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The Influence of National Culture on Crew Resource Management and Team Performance in Aircraft Accident and Incident Reports

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THE INFLUENCE OF NATIONAL CULTURE ON CREW RESOURCE MANAGEMENT AND TEAM PERFORMANCE IN AIRCRAFT ACCIDENT AND INCIDENT REPORTS

by

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ABSTRACT

THE INFLUENCE OF NATIONAL CULTURE ON
CREW RESOURCE MANAGEMENT AND TEAM PERFORMANCE IN AIRCRAFT
ACCIDENT AND INCIDENT REPORTS

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This study explored the influence of national culture on crew resource management (CRM) and team performance. Accident and incident reports involving foreign aircraft were qualitatively analyzed to discover the relationship between three of Hofstede's (1980, 1997) cultural values and the variables of teamwork behaviors, flightcrew task performance, and flightcrew error. The three cultural values used in the analysis were power distance, individualism and collectivism, and uncertainty avoidance. Low power distance flightcrews exhibited more instances of positive teamwork behaviors, fewer instances of negative teamwork behaviors, fewer instances of error behaviors, and more instances of task performance behaviors than high power distance countries. Individualist flightcrews exhibited more instances of positive teamwork behaviors, fewer instances of negative teamwork behaviors, fewer instances of error behaviors, and more instances of task performance behaviors. Flightcrews that were high in uncertainty avoidance exhibited more teamwork behaviors and fewer error behaviors than flightcrews that were low in uncertainty avoidance. Flightcrews low in uncertainty avoidance exhibited more instances of task performance behaviors than flightcrews high in uncertainty avoidance.

This thesis is dedicated to

Fred, Hui Chin, and Daniel Kuang

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INTRODUCTION

Research during the decade of the 1970s found that more than 70% of aircraft accidents involve human error (Helmreich & Foushee, 1993). This finding sparked interest in research on "pilot error" and on ways to reduce such human performance errors. After analysis of documented aircraft accidents, investigators concluded that the majority of "pilot error" is not related to the technical "stick-and-rudder" aspects of flight; most crashes are not caused by a lack of pilot proficiency in the technical skills of flying an aircraft. Rather, researchers found that the primary source of human performance error is failure in team communication and in team coordination (Helmreich & Foushee, 1993). In response to these findings, the aviation community expanded its focus from the traditional training of the individual pilot in the technical aspects of flight to include psychological training at the level of the flight crew. These new training programs were initially named Cockpit Resource Management and are now known as Crew Resource Management (CRM).

CRM is defined as "using all available resources—information, equipment, and people—to achieve safe and efficient flight operations (Lauber, 1984)." It focuses on psychological training in group dynamics, leadership, interpersonal communications, and decision-making (Helmreich & Merritt, 1998).

Research on the effectiveness of CRM found the training to have a positive impact (Helmreich, 1991). Crewmembers agree that the training is valuable, there are positive shifts in attitude after training, and crew behaviors shift in the direction of applying CRM concepts. With a supportive organizational climate, acceptance of CRM

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increases over time (Helmreich, 1991). Most importantly, analysis of Cockpit Voice Recorder transcripts of accidents and incidents found that crews apply CRM training even under the stressful conditions of emergency situations (Helmreich, 1991). In addition, Helmreich, Wilhelm, Gregorich, and Chidester (1990) found that CRM training increases the percentage of crews with above average ratings in performance and decreases the percentage of crews with below average ratings. Consequently, CRM is now accepted and valued in the aviation community.

With the success of CRM in the United States, news of its effectiveness carried into the international aviation community. Airlines from other countries became interested in these newly developed programs that increase safety and efficiency (Helmreich & Merritt, 1998). As a result, CRM training developed in the US was exported to other countries. The response to the training was unexpected; countries varied in their reaction to the concepts to which they were exposed. Some concepts appeared to be more easily understood and accepted in some countries than in others. For example, Korean pilots were puzzled by the training and its request to be assertive in the cockpit (Helmreich & Merritt, 1998), while New Zealand pilots resisted what was perceived as culturally insensitive training methods and culturally biased presentation of CRM concepts (Scott-Milligan & Wyness, 1987).

American developers of CRM never entertained the idea of modifying CRM training to fit the cultural needs of foreign airlines. The aviation industry has always seemed to adopt the notion that an airplane is an airplane and a cockpit is a cockpit; there is only one way of flying an airplane and professionalism dictates that the cockpit is "culture free" (Helmreich & Merritt, 1998). The difficulty of transferring CRM training to some foreign countries, however, casts doubt on this stance. The reaction overseas to these American-developed training programs raised the problem of whether CRM is culturally generalizable across nations.

In addition to varying degrees of acceptance of CRM between nations, there is a difference in crew factor accident rates across nations. Emerging nations in Africa, Latin America, and Asia have rates that are eight times that of industrialized nations in Europe, North America, and the Middle East (Weener, 1990). Crews from the around the world fly in aircraft that are built by western companies (e.g., Boeing). They also receive highly similar training in the technical aspects of flight; many foreign countries send their pilots to western countries for flight training. Under such circumstances, there may be factors that do not involve the technical aspects of flight that could account for the observed differences in accident statistics between nations. One factor that has been recognized is that of national culture affecting crew interaction in the cockpit (Federal Aviation Administration Human Factors Team, 1996).

The impact of national culture on flightcrew performance can better be understood in the context of a flightcrew performance model. A number of team performance models exist. The majority of them follow an input-throughput-output structure. The model guiding this research follows a similar structure (see Figure 1). This model of flightcrew performance is based primarily on the work of Davis (1999). Davis integrates the work of Dickinson and McIntyre (1997), Hackman (1983), Helmreich and Foushee (1993), and Salas, Dickinson, Converse, and Tannenbaum (1992), and applies this integrative model to flightcrews. This model will serve as a framework for discussing issues relevant to CRM, particularly issues regarding national culture.

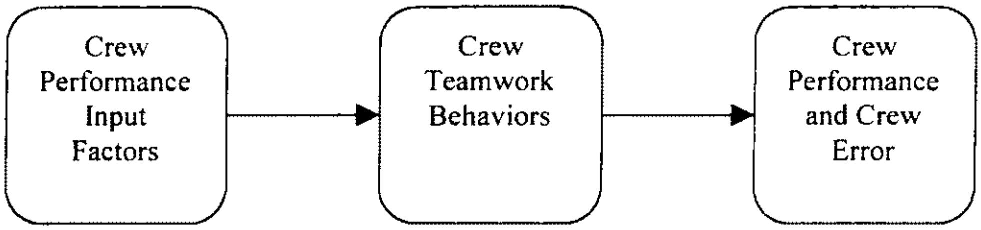

Figure 1. Model of Flightcrew Performance

In this model, crew performance input factors determine crew teamwork behaviors. Teamwork, then, is the throughput. The throughput then determines the output. In this model, the output is flightcrew performance and flightcrew error.

<u>Crew Performance Input Factors: National Culture</u>

Crew Performance input factors include environmental, organizational, group, and individual variables that influence teamwork (see Table 1). Because the focus of this study is on national culture, this is the only input variable that will be discussed. For a more thorough discussion of the other input variables and for the comprehensive model of flightcrew performance, refer to Davis (1999).

<u>National Culture</u>

There is scant research on the influence of cultural factors on flightcrew performance; research into this issue has only begun. With the globalization of CRM and its lack of success in some nations, it is important to discover the cultural factors that affect crew performance. Compounding the need for more research is the fact that accident rates vary across nations. Although some of the variability in accident rates can be attributed to national differences such as aviation infrastructure and aircraft condition, cultural factors likely account for additional variability (Phelan, 1994).

Table 1
Crew Performance Input Factors

Level of Input	Input Factor
Environmental	National culture Aircraft condition Aircraft equipment Weather Air Traffic Control Government regulations
Organizational	Organizational culture Resources Scheduling/Dispatch Procedures Reward systems Organizational structure
Group	Composition Climate Structure Norms
Individual	Aptitude/Intelligence Personality Attitudes Motivation Knowledge/Training Emotional state

Sources: Davis, 1999; Helmreich & Foushee, 1993.

Most of the cross-cultural literature that is relevant to crew performance addresses cultural values. One unifying link between members of a cultural ethnic group is the cultural values that they share. Values represent that which is desirable to a group or to an individual. Values predispose individuals to favor certain end states or certain outcomes (Kluckhohn & Strodtbeck, 1961). Cultural values, then, are the values that a cultural ethnic group shares.

Cultural values have been studied widely. Hofstede (1980) collected survey data from managers and employees from 53 different national subsidiaries of the IBM Corporation throughout the world. From an analysis of this large database, Hofstede derived four dimensions of national culture: power distance, individualism and collectivism, masculinity and femininity, and uncertainty avoidance. Each of the countries in his analysis falls along each of the dimensions at a certain level. Existing literature supports the notion that three of the four cultural dimensions are related to flightcrew performance. The cultural value of masculinity and femininity has not been linked to flightcrew performance as repeatedly or as strongly as the other three values. The three cultural values that are of interest in this study due to their relevance to crew performance are power distance, individualism and collectivism, and uncertainty avoidance.

Power distance. Power distance can be defined as the degree to which people with less power expect and accept that the distribution of power is unequal. In high power distance countries, such as Malaysia, Philippines, or Mexico, subordinates are not likely to question their superiors. For low power distance countries, such as Sweden, Denmark, or Austria, subordinates feel more comfortable questioning their superiors, and there is a general preference for consultation. In the context of flightcrews, when a captain commits an error, a Swedish first officer would be more likely to inform the captain of this error than a Malaysian first officer.

Individualism and Collectivism. Individualism and collectivism refer to the degree to which individuals are connected to their groups. Loose ties between individuals characterize individualism; people are expected to look after themselves. Collectivism is characterized by the integration of people into strong, cohesive ingroups. People emphasize the needs of the group over the individual, and there is a strong inclination to maintain harmony among group members. The US is among the countries highest in individualism, and countries such as Taiwan and Mexico are high in collectivism (i.e., low in individualism). In the context of flightcrews, collectivist crew members have a greater concern for harmony in the cockpit. They may be less willing to disagree openly with fellow crew members about decisions or actions.

Uncertainty avoidance. Uncertainty avoidance is the degree to which people feel threatened by situations that are unknown or uncertain. In countries that are high in uncertainty avoidance, such as Greece, Japan, or France, people experience anxiety in uncertain situations. They have a need for predictability that can be ensured through written or unwritten rules. This is an emotional need to leave as little to chance as possible. Countries that are low in uncertainty avoidance, such as Great Britain, Sweden, or Singapore, exhibit less anxiety under uncertain situations, and work environments are more relaxed. In flightcrews, pilots from high uncertainty avoidance countries are more likely to follow orders and adhere to standard operating procedures. In addition to the need for rules, people who are high in uncertainty avoidance are more likely to be committed to a chosen course of action than people who are low in uncertainty avoidance. People who are high in uncertainty avoidance are also less likely to be flexible about considering alternatives once their minds are set on a course of action.

Power distance and individualism. Power distance and individualism are negatively correlated (Hofstede, 1997). Many countries that are high in power distance are low in individualism. In other words, countries that are high in power distance are also likely to be more collectivist. Also, countries that are low in power distance are also likely to be more individualist. The implication of this correlation is that the findings for nations that are high in power distance and for nations that are low in individualism would be similar.

Differences Between Nations in the Cockpit

There is a large body of literature that illustrates Hofstede's cultural values in action. Little of this literature is directly related to the aviation industry and even less to CRM. The literature that does exist, however, illustrates how national culture can have an impact on the behavior of crew members.

One of the few studies directly related to aviation was conducted by Helmreich and his colleagues. They developed the Flight Management Attitudes Questionnaire (FMAQ) that includes items that assess Hofstede's concepts regarding cultural values (Helmreich, Merritt, Sherman, Gregorich & Weiner, 1993). In addition to measuring cultural values, this cross-cultural questionnaire measured pilots' attitudes regarding automation, command, communication, organizational climate, rules, stress, and work values (Helmreich & Merritt, 1998). Using this measure, differences in attitudes between nations were found.

For example, using the FMAQ, Merritt and Helmreich (1995) found differences between nations regarding attitudes toward command. Anglo pilots from Australia, New Zealand, the US, and Ireland scored higher on the Command Structure scale of the

FMAQ than non-Anglo pilots consisting of pilots from Brazil, Cyprus, Morocco, Philippines, and Japan. A high score indicates a preference for flattened command structure; there is less formal distance between the captain and the crew, and there is greater two-way communication. Endorsement of this scale indicates that it is acceptable for crew members to question decisions made by the captain, that the first officer may assume command of the aircraft under certain circumstances, that the captain should not automatically take physical control of the aircraft, and that more than the captain's flying proficiency is required for the successful management of the flight deck.

This difference can be explained by differences in the values of these national groups. Anglo cultures believe in egalitarianism, whereas non-Anglo cultures believe that people are not equal and that relational hierarchies determine one's place in one's family, one's clan, one's work organization, and one's society. Anglo pilots prefer leaders to consult with them before making decisions and to treat them as equals. Non-Anglo pilots, on the other hand, understand and accept their social position and do not expect to be treated as equals. While Anglo pilots prefer clear and direct communication and believe that every individual has the right to question anyone and anything, non-Anglo pilots find it necessary to use indirect and elaborate communication to honor relationships and maintain group harmony (Merritt & Helmreich, 1995).

Differences in attitudes toward command can be understood better by using Hofstede's (1980) dimensions discussed above. Anglo countries that scored high on the Command Structure scale are low in power distance and are individualist. Non-Anglo countries that scored low on the Command Structure scale are countries that are high in power distance and are collectivist; these values are found primarily in Asian and Latin American countries.

In another study relating culture to cockpit crew interactions, Redding and Ogilvie (1984) examined the effects of culture on cockpit communications. When comparing airlines from different nations, they found that crew members from lower power distance countries were less likely to perceive barriers to communication in the cockpit due to status. They also found that individualism is related negatively to perceived conflict. This finding is probably associated with the notion that interpersonal conflict is more "normal" in individualist cultures, hence there is less sensitivity to it.

