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Pilot Perception of Cockpit Organizational Framework’s Impact on Flight Safety and Subordinate Pilot Behavior

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Pilot Perception of Cockpit Organizational Framework's Impact on Flight Safety and Subordinate Pilot Behavior

By

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Abstract

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Past accidents have indicated that first officers (FO) are less likely to identify and correct captain errors than captains are to correct FO errors. Crew resource management (CRM) training was introduced in the late 1970s to improve captain teamwork skills to utilize the FO more effectively and to increase FO willingness to interject to preserve safety. Despite the effectiveness of CRM training programs, there continue to be incidences where subordinate pilots make weak or ineffective attempts to preserve safety.

This research investigated commercial and airline transport pilots' perception of the impact cockpit organizational framework (COF) has on both flight safety and subordinate pilot behavior. Six research questions asked if the COF used in determining pilot positional assignments is perceived as having an impact on flight safety and subordinate pilot behavior. It was hypothesized that COF had an impact, and that pilots would perceive a flight deck where both crewmembers were qualified as captains, referred to as a captain-captain (CAPT-CAPT) COF, as improving both. This quantitative research employed an online survey and non-probability sampling techniques that targeted commercial and airline transport-rated pilots. The survey was posted on the Survey Monkey website, which administered the survey and screened participants for suitability. To increase participation, participants were provided the opportunity to enter a

random drawing for one of three participation rewards. An a priori analysis estimated a minimum of 251 respondents were needed. Four-hundred fifty respondents participated in the study; 261 respondents provided data that were used in the analysis.

Cockpit organizational framework, the independent variable, was introduced to describe the combination of choices made by an aircraft operator regarding how pilot positional assignments are made. It was operationalized at two levels: a CAPT-CAPT and captain-first officer (CAPT-FO) COF. Pilot perceptions were the dependent variable. The survey utilized 27 structured close-ended questions, 24 of which measured pilot perceptions of COF on an 11-point Likert scale, and three of which measured perceptions of COF via four categorical choices. Statistical analysis utilized multiple techniques, including (a) *t*-test, (b) ANOVA, (c) ANCOVA, and (d) Chi-square tests of independence.

The results indicated that pilots perceived COF's impact on the three markers of safety, the first three research questions, as being statistically non-significant. However, results were statistically significant and with small to medium effect sizes for subordinate pilot behaviors, the second three research questions. Experience, as measured by total flight hours, was determined to have a statistically significant impact on pilot perceptions of COF. An additional and unplanned finding was that pilot perceptions of COF were strongly influenced by industry sector, with airline pilots favoring the CAPT-FO COF and business/corporate pilots the CAPT-CAPT COF. Airline pilot preference for the CAPT-FO COF was lower when asked about subordinate pilot behaviors, but business/corporate pilot preferences for the CAPT-CAPT COF increased for these questions. Based upon these results, it is recommended that pilot behavior in each of these two COFs be measured under experimental conditions to determine whether pilot perceptions of COF is consistent with actual subordinate pilot behaviors.

Dedication

This work is dedicated to all those with whom I served this Country in uniform and under arms. In particular, to the crew of Ranger 12, who met their fate off the coast of Libya attempting to land a vintage A-3 aboard USS Nimitz on a dark night with a pitching deck. I think of them and that night often.

Acknowledgments

To family and friends who have guided me on life’s journey. Especially, my parents who established in me the desire to achieve via work, perseverance, and inspiration; and my wife, Cindy, who has tolerated me and the impact of my need to achieve new and more challenging goals.

John Collins, my friend and mentor at the Addison Piper flight school, who encouraged me to serve my Country, and made possible my life-long relationship with Cindy. I lost track of John as the years went by, but I will always remember and appreciate how much he shaped my life.

I also must acknowledge MSGT Bruce E. Pflieger, the Regimental Drill Instructor at the Navy’s Aviation Officer Candidate School in 1984. I have never forgotten his speech to us regarding what service to Country means, what naval aviation meant to him as a “boots on the ground” Marine, and what his expectations were for us as graduates of AOCS. I frequently reflect on whether I have lived up to his expectations.

And lastly, to my friend and colleague Scott Mackee whose comments over a beer during a layover in KOKC inspired this inquiry.

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Chapter I: Introduction

The improving safety record of the commercial airline industry can be measured by noting the dramatic reduction in the total number of accidents per year since its inception. During the formative years of aviation between 1918 and 1926, there was an average of 75.8 reported accidents per year (Accident Graphs, 1918-1929, 2019). In contrast, U.S. commercial aviation averaged 5.5 fatal accidents per year between 2008 and 2014, and there were no recorded fatal accidents between 2014 and 2017 (Boeing Commercial Airplanes, 2018). This improvement in total accidents has come despite the growth in the industry since 1918.

Improvements in aviation safety developed in three distinct, although sometimes overlapping, evolutionary eras: (a) the technical era (the 1900s until the late 1960s), (b) the human factors era (early 1970s until the mid-1990s), and (c) the organizational era (mid-1990s to present day) (International Civil Aeronautics Organization, 2012). Improvements during the technical era included advances in airframe and engine technology, instrumentation, and communication. While not technical in nature, government involvement in regulating the licensing of pilots and commercial operators as well as governmental efforts to establish the basic infrastructure needed to support commercial aviation were additional changes which improved safety during these formative years (Wells & Rodrigues, 2004).

A significant improvement in aviation safety grew out of the lessons learned in the 1950s missile programs (Vincoli, 2014). Failures in these early missile launches produced catastrophic accidents and the loss of the entire vehicle. Following a failure, the causal factors were determined, fixed, and then the flight was re-attempted (Vincoli, 2014). This *fly-fix-fly* approach was effective when the costs of the vehicles were low or if the rockets were unmanned. However, as man-rated rockets were envisioned, a more proactive approach to safety was needed (Vincoli, 2014). The U.S. Air Force Ballistic Missile Division and later the National Aeronautics and Space Administration (NASA) developed a systems approach to managing safety, one that focused on proactively managing risk. Beginning in the late 2000s, this program, later known as Safety Management Systems (SMS), became a major focus of commercial aviation's efforts to implement a proactive approach to safety (International Civil Aeronautics Organization, 2012).

As aircraft technology improved, the role that human factors played in aircraft safety became more evident (Bowers et al., 1993; Helmreich & Foushee, 2010). Early improvements in the human factors of flight included understanding the physiological challenges of high-altitude flight and the inherent weaknesses of the human in this new environment. This early human-factors research tended to focus on the individual without considering the complex operational and organizational environment in which individuals operate (ICAO, 2012). However, during the 1970s and 1980s, several high-profile accidents highlighted flight deck teamwork as an important contributor to flight safety (Helmreich et al., 1999; NTSB, 1979). In these accidents, a subordinate member of the flight deck crew appeared to recognize that safety margins were being reduced to dangerous levels, and, despite their apparent awareness, made weak, ineffective attempts to interrupt the mishap sequence. These ineffective attempts to prevent the accident were also either ignored or rejected by the captain (Ministerio de Transportes y Comunicaciones, 1977; NTSB, 1979; NTSB, 1982; NTSB, 2011). Recognizing the need to improve intra-flight deck teamwork, the Federal Aviation Administration (FAA) directed that crew resource management (CRM) training be included as an integral element in all commercial operator training programs in Advisory Circular (AC) 120-51C, subsequently amended to AC 120-51E (FAA, 2004).

Early CRM programs integrated research on culture and authority into crewmember training. Hofstede (2001), investigating the impact culture has on human behavior and learning, identified four dimensions of culture: (a) power-distance (PD), (b) uncertainty avoidance (UA), (c) individualism-collectivism (IC), and (d) masculinity-femininity (MF). Hofstede’s research described cultural dimensions as operating at the individual level, but Helmreich et al. (2009) opened the aperture to include dimensions of culture operating at a group level, including: (a) national culture, (b) organizational culture, and (c) professional culture. When considered in the aggregate, research into culture indicates that personal behavior operates on multiple levels. While early CRM advocates believed that CRM training programs could be devised to overcome all adverse behaviors (Helmreich & Merritt, 2000), there may remain influences which: (a) prevent some captains from reducing the PD on their flight decks, and (b) prevent some FOs from overcoming cultural or other barriers that inhibit their willingness or ability to correct captain errors or take assertive action to prevent aircraft accidents. The industry currently relies on CRM training programs to improve an FO’s ability or willingness to intervene to preserve safety, but these programs by themselves have not eliminated the cultural barriers that may prevent such interventions (Helmreich & Merritt, 2000).

Edwards (1975) introduced the concept of a *trans-cockpit authority gradient* (TAG) as a powerful influence on how effectively flight deck crews function as teams.

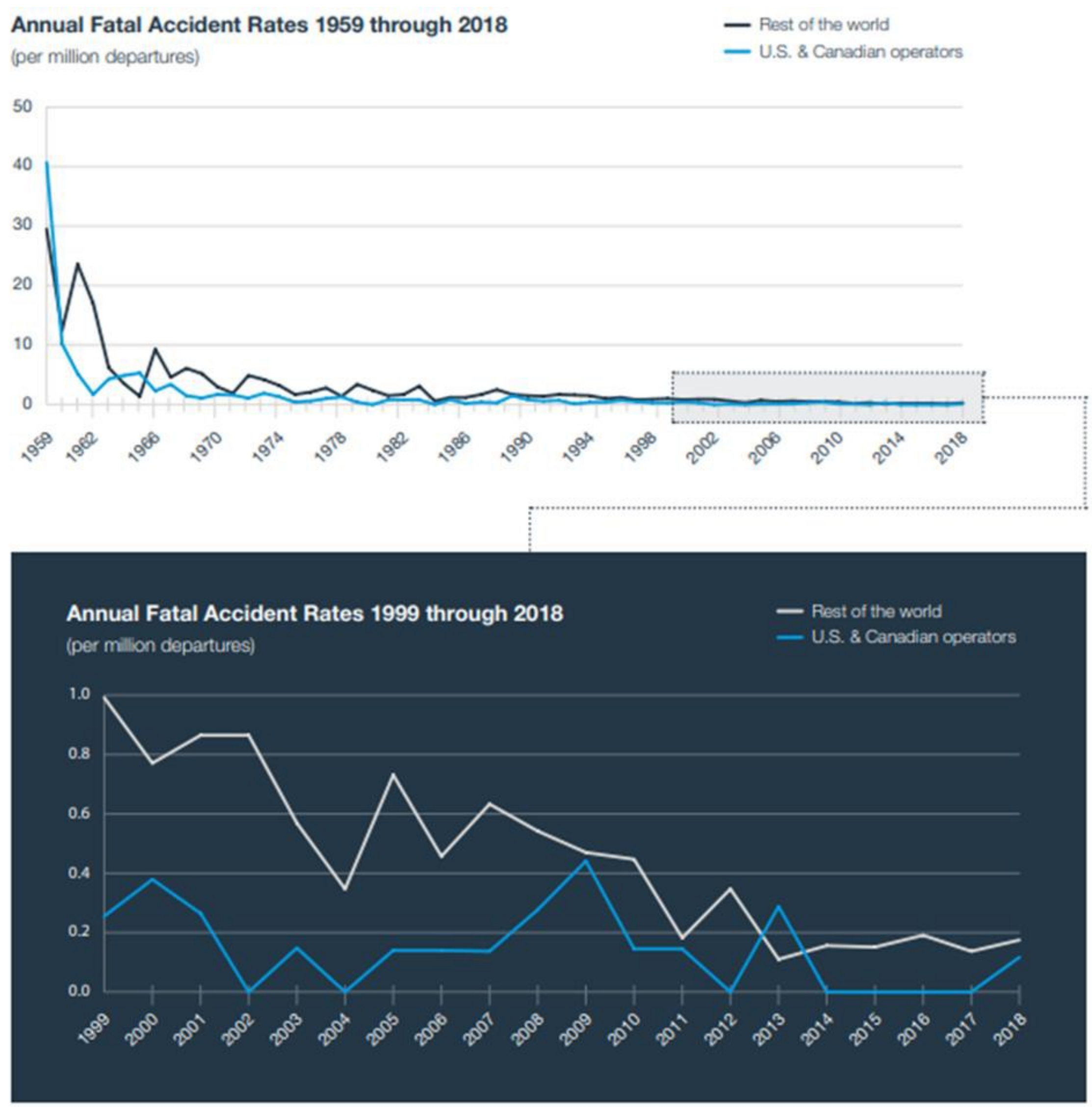
Specifically referencing the air carrier flight deck, Edwards described TAG as having a slope (left to right or vice versa) and a gradient (steep or flat). The direction of the slope describes the seat occupant that is exercising authority, left for the captain and right for the first officer (FO), and the gradient indicates the amount of authority being used. Edwards' research into culture, hierarchy, and authority identified the role these elements have on intra-flight deck teamwork and flight safety.

Following the introduction of CRM training programs, industry researchers began to investigate how organizational factors impact flight safety. They recognized the importance of developing a *safety culture* which is integrated across the entire organization to ensure safe practices are effectively implemented at the operational level (Reason, 1997; Stolzer et al., 2011). By considering the entire organization, and specifically leadership's role in developing a culture of safety, the industry began to look beyond the pilot and the plane to include the entire organizational system.

These incremental improvements helped commercial aviation achieve a safety record that has become the model for many high-risk industries (Institute of Medicine, 2000). Figure 1 illustrates the reduction in the commercial aircraft annual accident rate between the years 1959 and 2017 (Boeing Commercial Airplanes, 2018).

Figure 1

North American and World Mishap Rates, 1959-2018

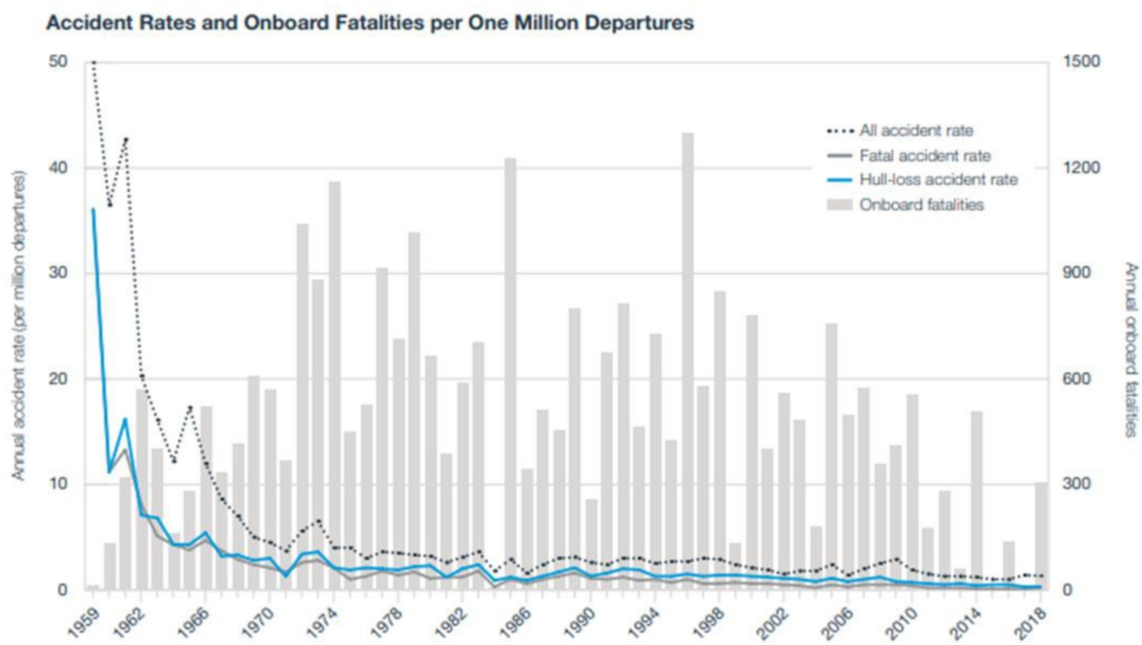


Note. North American and world mishap rates, 1959-2018, from "Statistical summary of commercial jet airplane accidents worldwide operations | 1959–2018," Copyright 2019 by Boeing Commercial Airplanes. Reprinted with permission.

As seen in Figure 1, annual commercial jet airplane accident rates in both North America and the world were approaching zero beginning in the 1970s, with the North American rate reaching zero during multiple years since 1998. However, Figure 2 shows the impact industry growth can have on total fatalities, even when accident rates are being reduced.

Figure 2

Total Fatalities and Total Aircraft Accidents, 1959-2018

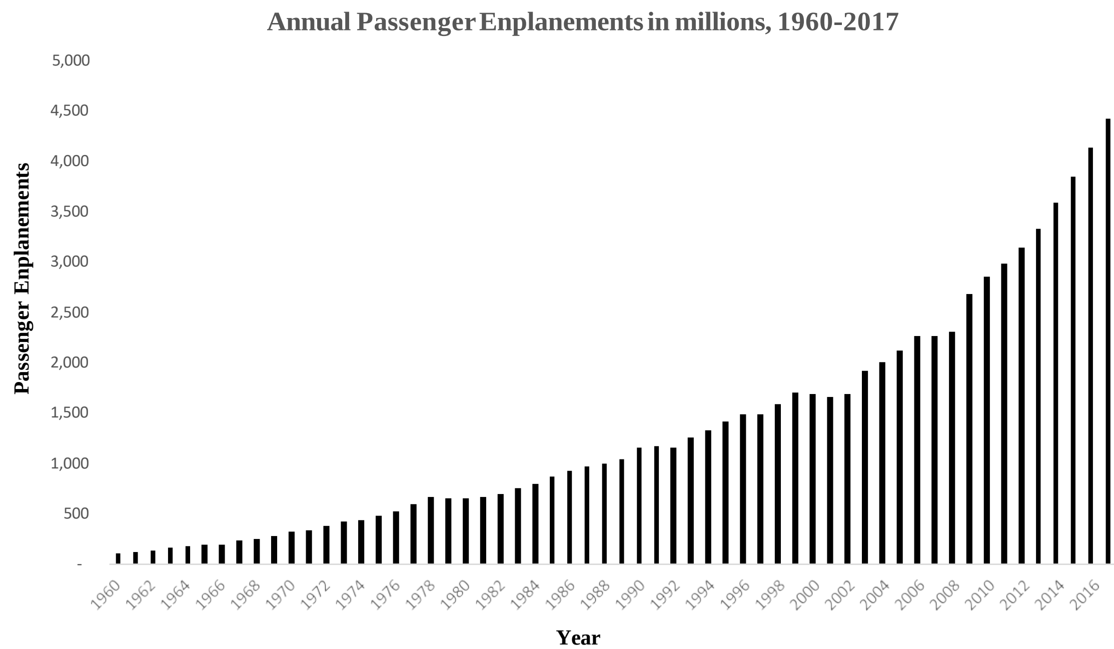


Note. Total fatalities and total aircraft accidents, 1959-2018. Copyright 2019 by Boeing Commercial Airplanes. Reprinted with permission.

In 1960, the worldwide fatal accident rate was approximately 11 accidents per million departures, resulting in just under 150 fatalities. In 2016, the accident rate had decreased to approximately 0.9 per million departures, but the total number of fatalities was essentially the same as in 1960 at just under 150. In fact, despite the reduction in accident rates between 1960 and 2016, only three years had equal to or fewer fatalities than occurred in 1960 (1984, 1999, and 2015). During this period, the worst year for total passenger fatalities was 1996, when approximately 1350 fatalities occurred, despite a 1996 accident rate approximately 90.9% lower than the 1960 accident rate. In 2018, the most recent year with data available, the accident rate was 0.016 accidents per million departures, resulting in 300 onboard fatalities. These data highlight an important fact for the aviation industry: as it grows, it must continue to achieve lower accident rates to avoid a higher number of total accidents and greater loss of life (Wells & Rodrigues, 2004). As Figure 3 shows, between 1960 and 2014, the commercial aviation industry grew 3242% (94 million passenger enplanements in 1960 to 3.142 billion in 2014), a growth rate greater than the 98% reduction in the industry fatal accident rate (11 accidents/million departures in 1960 to 0.2 in 2014).

Figure 3

Annual Passenger Enplanements in Millions, 1960-2017



Note. Adapted from “Air transport passengers carried,” by International Civil Aviation Organization, Copyright 2019 by Creative Commons Attribution 4.0.

Boeing’s Commercial Market Outlook for 2020-2039 forecasts a 3.2% annual fleet growth rate and a 4.0% annual growth rate in global air traffic (Boeing Commercial Airplanes, 2020). If these growth projections are achieved, then the continued development of additional safety improvements will be necessary to prevent higher total fatalities.

In 1994, the NTSB conducted a study of accidents that occurred between 1978-1990, where crew factors were found to be causal or contributing. The study examined who was the pilot flying (PF) during accidents and whether the pilot monitoring (PM) failed to challenge errors made by the PF that led to accidents. The data from this study are provided in Table 1.

