zero
2129:25	AVA052	zero four zero Avianca zero five two heavy

Accidents & incidents This was a factor in:

- 1995 CFIT of American Airlines 965 near Cali, Colombia (Aeronáutica Civil, 1996)
- 2007 serious navigation incident of LOT 282 near London, UK (AAIB, 2010)

Further reading The ICAO Manual of Radiotelephony states that plain language may be used in situations not covered by standard phraseology, but it "should be clear, concise, and unambiguous" (ICAO, 2007, p. iii). Estival, Farris and Molesworth (2016, p. 85) note how difficult it is to separate plain language from standard phraseology because "the two are intertwined in the real life context".

Related factors ACCOMMODATION, AMBIGUITY, CODE SWITCHING, COLLOQUIALISM, DISTRACTION, EXPLETIVE, FIRST LANGUAGE INFLUENCE, IDIOM, MESSAGE LENGTH, REPETITION, STANDARD PHRASEOLOGY

REPETITION

Meaning A speaker repeats words, phrases or sentences in the same section of dialogue. Repetition is a common feature of spoken language and an essential part of pilot-controller communication. However, excessive repetition may indicate an underlying problem.

Communication risk If a pilot or controller uses a lot of repetition: they might be experiencing a problem such as fatigue or startle effect; and the repetition may disrupt other communications or actions.

Language indicator In the dialogue below, the captain and FO **repeat the heading** multiple times.

Dialogue New York approach controller (APP) and crew of Avianca flight 052 speaking on January 25, 1990. Languages: English (controller, FO and captain) and Spanish (captain and FO).[22]

TIME (EST)	SPEAKER	SPEECH	TRANSLATION
2054:40	APP (radio)	Avianca zero five two turn right right turn heading two two zero I'm gunna have to spin you sir	
2054:45	FO (radio)	okay heading two two zero avianca zero five two	
2054:49	Captain	**dos veinte**	two twenty
2054:50	FO	**dos veinte**	two twenty
2055:07	Captain	cuanto	how much
2055:07	FO	**dos veinte**	two twenty
2055:08	Captain	**dos veinte**	two twenty
2055:09	FO	**dos veinte** si senor	two twenty sir
2055:54	APP (radio)	Avianca zero five two traffic in your turn twelve thirty five miles eastbound at six thousand	
2055:59	Captain	no contact - - ah si ahi esta	no contact - - okay we have it
2056:00	FO (radio)	Avianca we have the traffic in sight thank you	
2056:05	FE	[unintelligible]	
2056:07	Captain	seis mil	six thousand
2056:13	Captain	**dos veinte** no	two twenty no
2056:14	FO	**dos veinte**	two twenty

Further reading Repetition is a key part of the readback process in the pilot-controller communication loop (FSF, 2000). In everyday communication, Cook (1989) notes that native English speakers (NESs) are discouraged from using repetition as it is 'bad style'. Non-native speakers (NNSs) may have different attitudes to repetition.

Related factors AUTHORITY GRADIENT, FATIGUE, FIRST LANGUAGE INFLUENCE, STARTLE EFFECT, STRESS

STANDARD PHRASEOLOGY

Meaning A constructed language with a restricted vocabulary and grammar for RT communication. Standard phraseology is an essential part of pilot-ATC communication.

Communication risk If a pilot or controller does *not* use standard phraseology: some words may be confused (eg: English "nine" and German "nein"); listeners may not understand important information; and there may be frequency congestion.

Language indicator Standard phraseology consists of clearly defined protocols for vocabulary, grammar, message structures, exchange patterns and pronunciation. In the dialogue below, the FO does not follow the protocol for declaring an emergency and instead uses **non-standard phraseology**.

