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Hazards of Cross-Cultural Communication Failure in Aviation

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Abstract: This study examined the potential effects of cross-cultural communication differences on flight deck operations, with particular attention to how culturally homogeneous and heterogeneous flight crews operate across different cultural environments. Although Crew Resource Management (CRM) has been substantially influenced by Western cultural norms, particularly those associated with North America and Europe, modern aviation increasingly places pilots from diverse cultural backgrounds in multinational flight deck environments. Although previous research has identified differences in aviation operations and communication across cultures, much of the existing literature has focused on culturally homogeneous crews. This study addresses this gap by examining communication-related responses among culturally heterogeneous crews. A survey was distributed to 400 pilots employed by Part 121 scheduled airlines or their international equivalents. Participants were categorized into a culturally homogeneous reference group and three comparison groups based on the cultural environment in which they worked. Countries were classified using a derived score based on three of Hofstede's cultural dimensions: Power Distance (PD), Uncertainty Avoidance (UA), and Individualism (IDV). The findings indicated statistically significant differences between the culturally homogeneous reference group and the heterogeneous comparison groups across multiple survey questions. In addition, research findings suggest that cultural factors may contribute to differences in flight deck communication beyond language differences alone. The findings have implications for the application of CRM in culturally diverse flight operations. Current CRM approaches have been substantially informed by assumptions associated with low Power Distance and high Individualism and may not fully account for the cultural contexts in which multinational crews operate. Although existing CRM principles provide an important foundation for flight crew coordination and safety, the findings suggest a need for CRM approaches that are more adaptable to the cultural and operational contexts of individual operators. Further qualitative research is warranted to examine specific communication experiences and identify how cultural differences may contribute to communication challenges on the modern flight deck.

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Background

In 1990, Avianca Flight 052 exhausted its fuel while approaching John F. Kennedy International Airport. Although the captain requested confirmation that air traffic control (ATC) had been informed of their situation, the copilot did not explicitly declare an emergency. The captain's limited English proficiency may have contributed to the communication breakdown (Code7700.com, 2003). Seven years earlier, another Avianca Boeing 747 crashed near Madrid after the captain failed to respond adequately to the copilot's recommendation to follow the Ground Proximity Warning System (GPWS) alert (Helmreich, 1994). Similarly, in 1976, a Korean Airlines Cargo Boeing 707 crashed into a mountain following a misunderstanding involving a Standard Instrument Departure (SID) (Hazrati, 2015). Although language-related communication failures were evident in these accidents, cross-cultural differences also contributed to the communication breakdowns (Code7700.com, 2003; Hazrati, 2015). Because aviation communication relies on both verbal and nonverbal cues, cultural differences can influence how messages are expressed, interpreted, and acted upon (McNair, 2023).

During the latter half of the twentieth century, the aviation industry has made substantial safety improvements, particularly through reductions in mechanical failures. However, human error continues to account for a significant proportion of aviation accidents, with approximately 85% attributed to human error and approximately 60% directly associated with human factors (SKYbrary, n.d.). In response to the recognition of human factors as a significant safety concern, Crew Resource Management (CRM) became a standard practice in aircraft operations. While preserving the authority of the pilot in command (PIC), CRM emphasizes teamwork, communication, and crew advocacy to reduce excessive authority gradients within the cockpit (Federal Aviation Administration [FAA], 2004). Despite the widespread adoption of CRM, standardized programs may not transfer equally across different cultural and organizational environments. Helmreich et al. (1999) found that CRM programs specifically developed for an organization were generally more effective than programs adopted or purchased from external sources.

Many aviation practices, including CRM, were developed primarily within Western cultural contexts (Li et al., 2007). Although research has identified relationships between cultural characteristics and aviation safety outcomes, culture is rarely identified explicitly as a contributing factor in aviation accident investigations (Barnett, 2010; Enomoto & Geisler, 2017; Harris & Li, 2008; Li et al., 2007). Existing cross-cultural aviation research has largely focused on Aviation English, International Civil Aviation Organization (ICAO) standards, Western-based CRM practices, and pilot-controller communication. Consequently, the direct influence of cultural differences on aviation communication and safety remains comparatively underexamined. This gap is important because communication can be technically correct from a linguistic perspective while still being interpreted differently because of culturally influenced communication norms.

The ICAO was established through the 1944 Chicago Convention to promote international cooperation and standardization in civil aviation (ICAO, n.d.). Although Aviation English was initially recommended for international aviation operations, standardized language proficiency requirements became mandatory in 2008 (Gardilcic, 2003; SKYbrary, n.d.). Under

these standards, an expert rating for interactions applies to individuals who can communicate effectively across situations, recognize verbal and nonverbal cues, and respond appropriately (Gardilic, 2003, p. A-2). However, this standard does not explicitly address cultural differences in how verbal and nonverbal cues are expressed, interpreted, or responded to. Cultural background can influence communication behavior independently of language proficiency. Consequently, communication that is considered appropriate or assertive in one cultural context may be interpreted differently in another. Treating cross-cultural communication primarily as a matter of language proficiency may therefore overlook broader cultural influences that affect how messages are conveyed, understood, and acted upon. Greater attention to these cultural dimensions may provide additional insight into communication-related risks within increasingly diverse international aviation operations.

Statement of the Problem

Cross-cultural communication is an operational reality in modern aviation. Although it is often associated with interactions between individuals who speak different native languages, cross-cultural communication can also occur between individuals who share the same language but differ in their values, beliefs, cultural expectations, and communication practices. These underlying assumptions may create challenges when individuals from different cultural backgrounds interact within the cockpit. The Avianca accident described by Helmreich (1994) provides an example of how differences in authority, communication style, and willingness to challenge a superior may influence cockpit decision-making. This event illustrates that effective communication involves more than the transmission of words; it also depends on how messages are expressed, interpreted, and acted upon within a particular cultural and organizational context.

As aviation has become increasingly globalized, flight crews are more frequently composed of pilots from diverse cultural backgrounds. Although these pilots may share a common professional language through standardized Aviation English, differences in communication norms, expectations, and interpretations can still create opportunities for misunderstanding. Language proficiency alone may therefore be insufficient to ensure effective communication within multicultural flight crews. Despite the potential safety implications, relatively little research has specifically examined culture-based communication failures among pilots who work together in multicultural cockpit environments. Further research is needed to determine how cultural differences influence cockpit communication, CRM effectiveness, decision-making, and aviation safety.

Purpose of the Study

The purpose of this study was to examine whether cross-cultural communication represents a latent hazard in aviation by investigating how pilots from diverse cultural backgrounds responded to operational and communication-related survey questions. Hofstede's cultural dimensions were used to calculate a Derived Cultural Score (DCS), which was then used to classify countries outside the reference group into three comparison groups, referred to interchangeably as country groups. Statistical analyses were conducted to determine whether significant differences existed among the groups in pilots' perceptions of operational and communication-related issues. Identifying significant differences among country groups may

provide evidence that cultural factors influence communication and contribute to potential risks within aviation operations.

Research Questions

The following research questions were examined through a survey of international air carrier pilots:

1. Is there an operational difference between culturally homogeneous and culturally heterogeneous flight crews?
2. What is the extent, if any, of cross-cultural communication failures on the flight decks?
3. Does cross-cultural communication failure pose a latent hazard to aviation safety?
4. Does the proportion of cross-cultural communication failure differ between culturally homogeneous and culturally heterogeneous flight crews?

Assumptions and Limitations

The study was based on two primary assumptions: (1) relative cultural homogeneity within the reference group, consisting of pilots from the United States (U.S.) and Canada, and (2) greater cultural heterogeneity within the three comparison groups. The U.S. and Canada were selected as the reference group because pilots from these countries may share relatively similar cultural and aviation environments compared with pilots from the more culturally diverse international populations represented in the comparison groups. Accordingly, when statistically significant differences were identified among the comparison groups, the study assumed that these differences could be partly associated with cross-cultural communication challenges encountered in more culturally heterogeneous environments. An additional assumption was that Hofstede's country rankings and cultural dimensions provided an appropriate framework for identifying and evaluating cultural differences among the participating pilot populations. The following limitations were identified in the study:

1. Obtaining the desired sample size was challenging. Recruitment through airlines was particularly difficult, requiring the researchers to rely primarily on alternative recruitment methods. Some airlines and individual pilots may have declined to participate because of language or cultural differences, security concerns, or organizational confidentiality policies. These factors may have limited both the size and cultural diversity of the sample.
2. The findings were based on participants' individual perceptions and professional experiences. Consequently, responses may have been influenced by personal biases, differences in professional experience, and individual interpretations of the survey questions. Self-reported responses may therefore not fully represent participants' actual communication behaviors or operational experiences.
3. The study initially sought to obtain similar numbers of participants across the reference group and the three comparison groups. However, participant numbers varied among groups. Although efforts were made to recruit pilots from as many countries as possible, achieving equal representation across countries and study groups was not feasible.