Table 1

Pilot Flying and Pilot Monitoring/Challenging Errors During Accidents

	Percent of accidents		
	1978-1990	**1991-2001**	**1978-2001**
Captain's leg to fly	73	53	66
Captain flying at time of accident	81	79	80
Monitoring/challenging errors	84	68	79

In 2007, Dismukes et al. re-analyzed the NTSB data from 1994, compared it to current trends in aviation, and found the results to be essentially unchanged since 1994. The findings of Dismukes et al. (2007) are significant because it is a common practice that first officers (FOs) and captains fly alternating legs, meaning that captains and FOs would each be expected to fly approximately 50% of the legs. However, the percentage of accidents when the captain is the PF is much higher than the expected distribution (Dismukes et al., 2007). One question arising out of the findings of Dismukes et al. is whether FOs: (a) do not recognize when errors are being made or (b) are unwilling or unable to challenge errors. Almost two decades after CRM training was introduced, Fisher and Orasanu (2000) found that FOs were less likely to challenge captains than captains were to challenge FOs. These studies highlight that the problem of FOs not challenging captain errors has persisted even after the introduction of CRM mitigation strategies.

This same NTSB (1994) study also found that tactical decision and monitoring / challenging errors were two of nine recurring errors in aircraft accidents. Tactical decision errors were defined as "improper decision making, failing to change [the] course of action in response to a signal to do so, or failing to heed warnings or alerts that suggest a change in the course of action [is needed]" (Dismukes et al., 2007, p. 283). Monitoring / challenging errors were defined as "failing to monitor and / or challenge faulty action or inaction … by another crewmember" (Dismukes et al., 2007, p. 286). Both tactical decisions and monitoring / challenges errors were prominent in the NTSB results, occurring in 84 percent of the accidents between 1978 and 1990 and 68 percent between 1991 and 2001 (Dismukes et al., 2007).

Both research and accident investigations suggest that there may exist an imbalance between the monitoring / challenging performances of FOs relative to captains, and this imbalance may be causing accidents. It is the industry's recognition of teamwork related problems that provided the theoretical framework leading to early CRM research and the creation of CRM training programs (Helmreich et al., 1999; Munoz-Marron, 2018). However, in a 2009 accident involving an Avions de Transport Régional (ATR) 42, the NTSB (2011, p. 4) commented that, "Thirteen years after the FAA issued AC 120-51C [mandating CRM training], the NTSB continues to investigate accidents where one pilot does not question the actions or decisions of another pilot." The NTSB further commented that to overcome steep authority gradients, assertiveness training should be included in CRM programs (NTSB, 2011). Despite the industry's efforts to overcome steep authority gradients, FOs continue to exhibit an inability to recognize captain errors or an unwillingness to take effective action to correct these errors (Dismukes et al., 2007; NTSB, 1994; NTSB, 2011a).

While aviation has been a leading industry in research on crew behavior and teamwork, other industries have recognized the potential advantages offered by improving team effectiveness. In particular, the medical industry has conducted research into CRM as it attempts to reduce medical errors (Helmreich, 1990). Research in medicine frequently refers to authority gradients as a problem area in patient safety, and much of the research has focused on how best to mitigate the impact these authority gradients have on subordinate behavior (Bromiley, 2012).

The matrix organizational structure has been the subject of research in the business community. The matrix organization is described as an organizational structure that shares power among different members (Lukinaitė & Sondaitė, 2017). Lukinaite and Sondaite (2017) characterize a matrix structure as one where managers have influence without authority and accountability without control. This characterization describes the goal of CRM training to increase FO monitoring / challenging skills to be better able to influence outcomes without the formal authority of the *pilot-in-command* (PIC) designation. Chan (2008) describes a matrix organization as one that overlays the traditional vertical hierarchy with a horizontal structure. Therefore, the matrix organizational structure may be particularly appropriate for the aviation flight deck because, regardless of any attempts to flatten the organizational structure, there will still exist the FAA required designation of PIC, the traditional vertical hierarchy. What management researchers have discovered is, in certain circumstances, the matrix framework’s organizational strengths outweigh its weaknesses (Chan, 2008).

Any attempts to improve intra-flight deck teamwork via a flatter, more horizontal organizational structure must be balanced against the potential detriments. In classical organizational design theory, what distinguishes the matrix organizational structure from the traditional *one-boss* principle is the presence of multiple command structures (Levchuk et al., 2002). While a flatter organizational structure tends to improve communication and the ability of an organization to more easily cope with large amounts of information, it also tends to create ambiguity and potential conflict by increasing leader insecurity over their authority (Levchuk et al., 2002). Researchers in business management have studied both the benefits and detriments of a flatter organizational structure, but these issues have not been researched within the context of the aviation flight deck.

A review of research in the aviation industry found that interest in CRM remains high, but the research focus has shifted from investigating the fundamental aspects of how humans interact in the team environment to how best to implement what has been learned through prior research. Kanki et al. (2019), in their speculation about the future of CRM, state that “current guidance is sound and consistent with research findings” (p. 581). This statement seems to summarize the current state of CRM research in aviation. Helmreich (2006) and Munoz-Marron (2018) agree that the sixth generation of CRM, introduced circa 2000, remains the focus of many airline training programs today. This means that in the past 20 years, there has been little to no improvement in CRM-related pedagogy.

Statement of the Problem

Despite significant attempts to train first officers on how to overcome cultural, authority, or other barriers that inhibit their ability to correct captain errors, commercial aviation continues to see events where monitoring and challenging failures adversely impact aviation safety (NTSB, 2011a). These events provide evidence that attempts to train crewmembers to overcome these barriers have not fully achieved the expectations CRM advocates envisioned.

Research in organizational theory has identified both the benefits and weaknesses of a flatter, less hierarchical organizational structure, particularly in teams that must process large amounts of information in limited time and with limited resources (Chan, 2008). Researchers in business management have found evidence suggesting the adverse consequences of authority gradients and hierarchical structures can be mitigated through employing different organizational frameworks. However, a thorough search of the available body of knowledge from the aviation industry has produced only one research effort designed to measure the impact of either authority gradients or organizational structure in aviation, and this research was conducted in a military context (Alkov et al., 1992). Even though aviation continues to observe first officer resistance to the mitigation strategies designed to increase their challenging / monitoring skills, no research designed to investigate whether excessive authority gradients or hierarchical organizational structures are the root causes of this resistance was discovered. This research attempted to address this gap in aviation's body of knowledge by soliciting from pilots their perception of whether organizational structure has an impact on flight safety and subordina

te pilot behavior.

Purpose Statement

The purpose of this study was to examine the perceptions of active commercial and airline transport pilots on whether organizational structure influences flight safety and subordinate pilot behavior. Two different cockpit organizational frameworks (COF) were introduced: captain-first officer (CAPT-FO) and captain-captain (CAPT-CAPT), and a survey was used to determine whether pilots perceive COF as a factor in improving flight safety and subordinate behavior.

Significance of the Study

While the impact of the COVID-19 virus on future airline industry growth rates remains unknown, it remains important to continue to develop additional safety improvements, should industry growth rates return to projected levels. Past research has identified that organizational framework may have an impact on crew performance and teamwork (Lukinaitė & Sondaitė, 2017; Reason, 1990; Wiegmann & Shappell, 2001; Wriston, 2007). However, little research has been found investigating the impact different organizational frameworks have on intra-flight deck teamwork and crew performance. This study investigated pilot perceptions of whether COF impacts flight safety and subordinate pilot behavior.

Research Questions and Hypotheses

The research questions asked active commercial and airline transport-rated pilots their perceptions of the impact two different COFs may have on six markers of flight safety and subordinate behavior.

RQ1: Flight Deck Teamwork

Will active commercial and airline transport pilots perceive flight deck teamwork is improved by a CAPT-CAPT or CAPT-FO COF?

H_{01}. Pilots will perceive that flight deck teamwork is not improved in a CAPT-CAPT COF relative to CAPT-FO.

H_{A1}. Pilots will perceive that flight deck teamwork is improved in a CAPT-CAPT COF relative to CAPT-FO.

RQ2: Intra-Flight Deck Communication

Will active commercial and airline transport pilots perceive intra-flight deck communication is improved by a CAPT-CAPT or CAPT-FO COF?

H_{02}. Pilots will perceive that intra-flight deck communications are not improved in a CAPT-CAPT COF relative to CAPT-FO.

H_{A2}. Pilots will perceive that intra-flight deck communications are improved in a CAPT-CAPT COF relative to CAPT-FO.

RQ3: Fight Safety

Will active commercial and airline transport pilots perceive that flight safety is improved by a CAPT-CAPT or CAPT-FO COF?

H_{03}. Pilots will perceive that flight safety is not improved in a CAPT-CAPT COF relative to CAPT-FO.

H_{A3}. Pilots will perceive that flight safety is improved in a CAPT-CAPT COF relative to CAPT-FO.

RQ4: Willingness to Correct CAPT/PIC Errors

Will active commercial and airline transport pilots perceive FO/second-in-command (SIC) crewmembers will be more willing to correct CAPT/PIC errors in a CAPT-CAPT or CAPT-FO COF?

H_{04}. Pilots will perceive that there is not a higher likelihood the FO/SIC will correct captain errors in a CAPT-CAPT COF relative to CAPT-FO.

H_{A4}. Pilots will perceive that there is a higher likelihood the FO/SIC will correct captain errors in a CAPT-CAPT COF relative to CAPT-FO.

RQ5: Willingness to Enforce SOPs

Will active commercial and airline transport pilots perceive FO/second-in-command (SIC) crewmembers will be more willing to enforce compliance with standard operating procedures in a CAPT-CAPT or CAPT-FO COF?

H_{05}. Pilots will perceive that there is not a higher likelihood the FO/SIC will enforce compliance with standard operating procedures in a CAPT-CAPT COF relative to CAPT-FO.

H_{A5}. Pilots will perceive that there is a higher likelihood the FO/SIC will enforce compliance with standard operating procedures in a CAPT-CAPT COF relative to CAPT-FO.

RQ6 Willingness to Interject for Flight Safety

Will active commercial and airline transport pilots perceive FO/second-in-command (SIC) crewmembers will be more willing to interject to maintain flight safety in a CAPT-CAPT or CAPT-FO COF?

H_{06}. Pilots will perceive that there is not a higher likelihood the FO/SIC will interject to maintain flight safety in a CAPT-CAPT COF relative to CAPT-Pilot.

H_{A6}. Pilots will perceive that there is a higher likelihood the FO/SIC will interject to maintain flight safety in a CAPT-CAPT COF relative to CAPT-Pilot.

Delimitations

The population of inference was pilots with a commercial or airline transport pilot certificate. The target population was active commercial and airline transport pilots who were currently employed as pilots or had been employed as a pilot within the preceding 12 months. The target population was limited to only commercial and airline transport-rated pilots because of the higher likelihood they will have flown in the multi-pilot environment. Additionally, the population was limited to pilots who were actively employed as a pilot or had been employed as a pilot within the preceding 12 months to collect data from pilots who had recent experience in the multi-pilot environment. The sampling frame excluded retired airline pilots who may not have functioned as an FO for several years prior to retirement and who also may not have been exposed to the CRM training curriculums currently in use in commercial aviation.

The study employed an online survey design. Nonprobability sampling techniques were designed to cover both a broad base of commercial and airline-transport rated pilots and to target pilot groups with potentially different perceptions of COF. Specifically, survey responses were solicited from: (a) Curt Lewis & Associates database of registered pilots, (b) the online pilot forum for business/corporate pilots hosted by the National Business Aircraft, (c) the Future and Active Pilot Advisors (FAPA) newsletter and annual symposium conference, and (d) access to online forums associated with pilot associations from different industry sectors.

Limitations

Because the study was delimited to active commercial and airline transport pilots, the study's findings can only be generalized to current members of the commercial and airline industry. Generalizability to student, private, or military pilots cannot be assumed. Additionally, because of the use of nonprobability sampling techniques, the generalizability of the data to the target population also cannot be assumed. To mitigate the effect of nonprobability sampling, the sampling frame was designed to cover both a broad base of commercial and airline-transport rated pilots while also specifically targeting pilots from different sectors of the commercial aviation industry where different perceptions of COF may exist. The sampling strategy included use of the Curt Lewis & Associates database of registered pilots, the subscription list for the National Business Aircraft Association's (NBAA), use of the Future and Active Pilot Advisors (FAPA) member list, and access to the website forums for major aviation websites and of a major U.S. airline pilot association. Curt Lewis provided access to a database that is actively maintained by a commercial marketing enterprise and provided broad coverage of certificated pilots in the United States. The NBAA is a trade association representing pilots employed in the business aviation sector, and FAPA is a pilot service specifically targeting young commercial pilots. Online forums were chosen to provide exposure of the survey to a broad range of pilots from different industry sectors.

While the sampling strategy was designed to provide exposure of the online survey to a broad range of commercial and airline transport-rated pilots, it was recognized that these strategies mitigate the threat nonprobability sampling techniques posed to external validity, while not eliminating it. However, because of the explorative nature of this research, the results should provide data that, if determined to be significant, could be leveraged to justify more extensive and costly investigations using probability sampling techniques or experimental designs.

The potential for confounding variables which could impact the dependent variable was considered. Pilot experience was assessed as an important potential confounding variable because of the impact it may have on both the qualifications a pilot may have obtained (CAPT or FO) and on their willingness to embrace a new organizational framework. Dent and Powley (2003) argue that resistance to change is a perfectly rational response when change could be characterized as a loss. The experienced pilot who has risen to captain in the CAPT-FO framework may assess a new organizational framework where authority and status are shared more equally, as in the CAPT-CAPT COF, as a potential loss, and this perceived loss may impact pilot perceptions of COF. Therefore, the survey collected data on pilot experience at three levels: (a) total pilot hours, (b) PIC hours, and (c) SIC hours. These three items provided data on pilot experience, but only total pilot hours was used in an ANCOVA to measure the contribution this potential covariate had on pilot perceptions of COF.

Definitions of Terms

Accident An occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and the time all such persons have disembarked, and in which any person (occupant or non-occupant) suffers a fatal or serious injury, or the aircraft receives substantial damage (Wells & Rodrigues, 2004).

Advisory Circular (AC) Advisory Circulars are informational documents produced by the Federal Aviation Administration to inform and guide institutions and individuals within the aviation industry, as well as the public. ACs are intended to be informative in nature, not regulatory. However, many times they describe actions or advice that the FAA expects to be implemented or followed (Houston, 2016).

Accident Rate The number of accidents divided by a common base variable, usually one million departures or 100,000 flight hours (Wells & Rodrigues, 2004).

Airline Pilot A pilot operating as a flight deck crew member for a domestic, flag, and supplemental air carrier operation. Airline pilots may be referred to as a Part 121 or air carrier pilot.

Analysis of Covariance (ANCOVA) A statistical model that blends ANVOA and regression to determine whether categorical dependent variable means vary, while controlling for the effects of continuous confounding variables (covariates) (Keppel, 1991).

Analysis of Variance (ANOVA) A statistical model that measures variation to analyze the differences among and between group means with a single dependent variable.

Business/Corporate Aviation An industry segment that focuses on the business use of airplanes (NBAA, 2021).

Business/Corporate Pilot A pilot engaged in unscheduled flight activities, such as aerial application, charter flights, and aerial tours. This category of pilot also includes corporate pilots who transport company executives (Bureau of Labor and Statistics, 2021).

Bureau of Labor and Statistics (BLS) The federal agency that collects and disseminates various data about the U.S. economy and labor market (Investopedia, 2021).

Chi-Square Test of Independence A hypothesis testing model used when the data have one nominal variable to determine whether the number of observations in each category fits a theoretical expectation, and the sample size is large (McDonald, 2020).

Captain (CAPT) A term commonly used in the airline industry and other multi-pilot environments which is synonymous with the designated PIC. As used in this investigation, the captain will be considered the superordinate pilot.

CAPT-CAPT COF A COF frequently employed outside the airline sector which allows pilots who have obtained the requisite experience and met required performance standards to be designated as captain and function as PIC, regardless of the number of pilots who have previously qualified as CAPT/PIC. In this system, a captain can occupy either seat and function as either a PIC or SIC, with the duties and authorities associated with the CAPT/PIC position rotated between all pilots who have obtained the qualification.

CAPT-FO COF The COF almost universally present in the commercial airline sector. This framework has positional assignments fixed between captains who seldom if ever function in any capacity other than PIC, and FOs who seldom if ever function other than as SIC. It is reinforced by designating approximately half of a company's pilots as captains and giving them the title and qualification to function as CAPT/PIC, and the remaining half are not qualified as CAPT/PIC and therefore only able to function as a FO/SIC. It is also reinforced by establishing uniform standards which differentiate captains with four stripes on their uniform rank insignia and FOs with three stripes.

Cockpit The crew compartment in an airliner containing the instruments and controls used by the pilot, copilot, and flight engineer to operate the aircraft. For the purposes of this research, the term cockpit and flight deck have the same meaning and shall be used interchangeably.

Cockpit Organizational Framework (COF) The independent variable for the research. COF is a term introduced to describe the combination of choices made by an aircraft operator independently or in combination with pilots, regarding how positional assignments and flight deck duties are made, and how the carrier choses to differentiate between these positional assignments. This variable will be operationalized at two levels: CAPT-CAPT and CAPT-FO.

Crew Resource Management (CRM) The process of training crews to reduce "pilot error" by making better use of the human resources on the flight deck (Helmreich et al., 1999).

Curt Lewis & Associates An international, multi-discipline technical and scientific consulting firm specializing in aviation and industrial safety (Linkedin, 2020).

First Officer (FO) A flight crewmember who performs ground and flight duties as a pilot on aircraft requiring more than one pilot. The FO assists the pilot-in-command, referred to as the captain in most air carrier operations, in all phases of flight and ground operations. When part of a two-person flight deck crew, the first officer is not the pilot-in-command (Composition of flight crew, 14 CFR § 121.385, 1996). For the purposes of this study, the first officer is also the subordinate pilot.

Flight Deck The crew compartment in an airliner containing the instruments and controls used by the pilot, copilot, and flight engineer to operate the aircraft. In this paper, the term flight deck and cockpit have the same meaning and shall be used interchangeably.

Future and Active Pilot Advisors (FAPA) A career and advisory service for professional pilots at every stage of their careers, from the school selection stage to the retirement stage. It specializes in low-cost and high-quality information and consulting (Future and Active Pilot Advisors, 2020).

Individualism-Collectivism (IC) A societal, not an individual characteristic. IC is the degree to which people in a society are integrated into groups. On the individualist side are cultures where the ties between individuals are loose; everyone is expected to look after themselves and their immediate family. On the collectivist side are cultures where people, from birth onward, are integrated into strong, cohesive in-groups, often extended families, which continue protecting them in exchange for unquestioning loyalty and opposition to other in-groups (Hofstede, 2001).

Masculinity-Femininity (MF) A societal, not an individual characteristic that refers to the distribution of values between genders (Hofstede, 2001).

National Business Aircraft Association (NBAA) A leading industry / trade organization representing companies that rely on general aviation aircraft to help make their businesses more efficient, productive, and successful. The association represents more than 11,000 companies and professionals and provides more than 100 products and services to the business aviation community, including the NBAA Business Aviation Convention & Exhibition (NBAA-BACE), the world’s largest civil aviation trade show (NBAA, 2020).

Part 121 The part of the Federal Aviation Regulations which prescribes rules governing domestic, flag, and supplemental air carrier operations.

Part 121 Pilot A pilot operating under Part 121 of the Federal Aviation Regulations. A Part 121 pilot may be referred to as an airline pilot or air carrier pilot.

Part 135 The part of the Federal Aviation Regulations that prescribes rules governing the operating requirements for commuter and on-demand operations. It applies to turbojet engine powered aircraft with 1-30 seats, non-transport category turbo-propeller powered aircraft with 10-19 seats, and transport category turbo props with 20-30 seats (Air carrier and operator certification, 14 CFR § 135, 2021).

Part 135 Pilot A pilot operating under Part 135 of the Federal Aviation Regulations.

Pilot-in-Command (PIC) The flight deck crewmember who, whether manipulating the controls or not, is responsible for the operation of the aircraft in accordance with the rules of the air (ICAO, 2005). In the commercial airline industry, the PIC is normally referred to as the captain. For the purposes of this study, the PIC is also the superordinate pilot.

Power-Distance (PD) The extent to which the less powerful members of organizations and institutions accept and expect that power is distributed unequally. High PD represents an unequal distribution of power, and low PD represents a more equal distribution. In high PD cultures, both followers and leaders tend to endorse the unequal distribution of power between members. PD is measured from the subordinate crewmember's perspective (Hofstede, 2001).

Second-in-Command (SIC) A pilot who, when part of a two-person flight deck crew, is not the pilot-in-command (Composition of flight crew, 14 CFR § 121.385, 1996). In the commercial airline industry, the SIC is normally referred to as the first officer. The SIC is also the subordinate pilot.

Subordinate Pilot For the purposes of this investigation, a subordinate pilot is a flight deck crewmember who is not the designated PIC. The first officer is considered the subordinate pilot regardless of who is the pilot flying.

Survey Monkey A leading global provider of survey software products and purpose-built solutions that enables organizations to engage with their key stakeholders, including their customers, employees, and the markets they research and serve to measure, benchmark, and act on opinions (SVMK Inc., 2020).

Trans-Cockpit Authority Gradient (TAG) A term used to express the use of authority within the intra-flight deck team. Specifically referencing the flight deck environment, TAG is described using direction (left to right, captain to FO) and slope (steep or shallow).

TAG that is sloped steeply to the left describes a flight deck where the captain uses authority in an aggressive manner, suppressing inputs for other flight deck members (Edwards, 1975).