Dialogue Crew of Avianca flight 052 and New York approach controller speaking on January 25, 1990. Languages: Spanish (FE and captain) and English (FO and controller).[23]

TIME (EST)	SPEAKER	SPEECH	TRANSLATION
2132:39	FE	se apagaron--se apago el motor cuatro	flame out flame out on engine number four
2132:42	Captain	se apago	flame out on it
2132:43	FE	se apago el motor tres essential en number one--el dos--en el uno	flame out on engine number three essential on number two on number one
2132:49	Captain	muestreme la pista	show me the runway
	FO (radio)	Avianca zero five two we just ah lost two engines and ah **we need priority please**	
2132:54	APP (radio)	Avianca zero five two turn left heading two five zero intercept the localizer	

Accidents & incidents Not complying with this was a factor in:[24]

- 1990 fuel exhaustion crash of Avianca 052 at Cove Neck, NY, USA (NTSB, 1991a; see **Dialogue**)
- 2001 runway collision of SAS 686 and Cessna 525A Citation in Milan, Italy (ANSV, 2004)
- 2012 runway incursion involving safety vehicle and Piper PA-42 at Perth, Australia (ATSB, 2012)
- 2016 near collision between Air France Hop 25PG and AS532 helicopter at Marseille-Provence, France (BEA, 2019)

Further reading The ICAO Manual of Radiotelephony notes that standard phraseology is intended to provide "maximum clarity, brevity and unambiguity in communications" (ICAO, 2007, p. 3-2). There are differences in standard phraseology between countries (for the UK see CAA, 2015).

Related factors CODE SWITCHING, GRAMMAR, PLAIN LANGUAGE, PRONUNCIATION, VOCABULARY

STRESS

Meaning Physical, mental or emotional strain due to an external or internal stimulus. Individuals may react differently to the same stressor. Stress impacts many aspects of flight operations, not just communication.

Communication risk If someone is under stress: their voice pitch, amplitude and rate of speech may increase; the distinction between different vowel sounds may be blurred; and they may not understand important information. If a small group is under stress, hierarchical constraints may be imposed on how information is communicated.

Language indicator In the dialogue below, there is **an unintelligible word**, multiple **expletives** and **repetition of short exclamations** by the crew. There are also **expressions of irritation**.

Dialogue Crew of Pan Am flight 1736 speaking immediately before collision with KLM flight 4805 at Los Rodeos Airport, Tenerife, on March 27, 1977. Language: English.[25]

TIME (GMT)	SPEAKER	SPEECH	SOUNDS
1706:32.1	Captain	Let's get the **(* ## ##)** right here – get the **###** out of here ((chuckle))	
1706:34.9	FO	Yeh, he's anxious isn't he	
1706:36.2	FE	**Yeh after he held us up for an hour and a half, that ##**	
1706:38.4	FO	**Yeh, that #**	
1706:39.8	FE	Now he's in a rush	
1706:40.6	Captain	There he is – look at him – **###** – that – that **### ###** … is coming **Get off! Get off! Get off!**	
			Sound of takeoff warning horn & approaching KLM engines

Accidents & incidents This was a factor in:[26]

- 1977 runway collision of KLM 4805 and Pan Am 1736 in Tenerife, Canary Islands (CIAIAC, 1978; Roitsch, Babcock & Edmunds, 1978; see **Dialogue**)
- 1985 crash of Galaxy Airlines 203 at Reno, Nevada, USA (NTSB, 1986)
- 1990 fuel exhaustion crash of Avianca 052 at Cove Neck, NY, USA (NTSB, 1991a)
- 2008 loss of control of Aeroflot-Nord 821 at Perm, Russia (IAC, 2009)

Further reading Stokes & Kite (1994) give a comprehensive review of the effects of stress on performance in aviation. Driskell, Salas and Johnston (1999) report on how the task performance of small groups is affected by stressors (ie: noise, workload and time pressure). Weick (1990) discusses the effects of stress in the 1977 runway collision at Tenerife.

Related factors EXPLETIVE, FATIGUE, NOISE, REPETITION, TIME PRESSURE, WORKLOAD

STYLE SHIFTING

Meaning A speaker alternates between different language styles due to a change in the communicative context. Style is expressed through verbal and nonverbal features (eg: vocabulary, grammar, abbreviation, omission, intonation and facial expressions).

Communication risk If a pilot or controller switches between different language styles, listeners (eg: other pilots on the frequency) may not understand important information.