Differences in group size and country representation may have affected statistical comparisons and should therefore be considered when interpreting the findings.

4. The use of Hofstede's national cultural dimensions assumes that country-level cultural characteristics provide a meaningful representation of individual participants. However, individuals within the same country may differ substantially in their cultural values, experiences, and practices. Therefore, country-level classifications may not fully capture the cultural characteristics of individual pilots or the complexity of cross-cultural communication within aviation.

Review of the Literature

Culture is defined as “the characteristic features of everyday existence (such as diversions or a way of life) shared by a people in a place or time” (Merriam-Webster, 2024, para. 2). Culture distinguishes one group from another across multiple levels, including family, national, corporate, professional, and occupational contexts. Aviation, for example, has developed a distinct professional culture shaped by standardized procedures, communication practices, organizational norms, and shared expectations. Individuals begin acquiring cultural knowledge, values, and behavioral patterns early in life through their families and social environments. This early cultural learning can influence how individuals perceive, interpret, and respond to situations and interact with others throughout their lives (Hutchins et al., 2002).

Two prominent perspectives for understanding culture are essentialism and non-essentialism. Essentialist perspectives generally view culture as a relatively stable set of characteristics acquired through socialization that may continue to influence individuals' perceptions and behaviors over time. In contrast, non-essentialist perspectives emphasize that culture is dynamic and that individuals can acquire, adapt to, and participate in multiple cultures throughout their lives (Hutchins et al., 2002). Langstedt (2018) and Nathan (2015) criticize essentialist perspectives for potentially placing individuals in a passive role by portraying cultural characteristics as fixed or predetermined. However, essentialist perspectives are not necessarily intended to stereotype individuals. Rather, they can provide a framework for understanding how culturally shared values and behavioral patterns may influence how individuals perceive and respond to their environments (Fischer, 2011).

Individuals are often unaware of the extent to which their own cultural norms shape their perceptions of what is appropriate, normal, or correct. When individuals encounter behaviors from another culture that differ from these expectations, they may judge those behaviors according to their own cultural standards (Hutchins et al., 2002; Sen, 2023). Such judgments can lead to misunderstanding because unfamiliar behaviors may be interpreted through the lens of one's own cultural experiences rather than within the cultural context in which those behaviors occur (Sen, 2023). This process is particularly relevant to aviation, where pilots from different cultural backgrounds may operate under standardized procedures and use a common professional language while maintaining different expectations regarding communication, authority, decision-making, and interpersonal interaction. These differences can influence how messages are conveyed, interpreted, and acted upon during flight operations. Sen (2023, pp. 1-2) identifies four steps through which cultural misunderstandings can develop (1) We perceive the situation

as assessed and communication is attempted, (2) We struggle to understand the situation, (3) We assess the situation based on our own situation, and (4) We pass judgement based on our own understanding.

To describe and compare cultural differences across countries, Hofstede developed a multidimensional cultural framework consisting of six dimensions. The original model included four dimensions: (1) Power Distance (PD), (2) Individualism versus Collectivism (IDV/COL), (3) Masculinity versus Femininity, and (4) Uncertainty Avoidance (UA). Two additional dimensions were subsequently incorporated: (5) Long-Term versus Short-Term Orientation and (6) Indulgence versus Restraint (MindTools Content Team, 2023). Hofstede and his colleagues used these dimensions to characterize cultural patterns across countries. Within aviation research, Hofstede's framework has been used to examine how cultural differences may contribute to communication difficulties and Crew Resource Management (CRM) challenges. Among the six dimensions, Power Distance, Uncertainty Avoidance, and Individualism have been particularly associated with aviation communication and CRM issues (Barnett, 2010; Enomoto & Geisler, 2017; Fischer et al., 1996; Harris & Li, 2008; Hazrati, 2015; Helmreich, 1994; Hutchins et al., 2002; Li et al., 2007; Pekstici, 2018; Sen, 2023).

Power Distance refers to the extent to which a culture accepts and expects unequal distributions of power and hierarchy within organizations. Countries with higher PD scores tend to exhibit more hierarchical organizational structures and greater perceived differences in status between supervisors and employees (MindTools Content Team, 2023). In high-PD cultures, questioning or directly challenging a person in a position of authority may be viewed as inappropriate. In contrast, low-PD cultures generally favor more egalitarian organizational relationships in which status differences are less pronounced and employees may be more comfortable expressing disagreement with supervisors. This distinction has important implications for flight-deck communication. Enomoto and Geisler (2017, p. 284) note that in high-PD cultures, "the psychic cost of more direct communications is high to the junior copilot" when less-experienced personnel are expected to defer to older or more experienced leaders. In an aviation context, this dynamic could influence whether a copilot is willing to question, challenge, or contradict a captain during a critical situation. A copilot from a high-PD cultural background may perceive greater social or professional consequences associated with challenging authority, whereas a captain from a low-PD culture may expect direct communication and active participation from the other flight crewmember. When these differing expectations occur within the same cockpit, they may create a communication barrier in which a message is delayed, softened, or not expressed at all. Consequently, differences in Power Distance may represent a potential cultural factor contributing to communication failures and associated safety risks.

Uncertainty Avoidance refers to the extent to which a culture is comfortable with ambiguity and the unknown (MindTools Content Team, 2023). High-UA cultures tend to prefer clearly defined rules, procedures, and guidelines to reduce uncertainty and perceived risk. In contrast, low-UA cultures are generally more comfortable with ambiguity and may demonstrate greater flexibility when established procedures do not adequately address a situation (MindTools Content Team, 2023). This distinction has direct relevance to aviation operations, where pilots must balance adherence to standardized procedures with the need to adapt to changing

circumstances. Hodgson et al. (2013) found that, during training, individuals from high-UA cultures were more likely to follow standard operating procedures (SOPs) rigidly, even when those procedures had become irrelevant to the situation. This finding suggests that cultural differences in uncertainty avoidance may influence how pilots interpret and respond to situations in which established procedures conflict with changing operational conditions.

Individualism versus Collectivism describes the degree to which individuals identify with and prioritize the interests of the individual versus those of the group. Highly individualistic cultures place greater emphasis on personal autonomy, individual achievement, personal time, and freedom, with individuals generally expecting recognition or rewards for their contributions (MindTools Content Team, 2023). In contrast, collectivistic cultures place greater emphasis on group membership, social relationships, cooperation, and group harmony. Within collectivistic cultures, directly criticizing or embarrassing another group member may be considered inappropriate because it can cause the individual to lose face (Enomoto & Geisler, 2017). In aviation, these differences may influence how pilots communicate disagreement, provide corrective feedback, or raise concerns about another crewmember's actions. For example, a pilot from a collectivistic culture may be less inclined to directly challenge a crewmember if doing so could disrupt group harmony or cause embarrassment, whereas a pilot from a highly individualistic culture may be more comfortable expressing disagreement directly.

Although Hofstede's original research was published several decades ago, subsequent research has supported the applicability of his cultural dimensions to aviation. Merritt (2000) found substantial correlations between Hofstede's cultural dimensions and measures of national culture among pilot participants. Similarly, Merritt and Helmreich (1996) demonstrated relationships between national cultural characteristics and airline operational preferences, providing further support for the relevance of cultural dimensions to aviation. Merritt (2000) reported the following correlations between Hofstede's dimensions and pilot culture data: Individualism versus Collectivism, $r = .96$; Power Distance, $r = .87$; Masculinity versus Femininity, $r = .75$; and Uncertainty Avoidance, $r = .68$. These findings provide empirical support for using Hofstede's cultural dimensions as a framework for examining cultural differences among pilots and their potential influence on aviation communication and operational behavior.

A substantial proportion of aviation professionals worldwide are non-native English speakers (Gurmentor, 2021). The International Civil Aviation Organization (ICAO) has recognized the communication challenges associated with the widespread use of English among aviation professionals and has established standards for Aviation English proficiency. Although early ICAO guidance on English language proficiency was advisory, language proficiency requirements have subsequently been incorporated into international aviation standards. Pilots and other personnel required to communicate in English during international operations must demonstrate an appropriate level of English language proficiency, with the interval for recurrent evaluation dependent on the proficiency level achieved (Gardilic, 2003).