Uncertainty Avoidance (UA) This term indicates to what extent cultures program their members to feel either uncomfortable or comfortable in unstructured situations. Unstructured situations are novel, unknown, surprising, and different from the usual. High UA cultures try to minimize the possibility of such situations by strict behavioral codes, laws, and rules, disapproval of deviant opinions, and a belief in absolute truth (Hofstede, 2001).

List of Acronyms

ANCOVA	Analysis of Covariance
CAPT	Captain
CC	Captain-Captain COF
CF	Captain-First Officer COF
COF	Cockpit Organizational Framework
Bus/Corp	Business/Corporate
COVID-19	Coronavirus Disease 2019
CRM	Crew Resource Management
DF	Degrees of Freedom
ERAU	Embry-Riddle Aeronautical University
FAPA	Future Airline Pilots Association
FO	First Officer

FOD	Foreign Object Damage
FS	Flight Safety
IBM	International Business Machines
ICC	Inter-cockpit Communications
IRB	Institutional Review Board
NBAA	National Business Aircraft Association
NTSB	National Transportation Safety Board
PIC	Pilot-in-Command
SIC	Second-in-Command
SOP	Standard Operating Procedures
SPSS	Statistical Package for the Social Sciences
TEM	Threat and Error Management
TW	Teamwork

Chapter II: Review of the Relevant Literature

The following topics were considered most relevant to a discussion of how organizational framework could impact subordinate behavior:

- past accidents where subordinate crewmember behavior adversely impacted flight safety,
- human factors (HF),
- crew resource management (CRM),
- culture,
- organizational theory,
- impact of organizational structure/design on human behavior,
- authority, and
- impact of positional assignments and uniforms on behavior.

The proposed research will investigate whether commercial pilots believe a CAPT-CAPT or CAPT-FO organizational construct is more likely to result in subordinate behavior which improves flight safety. The general topic of flight safety is operationalized into questions on six safety and crew performance related parameters: (a) flight deck teamwork, (b) intra-fight deck communication, (c) overall flight safety, (d) likelihood of FO/SIC correcting CAPT/PIC errors, (e) likelihood of FO/SIC enforcing CAPT/PIC compliance with SOPs, and (f) likelihood of FO/SIC interjecting to ensure safety of flight.

Provided in the following review is a summary of past accidents where subordinate inaction was determined to be a causal or contributing factor. Additionally, research in human factors and CRM which are related to subordinate behavior will be introduced. A discussion on authority is included because the flight deck environment has an inherent authority structure where subordinate personnel must function, and studies have indicated these authority structures can have a dramatic impact on subordinate behavior and team effectiveness (Milanovich et al., 1998). Due to the lack of prior research available from the aviation industry on organizational theory in flight deck design, literature available from the fields of organizational sociology, business organization, and organizational engineering are included. Additionally, research conducted by the medical industry into organizational structure and authority and the impact both have on subordinate behavior is provided. The literature reviewed will provide a theoretical construct for how subordinate behavior is impacted by organizational framework, and therefore the relevance of investigating pilot perceptions of how different COFs may impact subordinate behavior.

Seminal Accidents

A review of some accidents which demonstrate the magnitude of the problem in getting subordinates to intervene against the poor decisions and actions of captains will be illustrative. These accidents were also instrumental in driving the industry toward improving flight deck teamwork and leadership techniques. Because accidents are investigated thoroughly, the aviation industry provides an environment where theoretical frameworks can be compared to real world results, and real-world results can help guide theory. A brief review of three high-profile accidents occurring between 1977 and 1982 highlight where team-performance failures resulted in the loss of life (Helmreich et al., 1999). These accidents share at least one common factor: none of the accidents involved mechanical failure as a primary causal factor - aircrew errors were the primary cause of these accidents. Additionally, in each of these accidents, it was determined that a subordinate member of the crew seemed aware that safety margins were being eroded to dangerous levels but made weak, ineffective, or, in some cases, no attempt to interrupt the mishap sequence.

***Tenerife Island (KLM 4805 and Pan Am 1736*)**

In 1977, two Boeing 747 aircraft, KLM 4805 and Pan Am 1736, collided on the runway at Los Rodeos Airport on Tenerife Island (Ministerio de Transportes y Comunicaciones, 1977). Both aircraft had been diverted to the Los Rodeos Airport after a terrorist bomb closed their destination, Las Palmas Airport on Gran Canaria Island. As the two aircraft waited for the Las Palmas Airport to reopen, a dense fog formed, reducing visibility to between 300 and 1500 meters. Due to the number of aircraft diverted to Los Rodeos, a portion of Runway 30's parallel taxiway was used to park aircraft, rendering it unusable as a taxiway. The blockage of the parallel taxiway forced air traffic controllers to direct departing aircraft to *back-taxi* on Runway 30, a process where aircraft use the runway to taxi opposite the direction of departing aircraft. When KLM 4805 arrived in position for takeoff on Runway 30, Pan Am 1736 was still back-taxing on Runway 30 with instructions to exit the runway and rejoin the parallel taxiway when beyond the portion of the taxiway blocked by parked aircraft. As the KLM flight completed its turn into takeoff position, the captain advanced the throttles to begin the takeoff, even though they had not received either the route to fly after takeoff (an ATC clearance) or a takeoff clearance. This initial attempt to takeoff was stopped by the FO who stated, "wait a minute, we don't have ATC clearance" (Ministerio de Transportes y Comunicaciones, 1977, p. 44). The captain replied, "yes" and reduced the thrust to idle.

The tower controller then issued KLM their ATC route clearance but not their takeoff clearance. Before the tower finished transmitting the ATC clearance, the captain again advanced the throttles and began the takeoff while the FO completed the required read back, even though the flight had still not received their takeoff clearance. The FO made no attempt to stop the captain as he made the same error he had made just moments earlier. However, the FE on the KLM flight queried the captain about the status of the Pan Am flight, twice asking whether they were clear of the runway. The first question was not answered, and the second question was answered emphatically, “Oh yes” (Ministerio de Transportes y Comunicaciones, 1977, p. 46). The KLM aircraft collided with the Pan AM jet 11 seconds later; 583 lives were lost.

United 173

In December 1978, a United DC-8 aircraft flying from Denver to Portland crashed near their destination airport after running out of fuel (NTSB, 1979). The flight proceeded normally until arriving in the Portland area when the crew received an unsafe down indication on both the left and right main landing gear. The crew used a backup visual system to confirm the landing gear were down but elected to remain in holding for over an hour to both reduce the fuel onboard and to give the flight attendants time to prepare the passengers for a potential emergency evacuation, should the landing gear collapse on landing. Despite several inquiries from both the FO and the FE about the quantity of fuel remaining, the captain did not share his intentions about how much fuel he planned to have on landing. Neither the FO nor the FE directly challenged the captain’s fuel management plan as the aircraft turned away from the airport for the final time. The aircraft was still headed away from the airport when it began to lose power due to fuel starvation. It crashed into a wooded area six miles southeast of the airport; 10 lives were lost.

Air Florida

In January 1982, an Air Florida Boeing 737 crashed into the 14th Street Bridge in Washington, D.C., killing 82 occupants onboard the jet and four motorists on the bridge (NTSB, 1982). The aircraft arrived at Washington National Airport at 1:29 P.M. on January 13, 1982 and was scheduled to depart approximately one hour later. However, the flight's departure was delayed until 3:59 P.M. due to a heavy snowstorm. While running the after-start checklist, the crew mistakenly failed to turn on the engine anti-ice system; the system is designed to prevent ice from accumulating on the engine's compressor blades and the temperature and pressure probes at the front of the engine. The NTSB determined that, due to this error, one of the pressure sensors was blocked by ice, resulting in erroneous engine thrust indications. After the aircraft was cleared for takeoff, the captain set takeoff thrust using the engine's pressure ratio gauges. The FO immediately began questioning the indications by stating, "that doesn't seem right" and "…that's not right," to which the captain replied, "Yes, it is…" (NTSB, 1982, p. 5). With insufficient thrust to maintain flying speed, the aircraft stalled and crashed.

Industry Recognition and Response

The industry's reaction to the Tenerife and United 173 accidents resulted in increased attention to crew errors, particularly to teamwork related errors. United 173 highlighted a problem also observed at Tenerife: both the FO and the FE recognized errors made by the captain but made weak or ineffective attempts to correct those errors (NTSB, 1979). At Tenerife, the FO corrected the captain's first error and stopped the first attempted takeoff. However, when the captain made the same error just moments later, the FO was silent (Ministerio de Transportes y Comunicaciones, 1977). The FE, recognizing the error being made by the captain, attempted to correct it by making indirect comments to the captain in the form of questions, but the captain rejected all these attempts. The short amount of time available for the KLM FO and FE to diagnose and correct the error may have interfered with their ability to effectively intervene. However, in the case of United 173, there was no shortage of time available, but neither the FO nor FE challenged the captain's actions to prevent the aircraft from running out of fuel (NTSB, 1979). In both the Tenerife and United 173 accidents, and again later with Air Florida, there appeared to be a barrier preventing subordinate crewmembers from acting to preserve flight safety. In the NTSB report for United 173, the Board made the following comment:

> Admittedly, the stature of a captain and his management style may exert subtle pressure on his crew to conform to his way of thinking. It may hinder interaction and adequate monitoring and force another crewmember to yield his right to express an opinion. (NTSB, 1979, p. 27)

The NTSB also discussed at length the United crew's communication as Flight 173 remained in holding while running out of fuel. The NTSB observed that both subordinate crewmembers used indirect or passive communication to voice their concern about the developing fuel crisis. The Board went as far as to recommend, "in the training of all airline flight deck crewmembers, assertiveness should be a part of the standard curricula…" (NTSB, 1979, p. 27). The statements made by the accident investigation teams in both accidents indicate there were problems with how crews were functioning:

how captains were using their authority and how subordinates were responding to that authority.

In a 2009 accident involving an Avions de Transport Régional ATR 42, the NTSB (2011, p. 4) commented that, “Thirteen years after the FAA issued AC 120-51C [mandating CRM training], the NTSB continues to investigate accidents in which one pilot does not question the actions or decisions of another pilot.” In a subsequent paragraph, the NTSB further commented that, “to overcome steep authority gradients, AC 120-51E suggests that assertiveness be included in CRM training programs” (NTSB, 2011, p. 4). Despite the industry’s efforts to the contrary, there may remain some barriers to FO willingness or ability to either recognize captain errors or take effective action to correct them.

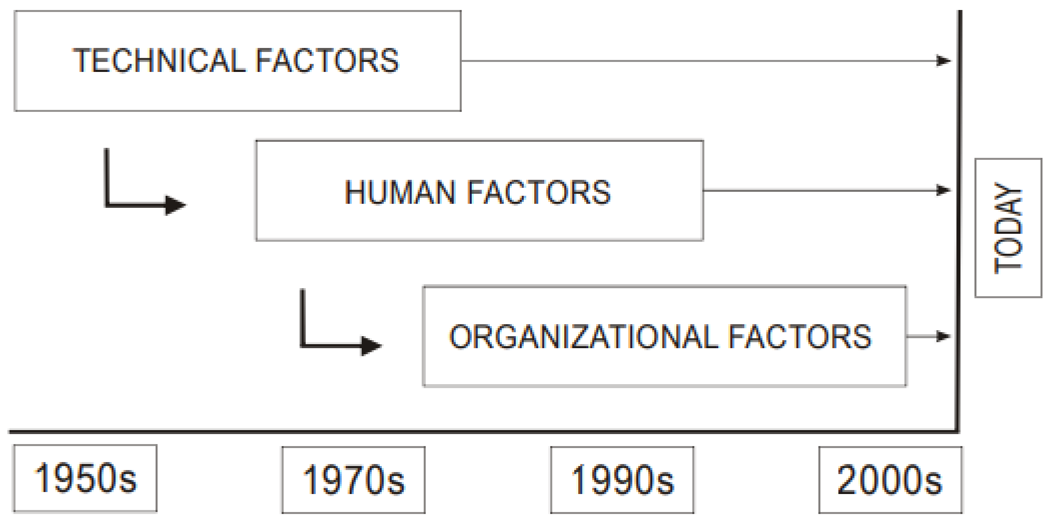
Human Factors (HF) in Aviation

Early improvements in human factors included understanding the physiological challenges of high-altitude flight and the inherent weaknesses of human beings in this new environment (Koonce, 1984). However, as aircraft technology produced better performance, instrumentation, automation, and improved safety systems, the critical role that human factors play in aircraft safety became more visible (Bowers et al., 1993). Between 1980-1989, approximately 70% of all hull loss accidents involved aircrew error as a casual factor (Kanki et al., 2010), demonstrating that, to achieve improvements in safety, an effort like that devoted to produce better aircraft was needed to improve the performance of the humans flying the aircraft.

The maturation of research into human factors identified organizational factors as a significant contributor to safety, and new research was focused on how the organizations humans create and within which they operate contribute to or detract from safety. Early human factors research tended to focus on the individual without considering the complex operational and organizational environment where they operate (ICAO, 2012). This evolution in safety is captured in the ICAO safety management manual (SMM) (2012) and is depicted graphically in Figure 4.

Figure 4.

The Evolution of Safety



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While the above discussion provides an effective framework to understand the evolution of flight safety, it is inaccurate to think that research into human factors did not begin until the 1970s. The Wright brothers were the first to achieve powered human flight at least partly because of their understanding of fundamental human factors (Millbrooke, 2006). In the race to be first in flight, many early aircraft designers were attempting to maximize stability, and in so doing were limiting the human ability to control the aircraft. As bicycle designers and builders, the Wrights recognized that humans could control an inherently unstable vehicle, and therefore designed their aircraft to have both stability and control (Grant, 2002; Velazquez, 2016). By including the human as an integral component in the aircraft system and designing an aircraft that could be *flown* by the human occupant, the Wrights employed HF concepts to achieve a successful man-machine interface, thereby becoming the first to achieve powered human flight.

The ICAO's model in Figure 4 accurately reflects the evolution of safety when it is remembered that, prior to the 1970s, the primary focus of HF research was how to improve the man-machine interface and to discover how the physiological challenges of flight affected human performance (Hawkins & Orlady, 1993). The evolutionary change that occurred in the 1970s was to consider the human as a major contributor to safety failures rather than a victim of safety failures. This evolutionary change is contextualized in the following passage.

> From an initial marriage of engineering and psychology with a focus on *knobs and dials*, contemporary human factors have become a multi-disciplinary field that draws on the methods and principles of the behavioral and social sciences, engineering, and physiology to optimize human performance and reduce human errors. (Kanki et al., 2010, p. 4)

As discussed in the seminal accidents section at the beginning of this chapter, the industry's accident record during the 1970s highlighted that significant improvements in safety were available through a focus on the human element. As shown in Figure 4, much of the research focus through the early 2000s was on organizational factors. The research proposed herein is an extension of this effort with research designed to investigate different organizational factors not considered by prior researchers. Specifically, the proposed research investigates the organizational framework currently utilized in most commercial aviation flight decks.

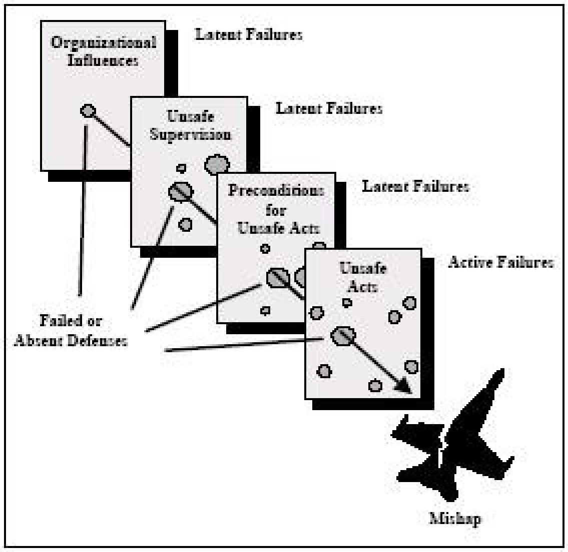
Edwards (1975), a leading researcher in the study of HF during the 1970s, formulated a theoretical human factors framework known as the SHEL model. The model's name is an acronym representing the four elements Edwards considered part of the system in which humans operate: Software, Hardware, Environment, and Liveware. Using a pilot as an example, during flight, a pilot will interact with the following: (a) software – entering data into and extracting information from operational flight programs (OFPs) used in flight control or flight management computers, (b) hardware – operating the controls (frequently referred to as the "knobs and dials") located on the flight deck to accomplish tasks such as raising and lowering the landing gear, adjusting the attitude of the aircraft via the flight control system, and activating or deactivating system components, (c) environment – adjusting the flight path to compensate for winds or to avoid terrain, and (d) liveware – interacting with other crew members or air traffic controllers.

While Edwards' (1975) initial model advanced the study of HF by providing a theoretical framework, Hawkins and Orlady (1993) offered an improvement to Edwards' model by adding an additional liveware component, the human operator. The human operator was added at the center of model, orienting the original four elements around this new central liveware component, and relabeling this new framework the Software, Hardware, Environment, Liveware, and Liveware (SHELL) model (Hawkins & Orlady, 1993). The SHELL model gained wide acceptance in the aviation industry and was eventually included in the ICAO's System Safety Manual to describe the fundamental HF framework (ICAO, 2012). By including a second liveware component and placing it at the center of the system, Hawkins and Orlady provided both an effective visual model and introduced a *liveware-to-liveware* relationship. This liveware-to-liveware relationship would become a major focus for aviation safety as CRM programs were introduced in the wake of the seminal accidents discussed earlier.

Reason (1990) classified errors, failures, conditions, or threats into two broad categories: active and latent. He defines an active failure / error as one in which effects are adverse and felt almost immediately and a latent condition or threat as one in which adverse consequences may lie dormant within the system, only becoming evident when they combine with other factors to breach the system's safety defenses (Reason, 1990). Reason would further expand upon these two broad categories to identify four levels of human failure as: (a) organizational influences, (b) unsafe supervision, (c) preconditions for unsafe acts, and (d) unsafe acts (Shappell & Wiegmann, 1997). The first three levels of human failure were defined as latent conditions because their presence in the system did not immediately result in an accident. Unsafe acts are defined as active failures. From these four levels, Reason (1997) would formulate one of the better-known frameworks for safety, the Swiss Cheese Framework (SCF), shown in Figure 5. The research proposed will investigate whether pilots perceive COF as an additional latent failure mode that can contribute to aviation accidents.

Figure 5

Reason's Swiss Cheese Framework (SCF) of Safety



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In 1989, NASA's Ames Research Center conducted a series of experiments to investigate pilot and team performance. A simulation-based experiment was conducted to measure leader personality characteristics on crew performance (Chidester et al., 1990). Twenty three-person crews were selected from the single crew base of one commercial air carrier. The personality of the captain was the independent variable, and team performance was the dependent variable. Captains were assessed and placed into three different personality profiles, one positive and two negatives. Captains possessing high attributes in instrumentality-expressivity (IE+) were placed in the positive profile group, and captains evaluated to be either negative-expressive (EC-) or negative-instrumental

(I-) formed the two teams hypothesized to have negative profiles. For research purposes, Chidester et al. operationally defined instrumentality as a person's level of goal orientation and independence, and expressivity is defined as a person's orientation toward communication and interpersonal exchange, interpersonal warmth, and sensitivity. Bozionelos and Bozionelos (2003) define instrumental traits as encompassing assertiveness, independence, ambition, and the need to dominate, and expressive traits encompassing sensitivity to the needs of others, altruism, warmth, and cooperativeness. The IE+ crews performed well across all assigned tasks and over the entire 2 days of testing, and EC- crews performed poorly on all tasks over the 2 days. Surprising results were seen in the I- group. The I- group initially performed poorly (at a level equal to EC-) but showed marked improvements by the final segment (performing at a level equal to EC+). I- captains, more authoritarian and described as the *right stuff* pilots, were met with greater resistance early, but crews seemed able to adjust to the strong leadership style over the 2 days. Despite the unexpected result for I- captains, the tests confirmed that EC+ crews had significantly better performance over the entire test period.

Crew Resource Management (CRM)

Historical records indicate that the threat of poor teamwork and abuse of authority are not new or unique to aviation. In 1707, a British Admiral named Sir Cloudesley Shovell crashed four ships into the rocks near the Isles of Scilly. Ex post facto accounts indicate that a low-ranking member of the crew on the admiral's flag vessel warned Shovell that the route was dangerous. However, because he questioned the admiral's decision, the seaman was punished for insubordination (Sobel, 1995). Shovell's example illustrates how poor leadership, improper use of authority, and the suppression of information provided by subordinates can impact safety.

In a more modern context, the seminal mishaps discussed earlier highlight the need to develop mitigation strategies to counter the threat of poor teamwork and the improper use of authority. In 1979, NASA convened a workshop designed to improve safety by reducing human error and improving flight deck teamwork. The research reviewed at the NASA workshop introduced the concept of CRM to the aviation industry (Cooper et al., 1980).

The initial focus of CRM programs was to improve crew teamwork by emphasizing how best to utilize subordinates to achieve safe flight operations (Helmreich et al., 1999). In 1984, John Lauber, a psychologist member of the NTSB, defined CRM as using all available resources, including information, equipment, and people, to achieve safe and efficient flight operations (Lauber, as cited in Kanki et al., 2010). Foushee and Helmreich (1988, p. 190) expanded this definition to, “CRM includes optimizing not only the person-machine interface and the acquisition of timely [and] appropriate information, but also the interpersonal activities including leadership, effective team formation and maintenance, problem solving, decision making, and maintaining situational awareness.” Helmreich et al. (1999) and Munoz-Marron (2018) described the evolutionary development of CRM strategies as evolving through six generational stages. The evolutionary development of CRM is summarized in Table 2.