In another study directly related to aviation, Sherman, Helmreich, and Merritt (1997) investigated the link between national culture and attitudes toward flight deck automation among 5,879 airline pilots from 12 nations. They found that differences in cultural values related to differences in reactions to automation. Nations differed in endorsement levels for the 11 items that surveyed attitudes toward automation. The average difference in endorsement levels across the 11 items for the 12 nations was 53%. This reflects a significant difference in attitudes toward automation across nations. The greatest differences in attitude were found for preference and enthusiasm for automation. The difference in agreement levels across nations was, on average, four times larger than the difference in agreement levels across different airlines within the same nation.

The patterns of response regarding automation can be explained by national culture. For example, more individualistic nations such as the US may be more willing to interact with computers and use them as a discretionary tool. More hierarchical nations, such as many Asian countries, may be more likely to accept the authority of computers without question. This is critically important in the context of flightcrew performance. During a time of crisis when there might be computer-based error, the pilots from individualist cultures may be more likely to override the automation and prevent an accident, whereas pilots from collectivist cultures may be less likely to take such action.

There are studies, then, that support the idea that national culture affects the behavior of crew members. The behavior of crew members, in turn, directly impacts flightcrew performance and flightcrew error. It is necessary now to examine the behaviors that affect flightcrew performance and error. In the next section, the components of teamwork are described. These teamwork behaviors directly impact crew performance and error.

Components of Teamwork

Teamwork can be defined as behaviors of members of a team that give rise to sharing of information and coordination of activities (Dickinson & McIntyre, 1997). Teamwork is also called team process or group process by some researchers.
The purpose of teamwork is to achieve team goals. Teamwork directly influences team performance and error.

Table 2 lists components of teamwork that make up the teamwork aspect of our performance model along with behaviors that illustrate each component. This part of the performance model is built upon the work of Bowers, Braun, and Morgan, Jr. (1997), Dickinson and McIntyre (1997), and Prince and Salas (1993). These teamwork behaviors are of particular interest because they affect team performance and they are likely to be influenced by culture. The components of teamwork that are in the performance model include: team orientation, leadership, communication, monitoring, feedback, backup

Table 2
Components of Teamwork With Behavioral Examples

1. Team orientation: Refers to the attitudes that team members have toward one another and the team task. It reflects acceptance of team norms, level of group cohesiveness, and importance of team membership.
   Assigns high priority to team goals
   Willingly participates in all relevant aspects of the team

2. Leadership: Involves providing direction, structure, and support for other team members. It does not necessarily refer to a single individual with formal authority over others. Team leadership can be shown by several team members.
   Explains to other team members exactly what is needed from them during an assignment
   Listens to the concerns of other team members
   Specify tasks to be assigned
   Ask for input, discuss problems
   Focus crew attention on task
   Provide feedback to other crew members about performance
   Establish procedures to monitor and assess the crew
   Inform crew members of mission progress
   Verbalize plans
   Reallocate work in a dynamic situation

3. Communication: Involves the exchange of information between two or more team members using proper terminology. Often the purpose of communication is to clarify or acknowledge the receipt of information
   Verifies information prior to making a report
   Acknowledges and repeats messages to ensure understanding
   Use standard terminology when communicating information
   Acknowledge communication by others
   Use nonverbal communication appropriately
   Provide information that is needed when asked for it
   Repeat vital information
   Provide information as required
   Ask for clarification of a communication
   Make no response (Negative)
   Acknowledge communication (OK, Roger)
   Reply with a question or comment
   Convey information concisely

Table 2
Continued

4. Monitoring: Refers to observing the activities and performance of other team members. It implies that team members are individually competent and that they may subsequently provide feedback and backup behavior
   Is aware of other team members' performance
   Recognizes when a team member performs correctly

5. Feedback: Involves the giving, seeking, and receiving of information among team members. Giving feedback refers to providing information regarding another member's performance. Seeking feedback refers to requesting input or guidance regarding performance. Receiving feedback refers to accepting positive and negative information regarding performance.
   Responds to other members' requests for performance information
   Accepts time-saving suggestions offered by other team members

6. Backup Behavior: Involves assisting the performance of other team members. This implies that members have an understanding of other members' tasks. It also implies that team members are willing and able to provide and seek assistance when needed.
   Fills in for another member who is unable to perform a task
   Helps another member correct a mistake

7. Coordination: Refers to team members executing their activities in a timely and integrated manner. It implies that the performance of some team members influences the performance of other team members. This may involve an exchange of information that subsequently influences another member's performance.
   Passes performance-relevant data to other members in an efficient manner
   Facilitates the performance of other members' jobs.

8. Assertiveness: Refers to the ability to initiate action.
   Confronts ambiguities and conflicts
   Asks questions when uncertain
   Maintains position when challenged
   Makes suggestions
   States opinion on decisions and procedures
   Advocates a specific course of action
   States opinions on decisions/procedures even to higher-ranking crew members

Table 2
Continued

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9. Decision-making: Refers to the ability to make logical and sound judgements based on available information.
    - Gathers required information
    - Identifies alternatives and contingencies
    - Anticipates consequences of decision
    - Cross-checks information sources
    - Uses data to generate alternatives
    - Evaluates information and assess resources
    - Provides rationale for decision

10. Situational Awareness: Refers to the ability to maintain an accurate perception of the internal and external environment
    - Comments on deviations
    - Demonstrates an ongoing awareness of mission status
    - Identifies problems
    - Demonstrates awareness of task performance of self and of others
    - Recognizes the need for action
    - Attempts to determine cause of discrepant information before proceeding.
    - Provides information in advance

11. Shared Mental Models: Consists of knowledge, attitudes, expectations, and behaviors that are shared by members of a team
    - Helps to develop common perception of cockpit environment
    - Helps to develop common perception of external environment
    - General activity monitoring

12. Managing Workload: Refers to managing the information processing demands that are placed on an individual or team by a task
    - Distributes tasks
    - Assigns resources to meet environmental demands
    - Balances task workload and team workload

Sources: Bowers, Braun, & Morgan, 1997; Davis, 1999; Dickinson & McIntyre, 1997; Prince & Salas, 1993; Swezey, Llaneras, Prince, & Salas, 1991.

behavior, coordination, assertiveness, decision-making, situational awareness, shared mental models, and managing workload.

Team Orientation

The first component of teamwork is team orientation. Team orientation refers to the attitudes that team members have toward one another, the team task, and the group's leader. It also reflects self-awareness as a team member, acceptance of team norms, and group cohesiveness. The quality of interpersonal relationships can result in different group climates. Crews that have good interpersonal relationships can maintain a positive group climate. These crews are more effective because the resulting positive group climate encourages participation and communication (Helmreich & Foushee, 1993).

Leadership

Providing direction, structure, and support for other team members reflects team leadership. The behavior is not only limited to formal team leaders. Any or several team members can show team leadership. Team members respond to the planning and organizing activities of their leaders (Dickinson & McIntyre, 1997). In the context of the flightcrew, the captain is the formal leader of the team of crew members. Members of the crew must also exhibit leadership behaviors and not only rely on the direction and support of the captain. Crews have better performance when their captains encourage teamwork (Ginnett, 1993).

Communication

Communication involves two or more team members exchanging information. It can also be an individual team member relaying information to other members. Communication is often used to clarify or to acknowledge the receipt of information

(Dickinson & McIntyre, 1997). Both task-related and team-related information is exchanged between team members. The purpose of communication is to acquire needed information and to accomplish cooperative tasks. Good and poor communication can mean the difference between success in achieving goals or failure in reaching goals (Kanki & Palmer, 1993).

With respect to CRM, Kanki and Palmer (1993) list five significant ways that communication can affect crew performance. Communication provides information, establishes interpersonal relationships, establishes predictable behavior patterns, maintains attention to task and monitoring, and acts as a management tool.

Monitoring

Monitoring team performance refers to team members observing the activities and performance of other team members while carrying out their own. It helps to ensure that things run as expected and that fellow team members are following procedures correctly and efficiently. Monitoring, however, is not meant to be "spying" (McIntyre & Salas, 1995). It only implies that team members should be individually competent and that they should have a good understanding of the tasks of other members of their team. This is due to a possible need for subsequent backup behavior and feedback (Dickinson & McIntyre, 1997).

Crews, like all teams, should exhibit monitoring behaviors. When workloads are high, particularly in emergency situations, a crew member who is less occupied may be able to notice an error committed by another member who is too busy to have noticed the anomaly. This monitoring behavior can prevent a catastrophe. For example, during an emergency situation, the co-pilot can notice the appearance of a signal indicating dangerously low fuel levels while the captain is busy handling the initial emergency. Because the co-pilot exhibits monitoring behavior and notices this anomaly, he can now take action to help avert a potential incident or accident.

Feedback

Feedback is an activity that follows monitoring. Team members, upon recognizing effective performance or ineffective performance by other team members during monitoring, may share their observations with those team members (McIntyre & Salas, 1995). Team members may give, seek, and receive feedback from fellow members. Members give feedback when they provide information regarding another member's performance. Seeking feedback involves asking for input or guidance regarding performance from other team members. Receiving feedback involves accepting information regarding one's performance, whether it is positive or negative. In the context of CRM, reviewing decisions and actions of crew members can help optimize future flightcrew activities (Helmreich & Foushee, 1993).

Backup Behavior

Backup behavior involves members assisting other team members when they need help. As in monitoring, this implies that team members must have a good understanding of fellow members' tasks. Backup behavior is only successful if team members are willing and able to give and seek assistance when needed (Dickinson & McIntyre, 1997). McIntyre and Salas (1995) describe back-up behavior as being the key to team performance exceeding performance of individuals. Teams perform better when members are willing to assist each other in times of need. In the context of CRM and flightcrews, backup behavior can mean the difference between life and death.

Continuing with the previous example of the copilot who notices the signal indicating low fuel levels while the captain is occupied with other matters, the copilot could bring this new emergency to the captain's attention or contact Air Traffic Control (ATC) to apprise them of the situation.

Coordination

Coordination involves the performance of team activities in a manner that encourages team members to react in harmony with the behavior of other team members. When the other components of teamwork (e.g., communication) are operating effectively together, then there is successful coordination. The individual actions of each team member combine to produce synchronized and coordinated performance (Dickinson & McIntyre, 1997).

Hackman (1993) describes feeling inspired when watching well-coordinated flightcrews in action. He perceives the smooth and seamless coordination between crew members to be as impressive as that of a well-rehearsed ballet. The period of time between a request and the resulting action is minimal and at times nonexistent for well-coordinated flightcrews.

Assertiveness

Assertiveness is the ability to initiate action (Swezey, Llaneras, Prince, & Salas, 1991). The absence of assertiveness has been cited as a causal factor in aircraft accidents (Prince & Salas, 1993). Junior crew members who do not exhibit assertiveness with their superiors can contribute to accidents. Their ineffective communication style can lead captains to ignore their request.

Decision-making

Decision-making involves the ability to make sound judgments using available information (Swezey, Llaneras, Prince, & Salas, 1991). Flightcrews are faced with many and varying decisions through the course of one flight. All of these decisions involve assessment of the situation, making a choice among alternatives, and assessing the risk associated with the decision (Orasanu, 1993). Decision-making styles can affect crew performance. Orasanu (1990) found that crews that provide rationales for decisions and that use more options during decision-making perform better than crews that did not exhibit such behaviors.

Situational Awareness

Situational awareness involves the ability to maintain an accurate perception of one's internal and external environment (Swezey, Llaneras, Prince, & Salas, 1991). Individual situational awareness is necessary for all pilots; effectiveness and safety are compromised if pilots do not practice situational awareness (Prince & Salas, 1993). Situational awareness is equally important for flightcrews to enhance team performance and flight safety. Hartel, Smith, and Prince (1991) found that lack of situational awareness was cited most frequently as the causal factor in an analysis of Navy and Marine mishaps. When reviewing Army accidents, Leedom (1990) found that failure to provide information about the situation to other members of the crew is a cause for accidents. Orasanu (1990) found that crews that were more effective had captains who would alert crews more often during a routine flight. More effective crews also had captains and first officers who exhibit higher situational awareness in comparison to less effective crews.

Shared Mental Models

Shared mental models (SMMs) consist of attitudes, expectations, knowledge, and behaviors that members of a team share (Canon-Bowers & Salas, 1990). SMMs are a mechanism for teams to organize information about their task and to organize information regarding each other's contribution to the task. For SMMs to exist, members of a team must understand the decision making situation, and they must effectively communicate this understanding to each member of the team. In addition, team members must develop a collective approach to reaching a decision, and they must collectively take appropriate action.

SSMs are believed to enhance team performance because they enable a team to analyze tasks accurately via the use of a common set of categories and language that facilitates information processing. In addition, SMMs help in the coordination of actions and in the changing of behavior to meet task demands (Kraiger & Wenzel, 1997). CRM training seeks to instill in crew members a SMM for team performance (Hackman, 1993)

Workload

Workload refers to information processing demands that are placed on an individual or team by a task. Like individual workload, team workload shapes performance. Performance is less effective at levels of low and high workload (Bowers, Braun, & Morgan, 1997; Johnston & Briggs, 1968). Teams with modest teamwork skills can function well only until workload increases. With increased workload, task and team demands exceed the team's ability to work together effectively. Workload demands vary across the stages of a flight. Effective crews can increase the coordination between team members to meet increased workload demands. Less effective crews, however, are unable to meet the demands of increased workload.

The teamwork behaviors described above directly affect team performance and error. In the next section, flightcrew performance and flightcrew error are discussed.

Flightcrew Performance and Flightcrew Error

The final part of the model to be discussed is that of flightcrew performance and flightcrew error. Flightcrew performance involves how well the tasks involved in flying the aircraft are completed. See Table 3 for a list of tasks related to the operation of an aircraft. Safety, efficiency, and errors indicate good or poor flightcrew performance.

Table 3
Tasks Related To Flightcrew Performance

Type of Task	Task
Aircraft control	Power control Flight control Navigation
Procedural	Checklists/Manuals Air Traffic Control Systems operations Abnormal operations

Note: Based on information provided in Helmreich & Foushee (1993).