Language indicator In the dialogue below, the controller uses **a formal style** (ie: standard phraseology) to contact one aircraft then changes to **a casual style** (ie: plain language) for another aircraft.

Dialogue FV controller speaking with Avianca flight 052 and American Airlines flight 692 near New York on January 25, 1990. Language: English.[27]

TIME (UTC)	SPEAKER	SPEECH
0206:00	FV	**Avianca zero five two heavy turn left heading of three zero zero**
0206:04	AVA052	Left heading three zero zero Avianca zero five two heavy
0206:12	FV	**American six ninety two how are we making out**
0206:15	AAL692	We got enough fuel for the approach and landing and that's it
0206:18	FV	**Ok understand**

Further reading Joos (1962) developed a widely-used classification of styles with five levels of formality: frozen, formal, consultative, casual and intimate. Trudgill (1992) suggests that stylistic differentiation in English is mainly signalled by vocabulary differences. For example, the following words may all refer to aircraft: airliner, bird, bus, crate, jet, plane and ship.

Related factors ACCOMMODATION, CODE SWITCHING, GRAMMAR, JARGON, PLAIN LANGUAGE, STANDARD PHRASEOLOGY, VOCABULARY

WORKLOAD

Meaning The amount of mental and/or physical work that someone has to do. Workload impacts many aspects of flight operations, not just communication. Workload varies with flight phase.

Communication risk If someone is under high workload: their voice pitch, amplitude and rate of speech may increase; utterances may be shorter; speech may be less fluent; and readbacks may be less accurate. If NNSs are under high workload, their speech may become more accented.

Language indicator In the dialogue below, the following indicate the pilots are experiencing high workload: **incorrect readback** of heading and **short utterances**. Factors contributing to the workload include: **a long message** from ATC, aircraft is **not trimmed**, excessive **bank angle** and **heavy rain**.

Dialogue Beirut controller and crew of Ethiopian flight 409 speaking near Beirut, Lebanon, on January 25, 2010. Language: English.[28]

TIME (UTC)	SPEAKER	SPEECH	SOUNDS
00:38:35	ATC (radio)	**Sir I suggest for you due to weather to follow heading two seven zero to be in the clear for fifteen miles twenty miles then to go to Chekka and it is up to you just give me the heading**	Sound similar to a horn not compatible with aircraft warning
00:38:41			Synthetic voice: **bank angle**
00:38:43			Synthetic voice: **bank angle**
00:38:44			Sounds similar to **trim wheel turning**
00:38:48	Captain	**Two one say again?**	
00:38:50	FO (radio)	**Confirm heading two one zero**	
00:38:52	ATC (radio)	Ethiopian four zero nine sir negative to proceed direct Cheka sir turn left now heading two seven zero	
00:38:59	Captain	**Left heading two seven zero?**	
	FO (radio)	**Roger**	
00:39:01	FO (radio)	**Left heading two seven zero**	Synthetic voice: **bank angle**
00:39:03			Synthetic voice: **bank angle**
00:39:04	FO (radio)	**Two seven zero is set**	
00:39:22			Sounds similar to **heavy rain**

Accidents & incidents This was a factor in:[29]

- 2010 loss of control of Ethiopian Airlines 409 near Beirut, Lebanon (MPWT, 2012; see **Dialogue**)
- 2013 CFIT of Asiana Airlines 214 at San Francisco, USA (NTSB, 2014)

Further reading Stokes and Kite (1994) note that workload becomes stressful when a person *perceives* it exceeds their ability to cope. Under high workload, highly practiced procedural routines and automatic processes are more resilient than processes requiring conscious control (Dietrich, Grommes & Neuper, 2004; Dismukes, Berman & Loukopoulos, 2007).

Related factors CALL SIGN CONFUSION, DISTRACTION, EXPLETIVE, MESSAGE LENGTH, RATE OF SPEECH, STERILE COCKPIT, STRESS

APPENDIX 15: Air Traffic Controllers for Avianca 052

During its flight from Colombia to New York, Avianca 052 flew through the airspace of the following ATC facilities: Miami ARTCC, Jacksonville ARTCC, Washington ARTCC, New York ARTCC, NY TRACON, and JFK Tower. The table below gives information about the air traffic controllers who handled Avianca 052 during the latter stages of the flight (NTSB, 1991).