Aviation English primarily emphasizes standardized phraseology while also requiring the ability to communicate using plain language when standardized phraseology is insufficient, particularly during abnormal and emergency situations (SKYbrary, n.d.-a). For non-native

English speakers, plain-language communication may present a greater challenge than standardized phraseology because it requires the use and interpretation of naturally occurring language rather than predefined expressions. Nevertheless, this ability is essential when unexpected situations arise that cannot be adequately addressed through standard phraseology. In such circumstances, pilots and air traffic controllers must be able to describe complex or unfamiliar situations clearly, convey intentions, clarify information, and establish a shared understanding. Consequently, proficiency in plain Aviation English is an important component of effective communication, particularly during abnormal and emergency operations.

Another important consideration is that understanding the cultural context in which English is used is not fully addressed by ICAO language-proficiency requirements. Effective communication extends beyond literal or semantic knowledge of a language to include pragmatic competence, or the ability to understand how meaning is shaped by context. When people communicate, they exchange more than words; they also bring their cultural values, norms, expectations, and assumptions into the interaction (Kale et al., 2021). Consequently, the pragmatic use and interpretation of English may vary according to the cultural backgrounds of the speakers. Hazrati (2015) and Mauranen (2006) both identified pragmatic differences as potential contributors to miscommunication in aviation. Mauranen (2006) describes communicative turbulence as a brief period of misunderstanding that is subsequently resolved through clarification and negotiation of meaning. Under normal circumstances, communication can recover when participants recognize a misunderstanding and have sufficient time to clarify the intended meaning and establish shared understanding. However, abnormal and emergency situations may not provide sufficient time for such clarification. During these situations, pilots may need to interpret information and respond immediately, making rapid and accurate mutual understanding particularly important.

Aviation has made substantial progress in addressing communication-related risks, particularly through Crew Resource Management (CRM) and its emphasis on open communication, information sharing, and the active exchange of safety-critical information among crew members. When communication is ineffective or information is not adequately shared, opportunities to identify and correct developing threats may be reduced. Historical accidents, including Avianca Flight 052, the Tenerife disaster, and the Korean Air crash in Tehran, illustrate the serious consequences that can arise when communication, coordination, and situational awareness break down. These events underscore the importance of effective communication not only as a matter of language proficiency but also as a function of shared meaning, cultural context, and the ability of crewmembers to communicate effectively under operational pressure.

Although CRM has contributed substantially to aviation safety, some of its underlying principles may reflect cultural assumptions associated with low Power Distance (PD) and low Uncertainty Avoidance (UA), characteristics commonly associated with Western cultures. This is understandable given that modern commercial aviation was largely developed within Western countries and, until relatively recently, many major aircraft manufacturers were based in Western nations (Li et al., 2007). Consequently, a potential cultural mismatch may arise when pilots from high-PD cultures operate within an aviation system and CRM framework developed around lower-PD expectations. In high-PD cultures, for example, greater deference to authority may

influence a pilot's willingness to question or challenge a captain, whereas CRM emphasizes assertive communication and the open exchange of information across the flight deck. Such cultural differences may create communication challenges that are not fully addressed by standardized CRM training. Importantly, these differences may remain unrecognized when CRM principles are assumed to be culturally universal. For example, although China is characterized by relatively high PD, the development of the Chinese AVIC ARJ21 incorporated CRM concepts based largely on lower-PD principles (Harris & Li, 2008).

Soeters and Boer (2000) found a positive correlation between accident rates and both Power Distance (PD) and Uncertainty Avoidance (UA), while Individualism (IDV) was negatively correlated with accident rates. These findings are supported by Barnett (2010) and Li et al. (2007), who identified relationships between high-PD cultures and aircraft accidents. Li et al. (2007, p. 424) concluded that "low-power distance cultures with high degree of individualism seems to be superior to collective, high power-distance cultures for promoting aviation safety, especially in terms of the processes and procedures at the higher organizational level." Collectively, these findings suggest that national cultural characteristics may be associated with differences in aviation safety outcomes and organizational practices.

Much of the research examining crew performance and pilot-controller communication has focused on culturally homogeneous crews. A notable exception is Peksatici's (2018) study of cross-cultural CRM in airlines operating in Turkey. Peksatici examined cultural differences between Turkish and expatriate pilots working together, providing valuable insight into how cultural differences may influence CRM and flight-deck interactions. However, the expatriate group consisted exclusively of European pilots, which limits the extent to which the findings can be generalized to pilots from other cultural backgrounds. Peksatici's (2018) research provides an important foundation for examining the relationship between culture and aviation operations, particularly because cross-cultural differences in flight-deck communication and CRM remain relatively underexplored. Building on this work, the present study expands the scope of investigation to include pilots from diverse cultural backgrounds worldwide. The objective is not only to determine whether differences exist among culturally defined pilot groups, but also to examine whether those differences are associated with communication and operational outcomes that may represent potential latent hazards to aviation safety.

Methodology

The target population for this study consisted of commercial airline pilots employed by Federal Aviation Administration (FAA) Part 121 scheduled airlines or non-U.S. international airlines operating under comparable regulatory frameworks. Previous research has identified a positive relationship between Power Distance (PD) and Uncertainty Avoidance (UA) and aviation accident rates, while Individualism (IDV) has been negatively associated with accident rates (Enomoto & Geisler, 2017; Soeters & Boer, 2000). Notably, the relationship between PD and IDV and accident rates has been reported as stronger than the relationship between UA and accident rates (Soeters & Boer, 2000). Therefore, PD and IDV were assigned greater weight than UA in the classification of countries used in this study. Data was collected through a survey of airline pilots from multiple countries. Participants were grouped according to derived cultural scores based on three of Hofstede's cultural dimensions: Power Distance (PD), Individualism

(IDV), and Uncertainty Avoidance (UA) (Hofstede Insights, 2024; Worldmeters, 2023). These dimensions were used to develop a derived country score that provided the basis for assigning each country to a comparison group. The following formula (1) was applied to calculate the derived cultural score for each country:

$$\text{Country Score} = .4\text{PD} + .4(100-\text{IDV}) + .2\text{UA} \quad (1)$$

Based on the derived Hofstede cultural scores, countries were divided into one reference group and three comparison groups. The reference group consisted of active airline pilots from the United States and Canada, and the three comparison groups consisted of pilots from all other countries included in the study, with countries classified according to their derived cultural scores (Appendices B and C). It was expected that countries characterized by low Power Distance (PD), high Individualism (IDV), and low Uncertainty Avoidance (UA), such as Denmark and other countries in Group 1, would experience fewer cross-cultural communication challenges than countries in the other comparison groups, although potentially more than the reference group. The primary distinction among the groups was the relative degree of cultural homogeneity and heterogeneity represented by the participating pilot populations.

Hofstede's cultural dimensions are measured on a scale ranging from 0 to 100 (MindTools Content Team, 2023). Previous research has identified a negative relationship between Individualism (IDV) and aviation accident rates (Enomoto & Geisler, 2017; Soeters & Boer, 2000). Because higher IDV scores are associated with lower accident rates, the IDV score for each country was transformed by subtracting the original score from 100. This transformation allowed the IDV dimension to be oriented in the same direction as PD and UA for purposes of calculating the derived cultural score.

For example, Denmark has a PD score of 18, an IDV score of 89, and a UA score of 23. After the IDV transformation, Denmark's scores were PD = 18, adjusted IDV = 11, and UA = 23. The transformed scores were then used to calculate the derived cultural score for each country (Appendix B). Under this scoring approach, lower values represented lower levels of PD, adjusted IDV, and UA, while the original high IDV values were represented by lower adjusted IDV values.