Of particular interest to this study is flightcrew error. Flightcrew error is action or inaction by the crew that leads to deviation from crew expectations or intentions (Helmreich, Klinect, & Wilhelm, 1999; Helmreich, Wilhelm, Klinect, & Merritt, in press;

Klinect, Wilhelm. & Helmreich, 1999). There are five types of error: intentional noncompliance errors, procedural errors, communication errors, proficiency errors, and operational decision errors. See Table 4 for a detailed list of error types and examples of each.

Table 4
Error Types

Error Type	Examples
Intentional noncompliance	Shortcut or ignore procedures Violation of SOPs/regulations Omitting required briefings Omitting required checklists Fail to observe sterile cockpit
Procedural	Slips, lapses, mistakes in the execution of regulations or procedure Incorrect entry into flight management computer Unintentionally skipping items on checklist
Communication	Incorrect communication between crew members Incorrect communication between crew and Air Traffic Control Incorrect interpretation between crew members Incorrect interpretation between crew and ATC
Proficiency	Lack of knowledge Lack of stick and rudder skill
Operational decision	Discretionary decisions not covered by regulation and procedure that unnecessarily increases risk Extreme maneuvers on approach Flying in adverse weather Over-reliance on automation

Note: Based on information in Helmreich, Klinect, and Wilhelm (1999), Helmreich, Wilhelm, Klinect, and Merritt (in press), and Klinect, Wilhelm, and Helmreich (1999).

Intentional noncompliance errors include conscious violations of regulations and standard operating procedures (SOPs). These can occur when crews choose to shortcut or to ignore procedures (Helmreich, Wilhelm, Klinect, & Merritt, in press). Procedural errors include slips or mistakes in the execution of regulations or procedures wherein the intention is correct but the execution is flawed. Communication errors result when information is transmitted or interpreted incorrectly within the cockpit or between the crew and ATC. Proficiency errors occur when there is a lack of knowledge or technical skill. Operational decision errors occur when there is no regulation or procedure to guide actions, and the discretionary decision that is made unnecessarily increases risk.

Crews may respond to errors in at least three ways. First, the crew can respond by trapping the error. This occurs when error is detected and addressed before it becomes consequential. Second, the crew can exacerbate the error. This involves the detection of the error, but action or inaction by the crew can lead to a negative outcome. Third, the crew can fail to respond entirely. In this circumstance, the crew fails to react to the error due to not detecting the error or ignoring the error.

The above model is a tentative flightcrew performance model that focuses on three components: national culture, teamwork, and flightcrew performance and error. The input of national culture affects teamwork behaviors that in turn impact flightcrew performance and flightcrew error.

CRM has increased in importance in the aviation industry in recent years as a means to improve flightcrew performance. However, countries with different cultural values respond differently to CRM training. The purpose of this study is to explore and develop a model of flightcrew performance that uncovers the impact of culture on teamwork that, in turn, impacts flightcrew performance and flightcrew error. One of the best means of conducting exploratory research of this type is qualitative analysis. The next section discusses the qualitative approach.

Qualitative Approach

Qualitative research is a method used to help uncover and understand the underlying constructs behind a phenomenon about which little is known (Strauss & Corbin, 1990). This approach is useful in this study because little is yet known about the influence of national culture on flightcrew performance; there is a paucity of available literature, as mentioned before.

This study uses a qualitative technique called template analysis (King, 1998). Template analysis is also known as codebook analysis or thematic coding. With this approach, a researcher creates a "template" in the form of a list of codes that represent themes identified in their textual data. A code is a tag or label that assigns units of meaning to a section of text to mark it as relating to a theme or issue in the data that is identified as important (King, 1998; Miles & Huberman, 1994). In the case of this study, the themes involve national culture, CRM, and team performance. The textual data are 32 aviation accident reports involving foreign aircraft. Some of the codes are identified *a priori*, but the list of codes can be modified and expanded as the text is interpreted and analyzed.

Coding of text can be done at various levels. The text can be coded at the level of words, phrases, sentences, or whole paragraphs (Miles & Huberman, 1994). Depending on the nature of the data and the interest of the study, the researcher chooses the level of analysis accordingly.

Miles and Huberman (1994) describe qualitative analysis as involving three activities occurring in parallel. The analysis includes the three components of data reduction, data display, and conclusion drawing/verification. Data reduction involves selecting, focusing, simplifying, abstracting, and transforming the data. This process of deciding which data chunks to code, deciding which data chunks to pull out, and deciding which patterns best summarize a number of chunks is part of the analysis of the data; these decisions are all analytic choices. In the case of this study, data reduction is in the form of coding the reports as textual data.

The second component of qualitative analysis is data display. A display is an organized and compressed assembly of information that allows for drawing conclusions. Displays can be in the form of matrices, graphs, charts, or conceptual networks consisting of nodes and connections. These displays help assemble organized information into an accessible and compact form so the analyst can draw justified conclusions or continue the analysis in a direction that the display suggests might be fruitful. Like data reduction, creation and use of displays is a part of analysis.

The third component of the analysis is conclusion drawing and conclusion verification. There are numerous analytical methods for drawing and verifying conclusions. For instance, noting patterns and themes, and noting relations between variables are tactics one can use. For this study, conclusion drawing and conclusion verification will help to support and further develop the team performance model used to guide this study.

The purpose of this study is to understand better how national culture can affect CRM and team performance in the cockpit. As mentioned above, qualitative analysis is a powerful method for exploring topics about which little is known. Little is known about the effect of culture on CRM and flightcrew performance; therefore, we use qualitative analysis to explore this topic. We will use two research questions to guide this research: (1) Does culture influence CRM and team performance, and if culture does have an influence, (2) In what manner does culture influence CRM and team performance?

Because this is a qualitative study, the researcher must remain open and sensitive to the data in order to gain more from the analysis (Strauss & Corbin, 1990). In this study, the researcher remained open and sensitive to the data so that the topic of the impact of culture on CRM and team performance could be thoroughly explored. Based on existing literature, however, this study expected to find that the cultural values of power distance, individualism and collectivism, and uncertainty avoidance would have an effect on teamwork behaviors that in turn would impact team performance and team errors.

I expected that in high power distance countries, subordinates might not be as likely to question their superiors. In low power distance countries, however, subordinates might feel more comfortable questioning their superiors, and there is likely a general preference for consultation. These differences in behavior may impact teamwork behaviors that are related to the questioning of superiors such as behaviors related to assertiveness.

Individualism and collectivism influences emphasis on individual or collective performance. I expected that pilots from highly individualist countries might discourage and prevent teamwork, whereas pilots from highly collectivist countries might encourage teamwork.

Uncertainty avoidance is likely to influence behaviors regarding rules and procedures, and it is also likely to influence behaviors regarding following a course of action. I expected that countries high in uncertainty avoidance would be more likely to adhere rigidly to rules and procedures. In addition, countries that are high in uncertainty avoidance were expected to be more committed to a course of action once it is chosen and less likely to be flexible in considering alternate courses of action.

METHOD

Sample

There is a population of 36 aircraft accident and incident reports that are available through the National Transportation Safety Board (NTSB) that involve aircraft from foreign airlines. Accidents and incidents involving foreign carriers were selected because they have variance on the cultural values described above. Each of the 36 accident and incident reports involving foreign carriers had to meet certain criteria to be selected for this study. First, only those reports with more than one crew member were selected because flightcrew interactions are of primary interest in this study. Second, the selected reports had to contain materials detailing flightcrew interactions such as transcripts from the cockpit voice recorder (CVR) or descriptions of crew member interaction in the various parts of the report. Reports of accidents with only one crew member or reports with information irrelevant to flightcrew interactions were eliminated. Of the 36 reports, 26 reports met these criteria. These 26 reports were used as the sample for this qualitative study.

At the beginning of the coding process, then, there were 26 reports. In the process of coding the text, 4 reports were eliminated from the sample. The 4 reports were eliminated for various reasons.

Two reports were completely illegible. Better copies were unobtainable due to the age of the reports; the NTSB stated that the researcher's copies were the best available copies. Two other reports upon closer examination did not contain intracockpit interactions and were eliminated.

Table 5
Data Used for Analysis of Reports

Nation	Aircraft Accident Number	Investigator Judgment	Cockpit Voice Recording
Canada	86-02	X	X
Canada	80-13	X	
Columbia	91-04	X	X
Dominican Republic	70-17	X	
France	75-4	X	
Iceland	73-20	X	X
Italy	71-9	X	
Japan	76-12	X	
Japan	1965	X	
Japan (Multiethnic)	70-02	X	
Japan	70-11	X	
Japan (Multiethnic)	78-7	X	X
Korea	84-10	X	
Mexico	95-02	X	
Mexico	80-10	X	
Philippines	77-6	X	
Puerto Rico	70-23	X	
Puerto Rico	70-9	X	
Norway (Multiethnic)	70-14	X	
Sweden/Norway	84-15	X	X
Taiwan	94-02	X	
Taiwan	86-03	X	

There were 22 aircraft accident and incident reports used in the analysis for this study. Table 5 lists the reports that were used in this study. First, the country represented in the report is listed. The aircraft accident report number for each report is then listed. The first two digits of the aircraft accident report number indicates the year in which the report was published. One of the reports does not have an aircraft accident report number; the NTSB had not assigned it a number. In the cell designated for the aircraft accident report number for this report, the year of the accident is entered. Also in the table is an indication of the type of data relied upon for analyses and conclusions. The table indicates whether investigator judgement was used, cockpit voice recordings were used, or both.

Table 6
Contents of Aviation Accident Reports

Summary of report

Factual Information
- History of Flight
- Injuries to Persons
- Damage to Airplane
- Other Damage
- Personnel Information
- Airplane Information
- Meteorological Information
- Aids to Navigation
- Communications
- Aerodrome and Ground Facilities Information
- Flight Recorders
- Wreckage and Impact Information
- Medical and Pathological Information
- Fire Survival Aspects
- Tests and Research
- Additional Information

Procedures

The NTSB aircraft accident reports were acquired either directly from the NTSB or ordered from the National Technical Information Service (NTIS).

Each report's contents differ in accordance with the nature of the aircraft incident or accident being reported. There are, however, key sections that are included in virtually every report. These are detailed in Table 6. For the sections of the report that are particularly relevant for the accident or incident in question, they are elaborated on in greater detail and may even be broken down into subsections.

Report lengths vary from 20 pages to over 200 pages. The severity of accidents or incidents also varies. An example of a less severe accident is the malfunction of the aircraft due to a maintenance problem wherein the flightcrew traps the error, and there are no injuries or damage to the plane. An example of a severe accident is an aircraft running out of fuel and crashing into a residential area resulting in massive destruction to the aircraft and dozens of fatalities and injuries.

Coding. The foreign airline involved in each report was given a score on each of the cultural values (power distance, individualism and collectivism, and uncertainty avoidance). The cultural value scores were assigned using index scores taken from Hofstede (1997). The scores range from 1 to 112 and represent the nation's endorsement of the cultural value relative to other countries. Nations with a score that is above the mean score for a dimension were labeled as being high in that cultural value. Nations with a score that is below the mean for a dimension were labeled as being low in that cultural value.

It should be noted that there were 3 multi-ethnic crews. One Japanese aircraft had a US first officer and flight engineer. Another Japanese aircraft had a US captain. In addition, a Norwegian aircraft had a British captain. The multi-ethnic crews were given a cultural value endorsement level in accordance with the nationality of the captain of the crew.

In addition, index scores for the cultural values were not available for three of the cultural groups: the commonwealth of Puerto Rico. the Dominican Republic, and Iceland.

A designation of high or low on each of the cultural dimensions was given to each cultural group by extrapolating from existing index scores of similar cultural groups. In Hofstede's (1980, 1997) study, Latin countries cluster together along the dimensions to endorse high power distance, low individualism (i.e., collectivism), and high uncertainty avoidance. Thus, Puerto Rico and the Dominican Republic were given these designations in endorsement level for the cultural values. Iceland is linked to the Scandinavian countries of Norway and Sweden. Thus, Iceland was given the same designations in endorsement level for each cultural value as was given to Norway and Sweden: low power distance, high individualism, and low uncertainty avoidance.

The reports were then analyzed and coded at the phrase level using codes developed by the researcher. This study is interested in the effect of national culture on CRM and team performance, so the researcher coded for the variables associated with CRM and team performance. The absence of behaviors was coded only when the NTSB investigator who wrote the report explicitly stated that there was an absence of a behavior. More than one code was assigned to certain segments of text because more than one team behavior was represented by the information contained in the text.

A preliminary set of code words was developed at the onset of coding. The code words were developed using the literature review on teamwork, task performance, and flightcrew error. During the coding process, 19 codes were added to the code list. They were added because they were discovered to be relevant and important for the better understanding of flightcrew performance and flightcrew error. Not all codes were used during the coding process. Unused codes are included in the code list so that it may be known that the researcher remained sensitive to these behaviors during coding. Appendix A contains the list of codes and the meaning of each code.

Once all the reports were coded, displays were created in the form of matrices. From the matrices, patterns, themes, and relations between variables were noted in order to verify and draw conclusions. These conclusions help to develop further the flightcrew performance model used to guide this study.

Intracoder reliability. To assess intracoder reliability, the researcher coded five pages of text in a report and coded the same five pages of text three weeks later. The researcher then divided the number of agreements by the total number of agreements and disagreements. The equation used was reliability = (number of agreements)/(total number of agreements + disagreements). The researcher obtained an intracoder reliability of 0.88.

Intercoder reliability. To assess intercoder reliability, a subject matter expert coded the same five pages of text as that was used in the assessment of intracoder reliability. The same equation was applied with the number of agreements between the two coders divided by the total number of agreements and disagreements between the two coders. An intercoder reliability of .76 was obtained.

RESULTS

For the 22 reports that were coded and analyzed, the results are presented in Table 7. Table 7 is a matrix that includes the nationality of the aircraft involved in the accident, the index scores for the cultural values for the nation involved, the level of endorsement for each cultural value, and the frequency of each code for each report. The codes in Table 7 are listed in alphabetical order. Appendix A contains an alphabetical list of all the codes along with the meaning of each code.

There were twelve components of teamwork, as discussed above. In this study, each component of teamwork was represented by its own respective set of codes. Refer to Appendix B for the set of codes that represent each of the twelve components of teamwork. In the teamwork behaviors section of Appendix B, codes are organized according to the teamwork component that they represent.