Table 2

Evolution of CRM (Helmreich et al., 1999; Munoz-Marron, 2018)

Generation Approximate Time Period Official Name Aircrew Name	Basis of Training	Focus of Training	Training Setting	Participants
1st Generation 1981-1986 Cockpit Resource Management "Charm School"	Corporate Management training "Managerial Grid"	Changing individual styles & behaviors Psychological Awareness Leadership techniques	Seminar/classrooms	Aircrew
2nd Generation 1986-early 1990s Cockpit Resource Management "Psycho-babble"	Cockpit group dynamics	Cockpit group dynamics Reducing errors	Seminar/classrooms	Aircrew
3rd Generation Early-mid 1990s Cockpit Resource Management	CRM Research ICAO/FAA CRM Guidance (AC-150-51)	Organizational Culture Specific skills and behaviors Loss of focus on error reduction	Seminar/classrooms	Aircrew Flight Attendants Dispatchers Maintenance Personnel
4th Generation Mid-late 1990s Crew Resource Management	FAA AQP Requirements ICAO/FAA CRM Guidance (AC-150-51A)	Integration of CRM into recurrent training programs Line oriented flight training (LOFT)	Full-flight Simulators	Aircrew
5th Generation Late 1990s Crew Resource Management	FAA AQP Requirements ICAO/FAA CRM Guidance (AC-150-51C)	Human error is unavoidable Error management skills Check Airman/Instructor CRM training	Full-flight Simulators	Aircrew
6th Generation 2000s to present Crew Resource Management	FAA AQP Requirements ICAO/FAA CRM Guidance (AC-150-51E)	Human error is unavoidable Threat recognition & error management Inclusion of external threats Check Airman/Instructor CRM training	Full-flight Simulators	Aircrew

The pace of CRM's evolutionary improvements was at least partially due to the immaturity of the early CRM programs (Helmreich et al., 1999). In the aftermath of the United 173 accident, United Airlines implemented the first comprehensive CRM program in the United States. Early CRM programs borrowed heavily from leadership and management courses developed by psychologists but designed for use outside of aviation. Participants assessed their management styles in an intensive seminar setting and utilized case studies that focused on both captain and subordinate crew errors (Helmreich et al., 1999; Kanki et al., 2010). These programs, while an effective first step, were not consistent with the organizational or professional culture of aviation. New training was needed that reflected the aviation environment and its culture (Helmreich et al., 1999; Munoz-Marron, 2018).

In 1986, NASA convened a workshop to allow industry leaders to contrast and compare the increasing number of newly developed CRM training programs, receive briefings for the academic community on the latest research in the field, and to facilitate information sharing between all members of the industry. At the 1986 NASA workshop, the consensus was that stand-alone CRM training would eventually be replaced by training integrated into the broader airline training program (Munoz-Marron, 2018). These second-generation CRM training programs expanded the focus beyond individual behaviors to train crews on group dynamics. Second generation CRM is most easily recognized by the renaming of the programs from *cockpit* resource management to *crew* resource management. Helmreich et al. (1999) identified key developments in the third and fourth generations of CRM as the broadening of the concept to include personnel outside of the flight deck (i.e., flight attendants, maintenance personnel, and dispatchers) as well as line orientated flight training (LOFT) scenarios that placed crews in training scenarios more realistic to real-world flight operations.

Salas and Prince (1999) proposed additional improvements in CRM training. Working at the Naval Air Warfare Centers Training Systems Division, they were tasked to introduce CRM training to the United States Navy. Salas and Prince assessed the status of CRM training from its introduction to 1999 and recognized the significant achievements made to shift the emphasis from focusing on individual behaviors to social interactions on the flight deck (i.e., crew coordination). However, they also found a general disagreement on how these CRM principles should be taught and what CRM programs should encompass. After completing this assessment, Salas and Prince (1999) clarified their definition of CRM by focusing on teamwork rather than social interactions or individual behavior. Their unique approach can best be explained by providing their definition of CRM: “a set of teamwork competencies that allow the crew to cope with situational demands that would overwhelm any individual crew member” (Salas & Prince, 1999, p. 163). While subtle, their approach differed from other programs by focusing on a teamwork strategy based on situational demands, an approach consistent with Edwards’ (1975) discussion of flight deck authority and the second generation of CRM development.

Current CRM training programs, the sixth generation of CRM development, are focused on managing threats, reducing errors, and improving crew teamwork (Munoz-Marron, 2018) and are labeled threat and error management/crew resource management (TEM/CRM) (Maurino & Murray, 2009). Helmreich and Merritt (2000) stated that the evolution of CRM training has now returned to its origin. They discussed the unfortunate history where some CRM zealots expanded the concept to include family issues and workplace sexual harassment. Helmreich and Merritt (2000) stated that the original goal of CRM was to reduce pilot errors and increase flight safety. With its renewed emphasis on reducing human error by improving teamwork, Helmreich et al. (1999) were satisfied that CRM had now found its proper place in the industry.

The FAA did not mandate use of the early CRM programs due to those programs focusing on personality traits and reliance on business management training techniques (Kanki et al., 2010). Work done by leading researchers in the development of behavioral markers (Helmreich et al., 1999) resulted in the FAA accepting CRM research and the resulting training programs as sufficiently developed to warrant publishing advisory guidance. The FAA published AC 150-51 in 1989, providing official guidance on how best to implement CRM programs (FAA, 1989). The behavioral markers identified by Kanki et al. were included in the first advisory circular and are still included in the current addition, AC 150-51E (FAA, 2004).

Culture

A great deal of research has been devoted to the impact of culture and its influence on both personal and interpersonal behavior. Geert Hofstede, an early researcher in this area, developed initial interest in the topic through his work to develop training programs for IBM (Hofstede, 1980). After obtaining success with training programs designed for employees in Europe, he attempted to export these programs for use outside of Europe. However, Hofstede and IBM observed that the programs successful in Europe were dramatically less effective elsewhere. Using survey data previously gathered by IBM, together with data from a survey he designed, Hofstede used country-level factor analysis techniques to identify fundamental cultural differences between the European and non-European IBM trainees (Kirkman et al., 2006). Hofstede then developed constructs to explain the behaviors he observed to be consistent within different national cultures. These societal-level behaviors were described as the mental programing that allows members of a community to predict the behaviors of other members of the community and reflects the shared values of the society. It was from this theoretical framework that Hofstede identified four cultural dimensions: (a) power-distance (PD), (b) uncertainty avoidance (UA), (c) individualism-collectivism (IC), and (d) masculinity-femininity (MF) (Hofstede, 1980). These dimensions were used extensively in early CRM research and were further developed as CRM research accelerated. In particular, the dimensions of PD and UA are still frequently referenced in recent research as cultural factors which impact subordinate behavior in a crew setting.

Power Distance (PD)

PD refers to the perception of how power and authority is distributed (Hofstede, 2001). PD is the extent to which less powerful members of organizations and institutions accept and/or expect that power is unequally distributed (Hofstede, 2006). Low PD cultures are characterized by a more even distribution of power between superiors and subordinates than in high PD cultures. In a low PD culture, a subordinate pilot (FO or FE) would be more likely to speak up regarding a decision they felt was inappropriate or unsafe. In a high PD culture, subordinate pilots would be very hesitant to question superordinate pilots because of their deference to the captain’s positional authority. Helmreich et al. (2009) reported that the United States ranked sixth lowest of 22 nations in PD culture. However, as shown in the seminal mishaps discussed earlier, PD issues can impact safety even in what are thought to be low PD cultures.

Individualism-Collectivism (IC)

Individualism and collectivism are opposite dimensions in Hofstede’s (2001) model. Hofstede emphasizes that these dimensions are characteristics that exist at a societal level, not the individual level. IC is defined as the degree to which people prefer to act as individuals rather than as members of groups (Taras et al., 2010). Individualist societies are characterized by a more loose-knit social structure. The individual and their immediate family are the focus of each person's value system. Collectivist societies are characterized by a tight social structure that places less emphasis on the individual and more on the group. The society's values are orientated toward the group, usually an extended family or community. Individuals in a collectivist society expect the group to take care of them, and, in return, they owe loyalty to the group and its leaders.

Uncertainty Avoidance (UA)

UA is a measure of how well an individual or society deals with unknowns or ambiguity. Individuals and societies with high UA avoid unknowns because they are uncomfortable with novel, unusual, or surprising situations (Hofstede, 2001). High UA societies also attempt to limit ambiguity by establishing strict laws, regulations, and rules to eliminate unusual behavior (Hofstede, 2001).

In some ways, the flight deck exemplifies both dimensions of Hofstede's UA culture. Operators establish standard operating procedures (SOPs) and expect all personnel operating their aircraft to closely adhere to these SOPs. Government authorities publish extensive and detailed regulations covering all aspects of flight operations and have a small army of inspectors tasked with enforcing these regulations. Additionally, aircraft manufacturers publish both normal and abnormal procedural checklists, and operators expend enormous resources training crews in the use of these checklists. Aircraft manufacturers also develop highly sophisticated automation systems designed to allow aircrew to only monitor the operation of these automated systems. Regulations, SOPs, automated systems, and checklists are tools to standardize crew behavior and reduce ambiguity even when confronted with non-normal events (i.e., a system malfunction, unexpected weather, or hijacking, etc.). However, aviation operations present aircrew with a highly dynamic environment where unique and highly ambiguous problems often must be resolved to ensure safety. Perhaps the best two examples of this reality are provided by United Flight 232 and US Airways Flight 1549 (NTSB, 1990; NTSB, 2010). The crew of United 232 experienced a failed fan disk in the rear engine of the DC-10 aircraft which destroyed the three hydraulic systems used to power the flight controls. With no flight controls, the crew was forced to land the aircraft using only asymmetric engine thrust (NTSB, 1990). The crew of US Air 1549 was forced to ditch an Airbus A320 in the Hudson River after being struck by numerous birds and suffering a total loss of thrust (NTSB, 2010). Thus, it can be said that there exists a *pilot paradox* where pilots are trained to be high UA operators but are simultaneously expected to be able to deal with uncertainty when an event occurs that is not covered by procedure.

Masculinity-Femininity (MF)

Like IC, MF are opposite dimensions which only exist at a societal level (Hofstede, 2001). MF measures how a society values behavior typically assigned to the genders. In a masculine society, behaviors such as assertiveness, competition, and the acquisition of property and power are valued (Hofstede, 2001). In a feminine society, behaviors such as friendliness, security, quality of life, and warm relationships are valued more highly (Hofstede, 2001). It is again worth noting that Hofstede’s emphasis is that these dimensions do not apply to the individual but are generalizations applied at the societal level. While still having value from a behavioral viewpoint, MF is currently seldom referenced when considering Hofstede’s work.

Helmreich et al. (2009) attempted to better explain the impact of culture on behavior by expanding the discussion beyond the dimensions Hofstede identified. Helmreich et al.'s research found evidence to support three additional cultural dimensions: (a) national culture, (b) organizational culture, and (c) professional culture.

National Culture

This type of cultural dimension refers to the tendencies present at a societal level resulting from the basic structure and organizing framework of a society (Helmreich et al., 2009). Relating back to Hofstede (2001), IC and MF dimensions could be considered dimensions of national culture.

Organizational Culture

Organizational culture is the dimension that develops within an organization, such as business, government, or military level cultures (Helmreich et al., 2009). Organizational culture is influenced by national culture, but because this culture is not the direct result of societal level influences, organizational cultures are more easily changed. However, the ability to change is frequently a function of the size of the organization and the strength of the organization's leadership (Thakor, 2011).

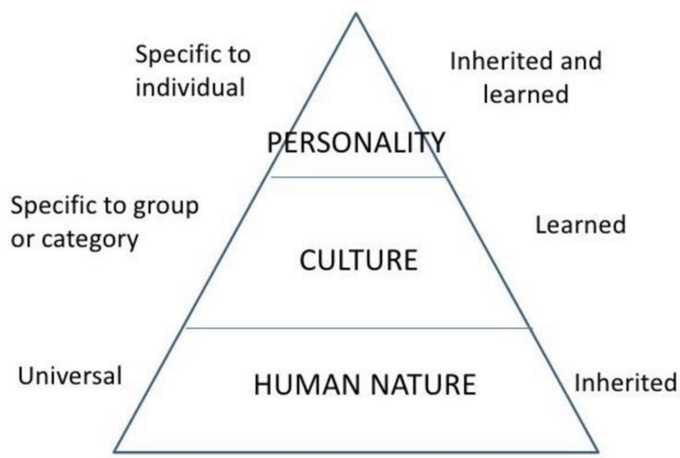
Professional Culture

This is the culture that exists within a profession, frequently the result of qualities members of the profession value. The professional culture of the pilot profession was fostered during the industry's formative years when aviation was considered a dangerous activity (Helmreich et al., 2009). Whether it was military, early airmail, or barnstorming airshow pilots, the profession initially fostered pride in being one of *the few* who could or would join the profession (Helmreich et al., 2009). This professional culture was also captured and popularized in the book, “The Right Stuff” with its depiction of the early astronauts (Wolfe, 2005).

Hofstede (2001) continued his research into culture, expanding it to also consider organizations. He viewed culture as the mental software which influences individual behavior, arranging the resulting behaviors into the pyramid model shown in Figure 6 (Hofstede & Hofstede, 2005). Both Hofstede’s and Helmreich et al.’s (2009) cultural dimensions lie in the middle layer of this model, between human nature and individual personality.

Figure 6

Three Levels of Uniqueness in Human Mental Programming



Note. Reprinted with permission from “Cultures and organizations: Software of the mind” by G. Hofstede and G. J. Hofstede, 2005, McGraw Hill. Copyright 2005 by McGraw Hill.

Within this one layer of human mental programming are several layers of cultural programming that, combined with human nature, contribute to individual personality (Hofstede & Hofstede, 2005).

When considered in the aggregate, research into culture indicates that personal behavior operates on multiple levels. Early CRM advocates believed that CRM training programs could be devised to overcome all adverse behaviors (Helmreich & Merritt, 2000). The industry has had some success in changing personal behaviors, but success has been less than some advocates predicted. There seem to remain influences which: (a) prevent some captains from reducing the PD on their flight decks, and (b) prevent some FOs from overcoming the barriers that may inhibit them from acting to prevent aircraft accidents. The industry currently relies on CRM training programs to improve an FO's ability or willingness to intervene to preserve safety, but these programs by themselves have not eliminated the cultural barriers that may prevent such interventions.

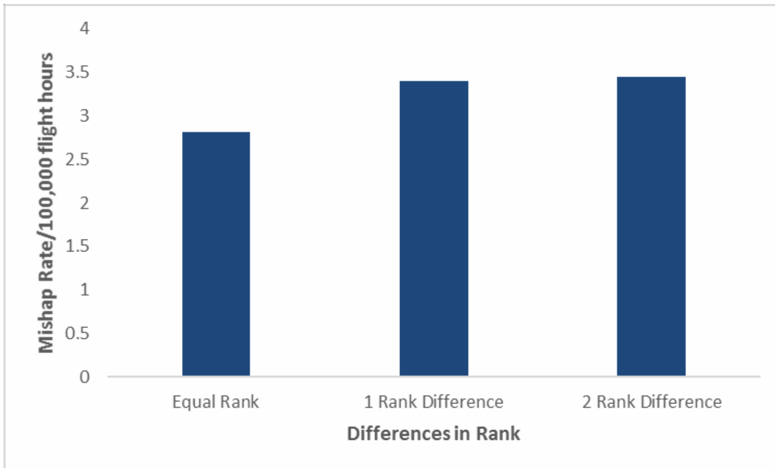
Research into Authority

Edwards (1975) introduced the concept of *trans-cockpit authority gradient* (TAG) to describe how authority influences intra-flight deck teamwork. Specifically referencing the air carrier flight deck, Edwards described TAG as having a slope (from left to right or vice versa) and a gradient (steep or flat). The direction of the slope describes the seat occupant that is exercising authority over another seat occupant, left for the captain and right for the FO. The gradient indicates the amount of authority being used within the flight deck. Thus, a steeply sloping left TAG describes a flight deck with a captain who is exerting a great amount of authority over the FO. A flight deck with zero slope would be a flight deck with a captain who allows subordinates an equal input in all decisions, and a right sloping gradient could result from a weak or indecisive captain and a strong or over-bearing FO. Referencing Admiral Shovell's loss of the British ships in the Isles of Scilly in 1707, Shovell's TAG would be sloped steeply to the left, indicating a strong authoritarian culture with little or no inputs from subordinates encouraged or even tolerated (in Shovell's case, TAG would likely approach the vertical). Through the concept of TAG, Edwards identified how the net of all other cultural influences, including the captain's own leadership style, manifest themselves on the flight deck. While cultural influences do exist, they are normally transparent to members of the crew (assuming they share a common national, organizational, and professional culture). But TAG is real and readily apparent as the working conditions that the captain establishes and where all crew members must function.

Alkov et al. (1992) investigated the impact TAG had on Navy and Marine Corps helicopter accidents. To measure TAG, they measured the differences in rank between aircrew. They characterized this difference in rank as: (a) equal rank (Lieutenant O3-Lieutenant O3; Commander O5-Commander O5), (b) one rank difference (Commander O5-Lieutenant Commander O4; Lieutenant O3-Lieutenant Junior Grade O2), and (c) two ranks difference (Commander O5-Lieutenant O3; Lieutenant Commander O4-Lieutenant Junior Grade O2). Using the Naval Safety Center aviation accident database, Alkov et al. reviewed all serious helicopter mishaps. They defined serious mishaps as those resulting in: (a) damages exceeding $200,000, (b) a permanent partial disabling injury, and/or (c) injuries requiring 5 or more days hospital or worse. The results are listed in Figure 7 below.

Figure 7

Navy/Marine Corps Helicopter Mishap Rates for Differences in Rank



Note. Adapted from "The effect of Trans-cockpit Authority Gradient on Navy/Marine Mishaps" Alkov, Borowsky, Williamson, & Yacavone, 1992, Copyright 1992 by Aviation, Space, and Environmental Medicine.

The results indicate that the mishap rates were lower on flight decks where the ranks of the pilots were equal. While these results indicate a possible relationship between rank and accident rates, it is important to note that the effects measured were not statistically significant, indicating the research may also have failed to detect any differences between these groups. Even though the results were not statistically significant, the study does indicate that rank differentials on the flight deck may have some impact on flight safety. The study had similar results for F-14 and A-6 aircraft, but because these data were for single-piloted aircraft (multi-crewed aircraft, but only one pilot with flight controls), the results are not applicable to the proposed study.

It is also worth noting that Alkov et al. (1992) defined TAG based on the military rank structure alone. It may be reasonable to assume that higher ranked military officers are more likely to establish a steeper TAG over lesser ranked officers, but actual authority gradient was not measured. TAG was assumed to be correlated with relative rank differences. This assumption fails to account for natural variances in human behavior which may be independent of rank. TAG, as defined by Edwards (1975), is an authority gradient, not a rank differential. To draw any conclusions about TAG from this experiment, even if the results had been statistically significant, requires the assumption that TAG varies directly with rank differential, an assumption that may be difficult to defend. While this research certainly contributed to the body of knowledge utilized when preparing this research proposal, the ability to make any inferences from this study should not be overstated. Despite this limitation, this study does indicate that further research is needed into whether COF can affect flight safety.

Prince et al. (2010) also used military helicopter pilots to investigate how experience affected flight deck behavior. To achieve a wide variance in the experience of the pilots tested, their research was conducted at one of the Navy's flight training squadrons. Pilots were assigned into three groups based upon experience and asked to fly two scenarios in a high-fidelity simulator. Intra-crew communications were recorded and analyzed for patterns representing behavioral markers. The results indicated that communication patterns of experienced pilots were the same whether flying with an experienced or inexperienced co-pilot. However, the speech patterns of the inexperienced pilots varied with the experience level of the other crewmember. When flying with a more experienced pilot, inexperienced pilots were hesitant to assertively direct the aircraft commander. However, when flying with pilots of equal or lessor experience, subordinate pilots seemed to recognize that the leader was no more competent than they were and therefore were not hesitant to provide direction to the aircraft commander (Prince et al., 2010). This research indicates that subordinate pilot behavior may vary based upon their perception of the relative experience level of the superordinate pilot.

Tarnow (2000) applied the lessons learned from the well-known Milgram (1974) behavioral studies to the challenges FOs face when intervening to correct captain errors. The Milgram study was designed to test just how far people would go if ordered to harm another human (McLeod, 2017). Participants, referred to as teachers, were instructed on how to run a panel designed to administer electrical shocks up to 450 volts to learners when they answered questions incorrectly. Unknown to the teachers, the learners were members of the research team, and the electrical panel was fake; no shocks were administered to the learners during the experiment. A member of the research team, called the experimenter and dressed in a white lab coat, sat next to the participant teachers and, if needed, urged them to administer shocks to the confederate learners. The results were that 65% of the teachers administered shocks of 450 volts, and all teachers proceeded up to the 300-volt level (Milgram, 1974). Tarnow points out the similarities between the Milgram experiment and the flight deck environment. In cases where the captain is making poor or dangerous decisions, Tarnow contends that the FO is taking on the role of the teacher, and the captain is taking on the role of the experimenter. To make his point, Tarnow borrows from both Milgram and another aviation researcher Ginnett (1993), whose research investigated subordinate behavior. Tarnow inserted segments from Milgram's findings into Ginnett's findings to produce the following observation (Milgram's findings are inserted in brackets).