For the U.S., the original Hofstede scores were PD = 40, IDV = 60, and UA = 46. After transforming the IDV score, the adjusted values were PD = 40, adjusted IDV = 40, and UA = 46. Therefore, the derived cultural score for the United States was calculated as follows:

$$\text{Country Score} = .4(40) + .4(100-60) + .2(46) = 41$$

The estimated sample size was calculated by using Taro Yamane's formula (2) for known populations, and Cochran's formula (3) for large or unknown populations (Ajireloja, 2023):

$$\text{Taro Yamane Formula: } n = \frac{N}{1+Ne^2} \quad (2)$$

$$\text{Cochran's Sample Size Formula: } n = \frac{Z^2 p(1-p)}{E^2} \quad (3)$$

where:

N = total population

n = estimated sample size

Z = Z-score of the desired confidence level

p = estimated proportion of the population with the characteristic of interest

E = the desired margin of error

For this study, a 95% confidence level was selected, corresponding to a critical Z value of 1.96. The estimated proportion of the population possessing the characteristic of interest was set at 50%, representing the most conservative estimate for population variability. A margin of error of 5% was selected. The estimated global population of active commercial pilots was approximately 350,000 (CAPA, 2023). These parameters were used to estimate the minimum sample size required for the study.

Sample size calculations:

$$\text{Yamane's Formula: } n = \frac{350,000}{1+350,000(.05^2)}$$
$$n = 399$$

$$\text{Cochran's sample size formula: } n = \frac{1.96^2 * .5(1-.5)}{.05^2}$$
$$n = \frac{3.8416 * .25}{0.0025}$$
$$n = 384.16$$

Both formulas produced similar estimates for the required sample size. Although an estimated number of commercial pilots worldwide is available, the exact size of the global pilot population remains uncertain. Therefore, Cochran's formula was selected because it is appropriate for large or unknown populations. Using a 95% confidence level, a 5% margin of error, and a 50% estimated population proportion, the formula yielded a required sample size of 384 participants.

A total of 400 individuals replied to the survey. The distribution of the respondents across the groups is as follows (1) Reference group (U.S. and Canada) - 101 respondents, (2) Group 1 - 50 respondents, (3) Group 2 - 108 respondents, and (4) Group 3 - 141 respondents

Research Instrument

The research instrument for this study was a survey distributed globally through Qualtrics to pilots employed by FAA Part 121 scheduled airlines or non-U.S. international airlines. The survey was designed to collect demographic and operational information necessary to classify participants into the reference group or one of the three comparison groups. All survey responses were collected through Qualtrics and subsequently exported for analysis using JMP Student Edition 18 (SAS Institute Inc.). At the time of survey distribution, participants could not be assigned to a specific study group because group classification depended on demographic information provided by participants. Following completion of the survey, participants were

assigned to the reference group or one of the three comparison groups based on their reported country of employment or other relevant demographic information. Responses from individuals who did not meet the study's eligibility criteria were excluded from the primary analysis but remained separately for potential future analysis. The survey was distributed through five primary recruitment channels (1) airline training departments, (2) LinkedIn airline pilot profiles, (3) airline pilot social media groups, (4) professional contacts, (5) and snowball sampling.

Validity and Reliability of the Survey

The survey included both operational and communication-specific questions (Appendix A). Most questions, particularly the operational questions, were designed as stand-alone items and were not intended to build upon one another. However, Questions 13 and 14 and Questions 15 and 16 were intentionally paired to examine related concepts and capture more nuanced information about participants' perceptions and experiences. The operational questions were designed to identify potential communication difficulties between pilot pairings as well as potential communication challenges between pilots and the broader organizational environment. This distinction was important because cultural differences may influence interactions not only between individual pilots but also between pilots and the organizations for which they work. Organizational policies, practices, communication norms, and expectations may reflect the cultural environment in which an airline operates and may therefore influence pilot-organization interactions.

The survey was designed to assess pilots' perceptions of scenarios and statements related to operational attitudes and cross-cultural communication. Through interviews and group discussions with current and former pilots across all four participant groups, the researchers reviewed the questions to identify ambiguous wording, unclear concepts, and potential differences in interpretation. Each question was discussed and revised as necessary to improve clarity and ensure that participants' understanding was consistent with the intended meaning of the question. This process was intended to strengthen the content validity of the instrument and ensure that the questions were understood by pilots from different cultural and professional backgrounds.

Ethical Assurances

The survey was administered anonymously and was configured to collect no personally identifying information, including participants' IP addresses. Because no identifying information was collected, the same survey URL was used for all participants. Before accessing the survey questions, participants were presented with an informed consent form. Individuals who did not provide consent were exited from the survey and were not permitted to participate. Participants were also informed they could withdraw from the survey at any time without penalty. Responses from individuals who withdrew before submitting the survey were not included in the study analysis.

Results

During the data collection period, more than 400 pilots from the target population completed the survey. Figure 1 provides a global overview of survey participation by country, with the number displayed for each country representing the total number of respondents. Countries are color-coded according to their calculated Hofstede cultural scores: low (green; 16.2 - 41.2), medium (yellow; 41.3 - 66.1), and high (red; 66.2 - 91.1).

Figure 1

Survey Responses by Country and Hofstede Score Category

Alongside grouping countries according to their calculated Hofstede cultural scores, the U.S. and Canada were treated as a distinct reference group for this study. Although both countries fell within the low-score range based on the calculated Hofstede dimensions, they were grouped separately because of their shared geographic and aviation environments and their role as the reference population for comparison with the other country groups. For the purposes of this study, the U.S. and Canada were therefore treated as a relatively culturally homogeneous reference group.

The distribution of linguistic and cultural characteristics among flight crews is illustrated in Figure 2. Flight crews in the U.S. and Canada were predominantly local pilots and native English speakers. In contrast, the three comparison groups demonstrated greater linguistic and cultural diversity, including higher proportions of non-native English speakers and expatriate pilots. Group 3, consisting of countries with high Hofstede scores, had the highest proportion of expatriate pilots. Group 2 had the highest proportion of native English speakers among its expatriate pilots.

Figure 2

Composition of Flight Crews Across Country Groups: English Language Status, Expatriate Proportion, and Expatriate Language Background

Response Patterns by Cultural Groups

Figure 3 presents the distribution of responses across the four assigned country groups, separated by flight-deck role (captain or first officer). Several cells in the response distribution table appear blank because of intentional elements of the survey design. The distribution of flight-deck roles within each group, along with the total number of respondents in each role, is presented in the bar chart below the response table to provide additional context for interpretation. The overall sample included enough captains and first officers to support statistical analysis. Captains outnumbered first officers in all groups except Group 1, where the distribution was approximately equal. The number of countries represented in each group was not equal. Instead, the groups were established based on Hofstede score ranges of approximately 25 points. To assess the robustness of the findings, the analysis was repeated using country groups containing an equal number of countries. The same survey questions remained statistically significant across the alternative grouping approach, with no exceptions. These results provide additional support for the stability of the findings across different country-group configurations.

Figure 3

Distribution of Survey Responses by Country Group and Role, with Participant Role Composition

Role	Question	Reference			Group 1 (Low Score)			Group 2 (Medium Score)			Group 3 (High Score)		
		Agree	Disagree	Neither	Agree	Disagree	Neither	Agree	Disagree	Neither	Agree	Disagree	Neither
Captain	Q1	97%		3%	100%			97%	3%		99%	1%	
	Q2	83%	9%	9%	96%	4%		82%	11%	7%	85%	7%	8%
	Q3	95%	3%	2%	63%	29%	8%	62%	23%	15%	65%	26%	9%
	Q4	86%	5%	9%	92%	8%		72%	13%	15%	63%	26%	11%
	Q5	83%	7%	10%	79%	17%	4%	62%	25%	13%	57%	20%	22%
	Q6	93%	3%	3%	92%	4%	4%	86%	10%	4%	87%	10%	3%
	Q12	52%	16%	33%	54%	42%	4%	52%	30%	18%	44%	46%	10%
	Q13	64%	24%	12%	50%	38%	13%	72%	20%	8%	70%	25%	6%
	Q14	29%	64%	7%	17%	67%	17%	34%	58%	8%	29%	57%	13%
	Q15				54%	46%		46%	45%	8%	52%	43%	6%
	Q16				54%	38%	8%	41%	54%	6%	47%	48%	4%
First Officer	Q7	100%			96%		4%	95%		5%	100%		
	Q8	84%	12%	5%	88%	4%	8%	86%	5%	8%	90%	6%	4%
	Q9	91%	7%	2%	62%	15%	23%	59%	14%	27%	73%	15%	12%
	Q10	93%	2%	5%	81%	8%	12%	65%	16%	19%	52%	31%	17%
	Q11	86%	5%	9%	81%	12%	8%	49%	19%	32%	54%	15%	31%
	Q12	47%	23%	30%	31%	31%	38%	16%	57%	27%	37%	48%	15%
	Q13	79%	16%	5%	62%	35%	4%	59%	30%	11%	60%	29%	12%
	Q14	26%	72%	2%	19%	77%	4%	24%	65%	11%	19%	62%	19%
	Q15				50%	35%	15%	59%	27%	14%	46%	44%	10%
	Q16				46%	42%	12%	41%	46%	14%	38%	46%	15%
Captain		58			24			71			89		
First Officer		43			26			37			52		

Aviation is a highly regulated industry, and pilots are required to complete recurrent training and undergo periodic evaluations to maintain professional qualifications. Given these regulatory and training requirements, a generally favorable response pattern was expected, with responses potentially skewed toward positive and compliant ratings. Therefore, the primary focus of the analysis was not the overall positivity of responses but differences in responses among the country groups.