The frequencies of codes that belong to each teamwork component were summed to give a total frequency that represents their respective teamwork component. For example, the frequency of the codes ACA, AQ, CAMB, CCON, MP, MS, and SODP were summed for each report to arrive at a total frequency of assertiveness behaviors that represent the teamwork component of assertiveness for each report. This aggregation of the data allowed for a more meaningful comparison of the nations in subsequent matrix displays. Table 8 is a matrix that contains the total frequency for each set of codes representing each teamwork behavior component. In addition to frequency totals for each teamwork behavior component, it includes the nationality of the aircraft involved in the accident, the index scores for the cultural values for the nation involved, and the level of endorsement for each cultural value.

Tables 9 through 17 are matrix displays that were used to look for patterns and themes in the data. For each of the tables, the nation of each aircraft is listed along with its designation of high or low endorsement of the cultural value in question. The order in which the nations appear reflect their index scores as given by Hofstede (1997). Nations higher on the list have a higher score for that cultural value, and nations lower on the list have a lower score for that cultural value; the nations are rank-ordered. The frequencies of the behaviors of interest for each aircraft are then detailed.

Tables 9 through 11 are matrix displays that give information about differences in frequency of teamwork behaviors between nations. As mentioned above, the nation of each aircraft is listed in rank order according to level of endorsement of the cultural value in question. The aircraft's designation of high or low endorsement of the cultural value in question is also given. The frequency of behaviors under each teamwork component is then detailed for each aircraft. Each of the three tables represents information for one of the three cultural values being studied. Table 9 contains power distance data, Table 10 contains individualism and collectivism data, and Table 11 contains uncertainty avoidance data.

In Tables 9 through 11, the positive and negative instances of teamwork behaviors are represented. Teamwork component names without parentheses represent positive instances of teamwork behavior for that category. Teamwork component names with parentheses represent negative instances of teamwork behavior for that category. For example, in Table 9, Columbia exhibited four instances of positive assertiveness behavior and one instance of negative assertiveness behavior.

Table 7

Frequency of Teamwork Behaviors, Team Errors, and Task Performance Across Nations

Nation	Power Distance Score	Power Distance Rank	Individualism Score	Individualism Rank	Uncertainty Avoidance Score	Uncertainty Avoidance Rank	ACA	ACK	AFB	ANC	(ANC)	AO	AQ	ARED	(ARED)	ASST	(ASST)
Canada	39	L	80	H	48	L											
Canada	39	L	80	H	48	L	1	24		2	3		1			2	
Columbia	67	H	13	L	80	H		39			1				2	1	1
Dominican Republic		H		L		H											
France	68	H	71	H	86	H								1			
Iceland		L		H		L		2	1				3				
Italy	50	L	76	H	75	H					1						
Japan	54	L	46	H	92	H				1							
Japan	54	L	46	H	92	H											
Japan (US first officer & flight engineer)	54	L	46	H	92	H						1				2	
Japan	54	L	46	H	92	H											
Japan (US captain)	40	L	91	H	46	L		17					5				
Korea	60	H	18	L	85	H					1			1			
Mexico	81	H	30	L	82	H											
Mexico	81	H	30	L	82	H											
Philippines	94	H	32	L	44	L											
Puerto Rico		H		L		H											
Puerto Rico		H		L		H										1	
Norway (British captain)	35	L	89	H	35	L			1								
Sweden/Norway	31	L	71/69	H	29/50	L		4			2		1			2	
Taiwan	58	H	17	L	69	H			2				1	3	1	3	
Taiwan	58	H	17	L	69	H											

Table 7
Continued

Nation	ATP	(ATP)	AWE	(AWE)	(BTW)	CAMB	CCI	(CCI)	CCON	(CCON)	CDI	CM	(CM)	COD	(COD)	(COM)	DA	(DA)
Canada			2									1		1				
Canada			2	3			2					1		2				
Columbia				2			1		1			1		5	1			
Dominican Republic												1						
France				1										1			1	
Iceland		1							1			1	1	3				
Italy	1		2									2					1	
Japan			4															
Japan				1								2		1				
Japan (US first officer & flight engineer)	2	2	4				2					4	2	2				2
Japan	1		1									2						
Japan (US captain)										1		11		4				
Korea			2	3				1				1						
Mexico		1		1								2		1				
Mexico																		
Philippines																		
Puerto Rico		2													1	1		
Puerto Rico			1									1		2				
Norway (British captain)			1	1	1		2					3	1				2	
Sweden/Norway		1	3	2				1				4		3			1	
Taiwan		4	9	5		1	2				1	3	2	5			2	
Taiwan			3	1								1						

Table 7
Continued

Nation	DGA	DO	DP	(DP)	DT	(DT)	EA	EE	EI	(EI)	EM	ET	(ET)	FAC	(FAC)	FAT	(FAT)	FBC	(FBC)
Canada							1												
Canada			3	1				1	1				1			1		10	
Columbia			3															8	
Dominican Republic									1										
France														1					
Iceland																		1	
Italy												1							
Japan									1					2					
Japan												1						1	
Japan (US first officer & flight engineer)							1			1			1						
Japan												2							
Japan (US captain)																1		5	
Korea			2											1					
Mexico							5	1					1	1			1		
Mexico					1									1					
Philippines														1					
Puerto Rico						1													
Puerto Rico											1							1	
Norway (British captain)		1	1		1	1	2		2	1							1		1
Sweden/Norway			2				1							1				5	
Taiwan	1				1			1	1			2						1	
Taiwan					1			1	1										

Table 7
Continued

Nation	FC	(FC)	FD	(FD)	FTR	GAM	(GAM)	GAMA	(GAMA)	GFB	(GFB)	GRI	(GRI)	HARM	(HARM)	I	IAC	IATC	ICC	ICCA
Canada	1									2										
Canada	2		2		1	1		5		20	2		2				2		1	
Columbia			2	1					1	82									1	2
Dominican Republic			1					2												
France								1												
Iceland										12										
Italy			1																	
Japan	1							5												
Japan	2							2									1			
Japan (US first officer & flight engineer)			2			1		4		1					1		2		1	
Japan								1									2			
Japan (US captain)	1		1							18						1				
Korea																				
Mexico	2							1	1											
Mexico		2																		
Philippines	1																			
Puerto Rico								1												1
Puerto Rico	1		2																	
Norway (British captain)	2	1	2	2	1	2	1	3	1	2					1		2	1		2
Sweden/Norway	2			1				5	5	9							1			
Taiwan	8	1	2		1	10		15	6	4	1	2		1						2
Taiwan	3							2	2		1									

Table 7
Continued

Nation	ID	IEFMC	IIC	IICA	INP	IP	(IP)	LC	LD	LK	LSRS	MNR	MS	OC	OOO	ORA	PC	(PC)	PCE	(PCE)
Canada						3											1			
Canada					1	2	1	1					1				2	1	2	
Columbia					2				2				1					1	1	
Dominican Republic																				
France					1			1												
Iceland										1							2		1	
Italy																	1	1	1	
Japan																	2		2	1
Japan																			2	
Japan (US first officer & flight engineer)			1			2			1	1							2		1	
Japan											1						1		1	
Japan (US captain)					2															
Korea	1														1					
Mexico		1					1			1							1		2	
Mexico											1									
Philippines																				
Puerto Rico																				
Puerto Rico																	1		2	
Norway (British captain)		1		1		1				1							1	1	3	3
Sweden/Norway					1	2	2			2				4		1	2			1
Taiwan	1					2	1			1		1				1	3		4	
Taiwan							1				1								1	

Table 7
Continued

Nation	PEE	(PEE)	PI	PIA	(PIA)	RC	RCA	RD	(RD)	RFB	(RFB)	RNA	(RNA)	RQC	SDF	SIOC	SO	SODP	(SODP)
Canada								1				2							
Canada			4	1		1		2		5		6	2					3	
Columbia			30			17				31	1		7	3				2	1
Dominican Republic									1			1							
France				1				1		1		1	2						
Iceland			16			4				11				3				1	
Italy												1							
Japan								1				3							
Japan	1							1				3							
Japan (US first officer & flight engineer)			1					2				4				1			
Japan								1				1							
Japan (US captain)			6			7				6				12				3	
Korea												2							
Mexico								1				3							
Mexico							1				1								
Philippines					1														
Puerto Rico													1						
Puerto Rico												1							
Norway (British captain)	3							1	1			2							
Sweden/Norway	3	1	7			4		4		6		1	2	7					
Taiwan												7					2		
Taiwan								1				1							

Table 7
Continued

Nation	SPO	ST	(ST)	STA	TCOP	TE	(TE)	URA	VSR	TP	(TP)	CC
Canada					1							
Canada	3			10								5
Columbia	3	1	1	46					1			4
Dominican Republic				1					1			
France												
Iceland	2			8			1					
Italy				3	1	1	1		2			
Japan	1			2						1		
Japan						3						
Japan (US first officer & flight engineer)				4								
Japan					1							
Japan (US captain)	2			2								2
Korea									1		1	
Mexico				2		1						
Mexico									5			
Philippines							1					
Puerto Rico							1	1				
Puerto Rico				3		1						
Norway (British captain)				3						1		
Sweden/Norway	2			10					1			5
Taiwan		1		4		1	1	1	3			
Taiwan								1	1			

Note: ( )'s indicate a negative instance of behavior. The behaviors are listed in alphabetical order. Refer to Appendix A for the meaning of each abbreviation.

Table 8

Frequency of Teamwork Behaviors Across Nations

Nation	Power Distance Score	Power Distance Rank	Individualism Score	Individualism Rank	Uncertainty Avoidance Score	Uncertainty Avoidance Rank	Assertiveness	(Assertiveness)	Backup Behavior	(Backup Behavior)	Communicatio n	(Communicati on)	Coordination	(Coordination)
Canada	39	L	80	H	48	L								
Canada	39	L	80	H	48	L	6		2		29			1
Columbia	67	H	13	L	80	H	4	1	1	1	90	3		
Dominican Republic		H		L		H								
France	68	H	71	H	86	H								
Iceland		L		H		L	5				25			
Italy	50	L	76	H	75	H							1	
Japan	54	L	46	H	92	H								
Japan	54	L	46	H	92	H							1	
Japan (US first officer & flight engineer)	54	L	46	H	92	H			2		1	1		2
Japan	54	L	46	H	92	H							2	
Japan (US captain)	40	L	91	H	46	L	8	1			42			
Korea	60	H	18	L	85	H								
Mexico	81	H	30	L	82	H								1
Mexico	81	H	30	L	82	H								
Philippines	94	H	32	L	44	L								
Puerto Rico		H		L		H				1				
Puerto Rico		H		L		H			1					
Norway (British captain)	35	L	89	H	35	L							1	1
Sweden/Norway	31	L	71/69	H	29/50	L	1		2		22			
Taiwan	58	H	17	L	69	H	2		3		2		3	
Taiwan	58	H	17	L	69	H								

Table 8
Continued

Nation	Decision Making	(Decision Making)	Feedback	(Feedback)	Leadrship	(Leadrship)	Managing Workload	(Managing Workload)	Monitoring	(Monitoring)	Shared Mental Model	(Shared Mental Model)	Situational Awareness	(Situational Awareness)	Followership	(Followership)
Canada	1		2		1								8			
Canada	9	5	25	2	29	1			6		2		13	6	2	
Columbia	1	1	113	1	62			2		1	1		5	10	2	1
Dominican Republic	1	1			1				2				1		1	
France	1		1		2		1		1				3	3		
Iceland			24		11						1		3	1		
Italy		1			4						1		4		1	
Japan	3				3				5		2	1	7			
Japan	2				1				2		3		4	1		
Japan (US first officer & flight engineer)	6	1	1		4				5		1		14	2	2	
Japan	3				1				1		1		3			
Japan (US captain)			24		12								4		1	
Korea		2			2		1						4	3		
Mexico	1				2	1			1	1	2		4	3		
Mexico				1			1									
Philippines														1		
Puerto Rico								1	1					4		
Puerto Rico					4						2		4		2	
Norway (British captain)	7	2	3		4	2	1	2	5	2	6	3	4	1	2	2
Sweden/Norway	5	3	15		20				5	5	3	2	9	7		1
Taiwan	6		6	1	5		4	1	25	6	4		24	10	2	
Taiwan	2			1			1		2	2	1		4	2		

Note: ( )'s indicate a negative instance of teamwork behavior.

Table 9

Power Distance and Frequency of Teamwork Behaviors

Nation	Power Distance Rank	Assertiveness	(Assertiveness)	Backup Behavior	(Backup Behavior)	Communication	(Communication)	Coordination	(Coordination)	Decision Making	(Decision Making)	Feedback	(Feedback)
Philippines	H												
Mexico	H								1	1			
Mexico	H											1	
Puerto Rico	H				1								
Puerto Rico	H			1									
Dominican Republic	H									1	1		
France	H									1		1	
Columbia	H	4	1	1	1	90	3			1	1	113	1
Korea	H										2		
Taiwan	H	2		3		2		3		6		6	1
Taiwan	H									2			1
Japan	L							1		2			
Japan (US first officer & flight engineer)	L			2		1	1		2	6	1	1	
Japan	L							2		3			
Japan	L									3			
Japan (US captain)	L	8	1			42						24	
Italy	L							1			1		
Canada	L									1		2	
Canada	L	6		2		29			1	9	5	25	2
Norway (British captain)	L							1	1	7	2	3	
Sweden/Norway	L	1		2		22				5	3	15	
Iceland	L	5				25						24	

Table 9
Continued

Nation	Power Distance Rank	Leadership	(Leadership)	Managing Workload	(Managing Workload)	Monitoring	(Monitoring)	Shared Mental Model	(Shared Mental Model)	Situational Awareness	(Situational Awareness)	Followership	(Followership)
Philippines	H										1		
Mexico	H	2	1			1	1	2		4	3		
Mexico	H			1									
Puerto Rico	H				1	1					4		
Puerto Rico	H	4						2		4		2	
Dominican Republic	H	1				2				1		1	
France	H	2		1		1				3	3		
Columbia	H	62			2		1	1		5	10	2	1
Korea	H	2		1						4	3		
Taiwan	H	5		4	1	25	6	4		24	10	2	
Taiwan	H			1		2	2	1		4	2		
Japan	L	1				2		3		4	1		
Japan (US first officer & flight engineer)	L	4				5		1		14	2	2	
Japan	L	1				1		1		3			
Japan	L	3				5		2	1	7			
Japan (US captain)	L	12								4		1	
Italy	L	4						1		4		1	
Canada	L	1								8			
Canada	L	29	1			6		2		13	6	2	
Norway (British captain)	L	4	2	1	2	5	2	6	3	4	1	2	2
Sweden/Norway	L	20				5	5	3	2	9	7		1
Iceland	L	11						1		3	1		

Note: ( )'s indicate a negative instance of teamwork behavior. Nations are listed in rank order.