CONTROLLER & FACILITY	PERIOD WITH AVIANCA 052	RANK	AGE	OTHER ATC EXPERIENCE
R67 Radar controller at New York ARTCC	20:09-20:47 EST	Full performance level ATC specialist	24	None
H67 Handoff controller at New York ARTCC	Assisted R67	Full performance level ATC specialist	30	None
APP CAMRN / LENDY controller at New York TRACON	20:47-21:03 EST	Full performance level ATC specialist	33	8 years military + 2 years for private corporation
FV Final vector controller at New York TRACON	21:03-21:15 EST and 21:25-21:34 EST	Full performance level ATC specialist & traffic management coordinator	33	None
TWR Local controller at JFK Tower	21:15-21:24 EST	Full performance level ATC specialist	32	$3^1/_2$ years military

APPENDIX 16: AVA052 Communication (21:02-21:04)

The table below shows all intracockpit and radio communication involving Avianca 052 for a two-minute period from 21:02 to 21:04 EST. This composite combines data from three transcripts: CVR, ATC 3 and ATC 4. Intracockpit dialogue times are from the CVR transcript and radio message times are from the ATC transcripts (converted to EST). Any discrepancies between the transcripts are detailed in footnotes. Spanish speech is in italics, followed by the English translation from the CVR transcript in square brackets. Utterances spoken by the Avianca first officer are shaded in grey. The speakers are:

- Air traffic controllers – New York CAMRN approach controller (APP) and New York final vector controller (FV);
- Avianca crew – captain, first officer (FO) and flight engineer (FE);
- Other aircraft – El Al Israeli Airlines Flight 842 (ELY842), Evergreen International Airlines Flight 102 (EIA102), U.S. Air Flight 117 (USA117), Pan American Airlines Flight 474 (PAA474) and Avensa Aerovias Venozolanas S.A. Flight 520 (AVE520).

TIME	SPEAKER	LANGUAGE	CONTENT
21:02:07	APP (radio)	English	El Al eight forty two heavy turn left heading zero nine zero
21:02:12	ELY842 (radio)	English	Left zero nine zero El Al eight four two
21:02:14	APP (radio)	English	Evergreen one zero two heavy turn right heading two two zero
21:02:18	EIA102 (radio)	English	Two two zero one zero two heavy [85]
21:02:22	APP (radio)	English	Evergreen one zero two affirmative and descend and maintain eight thousand
21:02:23	EIA102 (radio)	English	Ah leaving one three for eight thousand Evergreen ah one zero two heavy

[85] This message consists almost entirely of numerals. It illustrates how contextual knowledge is necessary to decode radiotelephony messages. “Two two zero” refers to the new heading issued by the controller, and “one zero two” is the numerical part of the aircraft’s call sign, EIA102.

21:02:26[86]	APP (radio)	English	Avianca zero five two turn left heading zero four zero
21:02:29[87]	FO (radio)	English	Left heading zero four zero Avianca zero five two
21:02:29	Captain	Spanish	*eh Ave Maria pues* [eh Ave Maria pues] [sic]
21:02:32	FO	Spanish	*pero ya es completa cierto* [88] [but now it is completed, isn't]
21:02:34	Captain	-	[sound of laugh]
	FO	Spanish	*completa* [complete]
21:02:36	Captain	Spanish	*mil pies* [one thousand feet]
21:02:37	FO	Spanish	*mil pies para cinco mil* [one thousand feet for five thousand feet]
21:02:38[89]	APP (radio)	English	Avianca zero five two heavy approach one one eight point four
21:02:42	FO (radio)	English	One one eight point four so long
21:02:44	APP (radio)	English	Avianca zero five two and before you go there is a wind shear alert on final at fifteen hundred feet it's an increase of ten knots then again at five hundred feet increase of ah ten knots by a seven twenty seven New York now on one one eight point four good night [90]

[86] The time is 21:02:24 in the CVR transcript.