Although Likert-style responses are commonly assigned numerical values for statistical analysis, treating the responses as continuous data was not considered appropriate for this study. Preliminary analysis indicated that the data violated the assumptions of ANOVA, including normality and homogeneity of variance. Attempts to address these violations through alternative approaches introduced additional concerns regarding the assumptions of nonparametric tests.

Accordingly, survey responses were treated as ordinal categorical data. Pearson's chi-square (χ^2) test was used to determine whether statistically significant differences existed among the country groups. However, initial analysis indicated that the expected frequency in several cells was less than five, violating an important assumption of the chi-square test. To address this issue, adjacent Likert-response categories were consolidated (agree, neither agree nor disagree, disagree) to increase expected cell frequencies and satisfy the test assumptions. After consolidation, the number of Likert-scale responses with cell counts less than five was reduced to seven. For these seven questions, Fisher's exact test was used to determine statistical significance because the expected frequencies remained insufficient for the Pearson chi-square test. Survey responses were analyzed according to four factors: (1) country group, (2) whether

English was the participant's native language, (3) flight-deck role (captain or first officer), and (4) employment status as a local or expatriate pilot.

For Questions 1-11, 15, and 16, agreement with the statement was classified as a positive response. Because of the wording of Questions 12-14, disagreement with the statement was classified as a positive response because it represented the response direction associated with potentially safety-favorable outcomes. Table 1 summarizes the questions for which statistically significant differences were identified.

Table 1

Summary of Survey Questions Showing Statistically Significant Differences in Responses

Question	Country	Language	Role	Expat
1,7				<i>X</i>
2,8				
3	<i>X</i>	<i>X</i>		
4,10	<i>X</i>			
5,11	<i>X</i>			
6,9			<i>X</i>	
7,1				
8,2				
9,6	<i>X</i>		<i>X</i>	
10,4	<i>X</i>			<i>X</i>
11,5	<i>X</i>			<i>X</i>
12	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>
13				
14				
15				<i>X</i>
16			<i>X</i>	<i>X</i>

Note. This table shows the survey questions that had statistically significant results when analyzed by country group, native language, cockpit role, or expatriate status. Some operational questions had a separate captain and first officer version. The paired questions are listed together in the Question column. When a response applies to captains, it is shown in italics (*X*).

Analysis by Country Group

Regardless of whether a respondent was a native or expatriate pilot, country-group classification was based on the respondent's country of employment. The expected cell-count assumption was violated for Questions 1, 2, and 6-10. Of these questions, only Questions 9 and 10 produced statistically significant results. Table 2 summarizes the statistically significant results for responses analyzed by country group. Because Questions 9 and 10 violated the expected cell-count assumption, Fisher's exact test was used to determine statistical significance for these questions.

Table 2

Survey Results Factored by Country Group

Question	Reference	Group 1	Group 2	Group 3	χ^2 (6)	<i>p</i>
Q3 (PIC) Command authority	95/2/3	63/8/29	62/15/23	65/9/26	23.58	< .001
Q4 (PIC) Minor error	86/9/5	92/0/8	72/15/13	74/11/15	19.48	.003
Q5 (PIC) Supervisor support	83/10/7	79/4/17	62/13/25	57/22/20	16.84	.010
Q9 (SIC) First officer action	91/2/7	62/23/15	59/27/14	73/12/15	–	.013 ^a
Q10 (SIC) Minor error	93/5/2	81/12/8	65/19/16	52/17/31	–	< .001 ^a
Q11 (SIC) Supervisor support	86/9/5	81/8/12	49/32/19	54/31/15	19.41	.004
Q12 Non-work conversation	19/32/49	36/22/42	39/21/40	47/12/41	25.40	< .001

Note. Values represent response percentage in order of positive/neutral/negative. Totals may not equal 100 due to rounding. PIC = Pilot in Command; SIC = Second in Command. ^a denotes results from Fisher's exact test due to the violation of the expected cell count assumption of Pearson's chi-square test.

Analysis of Responses by Native Language

When responses were analyzed according to whether the respondent was a native English speaker, the expected cell-count assumption was violated for Questions 1 and 8. Neither question produced a statistically significant result. In contrast, Questions 3 and 12 produced statistically significant differences when responses were analyzed by native language. Table 3 summarizes the statistically significant results for these questions.

Table 3

Survey Results Factored by Native Language

Question	Native English	Non-Native English	χ^2 (2)	<i>p</i>
Q3 (PIC) Command Authority	61/11/28	88/5/7	20.75	< .001
Q12 Non-work conversation	45/16/38	23/27/50	20.74	< .001

Note. Values represent response percentage in order of positive/neutral/negative. Totals may not equal 100 due to rounding.

Analysis by Role

The survey collected demographic information, including each respondent's flight-deck role. To ensure that survey questions were relevant to both captains and first officers while also capturing role-specific perspectives, five questions were presented in separate versions for each flight-deck role. Table 4 presents the paired questions for captains and first officers.

Table 4*Paired Questions by Role*

Captain	First Officer
Q1-Statement: If I make a mistake, I feel comfortable with my first officer correcting me.	Q7/(PIC Q1)-Statement: If the captain makes an error, I am comfortable bringing this error to their attention.
Q2-Statement: I am comfortable with minor variations from standard operating procedures (SOP) if the situation warrants. (Example: SOP requires a call of "glideslope alive" 2nm from the Final Approach Fix (FAF), however today you intercept the glideslope 5 miles before the FAF.)	Q8/(PIC Q2)-Statement: I am comfortable with minor variations from standard operating procedures (SOP) if the situation warrants. (Example: SOP requires a call of "glideslope alive" 2nm from the Final Approach Fix (FAF), however today you intercept the glideslope 5 miles before the FAF.)
Q4-Statement: If I happen to make a minor procedural error during operations, I do not expect repercussions/consequences outside of the flight deck.	Q10/(PIC Q4)-Statement: If I happen to make a minor procedural error during operations, I do not expect repercussions/consequences outside of the flight deck.
Q5-Statement: During an abnormal situation, I am confident that my supervisor will support me by exercising my judgement, if needed, to terminate the flight, even if not specifically mandated by the SOP, Quick Reference Handbook (QRH) or checklist.	Q11/(PIC Q5)-Statement: During an abnormal situation, I am confident that my supervisor will support me exercising my judgement, if needed, to terminate the flight, even if the SOP, QRH or checklist do not specifically mandate this.
Q6-Scenario: The First Officer stops the plane because they think you are about to deviate from a taxi clearance, there is no time to inform the captain. It turns out that the First Officer was mistaken. Statement: I understand that the First Officer was mistaken, but I accept that it was a valid safety concern.	Q9/(PIC Q6)-Scenario: You believe the captain is about to unintentionally deviate from a taxi clearance. There is no time to warn the captain. Statement: I am comfortable acting (stopping the plane), even if subsequently it turns out that I am wrong.

When factored by role, only question 1 violated the expected count assumption for Pearson χ^2 . Fisher's exact test is used as a non-parametric alternative. Table 5 summarizes significant responses when factored by role.

Table 5*Survey Results Factored by Role*

Question	Captain	First Officer	Pearson χ^2	χ^2 (2)
Q6 First officer action	88/4/8	73/15/13	19.145	< 0.001
Q12 Non-work conversation	33/17/49	41/26/34	10.138	.006
Q16 CRM effectiveness	46/5/49	41/14/45	6.423	.04

Note. Values represent response percentage in order of positive/neutral/negative. Totals may not equal 100 due to rounding.