Table 10

Individualism and Frequency of Teamwork Behaviors

Nation	Individualism Rank	Assertiveness	(Assertiveness)	Backup Behavior	(Backup Behavior)	Communication	(Communication)	Coordination	(Coordination)	Decision Making	(Decision Making)	Feedback	(feedback)
Norway (British captain)	H							1	1	7	2	3	
Sweden/Norway	H	1		2		22				5	3	15	
Iceland	H	5				25						24	
Canada	H									1		2	
Canada	H	6		2		29			1	9	5	25	2
Italy	H							1			1		
France	H									1		1	
Japan (US captain)	H	8	1			42						24	
Japan	H							1		2			
Japan (US first officer & flight engineer)	H			2		1	1		2	6	1	1	
Japan	H							2		3			
Japan	H									3			
Philippines	L												
Mexico	L								1	1			
Mexico	L											1	
Puerto Rico	L				1								
Puerto Rico	L			1									
Korea	L										2		
Taiwan	L	2		3		2		3		6		6	1
Taiwan	L									2			1
Dominican Republic	L									1	1		
Columbia	L	4	1	1	1	90	3			1	1	113	1

Table 10
Continued

Nation	Individualism Rank	Leadership	(Leadership)	Managing Workload	(Managing Workload)	Monitoring	(Monitoring)	Shared Mental Model	(Shared Mental Model)	Situational Awareness	Situational Awareness)	Followership	(followership)
Norway (British captain)	H	4	2	1	2	5	2	6	3	4	1	2	2
Sweden/Norway	H	20				5	5	3	2	9	7		1
Iceland	H	11						1		3	1		
Canada	H	1								8			
Canada	H	29	1			6		2		13	6	2	
Italy	H	4						1		4		1	
France	H	2		1		1				3	3		
Japan (US captain)	H	12								4		1	
Japan	H	1				2		3		4	1		
Japan (US first officer & flight engineer)	H	4				5		1		14	2	2	
Japan	H	1				1		1		3			
Japan	H	3				5		2	1	7			
Philippines	L										1		
Mexico	L	2	1			1	1	2		4	3		
Mexico	L			1									
Puerto Rico	L				1	1					4		
Puerto Rico	L	4						2		4		2	
Korea	L	2		1						4	3		
Taiwan	L	5		4	1	25	6	4		24	10	2	
Taiwan	L			1		2	2	1		4	2		
Dominican Republic	L	1				2				1		1	
Columbia	L	62			2		1	1		5	10	2	1

Note: ( )'s indicate a negative instance of teamwork behavior. Nations are listed in rank order.

Table 11

Uncertainty Avoidance and Frequency of Teamwork Behaviors

Nation	Uncertainty Avoidance Rank	Assertiveness	(Assertiveness)	Backup Behavior	(Backup Behavior)	Communication	(Communication)	Coordination	(Coordination)	Decision Making	(Decision Making)	Feedback	(Feedback)
Japan	H							1		2			
Japan	H							2		3			
Japan	H									3			
Japan (US first officer & flight engineer)	H			2		1	1		2	6	1	1	
France	H									1		1	
Korea	H										2		
Mexico	H								1	1			
Mexico	H											1	
Columbia	H	4	1	1	1	90	3			1	1	113	1
Puerto Rico	H				1								
Puerto Rico	H			1									
Dominican Republic	H									1	1		
Italy	H							1			1		
Taiwan	H	2		3		2		3		6		6	1
Taiwan	H									2			1
Japan (US captain)	L	8	1			42						24	
Norway (British captain)	L							1	1	7	2	3	
Sweden/Norway	L	1		2		22				5	3	15	
Iceland	L	5				25						24	
Philippines	L												
Canada	L									1		2	
Canada	L	6		2		29			1	9	5	25	2

Table 11
Continued

Nation	Uncertainty Avoidance Rank	Leadership	(Leadership)	Managing Workload	(Managing Workload)	Monitoring	(Monitoring)	Shared Mental Model	(Situational Mental Model)	Situational – Awareness	(Situational-Awareness)	Followership	(Followership)
Japan	H	1				2		3		4	1		
Japan	H	1				1		1		3			
Japan	H	3				5		2	1	7			
Japan (US first officer & flight engineer)	H	4				5		1		14	2	2	
France	H	2		1		1				3	3		
Korea	H	2		1						4	3		
Mexico	H	2	1			1	1	2		4	3		
Mexico	H			1									
Columbia	H	62			2		1	1		5	10	2	1
Puerto Rico	H				1	1					4		
Puerto Rico	H	4						2		4		2	
Dominican Republic	H	1				2				1		1	
Italy	H	4						1		4		1	
Taiwan	H	5		4	1	25	6	4		24	10	2	
Taiwan	H			1		2	2	1		4	2		
Japan (US captain)	L	12								4		1	
Norway (British captain)	L	4	2	1	2	5	2	6	3	4	1	2	2
Sweden/Norway	L	20				5	5	3	2	9	7		1
Iceland	L	11						1		3	1		
Philippines	L										1		
Canada	L	1								8			
Canada	L	29	1			6		2		13	6	2	

Note: ( )'s indicate a negative instance of teamwork behavior. Nations are listed in rank order.

Table 12
Power Distance and Frequency of Team Errors

Nation	Power Distance Rank	ICC	ICCA	IIC	IICA	VSR	OC	EM	FAC	(FAC)	ORA	URA
Philippines	H								1			
Mexico	H								1			
Mexico	H					5			1			
Puerto Rico	H		1									1
Puerto Rico	H							1				
Dominican Republic	H					1						
France	H								1			
Columbia	H	1	2			1						
Korea	H					1			1			
Taiwan	H		2			3					1	1
Taiwan	H					1						1
Japan	L											
Japan (US first officer & flight engineer)	L	1		1								
Japan	L											
Japan	L								2			
Japan (US captain)	L											
Italy	L					2						
Canada	L											
Canada	L	1										
Norway (British captain)	L		2		1							
Sweden/Norway	L					1	4		1		1	
Iceland	L											

Table 12
Continued

Nation	Power Distance Rank	IATC	ID	RCA	OOO	IEFMC	SIOC	LK	LSRS	EE	FTR	TE	(TE)
Philippines	H												1
Mexico	H					1		1		1		1	
Mexico	H			1					1				
Puerto Rico	H												1
Puerto Rico	H											1	
Dominican Republic	H												
France	H												
Columbia	H												
Korea	H		1		1								
Taiwan	H		1					1		1	1	1	1
Taiwan	H								1	1			
Japan	L											3	
Japan (US first officer & flight engineer)	L						1	1					
Japan	L								1				
Japan	L												
Japan (US captain)	L												
Italy	L											1	1
Canada	L												
Canada	L									1	1		
Norway (British captain)	L	1				1		1			1		
Sweden/Norway	L							2					
Iceland	L							1					1

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

Table 13

Individualism and Frequency of Team Errors

Nation	Individualism Rank	ICC	ICCA	IIC	IICA	VSR	OC	EM	FAC	(FAC)	ORA	URA
Norway (British captain)	H		2		1							
Sweden/Norway	H					1	4		1		1	
Iceland	H											
Canada	H											
Canada	H	1										
Italy	H					2						
France	H								1			
Japan	H											
Japan (US first officer & flight engineer)	H	1		1								
Japan	H											
Japan	H								2			
Japan (US captain)	H											
Philippines	L								1			
Mexico	L								1			
Mexico	L					5			1			
Puerto Rico	L		1									1
Puerto Rico	L							1				
Korea	L					1			1			
Taiwan	L		2			3					1	1
Taiwan	L					1						1
Dominican Republic	L					1						
Columbia	L	1	2			1						

Table 13
Continued

Nation	Individualism Rank	IATC	ID	RCA	OOO	IEFMC	SIOC	LK	LSRS	EE	FTR	TE	(TE)
Norway (British captain)	H	1				1		1			1		
Sweden/Norway	H							2					
Iceland	H							1					1
Canada	H												
Canada	H									1	1		
Italy	H											1	1
France	H												
Japan	H											3	
Japan (US first officer & flight engineer)	H						1	1					
Japan	H								1				
Japan	H												
Japan (US captain)	H												
Philippines	L												1
Mexico	L					1		1		1		1	
Mexico	L			1					1				
Puerto Rico	L												1
Puerto Rico	L											1	
Korea	L		1		1								
Taiwan	L		1					1		1	1	1	1
Taiwan	L								1	1			
Dominican Republic	L												
Columbia	L												

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

Table 14
Uncertainty Avoidance and Frequency of Team Errors

Nation	Uncertainty Avoidance Rank	ICC	ICCA	IIC	IICA	VSR	OC	EM	FAC	(FAC)	ORA	URA	IATC
Japan	H												
Japan	H												
Japan	H								2				
Japan (US first officer & flight engineer)	H	1		1									
France	H								1				
Korea	H					1			1				
Mexico	H								1				
Mexico	H					5			1				
Columbia	H	1	2			1							
Puerto Rico	H		1									1	
Puerto Rico	H							1					
Dominican Republic	H					1							
Italy	H					2							
Taiwan	H		2			3					1	1	
Taiwan	H					1						1	
Japan (US captain)	L												
Norway (British captain)	L		2		1								1
Sweden/Norway	L					1	4		1		1		
Iceland	L												
Philippines	L								1				
Canada	L												
Canada	L	1											

Table 14
Continued

Nation	Uncertainty Avoidance Rank	ID	RCA	OOO	IEFMC	SIOC	LK	LSRS	EE	FTR	TE	(TE)
Japan	H										3	
Japan	H							1				
Japan	H											
Japan (US first officer & flight engineer)	H					1	1					
France	H											
Korea	H	1		1								
Mexico	H				1		1		1		1	
Mexico	H		1					1				
Columbia	H											
Puerto Rico	H											1
Puerto Rico	H										1	
Dominican Republic	H											
Italy	H										1	1
Taiwan	H	1					1		1	1	1	1
Taiwan	H							1	1			
Japan (US captain)	L											
Norway (British captain)	L				1		1			1		
Sweden/Norway	L						2					
Iceland	L						1					1
Philippines	L											1
Canada	L											
Canada	L								1	1		

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

Table 15

Power Distance and Frequency of Task Performance and Miscellaneous Behaviors

Nation	Power Distance Rank	AO	CM	(CM)	SO	FC	(FC)	PC	(PC)	SDF	DA	(DA)	EA	I	TP	(TP)	CC
Philippines	H					1											
Mexico	H		2			2		1					5				
Mexico	H						2										
Puerto Rico	H																
Puerto Rico	H		1			1		1									
Dominican Republic	H		1														
France	H										1						
Columbia	H		1						1								4
Korea	H		1													1	
Taiwan	H		3	2	2	8	1	3			2						
Taiwan	H		1			3											
Japan	L		2			2						2	1				
Japan (US first officer & flight engineer)	L	1	4	2				2									
Japan	L		2					1									
Japan	L					1		2							1		
Japan (US captain)	L		11			1								1			2
Italy	L		2					1	1		1						
Canada	L		1			1		1					1				
Canada	L		1			2		2	1								5
Norway (British captain)	L		3	1		2	1	1	1		2		2		1		
Sweden/Norway	L		4			2		2			1		1				5
Iceland	L		1	1				2									

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

Table 16

Individualism and Frequency of Task Performance and Miscellaneous Behaviors

Nation	Individualism Rank	AO	CM	(CM)	SO	FC	(FC)	PC	(PC)	SDF	DA	(DA)	EA	I	TP	(TP)	CC
Norway (British captain)	H		3	1		2	1	1	1		2		2		1		
Sweden/Norway	H		4			2		2			1		1				5
Iceland	H		1	1				2									
Canada	H		1			1		1					1				
Canada	H		1			2		2	1								5
Italy	H		2					1	1		1						
France	H										1						
Japan (US captain)	H		11			1								1			2
Japan	H		2			2											
Japan (US first officer & flight engineer)	H	1	4	2				2				2	1				
Japan	H		2					1									
Japan	H					1		2							1		
Philippines	L					1											
Mexico	L		2			2		1					5				
Mexico	L						2										
Puerto Rico	L																
Puerto Rico	L		1			1		1									
Korea	L		1													1	
Taiwan	L		3	2	2	8	1	3			2						
Taiwan	L		1			3											
Dominican Republic	L		1														
Columbia	L		1						1								4

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

Table 17

Uncertainty Avoidance and Frequency of Task Performance and Miscellaneous Behaviors

Nation	Uncertainty Avoidance Rank	AO	CM	(CM)	SO	FC	(FC)	PC	(PC)	SDF	DA	(DA)	EA	I	TP	(TP)	CC
Japan	H		2			2											
Japan	H		2					1									
Japan	H					1		2							1		
Japan (US first officer & flight engineer)	H	1	4	2				2				2	1				
France	H										1						
Korea	H		1													1	
Mexico	H		2			2		1					5				
Mexico	H						2										
Columbia	H		1						1								4
Puerto Rico	H																
Puerto Rico	H		1			1		1									
Dominican Republic	H		1														
Italy	H		2					1	1		1						
Taiwan	H		3	2	2	8	1	3			2						
Taiwan	H		1			3											
Japan (US captain)	L		11			1								1			2
Norway (British captain)	L		3	1		2	1	1	1		2		2		1		
Sweden/Norway	L		4			2		2			1		1				5
Iceland	L		1	1				2									
Philippines	L					1											
Canada	L		1			1		1					1				
Canada	L		1			2		2	1								5

Note: ( )'s indicate a negative instance. Nations are listed in rank order. Refer to Appendix A for the meaning of each abbreviation.