[87] The time is 21:02:27 in the CVR transcript.

[88] This and the previous utterance refer to the information Zulu ATIS broadcast. The broadcast lasted 2 minutes 5 seconds and ended at 21:02:31. It provided information about potential hazards including weather, runways and NOTAMs (notices to airmen).

[89] The time is 21:02:39 in the CVR transcript.

[90] The CVR transcript is different: "there is a wind shear alert" is changed to "there's a wind shear"; "an increase of" to "an increase in"; "increase of ah ten knots by a" to "of ten knots by".

21:03:00[91]	FO (radio)	English	One eighteen four [92]
21:02:59	Captain	Spanish	*que rumbo me dijo cero cuarenta* [what heading did you say to me zero forty]
21:03:00	FO	Spanish	*si senor* [yes sir]
21:03:07	FO (radio)	English	New York approach Avianca zero five uh two leveling five thousand
21:03:11	FV (radio)	English	Avianca zero five two heavy New York approach good evening fly heading of zero six zero [93]
21:03:16[94]	FO (radio)	English	Zero six zero Avianca zero five two heavy [95]
21:03:18	FO	Spanish	*cero seis cero en el rumbo* [zero six zero on the heading]
21:03:20	FV (radio)	English	US Air one seventeen contact Kennedy Tower one one niner point one good day
21:03:26	USA117 (radio)	English	One seventeen good night
21:03:26	FE	Spanish	*que belleza* [what a beautiful]
	FE	Spanish	*autorizado* [cleared]
21:03:28	FV (radio)	English	Good night
21:03:33	Captain	Spanish	*puede ser* [it may be]
21:03:35	FE	Spanish	*si* [yes]
21:03:35	FV (radio)	English	Clipper four seventy four turn left heading two seven zero
21:03:37	Captain	Spanish	*claro* [sure]
21:03:39	PAA474 (radio)	English	Two seven zero Clipper four seven four

[91] The CVR transcript shows the time as 21:02:56. It also shows this utterance preceding the captain's utterance at 21:02:59.

[92] In the CVR transcript this utterance is "One one eight point four so long".

[93] In the CVR transcript "heading of" is changed to "heading".

[94] The time is 21:03:15 in the CVR transcript.

[95] In the CVR transcript "Zero six zero" is changed to "heading zero six zero".

21:03:41	FV (radio)	English	Avensa five twenty turn left heading of two five zero you're one four miles from outer marker maintain two thousand till established localizer cleared ILS two two left
21:03:46	FE	Spanish	*es cuando hay uno--con con mil libras o menos en cualquier tanque se debe hacer un* [when we have--with thousand pounds or less in any tank it is necessary to do]
21:03:50	AVE520 (radio)	English	Heading two five zero maintain two thousand till established cleared ILS two two left Avensa five two zero
21:03:53	FO	Spanish	*si senor* [yes sir]
21:03:56	FE	Spanish English Spanish English	*entonces el* go around procedure *dice aplique la potencia suavemente y evite las rapidas alteraciones del avion mantenga el minimo de* nose up attitude [then the go around procedure is stating that the power be applied slowly and to avoid rapid accelerations and to have a minimum of nose up attitude]
21:04:09	Captain	Spanish	*mantenga que* [96] [to maintain what]
21:04:10	FO	English Spanish	minimum minimum nose up attitude *o sea lo menos nariz arriba que uno pueda* [minimum minimum nose up attitude that means the less nose up attitude that one can hold]
	FE	Spanish	*esto si que anda bien* [this thing is going okay]

[96] The captain asked for a repeat of information given in Spanish by the flight engineer. The point he wanted repeating used an English expression: "nose up attitude".

APPENDIX 17: Translation of Spanish CVR Dialogue

The table below shows all the Spanish dialogue (with the original English translation) from the two-minute segment of the CVR transcript in Appendix 16. A new translation of the Spanish dialogue has been made by a bilingual English-Spanish speaker. The differences between the translations are highlighted in **bold** on the new version.