Analysis by Expatriate or Native Status

Responses were analyzed according to whether respondents were native or expatriate pilots in their country of employment. Statistically significant differences were observed for Questions 1, 10, 11, 12, 15, and 16. Table 6 summarizes the statistically significant results by expatriate status. Only Question 1 violated the expected cell-count assumption for Pearson's χ^2 test. Fisher's exact test was therefore used as an alternative for assessing statistical significance.

Although Question 1 produced a statistically significant result using Fisher's exact test ($p = .043$), 97.93% of respondents provided a positive response. In addition, Pearson's χ^2 test was not statistically significant; significance was observed only when Fisher's exact test was applied to account for the expected cell-count violation. The corresponding first-officer version, Question 7, also produced a very high positive response rate (98.2%) and was not statistically significant ($p = .26$). Given the extremely high proportion of positive responses and the negligible difference between the two questions, the statistical significance observed for Question 1 was not considered substantively meaningful. Accordingly, Question 1 was excluded from further interpretation.

Table 6

Survey Results Factored by Expat Status

Question	Expat	Non-Expat	χ^2 (2)	p
Q1 (PIC) First officer corrects captain	97/0/3	99/1/0	—	0.04 ^a
Q10 (SIC) Minor error	49/23/28	80/9/11	15.17	< 0.001
Q11 (SIC) Supervisor support	49/30/21	73/18/9	8.95	.01
Q11 (SIC) Supervisor support	39/14/47	35/25/41	6.37	.04
Q15 Communication style	39/8/53	63/8/29	18.52	< 0.001
Q16 CRM effectiveness	34/8/57	54/9/37	12.65	.001

Note. Values represent response percentage in order of positive/neutral/negative. Totals may not equal 100 due to rounding. PIC = Pilot in Command; SIC = Second in Command. ^a denotes results from Fisher's exact test due to the violation of the expected cell count assumption of Pearson's chi-square test.

Conclusions

Summary of Research Questions

1: Is there an operational difference between culturally homogeneous and culturally heterogeneous flight crews?

Five operational questions were presented in paired captain and first-officer versions, along with one captain-only question. Of these questions, all except Captain Question 2 and First Officer Questions 7 and 8 produced statistically significant differences for at least one of the factors examined. The questions presented hypothetical scenarios and asked participants how they would feel or respond under the specified circumstances. When responses were analyzed by country group, the reference group consistently reported higher proportions of positive responses than the comparison groups. In general, the proportion of positive responses decreased progressively across the comparison groups.

These findings suggest differences in how pilots perceive their security and confidence in their roles. CRM depends on the open exchange of information, and a work environment in which pilots feel secure when raising concerns or exercising appropriate authority may facilitate that exchange. Several of the operational questions addressed circumstances that could influence this sense of security. For example, pilots may consider whether a minor procedural error could

result in consequences beyond the flight deck, whether a conservative decision to terminate a flight would be supported during an abnormal situation, or whether a first officer feels sufficiently secure to take action in the interest of safety and whether the captain would accept that intervention. When pilots believe that good-faith actions, minor errors, or appropriate safety interventions will result in disproportionate repercussions, they may be less willing to communicate concerns or provide safety-critical information. Conversely, a supportive environment may encourage the open exchange of information needed to identify and address developing threats before they contribute to an adverse event.

A January 4, 2026, incident provides a contemporary example of a flight-deck interaction like those presented in Captain Question 6 and First Officer Question 9. During taxi, a Malaysian first officer reportedly warned a Taiwanese captain several times that the aircraft was taxiing too quickly. The first officer ultimately applied the brakes, after which the captain reportedly struck the first officer (Huang & Mazzetta, 2026). The incident also illustrates dynamics relevant to Captain Question 1 and First Officer Question 7, including the captain's resistance to correction and willingness by the first officer to challenge the captain and take corrective action. Although a single incident cannot establish a relationship between culture and flight-deck behavior, it provides a real-world example of the types of interpersonal and authority-related interactions examined by the survey.

Question 3, the only captain-only question, provides additional insight into participants' perceptions of their comfort exercising authority as captain. The comparison groups reported similar positive response rates, ranging from approximately 62% to 65%, whereas the reference group reported a substantially higher positive response rate of nearly 95%. Power Distance provides one possible framework for interpreting communication challenges that occur along an upward authority gradient, such as communication from a first officer to a captain. Individualism versus Collectivism may provide additional insight into communication in both directions. In more collectivistic cultures, greater emphasis on group harmony and avoidance of confrontation may influence how individuals' express disagreement or correct another member of the group, particularly when doing so could cause embarrassment or loss of face.

The similarity of the comparison-group responses to Question 3, contrasted with the substantially higher response rate in the reference group, suggests a difference between the reference group and the culturally heterogeneous comparison groups. Differences in native-language status provide additional context. Although native-language status is not itself a direct measure of cultural heterogeneity, most respondents in the comparison groups were non-native English speakers, whereas only 7% of respondents in the reference group were non-native English speakers. Because expatriate status was not statistically significant for Question 3, the observed difference may reflect factors other than expatriate status. One possible explanation is the participants' level of comfort communicating in English; however, the available data does not establish whether language proficiency explains the observed difference.

Overall, responses to the operational questions indicate differences between the reference and comparison groups in perceptions related to flight-deck security, authority, and communication. Pilots in the reference group consistently reported the highest proportions of positive responses, whereas the comparison groups generally reported progressively lower

proportions of positive responses. Expatriate first officers also reported lower levels of perceived security than their native colleagues. Taken together, these findings provide evidence of differences in reported perceptions between the culturally homogeneous reference group and the more culturally heterogeneous comparison groups. However, the findings should be interpreted as evidence of differences in perceptions and responses rather than as evidence that cultural heterogeneity itself causes reduced safety or performance.

2: What is the extent, if any, of cross-cultural communication failures on the flight decks?

Complementing the operational questions, the communication questions addressed the language component of cross-cultural communication. Questions 12 -14 were presented to all participants, whereas Questions 15 and 16 were presented only to respondents in the comparison groups because these groups were expected to represent greater cultural heterogeneity. Question 12 produced a particularly notable finding. Participants were asked to respond to the statement, “Sometimes during a non-work-related conversation with a pilot from another country, I feel like they do not fully understand what I am saying.” The results were statistically significant ($p < .0003$). Unexpectedly, however, the reference group reported the lowest proportion of positive responses, whereas Country Group 3 reported the highest, at 47%.

Gudykunst’s Anxiety/Uncertainty Management (AUM) Theory provides one possible framework for interpreting this unexpected finding. As summarized by Griffin (2006), the theory proposes that effective intercultural communication requires anxiety and uncertainty to remain within an appropriate range. Insufficient levels of anxiety or uncertainty may contribute to complacency, whereas excessive levels may interfere with effective communication and result in communication paralysis. From this perspective, differences in participants’ familiarity with cross-cultural interactions may influence how they recognize and respond to communicative difficulties. One possible explanation is that pilots in the reference group, who were generally expected to operate within a more culturally homogeneous environment, may have had less experience anticipating communicative differences. Consequently, when communicative turbulence did occur, they may have been less prepared to recognize or accommodate the difference, resulting in the observed response pattern. Conversely, pilots in the comparison groups may have had greater exposure to cultural and linguistically diverse interactions and therefore may have developed greater awareness or readiness to manage potential communication differences. The assumption of cultural homogeneity within the reference group should not, however, be interpreted as absolute. Cultural and linguistic variation undoubtedly exists within the U.S. and Canada, and some reference-group pilots may have substantial experience working with international or culturally diverse crews. This interpretation remains speculative because the study did not directly measure participants’ prior experience with cross-cultural communication or their levels of anxiety and uncertainty. Nevertheless, AUM Theory provides a potential theoretical explanation for why the reference group, despite being characterized as relatively culturally homogeneous, reported the lowest proportion of positive responses to Question 12.

Questions 13 and 14 examined participants’ ability to establish shared understanding during both non-safety-related and abnormal or emergency situations. For Question 13, which addressed non-safety-related communication, 66% of respondents reported a negative response.

More importantly, 27% of respondents reported a negative response to Question 14, which addressed abnormal or emergency situations. Thus, more than one-quarter of participants indicated they had experienced an abnormal or emergency situation in which they were unable to establish a shared understanding with other flight-deck crewmembers regarding the appropriate course of action. Given the time-critical nature of abnormal and emergency operations, this finding is particularly important because the inability to establish shared understanding may impede effective coordination and decision-making.