> The authority dynamic surrounding the role of the captain must be extremely powerful... [and] has resulted in crewmembers not speaking up when necessary [Hesitant Challenging] …This inclination may also result in excessive psychological dependence on the captain as leader to the extent that individual contributions to problem solving are neither voiced or attempted [Lack of Monitoring]. (pp. 30-31)

Tarnow points out parallels between Milgram's study and the flight deck environment. These parallels, if accurate, indicated that without strategies designed to overcome this tendency, we could expect upward of 65% of FOs not to challenge their captain when needed to prevent an accident. CRM programs were developed to counter this behavioral tendency, and the industry has potentially seen the benefits of this mitigation strategy through the lower accident rates discussed in Chapter 1. However, NTSB commentary during recent accident investigations continues to indicate that this problem has not been completely mitigated by CRM training alone (NTSB, 2011a; NTSB, 2014a).

Another study on the impact of authority, organizational structure, and leader behavior occurred during a Stanford University experiment on behaviors in the prison environment (Haney et al., 1973). In this study, college-aged men were randomly selected to participate in a simulated prison experiment. Participants were randomly assigned into either the guard or prisoner roles. The experiment was originally designed to last two weeks, but after only 6 days, it was halted due to the behavioral extremes displayed by both the guards and prisoners. While much of the focus of the study has been on where the study itself went wrong and how quickly the young men acting as experimental prison guards exhibited authoritarian and often sadistic behavior, equally important were the results of how quickly the experimental prisoners assumed submissive roles (Haney et al., 1973).

Organizational Theory and Structure

Researchers in team formation have theorized that variations in team performance can be related to the organizational structure of the team (Stewart & Barrick, 2000). Organizational structure is the framework that defines the lines of authority, formal communication channels, and the duties and rights of individuals in the organization (Tkalcevich, 2016).

The matrix organization is described as an organizational structure that shares power among different members (Lukinaitė & Sondaitė, 2017). While much of the published literature on this organizational structure is within the context of the business environment, many of the findings may be applicable to the organizational structure of the aviation flight deck. When laid out along the continuum of organizational design, Lukinaitė & Sondaitė describe design alternatives ranging from: (a) the traditional vertical and hierarchical structure with functional lines, to (b) a flatter, horizontal structure. The matrix structure is a mixed design with characteristics of both a traditional and flatter structure (Chan, 2008). Lukinaite and Sondaite (2017) characterize a matrix structure as one where managers have influence without authority and accountability without control. This aspect of the matrix structure offers some potential advantages in the flight deck environment because of the design's ability to provide FOs greater influence within the traditional flight deck authority structure.

Any attempts to improve intra-flight deck teamwork via a flatter, more horizontal organizational structure must be balanced against the potential detriments of such a change. Chan (2008) lists the strengths and weaknesses of a matrix structure as:

- increased frequency of communication,
- an increase in the amount of information the team can handle,
- flexibility in the use of human resources,
- increased motivation, job satisfaction, commitment, and personal development,
- heightened ease in achieving technical excellence,
- increased ambiguity about personnel assignments, and
- increased insecurity for managers and erosion of authority.

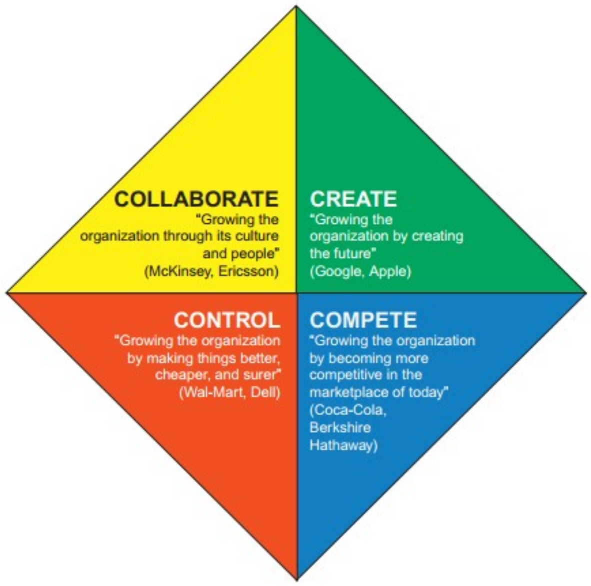
In classical organizational design theory, what distinguishes the matrix organizational structure from the traditional one-boss principle is the presence of multiple command structures. However, multiple command channels violate traditional management theory regarding unity of command (Joyce, 1986). The impact of a flatter organizational structure has been studied in the business management field, but little to no research on this topic was found in the context of the aviation flight deck.

While Joyce (1986) implies that any attempt to change the COF of the commercial aviation flight deck may violate traditional management theories, different organizational structures are not without precedence in aviation. Interviews with commercial pilots operating in the business aviation sector indicate that, contrary to the commercial airline sector, it is not unusual for flight departments to allow all pilots who have gained sufficient experience in either the aircraft or flight department to be designated as captains. Also contrary to the airline sector, it is common that pilot-in-command duties and seat assignments rotate amongst all qualified captains (Richard Schwartz, personal communication, April 20, 2014). Additionally, it is common practice in U.S. military tactical squadrons to initially assign new pilots to exclusively perform wingman duties but allow them to upgrade to flight lead status after they have accumulated the requisite number of flying hours. Following this upgrade, flight lead duties are then normally rotated to ensure an equal number of flight lead and wingman training events (Ryan Roberts, personal communication, December 30, 2014). Therefore, it was not uncommon for a squadron commander to lead a flight of four F-16s on a morning sortie then function as the junior wingman on an afternoon sortie. Thus, within the military's steeply hierarchical organizational framework there exists a flatter, more horizontal intra-flight organizational framework where leadership duties are shared and rotated amongst those who have obtained minimum experience and satisfied qualification standards. This practice may not be common in military organizations outside the United States, but it is also used in the Israel Defense Force Air Force (Ron et al., 2006).

Thakor (2011) outlined how businesses develop core competencies because of, and in support of, the strategic choices they believe will provide a competitive advantage. He further states that companies must also develop an organizational framework that best supports those core competencies. Errors made when making these strategic choices will make it difficult to achieve growth objectives (Thakor, 2011). Thakor assigned four basic values to business growth, giving each a unique color, to create the four colors of growth shown in Figure 8: (a) create-green, (b) complete-blue, (c) collaborate-yellow, and (d) control-red.

Figure 8

The Four Colors of Business Growth and the Competing Values Framework



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A company optimized to operate in an industry dominated by innovation (a green industry) will have a culture ill-suited for success in an industry where cost control (red) is the primary determinant of success. Similarly, a company optimized to perform best in a highly competitive market (blue) will have limited success if collaboration (yellow) is the key component for success. The four values and the organizational structure needed to support those values comprise what Thakor defines as the competing values framework (CVF).

Thakor's essential theory is that for a company to excel, it must have an organizational framework that supports the processes critical for success. If the structure of the firm does not support the values, culture, or core competencies the company is attempting to develop, it will struggle to achieve its goals (Thakor, 2011). Thakor is advocating that organizational structure is a strategic choice critical to success and therefore one that should not be the result of outdated or accidental choices. If we assume flight safety is one of the organizational goals for flight crews, then Thakor suggests the organizational design of the flight deck is an important determinant of whether crews will achieve this goal. His research suggests that there are certain organizational designs better suited for certain goals, and if organizational structure is not a strategic choice made by the organization, then the resulting structure will likely not be optimized to achieve the organization's goals. Extensive research has been conducted by Thakor and others to provide the business community with the theoretical framework needed to make these critical strategic choices, but little to no research in this area has been conducted by aviation researchers.

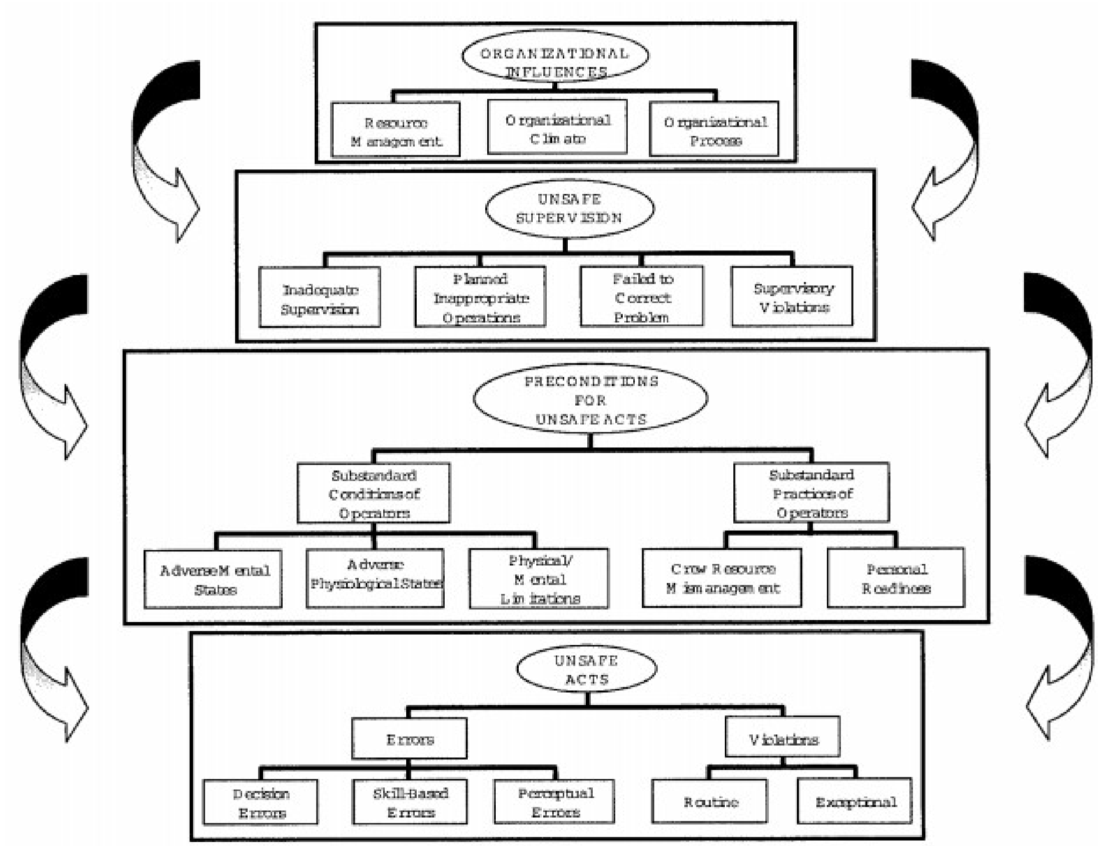
Other research into the critical role organizational structure plays in team performance can be found in recent studies in engineering. Levchuk et al. (2002) apply a systems engineering approach to designing organizational structure. Their research into organizational decision-making found evidence of a strong functional dependency between mission requirements and the optimal organizational design. Using these findings, they developed normative algorithms for optimizing human-team performance. While a system engineering analysis of this nature is likely far more complex than is needed for the typical two-person flight deck, Levchuk et al. employ many of the same theories as Thakor and other organizational theorists. These concepts provide a strong theoretical framework for the proposed research.

Organizational Influences on Aviation Safety

Reason's (1990) work on human error identified organizational influences as one of the latent failures that contribute to aviation accidents. Shappell and Wiegmann (1997), drawing on Reason's SCF, developed the Human Factors Analysis and Classification System (HFACS) to expand upon each of the human error levels. Originally developed for the U.S. military as a tool to help identify both latent and active human errors during accident investigations, the HFACS framework has proved useful as an error analysis and classification tool outside of military aviation (Wiegmann & Shappell, 2001). The visual representation of this framework is shown in Figure 9.

Figure 9

Visual Depiction of the HFACS Framework



Note. Reprinted from “A human error analysis of commercial aviation accidents using the human factors and classification system (HFACS)” by Douglas A. Wiegmann and Scott A. Shappell, 2001, U.S. Department of Transportation, Federal Aviation Administration. Copyright 2001 by the Federal Aviation Administration. Reprinted with permission.

Organizational influences are at the top layer of the HFACS structure. Reason (1990) and Wiegmann and Shappell (2001) recognized the important influence organizational factors can have on human performance and flight safety. Wriston (2007) also identified the importance of organizational structure when creating high-performance cultures. He states that traditional organizational structure is one of the two primary obstacles to achieving robust processes. He further states that one of the ways to achieve a high-performance culture is to rethink [organizational] structure (Wriston, 2007).

Impact of Positional Assignments

The dominant organizational and professional culture of the airline industry has the duties, responsibilities, rank, and title fixed and determined by a hierarchical seniority system. In many cases, both corporate and military aviation have developed a different organizational / professional culture than the culture dominant in the airline industry. Military aviation has a hierarchical rank structure, but it also allows lower ranked personnel to assume pilot-in-command responsibilities over higher ranked personnel when they have achieved sufficient experience, completed the required training, and demonstrated the requisite ability (Office of the Chief of Naval Operations, 2004; Secretary of the Air Force, 2015). Additionally, many corporate aviation departments allow an equal rotation of crew authority and responsibility by allowing the pilot flying to serve as pilot-in-command and occupy the left seat of the aircraft, the traditional seat of higher rank and authority (Richard Schwartz, personal communication, April 20, 2014). Along with this rotation, the hierarchical nature of corporate aviation is often further reduced by allowing all crewmembers who have achieved pilot-in-command qualification to use the title *captain* and wear captain rank insignia (Richard Schwartz, personal communication, April 20, 2014).

Milanovich et al. (1998) conducted an empirical study into positional status and flight deck dynamics, looking for patterns of authority on the flight deck. They reported that all too often captains fail to listen to FOs, and FOs fail to intervene to prevent accidents. The NTSB (1994) found that monitoring and challenging failures were evident in over 80% of accidents reviewed between 1978 and 1990. The common pattern in these accidents was an error made by the captain combined with the FO's failure to challenge the captain's decisions or correct the captain's errors.

Impact of Uniforms

Another choice that may influence behaviors is the uniform attire required for aircrew. While the uniform is almost ubiquitous in the airline flight deck, a review of the relevant literature revealed little in terms of past studies on its impact on culture or aircrew behavior. Timmons and East (2011) comment on the paucity of research conducted into the impact of uniforms in the workplace, stating, "there are only a few scholarly papers which take uniforms as their main focus" (p. 1037). Further, the review of the available literature for this proposal found no study isolating uniform attire as a variable in commercial aviation crew performance.

Craik (2003) discusses the cultural aspects of uniforms, focusing primarily on the political, sexual, and normative implications of uniform attire. The uniform choices made by an organization and the individual's wear of the uniform communicate a series of statements and non-statements about both the organization and the individuals in the organization. What uniform elements are included and excluded in the organization's required attire form the statements the organization intends to make via the uniform, and the wearer's compliance or non-compliance with the uniform regulations transmits the wearer's statements about their view of the organization and their own self-actualization. Uniforms serve as extremely effective indicators of the codification and internalization of the rules of conduct associated with the group (Craik, 2003). They also serve as a valuable aid in the shaping of minds within a group. Military leaders recognized the advantage of uniform requirements as a tool to instill discipline in the ranks and as a valuable part of the process to transform individual strength into collective power (Roche, 1996). In this capacity, the uniform becomes a key instrument in shaping the individual into an obedient member of a team. Additionally, the uniform not only identifies members of a group, but helps to establish both structure and order within the group. “The very existence of a uniform implies a group structure, at least a two-step hierarchy” (Joseph & Alex, 1972, p. 722). The uniform acts to ensure that upper-level members of the group control lower members of the group, and that lower-level members conform to this organizational construct (Joseph & Alex, 1972). Any person who recognizes the uniform and its implied structure becomes someone who has expectations about how uniform wearers will behave in their relative positions and are more likely to manifest these expectations in interactions with other group members (Joseph & Alex, 1972). The uniform, therefore, influences the wearers’ behavior and encourages them to act as occupants of their uniformed status.

Timmons and East (2011) studied one United Kingdom hospital’s attempt to reduce occupational boundaries in health care by a change in uniform policy. The hospital required all groups to wear the same uniform. This change produced a strong reaction by the professionals working at the hospital, even when normal resistance to change was considered (Timmons & East, 2011). This resistance was indicative of the professional tribalism that has long been recognized as a potential impediment to effective and safe healthcare (Strong & Robinson, 1990). A normal UK hospital may have upward of 20 uniforms designating different professional and occupational groups, along with additional within-group subdivisions indicated by different hats, badges, or other insignia (Timmons & East, 2011). Following the change, the only uniform differentiator remaining was a small epaulette of various colors indicating the profession of the wearer. The results of the study indicated strong negative impressions from most professional groups. The complaints were that management were attempting to replace professional identity with corporate identity, and there were more incidents of mistaken identity between professional groups (Timmons & East, 2011). In general, the study demonstrated the significant role uniforms play in the establishment and maintenance of professional boundaries in the workplace.

Relevant Literature Outside Aviation: Medicine

In 2000, the Institute of Medicine published “To Err is Human” where it estimated that medical errors were responsible for between 44,000 and 98,000 annual deaths (Institute of Medicine, 2000). This report generated a great deal of attention in the medical field, resulting in healthcare becoming interested in the concepts and techniques learned in aviation (Helmreich, 1990). The “To Err is Human” report introduced the medical industry to Edward’s concept of “authority gradients” (Institute of Medicine, 2000), and many medical researchers turned their attention to this concept thereby producing new research in this area. Cosby and Croskerry (2004) reported that medicine is a profession with a strong hierarchical structure, and that this structure evolved in part because of the skills and experience needed to be successful in the profession. Further, they found that there were many in the profession who believe junior members should not question decisions made by senior members, even when scientific merit does not support the decisions made by senior practitioners (Cosby & Croskerry, 2004). Cosby and

Croskerry (2004) also reference the military culture and discuss some techniques the military uses to reduce, or flatten, its hierarchical system. One example they cite is the *foreign object damage* walk (i.e., FOD walkdown) occurring daily on an aircraft carrier. All personnel, regardless of rank, are required to participate in these FOD walkdowns, thereby reinforcing the value that safety takes precedence over rank (this author has participated in many such FOD walkdowns and can verify their dual purpose of preventing FOD damage and reinforcing cultural values) (Cosby & Croskerry, 2004). Bromiley (2012) also discusses the adverse impact authority gradients seem to have in the medical profession by highlighting a well-known, but seldom discussed, fact that within the British health care system, there exists a hierarchical system with authority gradients between and within the professions and staff. He goes on the state, “the negative effects of powerful established hierarchies continually impede optimal team performance…seemingly on a daily basis” (p. 38).

Gaps in the Literature

Helmreich et al. (1999) observed “slippage in acceptance of basic [CRM] concepts, even with recurrent training” (p. 24). This important observation identifies a potential reason why the industry continues to see teamwork errors and a lack of subordinate assertiveness years after the introduction of CRM training. As recent as 2009 and 2014, there have been accidents where many of the same individual and team errors determined causal in the seminal accidents of the late 1970s and early 1980s have been documented by the NTSB (NTSB, 2011a; 2014a; 2014b). Little research has been conducted into the reasons for this slippage or how best to prevent this slippage away from the use of CRM’s best practices. Additionally, no recent research was discovered designed to investigate why, after 20 years of CRM training, there continue to be events where one pilot fails to either recognize or correct the errors made by another pilot.

Despite the findings of Alkov et al. (1992), further research into whether rank differentials impact flight safety has not been conducted by the aviation research community. It is also worthy to note that both Edwards' identification of the TAG construct and the Alkov et al. studies are 44 and 27 years old, respectively. While the TAG construct is not new, only one attempt to research its effect within the context of the multi-crew aviation flight deck was identified during this literature review.

Theoretical Framework

The discussion of culture, authority, organizational structure, and the history of CRM provide evidence of a potential relationship between COF, subordinate behavior, and flight safety. The COF present in most major commercial air carriers is one with a strong hierarchical structure based upon a numerical seniority system (Gann, 1961; Hopkins, 1982). Ginnett (1993) and Prince et al. (2010) found that hierarchies, authority gradients, and perceived experience levels impacted subordinate behavior. An NTSB (1994) study found that tactical decisions and monitoring / challenging errors were two of nine recurring errors in aircraft accidents, findings that were confirmed by Dismukes et al. (2007) in a subsequent study of the same data. Monitoring / challenging errors were defined as "failing to monitor and / or challenge faulty action or inaction … by another crewmember" (Dismukes et al., 2007, p. 286).

Thus, there exists a body of research indicating that organizational issues, authority, and hierarchical environments may impact subordinate behavior with a potential impact on flight safety. The proposed research is specifically designed to determine whether pilot perceptions are consistent with these research findings. If pilot perceptions are that a flatter, less hierarchical organization structure can improve safety by improving the behavior of subordinate pilots, then the basis for further studies using experimental techniques may be warranted.