In Tables 12 through 14, the format of the matrices is the same as that of Tables 9 through 11. The nation of each aircraft is represented along with endorsement levels for each cultural value. Rather than teamwork behavior frequencies, Tables 12 through 14 display data regarding error frequencies. The different errors are abbreviated; refer to the error section of Appendix B for the meaning of each abbreviation. Again, parentheses around a code represent a negative instance of a behavior. Table 12 contains power distance data, Table 13 contains individualism and collectivism data, and Table 14 contains uncertainty avoidance data.

Tables 15 through 17 again have the same format as Tables 9 through 14. The nation of each aircraft is represented along with endorsement levels for each cultural value. In Tables 15 through 17, frequency of performance of procedural tasks, performance of aircraft control tasks, and other miscellaneous behaviors are represented for each nation. The different tasks and miscellaneous behaviors are abbreviated; refer to the inputs, tasks, and miscellaneous section of Appendix B for the meaning of each abbreviation. Again, parentheses around a code represent a negative instance of a behavior. Table 15 contains power distance data, Table 16 contains individualism and collectivism data, and Table 17 contains uncertainty avoidance data.

For the analysis, the countries were separated into two groups for each cultural value. Countries high in the cultural value of interest were grouped together, and countries low in the cultural value of interest were grouped together. The high group and the low group for each display was then compared to see which group had more instances of which behavior. For a difference in behavior to be noted between groups, one of two criteria had to be met.

First, if more than one country exhibited a behavior in one group whereas no country in the other group exhibited the behavior, a difference was noted. For example, in Table 11, for the column labeled "(Backup Behavior)," two countries in the high power distance group exhibit the behavior whereas no low power distance countries exhibited the behavior. The difference in negative backup behavior between the two groups was thus noted; high power distance countries appear to exhibit more negative instances of backup behavior.

Another criterion that might have been met for a difference between groups to be noted is if one group had at least two or more countries exhibit a behavior more than that of the other group. For example, if the low power distance group had eight countries exhibit assertive behavior whereas the high power distance group only had six countries exhibit assertive behavior, a difference between groups would be noted. In this example, low power distance countries tend to exhibit more assertive behavior.

The number of countries within the high and low designation of each cultural value was equal for power distance. Eleven countries were high in power distance, and eleven countries were low in power distance. The number of countries was almost equally split between individualists and collectivists; there were twelve individualist countries and ten collectivist countries. The countries were not split as equally for uncertainty avoidance. There were 15 high uncertainty avoidance countries and 7 low uncertainty avoidance countries.

Because there was a greater difference in the number of members in each group for the cultural value of uncertainty avoidance, more stringent criteria had to be met by the high uncertainty avoidance group than the low uncertainty avoidance group for a difference to be noted. For example, it was not enough that only two more high uncertainty avoidance countries had to exhibit a behavior than were exhibited by the low uncertainty avoidance group. There had to be at least three more countries that exhibited the behavior in the high uncertainty avoidance group for a difference to be noted. Likewise, less stringent criteria had to be met by the low uncertainty avoidance group than the high uncertainty avoidance group for a difference to be noted. The low uncertainty avoidance group only had to have at least the same number of countries exhibit a behavior as the high uncertainty avoidance group for a difference between groups to be noted.

When looking at the displays in this manner, several interesting patterns emerged. First, for teamwork, the low power distance group exhibited more positive instances of teamwork behaviors than the high power distance group. The difference was 8 to 1. In addition, the low power distance group exhibited fewer negative instances of teamwork behavior than the high power distance group. The difference was 3 to 5. See Table 18 for a detailed listing of the positive and negative instances of teamwork behavior for each group. See Figure 2 for a graphical representation of the positive and negative instances of teamwork behavior for each group. Teamwork data also revealed that individualist countries exhibited more instances of positive teamwork behaviors than collectivist countries. The difference was 9 to 1. In addition, individualist countries exhibited fewer instances of negative teamwork behaviors than collectivist countries. The difference was 3 to 4. See Table 19 for a detailed listing of the positive and negative instances of teamwork behavior for each group. Also, see Figure 3 for a graphical representation of the positive and negative instances of teamwork behavior for each group.

Table 18
Power Distance: Comparison of Teamwork Frequencies

High Power Distance		Low Power Distance	
Positive Instance of Behavior	Negative Instance of Behavior	Positive Instance of Behavior	Negative Instance of Behavior
Workload	Backup Behavior	Assertiveness	Coordination
	Feedback	Communication	Decision Making
	Managing Workload	Coordination	Shared Mental model
	Monitoring	Decision Making	
	Situational Awareness	Feedback	
		Leadership	
		Shared Mental Model	
		Situational Awareness	

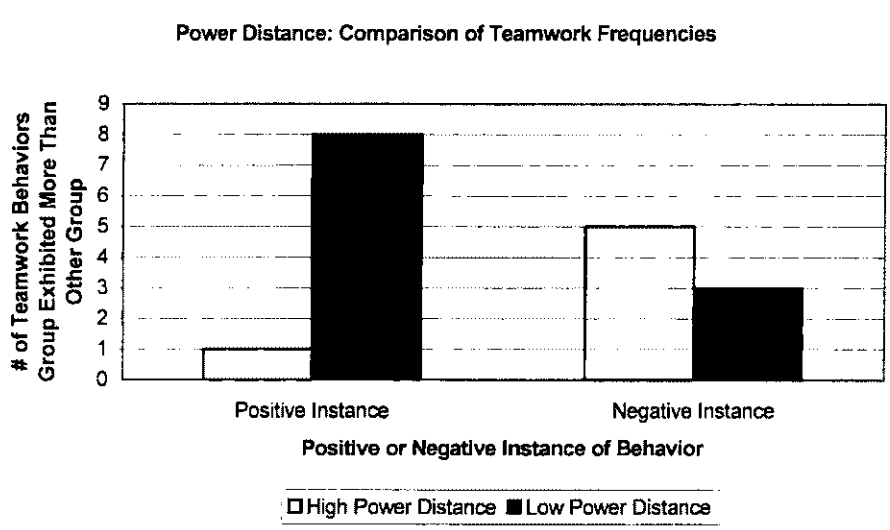

Figure 2. Power Distance: Comparison of Teamwork Frequencies

Table 19
Individualism: Comparison of Teamwork Frequencies

High Individualism		Low Individualism	
Positive Instance of Behavior	Negative Instance of Behavior	Positive Instance of Behavior	Negative Instance of Behavior
Assertiveness	Coordination	Managing Workload	Backup Behavior
Communication	Decision Making		Feedback
Coordination	Shard Mental Model		Managing Workload
Decision Making			Monitoring
Feedback			
Leadership			
Monitoring			
Shared Mental Model			
Situational Awareness			

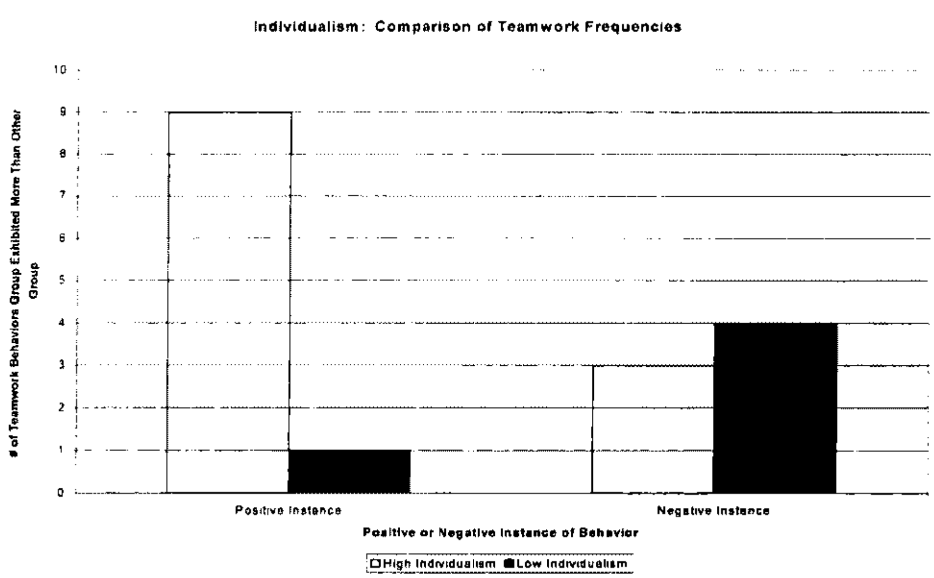

Figure 3. Individualism: Comparison of Teamwork Frequencies

A pattern was also found in the teamwork data for uncertainty avoidance. Teamwork data revealed that countries that are high in uncertainty avoidance exhibited more instances of positive teamwork behaviors than countries low in uncertainty avoidance. The difference was 8 to 3. Countries high in uncertainty avoidance also exhibited fewer instances of negative teamwork behaviors than countries low in uncertainty avoidance. The difference was 1 to 5. See Table 20 for a detailed listing of the positive and negative instances of teamwork behavior for each group. Also, see Figure 4 for a graphical representation of the positive and negative instances of teamwork behavior for each group

Table 20
Uncertainty Avoidance: Comparison of Teamwork Frequencies

High Uncertainty Avoidance		Low Uncertainty Avoidance	
Positive Instance of Behavior	Negative Instance of Behavior	Positive Instance of Behavior	Negative Instance of Behavior
Coordination	Situational Awareness	Assertiveness	Assertiveness
Decision Making		Communication	Coordination
Leadership		Feedback	Leadership
Managing Workload			Shared Mental Model
Monitoring			Followership
Shared Mental Model			
Situational Awareness			
Followership			

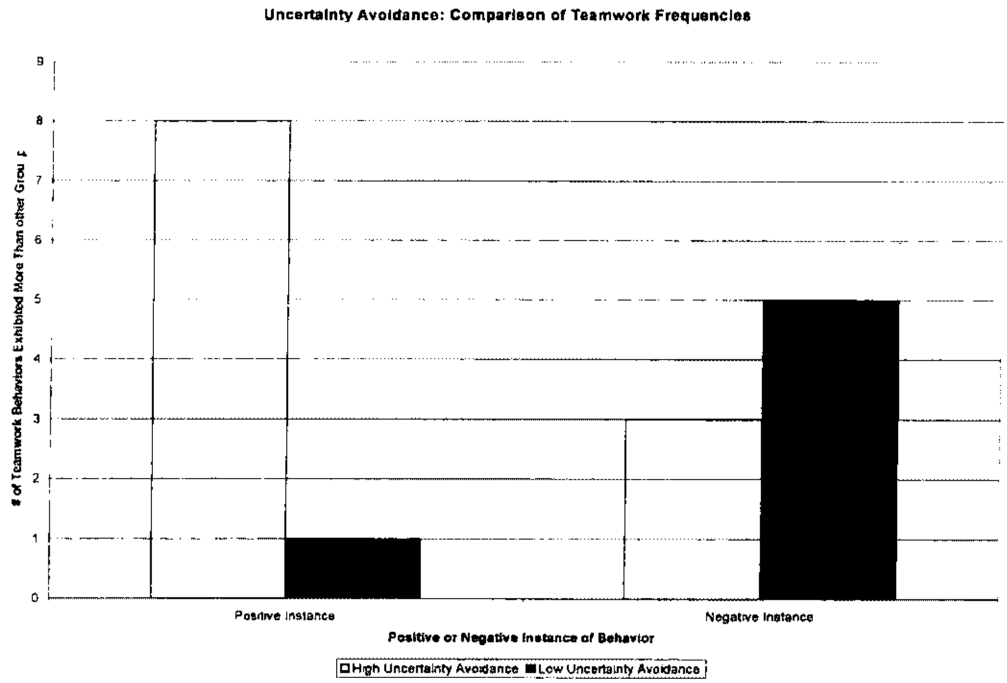

Figure 4. Uncertainty Avoidance: Comparison of Teamwork Frequencies

An interesting pattern was also found for team error. High power distance countries exhibited more instances of error behaviors than low power distance countries. The difference was 6 to 1. See Table 21 for a detailed listing of instances of error behaviors for each group. See Figure 5 for a graphical representation of instances of error behaviors for each group.

Collectivist countries were found to exhibit more instances of error behaviors than individualist countries. The difference was 5 to 1. See Table 21 for a detailed listing of instances of error behaviors for each group. See Figure 5 for a graphical representation of instances of error behaviors for each group.

Table 21

Cultural Values: Comparison of Error Frequencies

HPD	LPD	HIDV	LIDV	HUA	LUA
ICCA	LK	LK	ICCA	VSR	LK
VSR			VSR	FAC	IICA
FAC			URA	URA	OC
URA			ID	LSRS	ORA
ID			EE		IATC
EE					IEFMC
					FTR

Note: HPD is high power distance, LPD is low power distance, HIDV is high individualism, LIDV is low individualism (i.e., collectivism), HUA is high uncertainty avoidance, and LUA is low uncertainty avoidance. Refer to Appendix A for the meaning of the code abbreviations.