The final two communication questions examined whether participants modified their communication approach based on the national or cultural background of the other pilot (Question 15) and how effectively they perceived CRM to function across such differences (Question 16). Both questions demonstrated statistically significant differences when analyzed by expatriate status, while Question 16 also demonstrated a statistically significant difference by flight-deck role. Expatriate pilots reported higher proportions of negative responses than non-expatriate pilots on both questions. This pattern suggests that expatriate pilots were more likely to perceive a need to modify their communication approach when interacting with pilots from different national or cultural backgrounds and were more likely to perceive differences in CRM effectiveness. These findings may indicate that CRM principles do not function identically across culturally diverse flight-deck environments. However, the results should not be interpreted as demonstrating that CRM is ineffective; rather, they suggest that its effectiveness may vary according to the cultural and interpersonal context in which it is applied.

English-language proficiency provides one possible alternative explanation for these findings. However, the absence of statistically significant differences when responses were analyzed according to native versus non-native English status suggests that native-language status alone does not account for the observed differences. This finding is consistent with the possibility that cultural factors, rather than language background alone, contribute to differences in how pilots adapt their communication and perceive CRM effectiveness. Nevertheless, because language proficiency was not directly measured, the results cannot establish culture as the sole explanation.

Meaningful differences were identified across all four factors examined in the study (1) country group, (2) expatriate status, (3) native-language status, and (4) flight-deck role. Expatriate status was particularly associated with differences in reported communication adaptation and perceived CRM effectiveness. Collectively, these findings provide evidence that pilots' perceptions and communication experiences vary across culturally defined groups and operational roles. Although the results do not establish that cultural differences directly cause communication failures or aviation accidents, the reported difficulty establishing shared understanding during abnormal and emergency situations represents a potential latent safety hazard and warrants further investigation.

3: Does cross-cultural communication failure pose a latent hazard to aviation safety?

Aviation has evolved from a safety culture that primarily reacted to accidents and incidents toward a more proactive approach focused on identifying and mitigating risks before they result in adverse events. More recently, the emphasis has shifted toward predictive safety

management and the identification of potential threats before they become manifest. The high level of safety achieved in modern aviation can make latent hazards particularly difficult to identify because many potential threats are effectively managed before they result in accidents or incidents. Consequently, latent risks such as cross-cultural communication difficulties may remain largely undetected without focused research and systematic safety-management efforts.

The results of this study provide evidence of differences in cross-cultural communication experiences among the participants. Questions 12–14 produced several unexpected findings that warrant further consideration. First, the country-group results for Question 12 were opposite to the hypothesized direction. Despite this unexpected finding, statistically significant differences were identified when responses were analyzed by expatriate status and native-language status. Expatriate and non-native English-speaking pilots reported higher proportions of favorable responses to Question 12 than their respective comparison groups. These findings suggest that country group alone does not fully explain participants' perceptions of communication difficulties and that other cultural or linguistic factors may influence these experiences.

Second, Questions 13 and 14, which examined participants' ability to establish shared understanding on the flight deck, did not demonstrate statistically significant differences across the factors investigated. Nevertheless, the proportion of negative responses to these questions is noteworthy. A substantial proportion of participants reported experiencing situations in which shared understanding was not achieved, including during abnormal or emergency situations. Given the international composition of the study population and the presence of culturally diverse flight crews, some of these experiences likely occurred within cross-cultural flight-deck environments. Thus, the absence of statistically significant group differences does not eliminate the importance of the underlying finding: participants reported instances of communicative turbulence and difficulty establishing shared understanding during flight operations.

Finally, Questions 15 and 16 provide additional evidence concerning the relationship between culture and flight-deck communication. These questions addressed whether pilots modify their communication approach according to the national or cultural background of other crewmembers and whether CRM is perceived as equally effective across these interactions. The statistically significant differences identified for these questions, particularly those associated with expatriate status and flight-deck role, suggest that communication practices and perceptions of CRM effectiveness may vary across culturally diverse flight-deck environments.

Taken together, the findings provide evidence that cross-cultural differences are associated with pilots' reported communication experiences, perceptions of shared understanding, communication adaptation, and CRM effectiveness. The results do not establish that cultural differences directly cause communication failures or aviation accidents. However, the reported difficulty establishing shared understanding, combined with differences in communication practices and perceived CRM effectiveness, indicates a potential latent safety hazard. These findings support the need for further research examining how cultural differences interact with language, authority, communication practices, and CRM during normal, abnormal, and emergency flight operations.

4: Does the proportion of cross-cultural communication failure differ between culturally homogeneous and culturally heterogeneous flight crews?

Although not all responses followed the hypothesized pattern, the overall findings demonstrated meaningful differences in responses across the factors examined. Country group was more frequently associated with statistically significant differences in the operational questions, whereas expatriate status was more frequently associated with significant differences in the communication questions. Because most expatriate respondents were also non-native English speakers, the relative lack of statistically significant differences when responses were analyzed by native-language status suggests that language status alone may not fully explain the observed differences. Instead, the findings are consistent with the possibility that cultural factors contribute to differences in communication experiences and perceptions.

As described in the study assumptions, the comparison groups were expected to represent greater cultural heterogeneity than the reference group. Therefore, observed differences among these groups were interpreted as potentially reflecting, at least in part, cross-cultural communicative turbulence. The statistically significant differences identified by country group and expatriate status provide evidence that responses vary across culturally defined and operationally relevant groups. Although these findings cannot establish that cross-cultural differences directly cause communication failures, they support the conclusion that pilots operating within culturally heterogeneous and relatively homogeneous flight-deck environments may experience and perceive communication differently. This finding provides further support for considering cross-cultural communication as a potential latent hazard in aviation safety and warrants additional investigation.

Summary of Conclusions

Overall, the survey results generally followed the expected pattern. Differences were observed between the culturally heterogeneous comparison groups and the reference group, as well as across the other factors examined in the study. However, not all findings were consistent with the study's expectations. Question 12 provides an important example of an unexpected result. Statistically significant differences were identified for Question 12 across all factors examined. Most notably, the direction of the country-group results was opposite to the hypothesized relationship. This finding warrants further consideration because it suggests that the relationship between cultural characteristics and responses to this question may be more complex than initially anticipated.

Qualtrics also provided response-time data that allowed for additional descriptive observations beyond the primary survey analysis. Although response times were not formally analyzed by country group, notable differences were apparent in descriptive comparisons. Response times for the reference group and Country Group 1 were generally below the overall sample median, whereas response times for Country Groups 2 and 3 were generally above the median. The longer response times observed in Groups 2 and 3 were not limited to native pilots; expatriate pilots working in these countries also demonstrated longer response times. Response time does not directly measure cross-cultural communication failure and therefore cannot establish a relationship between response time and communication performance. However, in

time-critical aviation situations, delays in processing or responding to information could potentially have safety implications. Accordingly, response-time observations were treated as supplemental evidence that may support interpretation of the primary findings rather than as an independent outcome or standalone line of inquiry.

The examination of the research questions extended beyond country-group comparisons to include language, flight-deck role, and expatriate status. These additional factors provided further insight into the relationships examined in the study and helped identify whether observed differences were associated with factors beyond national cultural group.

As noted previously, aviation is a highly regulated industry, and pilots are subject to recurrent training, proficiency checks, and standardized operating requirements designed to maintain professional competency and safety standards. Therefore, although statistically significant differences were identified among the groups, these differences occurred within a population of generally highly trained and qualified aviation professionals. The findings should not be interpreted as indicating that one group is less competent or less safe than another. Rather, the purpose of this study was to examine whether cultural and communication differences may introduce a latent hazard within an otherwise highly standardized and regulated aviation environment. Identifying such differences may help clarify an area of aviation safety that remains insufficiently explored.

Future Research

Not all questions reached statistical significance. However, there is sufficient evidence to highlight the critical importance of intercultural communication in aviation. Further research is needed to explore the hazard and possible mitigations.

Longitudinal Confirmation

The data collected in this study represents a snapshot of cross-cultural communication within aviation at a specific point in time. Longitudinal research is therefore needed to confirm the present findings and examine whether observed differences change over time. An ongoing research program would provide greater value than periodic, isolated studies because it would allow researchers to identify trends, evaluate emerging communication challenges, and determine whether interventions are producing sustained improvements.

In addition to validating the current findings and measuring changes over time, longitudinal research could provide insight into how national and organizational cultures evolve and how pilots adapt to increasingly multicultural flight-deck environments. As aviation becomes more internationally integrated, cultural interactions and communication practices may change in response to globalization, workforce mobility, technological developments, and evolving training practices. Tracking these changes over time would help determine whether cross-cultural communication challenges diminish, persist, or emerge in new forms.