Milanovich et al. (1998) identified *status generalization* as a potential theory to explain why subordinate crewmembers fail to identify captain errors. They observed that typical captain-FO interactions reflected behaviors observed within status-differentiated positions. The key factor in establishing these status-based behaviors is that the airplane flight deck is characterized by a rigid hierarchical structure where the member's position is easily identified (Milanovich et al., 1998). Status generalization theory includes two broad principles: (a) "higher status individuals are more likely to exhibit superordinate behavior, including a tendency to reject inputs from lower-status group members", and (b) "lower status individuals are more likely to exhibit subordinate behavior, including hesitancy to question or challenge the actions of higher status team members" (p. 160). This theory is strongly supported by the behaviors displayed in the seminal mishaps reviewed earlier. Research conducted in the 1950s on U.S. Air Force bomber crews identified that this behavioral pattern existed not only in aircrew related decisions but in off-duty activities (Torrance, 1955).

Summary

Although the typical modern commercial aircraft flight deck consists of only two people, it remains a complex environment where several human factor elements simultaneously interact (Helmreich, 1990). The interaction of these factors in the two-person flight deck takes place within a hierarchy where authority to govern the actions of the crew rests primarily with one person, the captain. How effectively this authority is exercised may have a tremendous impact on flight safety because of the impact it may have on subordinate behavior (Ginnett, 1993; Prince et al., 2010). Research into authority highlights the dangers of excessive use of authority, and there is a tendency for those vested with authority to abuse it (Figgis & Laurence, 1907). This is not a new concept; it was John Dalberg-Acton (a.k.a. Lord Acton) who, in 1887, stated, “Power tends to corrupt, absolute power corrupts absolutely” (Figgis & Laurence, 1907, p. 504). In certain situations, there are clear advantages to giving individuals authority and the power to use that authority. Edwards (1975), in his discussion of TAG, asserted that the optimum TAG is one that slopes to the left, although he does not elaborate beyond this statement other than to state that a TAG too flat or too steep can prevent effective teamwork (Alkov et al., 1992). The question is not whether clear lines of authority can be a strength, particularly in time-critical and life-threatening situations, but how best to control the use of authority in situations that are not time-critical or life-threatening. Again, this challenge is not new. In the Federalist Papers, James Madison wrote one of the more eloquent passages in political thought:

> If men were angels, no government would be necessary. If angels were to govern men, neither external nor internal controls on government would be necessary. In framing a government which is to be administered by men over men, the great difficulty lies in this: you must first enable the government to control the governed; and in the next place oblige it to control itself. (Madison, 1788)

In Madison’s quote lies the heart of the matter. He points out that, when designing a government, the structure of the thing matters. The structure can provide a limit on the natural tendency toward the abuse of power, or it can encourage the abuse of power by allowing abuses to be unchecked by other sources of power.

The flight deck is a work environment, but, because more than one person is involved, it is an environment where power and authority issues are projected. As Madison and others suggest, designing a system that balances these issues is no small task. However, how best to accomplish this task has not been fully investigated by the aviation research community. The lack of research into organizational structure, and the resulting behavior of subordinates in different organizational structures, is a gap in the body of knowledge that should be investigated. A potential step in the attempt to fill this gap is to survey commercial pilots about whether they believe different COFs can offer improvements in flight safety.

Chapter III: Methodology

The objective of this research was to measure COF's impact on pilot perceptions of flight safety and subordinate behavior. This type of data is best obtained by querying pilots via targeted and structured questions (Vogt et al., 2012). Therefore, a quantitative research design which employed a self-administered online survey was used.

Research Method Selection

Vogt et al. (2012) recommend a survey research design when the following conditions are satisfied:

- the desired data is best obtained directly from the respondents,
- data can be obtained by answers to structured questions,
- respondents can be expected to give reliable information, and
- an adequate response rate is expected.

A quantitative-survey research design which employed a self-administered online survey was appropriate for the following reasons: (a) the respondents were well educated (i.e., able to read), (b) it was desired that each respondent receive identical questions, (c) the research was limited by time and financial resources, (d) there was no need to know the identity of the respondents, and (e) use of online techniques reduced the risk of COVID-19 exposure to researchers and respondents (Vogt et al., 2012). Finally, the survey utilized structured close-ended questions. Twenty-four questions asked pilots to rate their perception of which COF was more likely to result in improved flight safety or subordinate pilot behavior utilizing a 11-point Likert scale. The Likert format is especially effective for measuring respondent's perceptions of two different practices, the type of data this research was designed to collect (Vogt et al., 2012). Three questions asked respondents to choose which COF would be more likely to result in improved FO/SIC behavior from four categorical choices: (a) CAPT-CAPT, (b) CAPT-FO, (c) COF will have no impact on FO/SIC behavior, and (d) they are not certain of the impact of COF on FO/SIC behavior. A copy of the entire survey is provided in Appendix B.

Population/Sample

The population of inference for the study was pilots with a commercial or airline transport pilot certificate. The target population was active commercial and airline transport pilots who were currently employed as pilots or had been employed as a pilot within the preceding 12 months. According to the Federal Aviation Administration's U.S. Civil Airman Statistics database, the combined total of active commercial and airline transport pilots in the United States in 2019 was 255,340 (FAA, 2020). Due to the certification requirements for both transport category aircraft and commercial air carriers, a large percentage of aircraft conducting scheduled air carrier flight operations are designed for multi-pilot crews (Composition of flight crew, 14 CFR § 121.385, 1996). Therefore, pilots in the targeted population had experience in the multi-pilot crew environment to reference when answering questions about their perceptions of how COF may impact flight safety and subordinate behavior.

The population was limited to currently employed pilots to ensure the pilots surveyed had a recent frame of reference to draw upon when providing their perceptions of COF. Because of the recent COVID-19 global pandemic and the resulting economic downturn, the target population included pilots employed within the preceding 12 months to capture recently furloughed pilots. Furloughed pilots typically are those with the least amount of time with their employer (frequently referred to as *low occupational seniority*)

(Levine-Weinberg, 2020). In the contraction which resulted from the economic impact of COVID-19 pandemic, if the target population only included currently employed pilots excluding recently furloughed pilots, the results could be skewed toward the perceptions of more senior and experienced pilots.

Population and Sampling Frame

Babbie (2013) defines sampling frame as the list from which a sample is selected. For this research, the sampling frame included the following lists:

- Curt Lewis & Associates database of registered pilots,
- Pilots who are members of NBAA through requests for participation on the organizations pilot and safety forums,
- Future and Active Pilot Advisors (FAPA) registered members, and
- online forums associated with pilot associations from different industry sectors.

The sampling frame was designed to expose the survey to both commercial and airline transport pilots. Curt Lewis provided access to a database of pilot names and email addresses that is actively maintained by a commercial marketing enterprise. This database has been used in two recently completed research studies involving pilots (Techau, 2018; Vance, 2014). It was anticipated that this list provided broad coverage of all certificated pilots in the United States. NBAA is a trade association which represents pilots employed in the business aviation sector. FAPA is a service company specifically targeting young commercial pilots. It provides job counseling services, interview preparation services, and symposiums where pilots and employers can meet and network. Lastly, the plan utilized online forums associated with pilot associations from different industry sectors, including a U.S. airline pilot association representing 18,550 pilots (American Airlines active pilots, 2020), and online commercial forum sites designed to facilitate networking and exchange of information between professional pilots. The sampling frame was designed to provide exposure of the online survey to a broad range of commercial and airline transport-rated pilots.

Sample Size

Statistical analysis of the data utilized multiple analysis techniques, including: (a) *t*-test, (b) ANOVA, (c) ANCOVA, and (d) Chi-square tests of independence. The minimum sample size for *t*-test, ANOVA, ANCOVA, and Chi-square tests of independence were computed using the G*Power software application and are provided in Figures 10, 11, 12, and 13.

Figure 10

*G*Power Analysis for t-Test to Determine the Difference Between Two Means*

t tests –	Means: Difference between two dependent means (matched pairs)		
Analysis:	A priori: Compute required sample size		
Input:	Tail(s)	=	One
	Effect size dz	=	0.5
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
Output:	Noncentrality parameter δ	=	3.3541020
	Critical t	=	1.6802300
	Df	=	44
	Total sample size	=	45
	Actual power	=	0.9512400

Figure 11

*G*Power Analysis for ANOVA to Determine the Difference Between Means*

F tests –	ANOVA: Repeated measures, within–between interaction		
Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.25
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
	Number of groups	=	2
	Number of measurements	=	4
	Corr among rep measures	=	0.5
	Nonsphericity correction ϵ	=	1
Output:	Noncentrality parameter λ	=	18.0000000
	Critical F	=	2.6937209
	Numerator df	=	3.0000000
	Denominator df	=	102
	Total sample size	=	36
	Actual power	=	0.9517650

Figure 12

*G*Power Analysis for ANCOVA to Determine the Impact of a Covariate on the Dependent Variable*

F tests –	ANCOVA: Fixed effects, main effects and interactions		
Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	0.25
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
	Numerator df	=	2
	Number of groups	=	2
	Number of covariates	=	1
Output:	Noncentrality parameter λ	=	15.6875000
	Critical F	=	3.0322126
	Denominator df	=	248
	Total sample size	=	251
	Actual power	=	0.9507037

Figure 13

*G*Power Analysis for Chi-Square Test of Independence*

χ^2 tests – Variance: Difference from constant

Analysis:	A priori: Compute required sample size		
Input:	Tail(s)	=	One
	Ratio var1/var0	=	1.5
	α err prob	=	0.05
	Power (1–β err prob)	=	0.95
Output:	Lower critical χ^2	=	160.9148
	Upper critical χ^2	=	160.9148
	Df	=	133
	Total sample size	=	134
	Actual power	=	0.9505880

Pilot experience was included in this initial study of COF's impact because of the impact it can have on both the qualifications a pilot may have obtained (CAPT or FO) and on their willingness to embrace a new organizational framework. Therefore, the survey collects data on pilot experience at three levels: (a) total pilot hours, (b) PIC hours, and (c) SIC hours. These three items provided data on pilot experience, and total pilot hours was used in an ANCOVA to control for the contribution of pilot experience on pilot perceptions of COF.

Based upon the above discussion, the minimum sample size for this investigation was planned to be 300 respondents. This value exceeded the minimum sample size of 251 respondents recommended by the G*Power program (see Figure 12) for the ANCOVA analysis.

The sampling frame was delimited to include only commercial and airline transport pilots who were currently employed or had been employed as a pilot within the preceding 12 months. Question 8 of the survey asked respondents to answer yes or no to whether they were currently employed or had been employed in the preceding 12 months as a pilot. If respondents replied no to this question, they could complete sections A and B of the survey, were thanked for their participation, and exited from the survey without allowing them to complete section C. The survey utilized this design to both enforce the delimitation on pilot employment and mask that respondents were exited from the survey before completing section C, the section where questions related to the research questions were asked.

Sampling Strategy

Babbie (2013) outlines two major sampling methodologies: probability and nonprobability sampling. While probability sampling remains the primary method for selecting representative samples, its use may not be possible in certain situations (Babbie, 2013). In these situations, Babbie states that nonprobability sampling is acceptable, but researchers must acknowledge the limitations on generalization. A partial list of nonprobability sampling techniques includes: (a) expert selection, (b) volunteer sampling, (c)) self-selection web surveys, and (d) network, or snowball sampling (Wolf et al., 2016). Wolfe et al. also outline the potential advantages of online panels (sometimes referred to as an access panel) as increasing access to populations considered inaccessible and significantly lowering the cost and complexity of survey research. They also list other advantages of non-probability sampling which, with respect to online panels, include: (a) improved response rates, (b) potentially enhanced coverage, (c) elimination of selection bias, (d) multiple modes of delivery (d) lower costs, and (e) reduced time requirements. To mitigate the effect nonprobability sampling may have had on external validity, multiple sampling frames were used to cover both a broad base of commercial and airline-transport rated pilots while also specifically targeting pilot groups who may have had different perceptions of COF. Specifically, survey responses were solicited from: (a) Curt Lewis & Associates database of registered pilots, (b) an online pilot forum for business/corporate pilots hosted by the National Business Aircraft, (c) the Future and Active Pilot Advisors (FAPA) newsletter and annual symposium conference, and (d) access to online forums associated with pilot associations from different industry sectors. This sampling strategy was designed to expose the online survey to a broad range of commercial and airline transport-rated pilots. The relatively large sample size, multiple sampling strategies (self-sampling and snowball-network sampling), and the use of multiple sampling frames were designed to mitigate the threat nonprobability sampling techniques posed to external validity.

Data Collection Process

Due to time and cost limitations, nonprobability sampling techniques utilizing online panels were used. Specifically, participants were solicited to complete an online survey using the following techniques:

- self-selection sampling via email solicitation using the Curt Lewis & Associates' direct marketing database,
- self-selection sampling via requests for participation on an online pilot forum for business/corporate pilots hosted by the National Business Aircraft,
- self-selection sampling via email solicitation with members of the FAPA, and,

- self-selection sampling via requests for participation placed on pilot forums specialized in facilitating networking between pilots from different industry sectors.

The survey was entered into the Survey Monkey online software platform. Survey Monkey hosted the survey, making it available to all participants who entered the survey's URL address. Survey Monkey provided a layer of privacy for participants, as required by Embry-Riddle Aeronautical University (ERAU) Institutional Research Board (IRB) requirements; no personally identifiable data were collected by the research team. Respondents accessed the survey via a URL provided in the solicitation contact. Survey response data were available on and downloadable from the Survey Monkey website. Preliminary data analysis began once the minimum number of respondents was obtained, but the final analysis included all qualified responses received prior to the closure of the data collection websites. The data collection window remained open for four weeks.

Design and Procedures

This research was designed to investigate active commercial and airline transport pilot's perceptions of how different COFs impact subordinate behavior and overall safety in six flight safety related areas:

- flight deck teamwork,
- intra-fight deck communication,
- overall flight safety,
- likelihood of FO/SIC correcting CAPT/PIC errors,
- likelihood of FO/SIC enforcing CAPT/PIC compliance with SOPs, and
- likelihood of FO/SIC interjecting to ensure safety of flight.

Two COFs were introduced: (a) the traditional CAPT-FO framework almost universally used in most of the commercial airline industry, and (b) the CAPT-CAPT framework more prevalent in business and corporate aviation and military aviation. A survey was used to ask commercial pilots their perceptions of how these two COFs impact crew performance in the six areas listed above. Because of the explorative nature of this investigation, there was no theoretical model or existing survey suitable for modification or use. Therefore, a new survey was created for this research and is provided in Appendix B.

Once all approvals were received, a pilot study was conducted to assess the effectiveness of the survey and the data analysis techniques. Once the survey demonstrated acceptable performance, the research moved to the data collection phase.

Because the research involved collecting data from human participants, an application was submitted to the ERAU IRB. No data were collected until the proposal was approved by the ERAU dissertation committee, ERAU School of Graduate Studies reviewers, and the ERAU IRB. The final IRB approved informed consent statement was provided to respondents via the survey, and respondents could only access the survey following their review of the informed consent statement and affirming their intent to continue to the survey. The final informed consent statement is provided in Appendix D.

Participants who completed the survey were provided the opportunity to enter a random drawing for one of three participation rewards: a $300, $150, or $50 gift card. A separate link was provided to allow respondents to enter personally identifiable information for use in determining and notifying reward winners. The random drawing utilized three randomly generated numbers from a list of numbers equal to the number of participants entered in the drawing. There was no ability to associate names entered on the participation reward website with responses provided via the survey site. Survey Monkey also hosted the random drawing website.

Sources of the Data

Data was collected from the target population via an online survey utilizing nonprobability sampling. As described earlier, lists from industry and trade associations, pilot associations serving present and future commercial and airline transport pilots, and contacts made through on-line pilot forums were used to solicit participation. The dependent variable was respondent perceptions as reflected through answers to survey questions. A copy of the online survey is provided in Appendix B.

Ethical Consideration

The survey design involved human participants, which required the participants to be treated in accordance with established ethical standards. Vogt et al. (2012) state that these ethical standards should include consideration in at least three areas: (a) consent, (b) harm, and (c) privacy. To ensure compliance with ethical standards, the following procedures were utilized:

- all participants were provided a consent form for review prior to completing the online survey. The consent form is provided in Appendix D,
- all involvement with the research was voluntary; participants could exit the website at any time, and
- no personally identifiable information was collected by the research team.

The research plan was submitted to the ERAU IRB, and approval was obtained prior to data collection. The IRB request and approval is included in Appendix C.

This researcher's prior involvement in this area of investigation is limited to attempts to execute an experimental research design to investigate subordinate behavior in different COFs. This research plan was interrupted by closure of the ERAU campus during the COVID-19 pandemic and the resulting inability to execute an experimental research design utilizing human subjects within program time constraints.

Measurement Instrument

Because of the explorative nature of the proposed investigation, there was no theoretical model or existing survey suitable for modification and use. Therefore, a new survey was created and is provided in Appendix B. The survey was divided into three sections. Section A collected basic demographic and pilot experience data including (a) age, (b) gender, (c) pilot certificates currently held, (d) total flight time, (e) recency of flight experience, (f) PIC flight hours, and (g) SIC flight hours. Section B collected data on pilot employment including (a) employment status, (b) industry sector where currently employed, (c) present and past type of pilot operations performed, (d) present and past pilot qualifications obtained, and (e) the type of COF used by present and past employers. Survey Question 8, the question on employment status, was used to screen pilots based upon whether the respondent was in the target population. This question asked whether the respondent was currently employed or had been employed within the preceding 12 months. If they answered no to Question 8, they were allowed to answer the remaining questions in section B but were exited from the survey without gaining access to section C. If they answered yes to Question 8, they completed section B and were allowed to continue to section C. Demographic and employment data received from respondents who completed sections A and B of the survey were retained but not used in the analysis.

Section C of the survey contained 27 questions where the research questions were operationalized. These questions asked for the respondent's perceptions of the impact COF had on the following safety and crew performance markers:

- flight deck teamwork,
- intra-flight deck communication,
- overall flight safety,
- likelihood of FO/SIC correcting CAPT/PIC errors,
- likelihood of FO/SIC enforcing CAPT/PIC compliance with SOPs, and
- likelihood of FO/SIC interjecting to ensure safety of flight.

The first three markers focus on perceptions of how COF impacts key flight safety related parameters, and the latter three focus on the perception of how COF might impact FO/SIC behavior. Four questions were asked for each of the flight safety related markers, and five questions were asked for each of the FO/SIC behavior markers.

Survey bias refers to any property of the survey questions that encourages a particular response (Babbie, 2013). For each of the flight safety related markers, two matched-pairs questions were used. Within the matched pairs, the wording of the questions was identical except for the type of COF specified, CAPT-CAPT or CAPT-FO. This same pattern was followed for the questions related to subordinate behavior, with two matched-pairs questions, as described above.

Asking the same question twice, once with the CAPT-CAPT COF and another with the CAPT-FO COF, not only reduced survey bias but also provided increased data accuracy and better assessment of reliability and validity. Hair et al. (2015) state that composite scores representing the combination of multiple items are more accurate in representing core constructs than single response measures. Similarly, Techau (2018) employed the Unified Theory of Acceptance and Use of Technology (UTAUT2) theoretical model, which used multiple questions, each worded slightly differently, to allow for measurements of both respondent and instrument reliability through analysis of item-to-total and inter-item correlations. In addition to the matched-pair design, an additional question was added for each of the three question groups related to subordinate pilot behavior which directly asked for the respondent's perception about which COF would likely improve FO/SIC behavior. The questions asked in the survey are available in Appendix B.

The independent variable, COF, was operationalized via the questions asked in the survey. All but three of the questions in section C of the survey asked pilots to record their perceptions of COF on a 11-point Likert scale. While Likert type data is ordinal data when analyzed singularly, the analysis averaged participant responses across all six-flight safety and crew performance markers and within each of the six separate markers. These averaged values produced composite values representing pilot perceptions, thereby producing Likert Scale data for the purposes of data analysis (Boone, Jr. & Boone, 2012). An additional three questions not employing a 11-point Likert scale asked respondents to choose which COF would more likely result in improved FO/SIC behavior from four categorical choices: (a) CAPT-CAPT, (b) CAPT-FO, (c) COF will have no impact on FO/SIC behavior, and (d) they are not certain of the impact of COF on FO/SIC behavior. An expanded discussion on data treatment will be provided in a subsequent paragraph.

Variables and Scales

The independent variable, COF, was operationally defined as the combination of choices made by an aircraft operator independently or in combination with pilots regarding how positional assignments and flight deck duties are made and how the carrier choses to differentiate between these positional assignments. The variable was operationalized at two levels, CAPT-CAPT and CAPT-FO.

The COF almost universally present in the commercial airline sector has positional assignments fixed between captains who seldom if ever function in any capacity other than PIC, and FOs who seldom if ever function other than as SIC. This structure is reinforced by giving approximately half of a company's pilots the title and qualification of CAPT/PIC, with the other half not qualified as CAPT/PIC and therefore only able to function as a FO/SIC. The airline sector's organizational framework is further reinforced by establishing uniform standards which differentiate captains with four stripes on their uniform rank insignia and FOs with three stripes. The COF dominant in the airline sector has been operationally defined as the CAPT-FO framework.