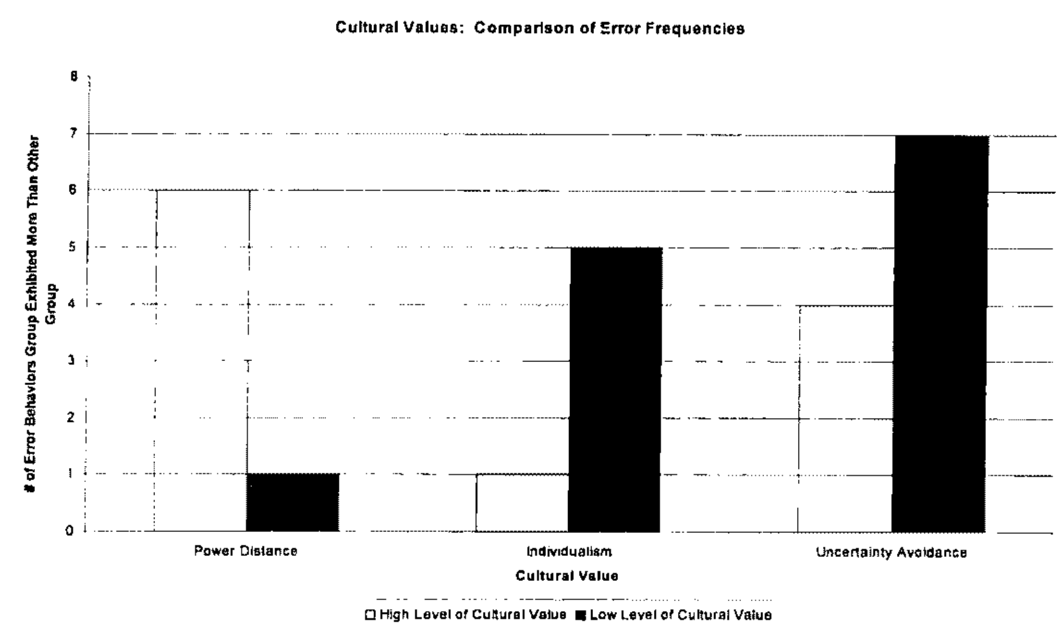

Figure 5. Cultural Values: Comparison of Error Frequencies

There was also a pattern found for uncertainty avoidance. Low uncertainty avoidance countries exhibited more error behaviors than high uncertainty avoidance countries. The difference was 7 to 4. See Table 21 for a detailed listing of instances of error behaviors for each group. See Figure 5 for a graphical representation of instances of error behaviors for each group.

Table 22
Cultural Values: Comparison of Task Performance and Miscellaneous Behavior Frequencies

HPD	LPD	HIDV	LIDV	HUA	LUA
	CM FC PC EA TP	CM FC PC DA EA TP		CM	FC I TP

Note: HPD is high power distance, LPD is low power distance, HIDV is high individualism, LIDV is low individualism (i.e., collectivism), HUA is high uncertainty avoidance, and LUA is low uncertainty avoidance. Refer to Appendix A for the meaning of the code abbreviations.

For task performance and miscellaneous behaviors that include behaviors regarding automation, differences between the groups were noted. Low power distance countries exhibited more instances of task performance than high power distance countries. The difference was 5 to 0. See Table 22 for a detailed listing of instances of task performance for each group. See Figure 6 for a graphical representation of instances of task performance for each group.

In addition, individualist countries exhibited more task performance behaviors than collectivist countries. The difference was 6 to 0. See Table 22 for a detailed listing of instances of task performance for each group. See Figure 6 for a graphical representation of instances of task performance for each group.

Finally, low uncertainty avoidance countries exhibited more task performance behaviors than high uncertainty avoidance countries. The difference was 3 to 1. See Table 22 for a detailed listing of instances of task performance for each group. See Figure 6 for a graphical representation of instances of task performance for each group.

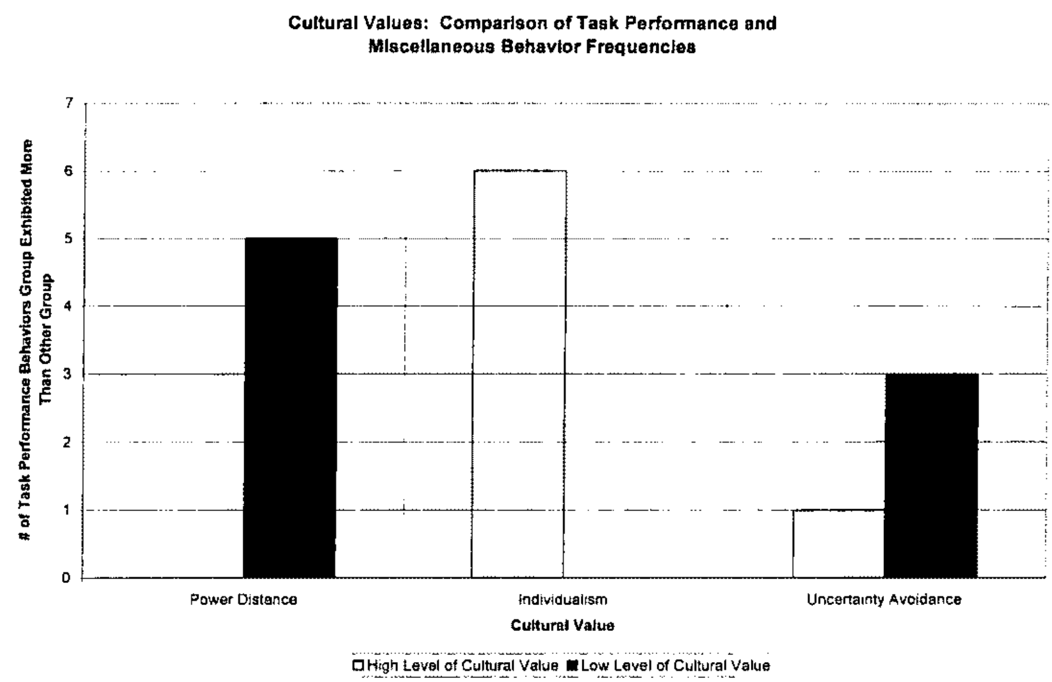

Figure 6. Cultural Values: Comparison of Task Performance and Miscellaneous Behavior Frequencies

DISCUSSION

The goal of this study was to explore qualitatively the effects of national culture on CRM and team performance. To discover whether national culture impacts CRM and team performance, accident and incident reports involving foreign aircraft were coded and analyzed to look for differences between nations. The results of this study suggest that there might be differences between nations with differing cultural values.

In the analysis of the matrix displays, differences between groups were noted. Low power distance countries exhibited more instances of positive teamwork behaviors, fewer instances of negative teamwork behaviors, fewer instances of error behaviors, and more instances of task performance behaviors than high power distance countries. This trend suggests that low power distance countries exhibit better teamwork, commit fewer errors, and exhibit more task performance than high power distance countries.

Another trend was found for individualism and collectivism. Individualist countries exhibited more instances of positive teamwork behaviors, fewer instances of negative teamwork behaviors, fewer instances of error behaviors, and more instances of task performance behaviors. This trend suggests that individualist countries exhibit better teamwork, commit fewer errors, and exhibit more task performance than collectivist countries.

The third trend that was found was that high uncertainty avoidance countries exhibited more teamwork behaviors and fewer error behaviors than low uncertainty avoidance countries. This trend suggests that countries that are high in uncertainty avoidance exhibit better teamwork and commit fewer errors than countries low in uncertainty avoidance. Countries low in uncertainty avoidance, however, exhibited more instances of task performance behaviors than countries high in uncertainty avoidance. This suggests that countries high in uncertainty avoidance might have better teamwork and might commit less errors, but they do not exhibit as much task performance as countries low in uncertainty avoidance. It must be noted that the analysis of the uncertainty avoidance data must be approached with caution, however, due to the lack of variability in the sample. There were 15 high uncertainty avoidance countries compared to only 7 low uncertainty avoidance countries.

These findings help support the flightcrew performance model that guided this study. It was found that the crew performance input factor of national culture does appear to have an impact on crew teamwork behaviors. In addition, there appears to be a relationship between crew teamwork behaviors and crew errors and crew task performance. Countries with different cultural values exhibit different teamwork behaviors. For the analysis regarding the cultural values of power distance and individualism, countries that exhibited better teamwork behaviors exhibited fewer error behaviors and more task performance behaviors. For the analysis regarding the cultural value of uncertainty avoidance, countries that exhibited better teamwork behaviors exhibited fewer error behaviors. These findings lend support to the flightcrew model depicted in Figure 1.

National culture appears to have an impact on teamwork behaviors and team performance. Now the direction of the impact must be explored.

It is understandable why low power distance countries would exhibit better teamwork behaviors. Because the distribution of power is seen as more equal, crew members are more likely to communicate with each other. Whether it is between leader and subordinates or between subordinates themselves, there will be more communication and feedback given and received between crew members. The data reflect that there is more communication and feedback between crew members in a low power distance flightcrew. Also reflected in the data is greater coordination, more examples of shared mental model, and better situational awareness for lower power distance groups. These teamwork components were prevalent in low power distance groups probably because there is greater flow of information between all members of the crew via communication and feedback. And because there is this better overall teamwork, there are fewer errors and more task performance exhibited by low power distance groups than high power distance groups who probably do not appear to communicate as much.

The influence of individualism and collectivism, however, is more puzzling. It was expected that collectivist teams would exhibit better teamwork behaviors because they are more oriented towards the needs of the group (i.e., the team) than individualists who are oriented more towards the needs of the individual. Perhaps this is true in favorable situations wherein a flight is going according to plan and there are no problems or emergencies; collectivist groups might perform better under these circumstances. However, one must remember the context of this analysis. This study examines aircraft accident and incident reports; these are situations that are highly unfavorable.

Under favorable conditions, it probably would facilitate team performance if the team were focused on maintaining harmony within the group. Under the unfavorable circumstances of these accidents and incidents, however, it is probably better to act in an individualist manner. Individualists are more likely to speak their mind. They are not so concerned with maintaining harmony in the cockpit and would be more willing to disagree openly with fellow crew members about decisions or actions if they think that it would help in containing the emergency.

This interpretation is mirrored in the results of Merritt and Helmreich's study (1995) discussed above. They found that pilots who are low in power distance and are individualist prefer clear and direct communication and believe that every individual has the right to question anyone and anything. Pilots who are high in power distance and collectivist, however, find it necessary to use indirect and elaborate communication to honor relationships and maintain group harmony (Merritt & Helmreich, 1995). Under unfavorable situations wherein time is of the essence, the clear and direct communication style of those who are low in power distance and who are individualist is preferred.

In addition, Hofstede (1997) notes that individualists view tasks as more important than relationships. Crew members who are individualist are probably more concerned with the task of preventing a catastrophic accident than with saving the "face" of a superior or a fellow crew member by not speaking up when they notice an anomaly.

An example of power distance and collectivism coming into play would be the accident involving an aircraft from Columbia (National Transportation Safety Board, 1991). Columbia is a collectivist country that is high in power distance. Behaviors of the crew that contributed to the accident may be explained by these two cultural values. Although the subordinates knew about the dangerously low fuel levels that ultimately contributed to the crash of the aircraft, they did not directly inform the captain of the emergency. The crew would not question the decisions and actions of the captain due to the influence of high power distance, and they did not want to make the captain "lose face" due to the influence of collectivism. If the subordinates had spoken up about the emergency, they would be questioning their superior and they would also be damaging the harmony among the group. This example illustrates how the influence of both power distance and collectivism can contribute to an accident (Helmreich & Merritt, 1998).

The data demonstrate that the individualist groups exhibited more communication and feedback behaviors. Again, communication and feedback probably lead to better coordination, decision-making, situation awareness, and a better shared mental model because of the exchange of information between crew members.

The findings for uncertainty avoidance are also puzzling. One of the results that was particularly puzzling was that countries high in uncertainty avoidance exhibited more teamwork behaviors than countries low in uncertainty avoidance. It was not expected that uncertainty avoidance would have an influence on teamwork; uncertainty avoidance was expected to influence adherence to rules and regulations. It is unclear what characteristics of high uncertainty avoidance countries would lead to better teamwork. Perhaps it is the need to avoid uncertain situations that motivate crew members of high uncertainty avoidance countries to work better together as a team.

Countries high in uncertainty avoidance committed fewer errors than countries low in uncertainty avoidance. This is understandable since countries high in uncertainty avoidance had better teamwork than countries low in uncertainty avoidance. Looking at the particular errors that each group committed, however, one finds something that was unexpected.

One of the errors that the high uncertainty avoidance group committed more often than low uncertainty avoidance group is that of flying under adverse conditions. Using the Columbian aircraft accident as an example again, one of the contributing factors to the crash was flying under the adverse condition of having low fuel levels (National Transportation Safety Board, 1991). The finding that countries high in uncertainty avoidance fly under adverse conditions more than countries low in uncertainty avoidance could be explained by the nature of groups that are high in uncertainty avoidance. People who are high in uncertainty avoidance are more likely to be committed to a chosen course of action than people who are low in uncertainty avoidance. People who are high in uncertainty avoidance are also less likely to be flexible about considering alternatives once their minds are set. So, with regard to flying under adverse conditions, people who are high in uncertainty avoidance are more likely to commit this error. They are committed to fly a mission a certain way, and they will fly it in that manner regardless of problems such as low fuel levels.

It had been expected that high uncertainty avoidance countries would be less likely to violate standard operating procedures and regulations, but the opposite finding was true. It was the high uncertainty avoidance groups that exhibited more violations of procedures and regulations. For example, Italy is a country that is high in uncertain avoidance. A captain of an Italian crew exceeded limitations as specified in his company's operations manual with regard to the use of reverse thrust while attempting to land (National Transportation Safety Board, 1971). This could also be explained by the need for those with high uncertainty avoidance to complete the mission as planned. For the Italian captain, the need to land the plane as planned possibly surpassed the need to follow company policy regarding the use of reverse thrust.

National culture does appear to have an impact on teamwork behavior and team performance and error. Contrary to expectations, flightcrews from individualist countries appear to perform better than crews from collectivist countries. The qualification should be added, though, that this might be true under highly unfavorable situations because this study was conducted using accident and incident reports. In addition, high uncertainty avoidance countries perform better than low uncertainty avoidance countries, in general.

It should be noted also that, as discussed above, power distance and individualism are negatively correlated. As can be seen in Table 6, countries that are high in power distance are more collectivist, and countries that are low in power distance are more individualist. This correlation between cultural values helps to explain why crews from countries that are high in power distance performed similarly to those crews from countries that are collectivist. This correlation also explains why crews from countries that are low in power distance performed similarly to crews from countries that are individualist.

There were several limitations to this study. First, it is unknown whether the correct cultural value was assigned to each flightcrew. In assigning values to individuals from national data, an "ecological fallacy" may have been committed (Robinson, 1950). It must be understood that because a nation overall tends to endorse a certain cultural value, individuals within the nation differ in their endorsement of that cultural value (Smith & Schwartz, 1997). However, under the circumstances of this study, using national data was the only way to assign values to each flightcrew.