TIME	SPEAKER	CONTENT IN CVR TRANSCRIPT	NEW TRANSLATION
21:02:29	Captain	*eh Ave Maria pues* [eh Ave Maria pues]	[eh **Hail Mary then**]
21:02:32	FO	*pero ya es completa cierto* [but now it is completed, isn't]	[but **it's completed now certainly**]
	FO	*completa* [complete]	[complete**d**]
21:02:36	Captain	*mil pies* [one thousand feet]	[one thousand feet]
21:02:37	FO	*mil pies para cinco mil* [one thousand feet for five thousand feet]	[one thousand feet for **five thousand**]
21:02:59	Captain	*que rumbo me dijo cero cuarenta* [what heading did you say to me zero forty]	[what heading did you **tell me** zero forty]
21:03:00	FO	*si senor* [yes sir]	[yes sir]
21:03:18	FO	*cero seis cero en el rumbo* [zero six zero on the heading]	[zero six zero on the heading]
21:03:26	FE	*que belleza* [what a beautiful]	[**beautiful**]
	FE	*autorizado* [cleared]	[cleared]
21:03:33	Captain	*puede ser* [it may be]	[it may be]
21:03:35	FE	*si* [yes]	[yes]
21:03:37	Captain	*claro* [sure]	[sure]

21:03:46	FE	*es cuando hay uno--con con mil libras o menos en cualquier tanque se debe hacer un* [when we have--with thousand pounds or less in any tank it is necessary to do]	[**it's** when **there is one - with with one** thousand pounds or less in any tank **you must do one**]
21:03:53	FO	*si senor* [yes sir]	[yes sir]
21:03:56	FE	*entonces el* go around procedure *dice aplique la potencia suavemente y evite las rapidas alteraciones del avion mantenga el minimo de* nose up attitude [then the go around procedure is stating that the power be applied slowly and to avoid rapid accelerations and to have a minimum of nose up attitude]	[then the go around procedure **says apply the power gently** and **avoid rapid changes in the plane keep the minimum** nose up attitude]
21:04:09	Captain	*mantenga que* [to maintain what]	[**keep** what]
21:04:10	FO	minimum minimum nose up attitude *o sea lo menos nariz arriba que uno pueda* [minimum minimum nose up attitude that means the less nose up attitude that one can hold]	[minimum minimum nose up attitude **in other words** the **least** nose up that **you can**]
	FE	*esto si que anda bien* [this thing is going okay]	[**this** is going **well**]

APPENDIX 18: Transcription Protocol for CVR & ATC Audio

The analysis of CVR and ATC transcripts in this dissertation highlighted shortcomings in the format and content of the NTSB transcripts. The following protocol for transcribing CVR and ATC audio data attempts to address the shortcomings. The protocol has three stages: compiling broad transcripts of all audio data, cross-checking the broad transcripts, and compiling narrow transcripts of critical communications. Conversation analysis (CA) offers an established and rigorous procedure for transcribing audio data (Liddicoat, 2007). However, it is time-consuming and requires expertise, and as a result has had limited application in aviation accident analysis. This protocol proposes that the CA transcription procedure only be applied to the critical communications.

TRANSCRIPTION PROTOCOL

STAGE	ACTION
1. Compile broad transcripts	• Transcribe all words including expletives • Include fillers and other noises such as laughter, coughing, etc • Use the same time zone for all transcripts (i.e., UTC or local time) • Show start times of utterances to nearest 0.1 sec • Show end times of utterances to nearest 0.1 sec • Show length of pauses within utterances to nearest 0.1 sec • Clearly indicate overlapping & interrupted speech • Clearly indicate sections that are unclear with a symbol such as (?)
2. Cross-check broad transcripts	• 2 transcribers cross-check each others' transcriptions • Cross-check dialogues that occur in both CVR & ATC transcripts • Clearly indicate sections that are unclear with a symbol such as (?)
3. Compile narrow transcripts	• Conduct close analysis of critical communications using conversation analysis transcription system