A COF frequently employed outside the airline sector allows pilots who have obtained the requisite experience and meet required performance standards to be designated as captain and function as PIC, regardless of the numbers of pilots who have previously qualified as CAPT/PIC. Pilots who have obtained the captain qualification can occupy either seat and function as either a PIC or SIC, with the duties and authorities associated with the CAPT/PIC position rotated between all pilots who have obtained the qualification. This COF has been operationally defined as the CAPT-CAPT framework.

The CAPT-FO and CAPT-CAPT structures represent the two levels of the independent variable. The independent variable was operationalized by asking pilots their perceptions of how these two COFs impact a range of six safety and crew effectiveness parameters. Pilot perceptions was the dependent variable.

Data Analysis Approach

Statistical analysis of the survey data utilized multiple techniques, including: (a) *t*-test, (b) ANOVA, (c) ANCOVA, and (d) Chi-square tests of independence. For the analysis of pilot perceptions on the impact of COF, participant responses were entered into MS Excel and IBM SPSS software. Responses were averaged for all levels of the six-flight safety and crew performance markers producing composite values between the two levels of COF. While individual Likert data is considered ordinal data, when combined into composite scores of three or more data points, they can be considered scaler in nature and analyzed using parametric techniques (Boone, Jr. & Boone, 2012). With 261 respondents providing usable data, the Likert data satisfied the requirement to be classified as Likert Scale data and were analyzed using parametric techniques. Prior to any parametric analysis, the data was plotted and visually examined for normality and, where needed, transformed to achieve normality before parametric techniques were employed. The *t*-test is an appropriate parametric technique for measuring the difference between two means with a single dependent variable and therefore was used to compare pilot responses for all six-flight safety and crew performance markers.

The potential for confounding variables which could impact the dependent variable was considered. While several factors were considered as potential confounds, only one was considered significant enough to warrant investigation during this study of

COF: pilot experience. Pilot experience was assessed as worthy because of the impact it potentially had on both the qualifications a pilot may have obtained (CAPT or FO) and their willingness to embrace a new organizational framework. Dent and Powley (2003) argue that resistance to change is a perfectly rational response when change could be characterized as a loss. The experienced pilot who has risen to captain in the CAPT-FO framework may assess a new organizational framework where authority and status are shared more equally, as in the CAPT-CAPT COF, as a potential loss, and this perceived loss may impact pilot perceptions of COF. Therefore, the survey collected data on pilot experience at three levels: (a) total pilot hours, (b) PIC hours, and (c) SIC hours. These three items provided data on pilot experience, and total pilot hours was used in an ANCOVA to control for the contribution of pilot experience on pilot perceptions of COF.

Pilot Study

Because no prior research investigating COF was found, a survey was created specifically for this investigation. Therefore, a limited pilot study was conducted to test the effectiveness of the instrument, respondents' understanding of the COF construct, and their understanding of the survey questions. Additionally, the results of the pilot study were used to verify the suitability of the Survey Monkey data collection system and the effectiveness of the resulting data in answering the research questions.

Pilot Study Data Collection. Once IRB approval was granted, a limited scale pilot study began. The pilot study was conducted exclusively through email contacts with pilot colleagues of the lead researcher. Fifteen emails containing an invitation to participate were sent out to current professional pilots, which included a link to the Survey Monkey pilot study website. These email solicitations were followed up with phone or in person contacts asking for the pilot's participation. The 15 invitees were chosen to provide a range of pilot experience to include: (a) pilots with corporate aviation experience, (b) pilots from the major airline industry, (c) pilots from the regional airline industry, and (d) pilots with a military background. All but one invitee agreed to complete the pilot study survey; however, only 10 responses were received.

Once the pilot study surveys were completed, a call or in person visit was made with each respondent. Four questions were asked: (a) how long it took to complete the survey, (b) were there any problems either with the survey or the Survey Monkey website, (c) were the COF constructs and related questions clear and understandable, and (d) were there any additional comments.

Pilot Study Data Preparation. Pilot study data was downloaded from the Survey Monkey website in both .xls and .sav formats for use in Microsoft Excel and IBM SPSS software, respectively. The downloaded data required extensive cleaning to make it suitable for analysis in either software. Raw data downloaded from Survey Monkey included the survey question as a header with no formatting codes, resulting in columns of excessive width. Editing the data for format was completed in Excel, and the Excel files were then imported into SPSS. There were no missing data in the pilot study.

Main Study

The following paragraphs provide a detailed account of the data collection process, including where the process differed from the plan specified in the research proposal used to conduct this research. In general, the proposed collection plan was executed but with minor changes required by real world exigencies.

Main Study Data Collection. Data were collected using the nonprobability sampling techniques specified in the Methodology chapter of this document. Specifically, this sampling plan included utilizing the following organizations and website forums:

- Curt Lewis & Associates database of registered pilots,
- NBAA newsletter and email contact lists,
- Future and Active Pilot Advisors (FAPA) registered members, and
- online forums associated with the pilot association for a major air carrier.
    - Airliners.net,
    - Airlinepilotcentral,
    - JetCareers,
    - ProPilotWorld,
    - PilotsofAmerica.

The combination of these efforts resulted in obtaining 420 total and 231 usable responses by the end of the third week of data collection. The survey sites were closed at the end of the fourth week with 450 total and 261 usable responses. The survey itself was designed to screen out pilots who were not actively employed, and the combination of the survey screening process and currently employed pilots choosing not to provide section C data resulted in only 262 respondents, 58.0% of the 450 total respondents, completing all three survey sections. Of the 188 respondents providing unusable data, 83 respondents, 44.1%, were screened by the survey itself as not currently employed in the industry, and 105, or 55.9%, were currently employed pilots who chose not to complete the entire survey. The resulting sources of the data, solicitation techniques, and targeted demographic and industry sectors are provided in Table 3.

Table 3

Sources of Data and Collection Techniques

Source of Data	Solicitation Technique	Demographic/Industry Sector
NBAA	Pilot forum postings	Business/corporate aviation
Curt Lewis Associates	Email/newsletter	Professional pilots/safety specialists
FAPA	Email/newsletter/social media	Entry level/younger pilots
Airline Pilot Association	Pilot forum postings	Air carrier/unionized/experienced pilots
Web-based Pilot Forums	Pilot forum postings	Broad range of pilots

While the sampling technique was non-probabilistic in nature, the sources of data were intended to target specific pilot groups to obtain a sample of pilots representing the population of commercial and airline-transport rated pilots. Where possible, the demographics of the sample will be compared to FAA supplied industry population data as a measure of the success of this sampling strategy.

Initial Contacts and Forum Posts. The first step in the data collection process began with email communications with Dr. Curt Lewis of Curt Lewis Associates. As discussed during the research design phase of the study, Dr. Lewis added a section to his aviation safety newsletter requesting participation from subscribers.

During the research design process, email and phone communications were made with the NBAA requesting their support as a technique to increase corporate and business pilot participation in the study. Tentative agreements were thought to be received to use the NBAA monthly magazine, Business Aviation Insider, and their daily email newsletter, Insider Daily, to request member participation. However, when follow up contacts were made to implement the plan, it became apparent that, for business reasons, the magazine and daily newsletter would not be available. Despite this initial setback, NBAA remained supportive and subsequently agreed to provide access to their popular Air Mail social network and web-based forums in exchange for purchasing an NBAA membership. These forums proved extremely valuable in obtaining participants, producing 146 total responses and 85 usable responses, 32.4% and 32.6% of the total and usable responses, respectively. NBAA did add an additional restriction that no postings on their forums could offer compensation or monetary awards for participation. Therefore, the participation awards were not mentioned on the NBAA forum postings.

A similar unexpected complication occurred with the FAPA organization. As with NBAA, communications were made during the research design process that indicated their willingness to provide support as a technique to increase the number of less experienced or entry level pilots participating in the study. However, when contacted to execute the research design, they requested the lead researcher contact higher level members of the company to obtain additional permissions. Ultimately discussions with the Chief Executive Officer and Director of Marketing resulted in an agreement where FAPA would provide support via their newsletter and social media presence in exchange for the lead researcher's participation in upcoming Future Pilot seminars.

Initial use of the online pilot forum for a major airline's pilot association also began immediately after receiving approvals to conduct research. Postings were placed on the pilot general discussion board. An example of an online forum posting is provided in Appendix E. No unexpected complications were associated with this forum posting.

Additional Forum Postings. Two weeks after the data collection process began, Survey Monkey participation data indicated that pilot participation had slowed, with two days near the end of this two-week period with no new survey completions. The total number of usable responses received at the end of the second week was 131, just over half the minimum required 251 usable responses. To address the decreasing response rate and shortage of usable data, the third week of data collection began with follow up postings placed on the NBAA Air Mail and major airline pilot association forums informing members that the survey would be closing soon and again requesting participation. Additionally, the list of pilot forums was expanded to include the following web-based forum sites:

- Airliners.net,
- Airlinepilotcentral,
- JetCareers,
- ProPilotWorld,
- PilotsofAmerica, and
- PPRuNE.

These additional sites were chosen based upon two criteria: (a) the number of pilots participating in the forums, and (b) whether they were managed forums, which ensured members were professional pilots. These web-based pilot forums also employed forum administrators who monitored forum content and protected the sites from online marketers or malicious actors. Therefore, prior to posting any requests for participation, the administrators were contacted and provided the proposed posting for approval. Airliners.net restricted postings to their "*travel, polls, and preferences*" forum, and PPRuNE denied the request to post any information related to the survey. All other sites approved the requests. Simultaneously with the expanded use of the pilot forums, both the Curt Lewis and FAPA newsletters were published with the requests for support.

Main Study Data Preparation. Main study data were downloaded from the Survey Monkey website in both Microsoft Excel and IBM SPSS formats. As in the pilot study, considerable time was needed to format the data to make the data file user friendly and to allow for the full capabilities of the SPSS software during data analysis. In the case of categorical questions and responses, Survey Monkey downloaded each categorical response into separate columns, one column for each response. In preparation for analysis, these data were combined into one column, and a numeric coding variable was assigned to each response option. For example, for the question, "what pilot certificate and class ratings do you currently hold", the following coding variables were created: (a) 1=commercial pilot single-engine, (b) 2=commercial pilot multi-engine, (c) 3=airline-transport pilot single-engine, (d) 4=airline-transport pilot multi-engine, and (d) 5=other. These coding variables were entered into the Values column of the SPSS Data Editor, and the responses were recoded into the above numeric values in the SPSS data file. This process was repeated for all categorical data.

There were numerous cases where respondents added non-numeric characters to open-ended responses that were intended to provide numeric data (flight hours, age, etc.), thereby transforming it into nominal data. For example, when responding to the open-ended question of, "please provide your total flight time," 16 participants provided non-numerical responses by adding a + to indicate that actual flight time was more than the given value, or the words "approximately" or "hours" to better describe the nature of their responses. These data were changed to numerical values by eliminating the superfluous characters. No such data editing was required for section C data, where close-ended responses were employed.

Reliability Assessment Method

The research design improved reliability by using the following methods: (a) incorporating a pilot study into the design to test for instrument inconsistency, (b) operationalizing the independent variables into multiple questions to allow for analysis of differences in participant responses within each of the repeated questions, and (c) the use of a survey which provided consistency in both question content and delivery mode (Babbie, 2013). Techau (2018) found composite scores representing the combination of multiple items to be more accurate in representing core constructs than single response measures while also providing measurements of both respondent and instrument reliability through analysis of item-to-total and inter-item correlations. Additionally, Hair et al. (2015) recommend performing a post hoc measure of reliability, utilizing a split-half reliability test. A post hoc analysis using Cronbach's alpha was performed using IBM SPSS software.

Validity Assessment Method

Internal validity was improved using the same methodologies designed to improve reliability, including a pilot study and use of an online survey to increase delivery consistency in both question content and mode. Survey bias is a potential threat to internal validity (Babbie, 2013), and two matched-pairs questions were used to reduce survey bias. Within the matched pairs, the wording of the questions was identical except for the type of COF specified, CAPT-CAPT or CAPT-FO. Asking the same question twice, once with the CAPT-CAPT COF and another with the CAPT-FO COF, reduced survey bias, increased validity, and provided a better assessment of reliability (Hair et al., 2015).

The potential impact of confounding variables posed a threat to internal validity. The operational definition of COF aggregates the combination of choices made by an aircraft operator independently, or in combination with pilots, regarding how positional assignments and flight deck duties are made, but it does not include variations within the individual pilot's background and experience. As discussed earlier, the experienced pilot who has risen to captain in the CAPT-FO framework may assess a new organizational framework where authority and status are shared more equally as a potential loss, and this perceived loss may have impacted pilot perceptions of COF (Dent & Powley, 2003). To address this potential threat to internal validity, data on pilot experience were collected and an ANCOVA performed to control for the contribution of pilot experience on pilot perceptions of COF.

Creswell (2014) provides a list of potential threats to external validity that should be considered. The primary threat to external validity in this study was the nonprobability sampling strategy employed. To mitigate the effect of nonprobability sampling, the sampling frame was designed to cover both a broad base of commercial and airline-transport rated pilots while also specifically targeting pilot groups who may have different perceptions of COF. The sampling strategy included lists from industry and trade associations, pilot associations serving present and future commercial and airline transport pilots, and contacts made through networking efforts. This sampling strategy was designed to provide exposure of the online survey to a broad range of commercial and airline transport-rated pilots. The relatively large sample size, multiple sampling strategies (self-sampling and snowball-network sampling), and the use of multiple sampling frames were designed to mitigate the threat nonprobability sampling techniques posed to external validity. However, it is recognized that these strategies only mitigated this threat; they did not eliminate it. The results of the study are reported with the recognition that this threat was mitigated but likely not eliminated.

Data Analysis Process/Hypothesis Testing

Microsoft Excel and IBM SPSS statistical software were used in the data analysis process. The following statistical analysis techniques were used to conduct the null hypothesis statistical testing (NHST): (a) t-test, (b) ANOVA, (c) ANCOVA, and (d) Chi-square tests of independence. As stated in Chapter 1, the null hypothesis testing assumed there were no differences in pilot perceptions of flight safety and crew performance between the two levels of COF. Where data produced a statistically significant difference between pilot perceptions, the null hypothesis was rejected. Any measurable differences with confidence levels greater than 95% ($p < 0.05$) were considered statistically significant.

T-Test Analysis. A *t*-test was used to test for differences in pilot perceptions within each of the six safety and crew performance markers established via the survey. Likert data for each of the two levels of COF were averaged and a t-test used to measure for a statistical difference between the CAPT-CAPT and CAPT-FO COF.

ANOVA. To determine the impact of industry group and current COF, an ANOVA was used to determine whether these two categorical factors impacted pilot perceptions of COF. Microsoft Excel and IBM SPSS software were used to complete the ANOVA analysis.

ANCOVA. To determine the impact of pilot experience as a potentially confounding variable, an ANCOVA was used to control for the contribution of pilot experience on perceptions of COF. Microsoft Excel and IBM SPSS software were used to complete the ANCOVA analysis.

Chi-Square Tests of Independence. Three questions asked the respondent to choose which COF produced improved subordinate behavior. These questions did not utilize the 11-point Likert scale, instead measuring pilot perceptions via four categorical choices: (a) CAPT-CAPT, (b) CAPT-FO, (c) COF will have no impact on FO/SIC behavior, and (d) they are not certain of the impact of COF on FO/SIC behavior. Differences in the responses within these three questions were analyzed using a Chi-squared test for independence. Microsoft Excel and IBM SPSS software were also used to perform these analyses.

Summary

The objective of the research was to measure pilot perceptions on how different COFs impact subordinate behavior and flight safety. A quantitative-survey research design was used which employed a self-administered on-line delivery mode. The survey utilized structured close-ended questions with answers measured on a 11-point Likert scale format on all but three questions. Three questions asked respondents to choose which COF would more likely result in improved FO/SIC behavior from four categorical choices: (a) CAPT-CAPT, (b) CAPT-FO, (c) COF will have no impact on FO/SIC behavior, and (d) they are not certain of the impact of COF on FO/SIC behavior. The population of inference for the study was pilots with a commercial or airline transport certificate, and the target population was active commercial and airline transport pilots who were currently employed as pilots or had been employed as a pilot within the preceding 12 months. Due to time and cost limitations, nonprobability sampling techniques utilizing online panels were used.

Two COFs were introduced: (a) the traditional CAPT-FO framework almost universally used in the commercial airline industry, and (b) the CAPT-CAPT framework which is more prevalent in business and corporate aviation and military aviation. The survey asked respondents their perceptions of how these two different COFs impacted crew performance and flight safety in six different behavioral markers. A pilot study was conducted to assess the survey as well as the effectiveness and appropriateness of the planned data analysis techniques. The CAPT-FO and CAPT-CAPT structures represented the two levels of the independent variable. The independent variable was operationalized by asking pilots their perceptions of how these two COFs impact a range of safety and crew effectiveness parameters. Pilot perceptions were the dependent variable. Any patterns with confidence levels greater than 95% ($p < 0.05$) were considered statistically significant.

Because the proposed research involved collecting data from human participants, an application was submitted to the ERAU IRB. All participants completing the survey were provided the opportunity to enter a random drawing for one of three participation rewards.

Chapter IV: Results

This study investigated commercial and airline transport pilot perceptions of the impact of COF on both flight safety and subordinate pilot behavior. A quantitative research design was used which employed an online survey and non-probability sampling techniques to target commercial and airline transport-rated pilots. There were 450 responses to the online survey. Of this total number, 261 responses, or 58.0% of respondents, provided usable data. The large number of unusable responses was due to: (a)) 83 responders, 18.4% of total responses, who answered no to Question 8 indicating they were not currently employed in the industry and were therefore prevented from completing section C of the survey, and (b) 105 responders, or 23.3% of total responses, were currently employed pilots but who chose not to provide section C data. This chapter will present the results of both the pilot study and main study, the demographic characteristics of the respondents, the descriptive statistics of the data, the results of reliability and validity testing, and the results of hypothesis testing. The results will focus primarily on the research questions and hypotheses posed in Chapter 1, but will, when able, discuss information obtained from the data not related to the research questions.

Pilot Study

Because no prior research investigating COF was found, the survey was created specifically for this investigation. Therefore, a limited pilot study was conducted to test the effectiveness of the instrument, the respondents understanding of the COF construct, and their understanding of the survey questions. Additionally, the results of the pilot study were used to verify the suitability of the Survey Monkey data collection system and the effectiveness of the resulting data in answering the research questions.

Pilot Study Results

Respondents who participated in the pilot study were contacted and interviewed to determine the effectiveness of the survey. No interviewees reported any technical issues with either the survey or the Survey Monkey website. Each interviewee reported that they understood the COF construct as described in the introduction to section C of the survey, the intent of the questions, and how to use the 11-point Likert response scale. Two respondents commented positively on their interest in the concept, and one candidly voiced their objection to the concept and the study, stating that he considered it an "*anti-union*" study. However, the comments about the nature of the study, while considered a foretelling of the study results, were not deemed as an adverse critique of the survey itself.

One comment was received about the repetitive nature of the questions asked. This respondent stated that asking the same question four times with only the wording of the question changed seemed excessively repetitive. However, Techau (2018) reported that the UTAUT2 survey employed a model where the same constructs were asked multiple times using questions worded only slightly differently. Hair et al. (2015) also state that multiple items and responses are a more effective measurement of constructs than single item measures. Therefore, no changes were made to the survey based upon these comments. The repetitiveness would prove a valuable tool when dealing with the limited number of missing data in the main study. Preliminary data analysis was completed using *t*-test, ANOVA, and ANCOVA. However, this analysis was only designed to validate the data collection and analysis processes, so a detailed discussion of the results of this data analysis will not be provided except to state that it confirmed the appropriateness of commencing the main study.

Main Study

The following paragraphs provide detailed information on the results obtained from the main study. It will provide data about the demographics of the sample used in this study, including the gender, age, flight experience, industry in which they are currently employed and in which they have been employed in the past, and their experience with the two types of COFs. Additionally, statistical information on the data collected will be provided.

Missing Data

Missing data will be discussed in two broad categories: missing section C data and other missing data. Of the 450 respondents, 262 respondents provided data in all three sections of the survey. All respondents provided section A and B data, although there were isolated cases of missing data in sections A and B which will be discussed later. If section C data were provided, the data were considered usable; if no section C data were provided, they were considered unusable. Sections A and B of the survey collected demographic and pilot experience data, and section C operationalized the research questions through 27 survey questions. Data provided in sections A and B of the survey could not be utilized unless they were accompanied by section C data. Therefore, data from respondents who provided usable section A and B data but who provided no section C data or had excessive missing section C data were considered unusable data and excluded from the analysis.

Unusable data fell into two broad categories: unusable data from currently employed pilots and from pilots not currently employed. Unusable data from pilots not currently employed were expected and a component of the survey design. Respondents who answered *no* to Survey Question number 8, “are you now or have you been employed as a pilot within the preceding 12 months,” could complete sections A and B of the survey but were exited from it without access to section C. Respondents who answered “yes” to question eight were allowed access to section C.

There were some pilots who were currently employed and allowed access to section C but who chose to voluntarily exit the survey without providing section C data. Table 4 provides a breakdown of data based upon usability and whether the cause of the section C non-response was due to survey design or the respondent’s voluntary choice.