Another limitation is that the flightcrew may have been impacted by something other than national culture. For example, there are other input factors to consider such as organizational culture. Organization culture might have such a strong influence as to overcome national culture. For example, a company in a high power distance country that fosters employee involvement in decision making can alter the behavior of employees to not match that of their fellow countrymen in general. In this study, we did not take into account such input factors.

As stated above, this study was conducted using aircraft accident and incident reports wherein there is a highly unfavorable situation. The results suggest that national culture does play a role in how flightcrews behave under such unfavorable circumstances. It can not be known from the data whether this is true for the regular operation of an aircraft. Future research can address this issue.

SUMMARY AND CONCLUSIONS

The results of this study indicate that national culture does appear to have an impact on teamwork behavior and team performance and error. Flightcrews from individualist and low power distance countries appear to perform better than flightcrews from collectivist and high power distance countries. In addition, flightcrews from countries that are high in uncertainty avoidance appear to perform better than flightcrews from countries low in uncertainty avoidance, in general.

These results have implications for the treatment of issues within the international aviation community. In particular, the notion that CRM training should be modified to fit the cultural needs of foreign airlines should seriously be considered.

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APPENDIX A

Alphabetized Code List

(AFB)*	Rejects information regarding current status
(GFB)*	Doesn't give information regarding current status
AC	Ask for clarification
ACA	Advocate a course of action
ACK	Acknowledge communication
AE	Aircraft equipment
AFB	Accepts information regarding current status
AMS	Awareness of mission status
ANC	Anticipate consequences
AO	Abnormal operations
AQ	Ask questions when uncertain
AR	Assess resources
ARED	Assigns resources to meet environmental demands
ASST	Provide assistance to another
ATCE	Air traffic control (environmental input)
ATCT	Air Traffic Control (tasks)
ATP	Awareness of task performance of self and others
AWE	Awareness of environment
BTW	Balance task workload and team resources
CAMB	Confront ambiguities
CCI	Cross-check information
CCON	Confront conflicts
CDI	Attempt to determine cause of discrepant information
CM	Checklists/Manuals
COD	Comment on deviations
COM	Correct other's mistake
CON	Aircraft condition
DA	Disengage automation
DGA	Use data to generate alternatives
DO*	Performance distracts others
DP	Discuss problems
DT	Distributes tasks
EA	Engage automation
EE	Exacerbate error
EI	Evaluate information
EM	Extreme maneuvers on approach
ET	Executes duties in a timely manner
FAC	Flying in adverse conditions
FAT	Focus attention to a task
FAW	Flying in adverse weather
FBC	Give feedback to crew
FC	Flight control

APPENDIX A
Continued

FD	Follows direction
FOSC	Fail to observe sterile cockpit
FTR	Fail to respond
GAM	General activity monitoring
GAM	General activity monitoring
GAMA	General activity monitoring of automation
GFB	Gives information regarding current status
GR	Government regulations
GRI	Gather required information
HARM	Performs task in harmony with others
I	Under the influence of alcohol or drugs
IAC	Identify alternatives/contingencies
IATC	Does not inform ATC of change
ICC	Incorrect communication between crew members
ICCA	Incorrect communication between crew and ATC
ID	Incorrect decision
IEFMC	Incorrect entry into flight management computer
IIC	Incorrect interpretation between crew members
IICA	Incorrect interpretation between crew and ATC
INP	Ask for input
IP	Identify problems
LC	Listen to concerns
LD	Language difference
LK	Lack of knowledge
LSRS	Lack of stick and rudder skill
MNR*	Make no response to communication
MP	Maintain position when challenged
MS	Make suggestions
NAV	Navigation
OC	Omit call-outs
OOO	Over-reliance on other's opinion
ORA	Over-reliance on automation
ORB	Omitting required briefings
ORC	Omitting required checklists
PC	Power control
PCE	Common perception of cockpit environment
PDO	Performs duty of occupied other
PEE	Common perception of external environment
PI	Provide information when asked
PIA	Provide information in advance
RAW	Reallocate work
RC	Repeat communication
RCA	Does not request change from ATC

APPENDIX A
Continued

RD	Provide rationale for decision
RFB	Requests information regarding current status
RNA	Recognize need for action
RQC	Reply with a question or comment
SIOC	Unintentionally skipping items on checklist
SO	Systems operations
SODP	State opinion on decisions/procedures
SPO	Share plans with others
ST	Use standard terminology
STA	Specify tasks
TCOP	Takes control of plane
TE	Trap error
URA	Under-reliance on automation
VC	Verify communication
VSR	Violation of SOPs/regulations
W	Weather

Note: * Indicates a negative instance of teamwork behavior.

APPENDIX B

Code List

<u>Teamwork Behaviors</u>

Assertiveness

ACA	Advocate a course of action
AQ	Ask questions when uncertain
CAMB	Confront ambiguities
CCON	Confront conflicts
MP	Maintain position when challenged
MS	Make suggestions
SODP	State opinion on decisions/procedures

Backup Behavior

ASST	Provide assistance to another
COM	Correct other's mistake
PDO	Performs duty of occupied other

Communication

AC	Ask for clarification
ACK	Acknowledge communication
LD	Language difference
MNR*	Make no response to communication
PI	Provide information when asked
RC	Repeat communication
RQC	Reply with a question or comment
ST	Use standard terminology
VC	Verify communication

Coordination

DO*	Performance distracts others
ET	Executes duties in a timely manner
HARM	Performs task in harmony with others

Decision-making

AR	Assess resources
ANC	Anticipate consequences
CCI	Cross-check information
DGA	Use data to generate alternatives
EI	Evaluate information
GRI	Gather required information
IAC	Identify alternatives/contingencies
RD	Provide rationale for decision

APPENDIX B
Continued

Feedback	
(AFB)*	Rejects information regarding current status
(GFB)*	Doesn't give information regarding current status
AFB	Accepts information regarding current status
GFB	Gives information regarding current status
RFB	Requests information regarding current status
Leadership	
DP	Discuss problems
FAT	Focus attention to a task
FBC	Give feedback to crew
INP	Ask for input
LC	Listen to concerns
RAW	Reallocate work
SPO	Share plans with others
STA	Specify tasks
TCOP	Takes control of plane
Managing Workload	
ARED	Assigns resources to meet environmental demands
BTW	Balance task workload and team resources
DT	Distributes tasks
Monitoring	
GAM	General activity monitoring
GAMA	General activity monitoring of automation
Shared Mental Model	
GAM	General activity monitoring
PCE	Common perception of cockpit environment
PEE	Common perception of external environment
Situational Awareness	
AMS	Awareness of mission status
ATP	Awareness of task performance of self and others
AWE	Awareness of environment
CDI	Attempt to determine cause of discrepant information
COD	Comment on deviations
IP	Identify problems
PIA	Provide information in advance
RNA	Recognize need for action
Followership	
FD	Follows direction

APPENDIX B
Continued

<u>Error</u>

Communication error

ICC	Incorrect communication between crew members
ICCA	Incorrect communication between crew and ATC
IIC	Incorrect interpretation between crew members
IICA	Incorrect interpretation between crew and ATC

Intentional noncompliance error

FOSC	Fail to observe sterile cockpit
IATC	Does not inform ATC of change
OC	Omit call-outs
ORB	Omitting required briefings
ORC	Omitting required checklists
RCA	Does not request change from ATC
VSR	Violation of SOPs/regulations

Operational decision error

EM	Extreme maneuvers on approach
FAC	Flying in adverse conditions
FAW	Flying in adverse weather
ID	Incorrect decision
OOO	Over-reliance on other's opinion
ORA	Over-reliance on automation
URA	Under-reliance on automation

Procedural error

IEFMC	Incorrect entry into flight management computer
SIOC	Unintentionally skipping items on checklist

Proficiency error

LK	Lack of knowledge
LSRS	Lack of stick and rudder skill

Responding to error

EE	Exacerbate error
FTR	Fail to respond
TE	Trap error

<u>Input Factors, Tasks, and Miscellaneous</u>

Environmental input factors

CON	Aircraft condition
AE	Aircraft equipment
ATCE	Air traffic control (environmental input)

APPENDIX B
Continued

GR	Government regulations
W	Weather
Procedural tasks	
AO	Abnormal operations
ATCT	Air Traffic Control (tasks)
CM	Checklists/Manuals
SO	Systems operations
Aircraft control tasks	
FC	Flight control
NAV	Navigation
PC	Power control
Automation	
EA	Engage automation
DA	Disengage automation
Intoxication	
I	Under the influence of alcohol or drugs

Note: * Indicates a negative instance of teamwork behavior.

APPENDIX C

Excerpt From a Coded Report: Aircraft Accident Number 76-12

History of the Flight

Japan Air Lines Co., Ltd. (JAL) Flight 422, a Boeing 747-246, (JA8122) was a regularly scheduled international passenger and cargo flight from Charles DeGaulle International Airport, Paris, France, to Haneda International Airport, Tokyo, Japan. En route stops were scheduled at London, England, and Anchorage, Alaska.

When Flight 422 landed in Anchorage at 1742, 1/ light snow had been filling on the airport, and adding to residual accumulations of snow and ice. However, the airport was operational with fair to good braking action reported. Snow was being removed by airfield maintenance personnel. The crew was changed when the flight landed in Anchorage.

About 1757, 22 kn winds, with gusts to 29 kn developed from the south, southeast. Air temperatures averaged 40 degrees F however, surface temperatures were below freezing. About 1815, light rain began.

About 1904, after being briefed and dispatched, Flight 422 departed the terminal and taxied to runway 6R via the east-west taxiway which parallels runways 6/24.

The captain stated that he had received the latest weather information, with winds given from 120' to 130 degrees at 15 kn, gusting to 32 kn.
[He stated that he was concerned that the 20-kn maximum crosswind (1) ANC
component for takeoff would be exceeded.] 1

[The captain, who was at the controls, said that braking action was
good during taxiout; the first officer stated, however, that the aircraft (2) (PCE)
tended to slide on the taxiway.] 2

[As the captain began his takeoff roll, he heard a loud noise to his left (3) AWE
which sounded to him like the noise of a compressor stall; he (4) RNA
immediately aborted the takeoff.] 3,4 [The first officer and flight engineer (5) PCE
also heard the noise] 5 and [the first officer stated that he heard the noise (6) AWE
as the engine pressure ratios (EPR) were advanced from 1.3 to 1.4.] 6 (7) GAMA
[The flight engineer saw the needle on the No. 2 EPR gauge flicker] 7 As
the aircraft was being taxied back to the terminal and while it was still
on the runway, the EPR for the [No. 2

APPENDIX C
Continued

engine was advanced to 1.46 but nothing unusual was noted. The aircraft did not slip or slide on the runway at that time. (8) PC (9) GAMA

At 1942, the aircraft arrived back at the terminal and maintenance personnel checked the Nos. 1 and 2 engines. Fuel was added which increased the total fuel on board to 7,000 lbs over that planned for the flight. The extra fuel was added to compensate for anticipated waiting time at the end of the runway before the next takeoff.

While parked at the terminal, the captain remained in the aircraft and monitored both company and tower frequencies. During this time, the dispatcher received an urgent telex from the JAL Tokyo Head Office stating that the aircraft would not be permitted to land at Haneda International Airport after 2300 Japanese standard time because of curfew regulations. Therefore, Flight 422 had to depart Anchorage no later than 2100 A.s.t. to land in Tokyo before the curfew. This information was relayed to the captain and he decided to taxi out, when ready, and wait at the end of the taxiway for favorable winds. (10) GAMA (11) EI

At 2004, JAL Flight 1008, a DC-8, departed on runway 6L and reported, in detail, to the JAL dispatcher about taxi and takeoff conditions. The report was made on company frequency and was heard by the captain of Flight 422. One of Flight 1008's comments was that braking action was "nil" on txiout. (12) GAMA

About 2020, State airport personnel were dispatched to evaluate the braking action that could 'Le expected on the runways; however, the taxiways were not checked.

About 2030, Flight 422 was towed out from the terminal gate but the departure was delayed because the tractor slipped on ice and the ramp had to be sanded.

At 2030:30, the Federal Aviation Administration (FAA) ground controller in the tower advised Wien Air Alaska Flight 15 that the ramp area was slick and the taxiway to runways 6L and 6R were "very slick." At 2035:25, a field maintenance truckdriver advised the tower that runway 6R was "slick" and that sand would be spread on it "right away."

About 2046, Flight 422 requested taxi instructions and the tower gave the flight the choice of using either runway 6L or 6R and (13) RFB-ATCE

APPENDIX C
Continued

reported the winds as 140 degrees at 25 kn. The captain requested runway 6R.

At 2048:35, Flight 422 was cleared to cross runway 13/31 and it began to taxi on the east-west taxiway toward runway 6R. No sand or urea 2/ had been spread on the taxi-way. The aircraft ' s taxi speed averaged about 9.9 kn. The captain stated that he taxied about 5 to 10 kns as indicated by his inertial navigation system (INS).

At 2053, the tower requested that Flight 422 use caution on the taxiway past the runway 6L turnoff because it was "extremely slick."

The captain stated that he had not experienced any difficulty in taxiing; however, shortly after the tower advisory, the aircraft began to slide to the right. The captain stated that he used both nosewheel steering and brakes to correct the slide, and the aircraft responded satisfactorily after which he reduced his speed to 5kn. He stated that immediately after the correction, the aircraft again began to slide and the nose swung left about 10 degrees to to the taxiway's certerline. He applied full brakes and told the first officer to do the same but the aircraft continued to slide. He applied a small amount of reverse power on all four engines and the aircraft stopped. He felt that the landing gear was still on the paved surface and that perhaps he had hit a taxi light. He gave the order to shut down the engines and directed the first officer to call for a tractor to tow the aircraft back. He said that he believed it to be too risky to taxi further.

The aircraft then canted to the right and slowly changed its heading (counterclockwise) to about 70 degrees to the taxiway, slid backward down the embankment, and came to rest 90 degrees to the taxiway. The statements by the first officer and flight engineer essentially confirm the captain's account of the accident.

The emergency evacuation was executed efficiently by the cabin crew. All passengers had left the aircraft within 60 seconds.

The accident occurred during the hours of darkness at latitude 610 10' 11'' N and longitude 149 degrees 59' 20''W.

VITA

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