Simulator Based Research

Simulator-based research would provide a unique opportunity to examine an operational environment that is normally inaccessible to outside researchers. Such research could determine whether the communicative and operational differences identified in this study are also evident under controlled flight-deck conditions. Simulator studies could allow researchers to observe how culturally heterogeneous and homogeneous crews communicate, make decisions, respond to authority gradients, and establish shared understanding during high-stress and time-critical situations.

Using the same cultural groupings employed in the present study would allow researchers to compare the performance and communication behaviors of culturally heterogeneous and relatively homogeneous crews under standardized conditions. Researchers could introduce comparable abnormal and emergency scenarios and examine differences in communication patterns, decision-making, challenge-and-response behaviors, and CRM effectiveness. This approach would complement the self-reported survey data by providing direct behavioral observations rather than relying solely on participants' perceptions and recollections.

Lost Data

One of the central premises of this research is that cultural differences influence how individuals perceive, interpret, and interact with the world around them. However, the research design could not account for potential bias introduced by missing or unobserved data. Data were unavailable from individuals who could not be reached through the available recruitment channels as well as from potential participants who chose not to respond. Consequently, it is not possible to determine whether nonresponse and recruitment-related data loss were distributed randomly across the country groups. This represents an important area for future investigation because participation itself may be influenced by cultural characteristics. For example, individuals from, or working in, countries characterized by lower Individualism (IDV) and higher Power Distance (PD) and Uncertainty Avoidance (UA) may be less likely to participate in research because of concerns regarding authority, uncertainty, confidentiality, or potential consequences associated with participation. This possibility could introduce systematic nonresponse bias and affect the representation of cultural groups within the sample.

Missing data may also result from participants selectively skipping questions, particularly those addressing sensitive topics. For example, participants who are highly conscientious or concerned about organizational consequences may be reluctant to answer questions about safety issues involving cross-cultural communication. If such omissions are systematically associated with participant characteristics or responses, the resulting data may not accurately represent the perspectives of the broader population. Additionally, disproportionate survey attrition can result in the loss of unique qualitative perspectives from participants who discontinue the survey before completion. Future research should examine patterns of item nonresponse and survey attrition across cultural groups, assess their potential effects on the findings, and consider recruitment and data collection strategies that encourage participation while protecting confidentiality. Such efforts could improve sample representativeness and strengthen the validity of conclusions.

regarding the influence of cultural differences on cross-cultural communication and aviation safety.

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Appendix A – Survey Questions

Background questions

- Are you a pilot for a FAA Part 121 (scheduled) airline, or foreign equivalent?
- What is your home country?
- In which country do you currently work?
- Does your employer hire foreign pilots?
- Are you a native English speaker?
- What is your role? (Captain or First Officer)?
- How long have you been a professional pilot?

Captain Questions

(Likert Statements)

1. Statement: If I make a mistake, I feel comfortable with my first officer correcting me.
2. Statement: I am comfortable with minor variations from standard operating procedures (SOP) if the situation warrants.
(Example: SOP requires a call of “glideslope alive” 2nm from the Final Approach Fix (FAF), however today you intercept the glideslope 5 miles before the FAF.)
3. Statement: I am comfortable exercising my command authority as captain even if it might offend my first officer.
4. Statement: If I happen to make a minor procedural error during operations, I do not expect repercussions/consequences outside of the flight deck.
5. Statement: During an abnormal situation, I am confident that my supervisor will support me exercising my judgement, if needed, to terminate the flight, even if not specifically mandated by the SOP, Quick Reference Handbook (QRH) or checklist.
6. Scenario: The First Officer stops the plane because they think you are about to deviate from a taxi clearance, there is no time to inform the captain. It turns out that the First Officer was mistaken.
Statement: I understand that the First Officer was mistaken, but I accept that it was a valid safety concern.

First Officer Questions

(Likert Statements)

7. Statement: If the captain makes an error, I am comfortable bringing this error to their attention.
8. Statement: I am comfortable with minor variations from standard operating procedures (SOP) if the situation warrants.

(Example: SOP requires a call of “glideslope alive” 2nm from the Final Approach Fix (FAF), however today you intercept the glideslope 5 miles before the FAF.)

9. Scenario: You believe the captain is about to unintentionally deviate from a taxi clearance. There is no time to warn the captain.
Statement: I am comfortable acting (stopping the plane), even if subsequently it turns out that I am wrong.
10. Statement: If I happen to make a minor procedural error during operations, I do not expect repercussions/consequences outside of the flight deck.
11. Statement: During an abnormal situation, I am confident that my supervisor will support me exercising my judgement, if needed, to terminate the flight, even if the SOP, QRH or checklist do not specifically mandate this.

Communication Questions (All Participating Pilots)

(Likert Statements)

12. Statement: Sometimes during a non-work-related conversation with a pilot from another country, I feel like they do not fully understand what I am saying.
13. There is a minor misunderstanding on the flight deck about an instruction or procedure. You point this out to the other pilot, but it seems that you cannot come to a shared understanding of the instruction. You decide that it is not safety related so you dismiss it.
Statement: This has occurred during my flying career.
14. Scenario: There has been a non-normal or emergency situation in which my flight deck colleague and I were unable to come to a shared understanding of the best course of action.
Statement: This has occurred during my flying career.

Communication questions (pilots working outside of reference group countries)

15. Statement: The way I communicate while flying is unaffected by the national/cultural background of the pilot I am paired with for a particular flight.
16. Statement: Crew Resource Management (CRM) effectiveness is unchanged regardless of the national/cultural background of the person I am flying with in the cockpit.

APPENDIX B – COMPARISON GROUPS

Group 1 Country	Score	Group 2 Country	Score	Group 3 Country	Score
Denmark	16.2	Latvia	42.2	Sri Lanka	67
Sweden	23.4	Estonia	43.2	Poland	67
Netherlands	25.8	Jamaica	45	Slovakia	67.4
Iceland	28.8	Luxembourg	46	Tanzania	68
Austria	29.8	Hungary	46.4	United Arab Emirates	68.4
Norway	30	Lithuania	47.8	Brazil	68.4
United Kingdom	30.6	Czech Republic (Czechia)	49.6	Croatia	68.4
New Zealand	31	Belgium	52.4	Senegal	69
Switzerland	33.6	Hong Kong	53	India	69.2
Ireland	35	Spain	53.2	Sierra Leone	70
Finland	35	Slovenia	53.6	Syria	70
Germany	35.4	Italy	53.8	Mongolia	70.2
Australia	36.2	Kenya	54	Thailand	70.8
Israel	39	Singapore	54	Colombia	71.2
		France	54.8	Morocco	72
		Japan	55.2	Tunisia	72.2
		Argentina	56.4	Burkina Faso	73
		Puerto Rico	57.6	Jordan	73
		South Korea	57.8	Suriname	73.6
		Malta	58	Ukraine	73.8
		Dominican Republic	59.8	Honduras	74
		Trinidad and Tobago	59.8	Pakistan	74
		Zambia	60	Algeria	74.4
		Uruguay	60	Peru	75
		South Africa	60.2	Ecuador	75
		Greece	60.4	Fiji	75.2
		China	60.8	Mexico	75.2
		Taiwan	61	Romania	75.6
		Portugal	61.4	Serbia	76
		Vietnam	62	Ethiopia	76.2

Nepal	62	Malaysia	76.4
Bhutan	62.4	Mozambique	76.8
Saudi Arabia	62.4	Georgia	77
Chile	62.8	Venezuela	77.2
Namibia	63	North Macedonia	77.4
Turkey	65	Bosnia and Herzegovina	77.4
Bulgaria	65	El Salvador	77.6
Lebanon	65.4	Belarus	77.8
Costa Rica	65.6	Egypt	77.8
Malawi	66	Russia	77.8
		Angola	78
		Indonesia	78.8
		Albania	79.2
		Bolivia	79.4
		Philippines	79.6
		Paraguay	80.2
		Azerbaijan	80.4
		Kuwait	80.8
		Ghana	81.4
		Bangladesh	82
		Montenegro	82.4
		Nigeria	83
		Guatemala	83.2
		Moldova	84.2
		Armenia	84.8
		Kazakhstan	84.8
		Qatar	86
		Libya	86.6
		Iraq	88
		Panama	90.8