Table 4

Classification of Data Based upon Section C Missing Data

		Unusable Data		
Type of Data	Usable Data	Chose not to Provide Data	Unable to provide data	Total Respondents
Pilots Currently Employed	261	105	0	367
Pilots Not currently employed	0	0	83	83
Total number of respondents				450

While interesting, the reason why pilots did not provide section C data had no impact on data analysis; these data were considered unusable and deleted from the data file prior to analysis.

Within the usable data, there were 23 isolated cases of missing section C data out of a total potential number of 7,047 responses (261 respondents and 27 section C questions), resulting in a 99.7% section C response rate. The 23 cases of missing data came from 14 respondents. Each case of missing section C data was evaluated to determine whether the failure to provide data was the result of inadvertent errors or an explicit intent not to provide data. To be classified as inadvertent, both of the following requirements had to be satisfied: (a) the respondent provided data for the question's matched-pair question, and (b) there were no more than three total instances of missing section C data for that respondent. If both conditions were satisfied, then the respondent's answer for the question's matched pair was used to replace the missing data. One respondent failed to satisfy the above criterion because of five cases of missing section C data. This respondent's data were therefore classified as unusable and excluded from the analysis. Two respondents had three instances of missing data, one respondent had two instances of missing data, and 10 respondents had a single instance of missing section C data. Each of these 13 respondents provided data for the matched-pair question, so their missing data were replaced with the respondent's response for the matched pair.

When unusable data were removed from the analysis, only two cases of missing section A and B data remained, both from section A demographic data. One case of missing data was age data, and the second was gender data. Because of the scaler nature of age data, the missing age data was replaced by the mean value of age for all usable respondents. Because of the nominal and binary nature of gender data, no substitution of gender data was made. The respondent who failed to provide gender data was removed from any analysis involving gender. Once missing data were addressed, all subsequent analyses involved only usable data with the described replacements for missing data.

Demographics Results

The descriptive statistics for the respondents providing usable data are divided into two general categories: respondent demographics and industry/experience data. These two general categories correspond to the data gathered in sections A and B of the survey, respectively. While non-probabilistic sampling techniques were used, the sampling plan attempted to obtain a sample representative of the population of commercial and airline-transport rated pilots by targeting industry sectors comprising that population. The following paragraphs provide summaries of the demographic characteristics of the pilot sample and will, when possible, compare these data to known population data.

Gender

The under-representation of females in the pilot profession was reflected in the study data (FAA, 2020). Table 5 provides a summary of both the number and percentages of respondents by gender and FAA population data for comparison.

Table 5

Gender of Respondents and FAA Population Statistics

Gender	Commercial Pilots		ATP Pilots		Total Pilots	
	n	%	n	%	n	%
Study Participants						
Male	111	98%	252	97%	253	97.3%
Female	2	2%	7	3%	7	2.7%
FAA Population Data						
Male	93825	93%	157444	95%	611825	92.0%
Female	7038	7%	7503	5%	52740	8.0%

Note. [a] FAA population data statistics adapted from 2019 Active Civil Airmen Statistics. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/. [b] N values not additive; pilots can hold multiple pilot certificates.

The sampling strategy did not specifically target female pilots to increase their representation in the sample but instead targeted pilot groups without regard to gender with the expectation that a large sample size would likely produce a representative sample. While female representation in the study sample group did not exactly match the percentages of females in the pilot population, it did generally reflect the gender characteristics of the target population.

Age

FAA age data reports the average age of pilots by the type of certificate they hold. Therefore, to compare the age characteristics of the survey sample to FAA population data, respondent data were grouped by certificates held, and then the average age for each certificate type was calculated. The age characteristics of the sample and the FAA mean age data for both commercial and airline-transport rated pilots are provided in Table 6.

Table 6

Age of Respondents and FAA Population Statistics

	Sample Statistics - Age							FAA Mean Age
Type Certificate	n	M	SD	Mdn	Min.	Max.	IQR	
Commercial	113	48.50	11.0	50.50	27	73	18.75	45.9
Airline-Transport	260	51.20	10.7	53.00	27	78	18.00	50.8

Note. FAA population data statistics adapted from 2019 Active Civil Airmen Statistics. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

Of the 261 usable responses, 260 held ATP certificates, and 112 held both a commercial and ATP certificate. Pilots can hold multiple certificates, commercial single-engine and ATP multi-engine certificates the most common example in the data. However, FAA population data also captures this duplication of certificates in the Civil Airmen Statistics, so no adjustments were made to the data based upon the respondents holding multiple pilot certificates. As can be seen in Table 6, the average age of both commercial and ATP rated pilots used in this study generally approximates the age characteristics of the target population.

Flight Experience in Hours

Civil aviation pilot experience is generally measured by the number of flight hours flown. Respondents were asked to provide four measures of their flight experience in section A of the survey: (a) total flight time, (b) flight time in the past 12 months, (c) pilot-in-command time, and (d) second-in-command time. The statistical summary of this data is provided in Table 7.

Table 7

Flight Experience of Respondents

Type of Hours	M	SD	Mdn	IQR	Min.	Max.
Total Flight Hours	12,264	6,431	11,000	9,400	1,100	33,000
Flight Time - Past 12 Months	245	184	200	245	0	1,000
PIC Flight Hours	7,288	4,884	6,000	6,373	23	27,000
SIC Flight Hours	4,626	3,706	3,500	4,000	25	25,000

The high relative values of both the mean and medians reflect the overall high experience level of the respondents, while the high SD and IQR values indicate a broad range of flight experience in the survey sample. The high average number of flight hours flown in the past 12 months indicates the screening process designed to eliminate pilots not currently employed in the aviation industry was likely successful. The FAA Civil Airman Statistics provide no information on flight hours, so no comparison between the sample group and the targeted pilot population was available.

Certificates Held

Respondents were asked to provide data on the pilot certificates they currently hold. As discussed earlier, pilots can hold more than one certificate; the most common example of duplicate certificates in the survey sample were pilots holding both a commercial single-engine and ATP multi-engine certificate. Therefore, the number of certificates held by the sample group was larger than the total number of respondents. Summary data on the certificates held by the respondents is provided in Table 8.

Table 8

Certificates Held by Respondents and FAA Population Statistics

Type of Pilot Certificate	Respondents holding the Certificate [a]	% of Respondents Holding the Certificate [b]	% of FAA Certificates Held [b, c, d]
Commercial - Single Engine	102	32.4%	37.9%
Commercial - Multi-engine	31		
ATP - Single Engine	18	67.6%	62.1%
ATP - Multi-engine	259		

Note. [a] Values not additive; pilots can hold multiple pilot certificates. [b] Values given are percentages of commercial and ATP certificates held. [c] FAA civil airman statistics do not differentiate between single and multi-engine class ratings in certificate data. [d] FAA population data statistics adapted from 2019 Active Civil Airmen Statistics. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

The survey asked pilots to provide both certificate and class data (e.g., commercial single-engine, ATP multi-engine). However, FAA Civil Airman Statistics provide pilot certificate data categorized only by certificate. Therefore, to compare the statistics of the study group to FAA pilot population data, the study group single and multi-engine data were combined for each certificate and the combined number divided by the total number of respondents to obtain the percentage of certificates holders in the study sample. Similarly, FAA data on the number of each type of certificate were divided by the total number of commercial and ATP certificates to obtain the percentage of each certificate held in the population of commercial and ATP rated pilots. As can be seen in Table 8, the percentage of commercial and ATP certificates held by the sample group is generally representative of the population of commercial and airline-transport rated pilots.

Industry Statistics

Data were collected on the industry sector where respondents were currently employed. The survey provided four close-ended responses for industry sector: (a) business/corporate, (b) Part 121, (c) Part 135, and (d) other. Parts 121 and 135 are names given to two types of scheduled air carriers, as defined by the paragraph in the Federal Aviation Regulations which regulates their operations. Part 121 is the section which regulates scheduled air carriers of large and turbojet aircraft, and Part 135 is the section which regulates operators of small aircraft (Composition of flight crew, 14 CFR § 121.385, 1996). Business/corporate aviation is an industry segment that focuses on the business use of airplanes (NBAA, 2021). Respondent data on the industry segment in which respondents were currently employed are provided in Table 9.

Table 9

Industry Statistics of Respondents

Industry Sector	Respondent's Current Industry Sector	% of Respondent
Business/Corporate	120	46.0%
Part 121	110	42.1%
Part 135	14	5.4%
Other	17	6.5%
Total	261	100.0%

For comparison purposes, the latest U.S. Bureau of Labor and Statistics (BLS) data on pilot employment by industry sector are provided in Table 10.

Table 10

Comparison of Pilot Jobs by Sector

	Study Sample		Pilot Population	
Industry Sector	Respondent Jobs/Sector	% Respondent Jobs/Sector	Jobs/Sector	% Jobs/Sector
Airline pilots	126	48.3%	85,500	67.3%
Commercial pilots	135	51.7%	41,600	32.7%
Total	261	100.0%	127,100	100.0%

Note. Pilot population employment data obtained from 2019 Bureau of Labor Statistics. Retrieved from Airline and Commercial Pilots: Occupational Outlook Handbook: U.S. Bureau of Labor Statistics (bls.gov).

BLS defines a commercial pilot as involved in unscheduled flight activities, such as aerial application, charter flights, and aerial tours (Bureau of Labor and Statistics, 2021). BLS also includes corporate pilots who transport company executives in the commercial pilot category. BLS defines airline pilots as those who work primarily for airlines that transport passengers and cargo on a fixed schedule (Bureau of Labor and Statistics, 2021). Using the BLS definitions, an approximate comparison between BLS employment data and the respondent group can be obtained by considering business/corporate pilot jobs and other pilot jobs as comprising commercial pilot jobs (unscheduled operations) and Part 121 and 135 jobs as airline jobs (scheduled operations). Table 10 includes the results of this reclassification of respondent employment data to enable a comparison to BLS population data. Table 10 indicates that commercial pilots may have been oversampled in this study, with the pilot sample comprised of 51.7% of commercial pilots and 48.3% airline pilots, compared to 32.7% for commercial pilots and 67.3% for airline pilots in the BLS population data. Therefore, the pilot sample used for this study may not be representative of the pilot population regarding the industry sector in which they were currently employed.

The NBAA pilot forum sourced 85 usable survey respondents, all but five of which were commercial pilots. This accounted for 32.5% of all usable responses, numbers which are consistent with the distribution of pilot jobs as indicated by BLS population data. However, an additional 44 commercial pilots were sourced from eight other recruiting platforms, which increased the percentage of commercial pilots relative to airline pilots. The generalizability of the results of this study to the population of commercial and airline-transport rated pilots will be limited because of the over representation of commercial pilots.

Pilot Qualifications

To determine whether pilot perceptions of COF were impacted by the qualifications the respondents held, pilots were asked to provide both their current and past pilot qualifications. The data received are provided in Table 11.

Table 11

Current and Prior Pilot Qualifications

Pilot Qualification	Current Qualifications	% Current Qualifications	Prior Qualifications [a]	% Prior Qualifications [b]
CAPT	206	78.9%	230	88.1%
FO	46	17.6%	187	71.6%
Dual Qualified, CAPT and FO	3	1.1%	4	1.5%
Single Pilot	6	2.3%	120	46.0%
Total	261	100.0%	541	

Note. [a] Pilots could choose multiple responses for prior qualifications; therefore, total number of responses exceeded number of respondents. [b] Values represent the percentage of usable respondents who obtained the qualification in past operations.

Only 17.6% of respondents were qualified as FOs in their current operations, and 78.9% were qualified as captains. No industry or FAA data are available to provide a comparison of the respondent group to population statistics with regard to pilot qualifications, but because the CAPT-FO COF is the dominant organizational framework in the airline industry (Gann, 1961; Hopkins, 1982) and the airline industry represents 67.3% of pilot jobs (Bureau of Labor and Statistics, 2021), the high percentage of captains and low percentage of FOs in the respondent group is potentially inconsistent with the expected distribution of qualifications in the population. As discussed earlier with job sector data, a potential contributor to this imbalance in pilot qualification data was the combination of using both the NBAA pilot forum and other online pilot forums which produced significantly higher response rates from business/corporate pilots. The combination of these sources resulted in an over-sampling of business/corporate pilots, which also likely resulted in the over-representation of captains because the CAPT-CAPT

COF is a more common organizational structure in the business/corporate sector (Richard Schwartz, personal communication, April 20, 2014).

However, the distribution of prior qualifications in the pilot sample would be expected in the population of commercial and airline transport-rated pilots. The typical career progression for airline pilots is to start at an entry level carrier, typically a regional carrier, rising on the seniority list until qualifying as captain, before moving to another carrier that offers improved career opportunities, at which point the process starts over. The high percentage of respondents who have experience as both captain and FO would be expected of the general population of commercial and airline transport-rated pilots.

COF Experience

Pilots were asked for their experience with different COFs to determine the degree to which this may have impacted their perceptions of COF. Specifically, pilots were asked whether they had experience with a CAPT-FO and CAPT-CAPT COF, both at their current employer and at past employers. However, because COF was not operationally defined until section C, these section B questions utilized plain language to ask pilots how pilot positions were assigned at their current and past employers, and the responses were categorized according to the definition of COF. If pilots reported that positional assignments were fixed and they always functioned as either the captain/PIC or first officer/SIC, their responses were categorized as the CAPT-FO COF. If positional assignments were rotated and they were equally likely to function as either captain/PIC or first officer/SIC, their responses were categorized as the CAPT-CAPT COF. Present and past COF experience data are provided in Table 12.

Table 12

COF Experience of Respondents

COF	Current Employer COF	% COF at Present Employer	Prior COF Experience [a]	% Respondents with Prior COF Experience [b]
Captain-FO	135	51.7%	227	87.0%
Captain-Captain	121	46.4%	144	38.6%
Other	5	1.9%	2	0.5%

Note. [a] Pilots could choose multiple responses for prior experience; therefore, the total number of responses exceeded the number of respondents. [b] Values represent the percentage of usable respondents who experienced the specified COF in past operations.

Present employer COF was nearly equally divided between CAPT-FO and CAPT-CAPT. However, as stated earlier, the CAPT-FO COF is the dominant COF in the airline segment of the industry (Gann, 1961; Hopkins, 2000), and the airline industry represents 67.3% of pilot jobs (Bureau of Labor and Statistics, 2021). Therefore, if the study sample was representative of the population, current COF experience would be expected to correlate with the distribution of pilot jobs shown in Table 10. The distribution of present pilot jobs by industry sector in the study sample was nearly equally distributed between airline pilots and commercial pilots, a value closely correlated with the current employer COF data shown in Table 12. It is likely that the oversampling of business/corporate pilots also resulted in the over representation of pilots whose current employers utilized the CAPT-CAPT COF. The over representation of pilots whose current employers utilized the CAPT-CAPT COF resulted in the study sample being non-representative of the population of commercial and airline-transport rated pilots for this characteristic. Respondent's prior COF experience shows pilots have a greater experience with the CAPT-FO COF, results more consistent with the knowledge that the airline industry, with approximately two-thirds of the total number of pilot jobs, has the CAPT-FO COF as the dominant organizing framework.

Because COF is a new concept introduced for this research, there are no benchmark data to reference to determine whether this sample was representative of the population's current or prior experience with COF. However, the likely oversampling of business/corporate pilots may also have resulted in an over-representation of pilots who are currently utilizing the CAPT-CAPT COF.

The sampling strategy for this study employed non-probabilistic techniques with the understanding this could produce a sample not representative of the targeted population. In this case, the sampling plan produced a pilot sample whose demographic characteristics were generally representative of the population of commercial and airline-transport rated pilots, but who's current industry sector, qualification, and COF experience may not be representative of the population of commercial and airline-transport rated pilots. While it is likely that the study sample did not represent the population of commercial and airline-transport rated pilots in some employment characteristics, the fact that the sample group had broad experience in both the type of pilot qualifications earned and COFs indicates the suitability of the sample for this study. However, the generalizability of the results to the population of professional pilots should not be overstated.

Descriptive Statistics

The research questions were operationalized in section C of the survey. Pilots were asked to provide their perceptions of which COF was more likely to improve performance in three categories related to flight safety and three categories related to subordinate pilot behavior. The categories related to flight safety were: (a) flight deck teamwork, (b) inter-cockpit communications, and (c) overall flight safety. Chidester et al. (1990) found that crews with higher numbers of words spoken performed better as teams and committed fewer errors, thus providing the rationale for the first two questions in the survey. The third question gave pilots the opportunity to comment directly on their perceptions of COF's impact on flight safety. The categories related to subordinate pilot behavior asked respondents their perceptions on the likelihood that subordinate pilots would: (a) correct captain errors, (b) enforce standard operating procedures, and (c) interject to preserve flight safety. NTSB data and prior research indicate that subordinate pilots are more likely to commit monitoring and challenging failures that lead to accidents (Dismukes et al., 2007; NTSB, 1994). These three questions asked pilots to state their perceptions of which COF would more likely result in improved monitoring and challenging performance by subordinate pilots.

The degree to which respondents agreed or disagreed with statements that the specified COF would result in improved safety was measured using an 11-point Likert scale. To reduce survey bias, the survey design utilized matched question pairs with the exact wording within these pairs identical except for the specified COF. The first matched-pair questions utilized the COF terminology introduced in section C of the survey in the question. An example of this matched-pair design and the COF terminology is provided below:

- I believe the CAPT-FO organizational framework would result in improved cockpit teamwork relative to the CAPT-CAPT organizational framework.

- I believe the CAPT-CAPT organizational framework would result in improved cockpit teamwork relative to the CAPT-FO organizational framework.

The definitions of the CAPT-CAPT and CAPT-FO organizational frameworks were provided for respondents to review in the instructions for section C of the survey. However, the COF construct and the definitions are used for the first time in this study. Therefore, respondents had no prior experience with these terms and definitions. This lack of familiarity with COF was exacerbated by the fact that the instrument was a self-administered online survey, meaning that, if there was any confusion about COF terms or definitions, respondents were unable to seek assistance. This issue introduced an element of risk that warranted the design of a second set of matched-pair survey questions which utilized plain language descriptions of COF in lieu of COF terminology. An example of the plain language matched-pair questions is provided below.

- I believe cockpit teamwork would be improved if both cockpit crewmembers were qualified as captains.
- I believe cockpit teamwork would be improved if one cockpit crewmember was qualified as captain and the other crewmember was qualified as first officer.

The resulting survey design asked each respondent four questions for each of the six-flight safety and subordinate behavior markers. The matrix describing this design and the order in which the questions were asked is provided in Table 13.

Table 13

Survey Question Matrix and Matched-Pair Design

	Type of COF Producing Improved Safety	
Question Format	CAPT-FO	CAPT-CAPT COF
COF Terminology	Question 1 (CF1)	Question 2 (CC2)
Plain Language	Question 4 (CF4)	Question 3 (CC3)

This survey design: (a) provided a measure of survey validity, (b) provided a measure of pilot understanding of the new COF construct and the terminology used to define the two levels of COF, and (c) reduced the risk associated with using a self-administered online survey to collect data on constructs pilots heretofore had no familiarity.

The 261 usable responses for each of the 24 section C questions were averaged to produce a composite score. Additionally, pilot responses for CF1 and CF4, and CC2 and CC3 were averaged together to produce a combined score for each level of COF (CAPT-CAPT and CAPT-FO). A description of section C data is provided in Table 14.

Table 14

Survey Data Descriptive Statistics

Safety/Behavior Marker	M [a b]	SD	Mdn	IQR
Flight Deck Teamwork				
Questions 1 - CF1	5.60	3.142	5	5.0
Questions 2 - CC2	4.90	2.950	5	4.0
Questions 3 - CC3	5.29	3.118	5	5.0
Questions 4 - CF4	5.13	2.994	5	5.0
Questions CF1 & CF4 Combined	5.36	3.075	5	5.0
Questions CC2 & CC3 Combined	5.10	3.038	5	5.0
Inter-Cockpit Communications				
Questions 1 - CF1	5.16	2.932	5	4.0
Questions 2 - CC2	4.77	2.842	5	4.0
Questions 3 - CC3	5.23	2.981	5	5.0
Questions 4 - CF4	4.98	2.842	5	4.0
Questions CF1 & CF4 Combined	5.07	2.887	5	4.0
Questions CC2 & CC3 Combined	5.00	2.918	5	4.0
Flight Safety				
Questions 1 - CF1	5.04	3.101	5	5.0
Questions 2 - CC2	5.03	3.029	5	4.0
Questions 3 - CC3	5.63	3.079	5	5.0
Questions 4 - CF4	4.72	2.961	5	5.0
Questions CF1 & CF4 Combined	4.88	3.033	5	5.0
Questions CC2 & CC3 Combined	5.33	3.066	5	5.0
Likelihood to Correct CAPT errors				
Questions 1 - CF1	3.92	2.796	4	3.0
Questions 2 - CC2	6.02	2.796	6	4.0
Questions 3 - CC3	6.15	2.779	7	3.0
Questions 4 - CF4	4.05	2.640	4	3.0
Questions CF1 & CF4 Combined	3.98	2.717	4	3.0
Questions CC2 & CC3 Combined	6.09	2.785	6	3.0
Likelihood to Enforce compliance with SOPs				
Questions 1 - CF1	4.20	2.770	4	3.0
Questions 2 - CC2	5.73	2.761	6	3.0
Questions 3 - CC3	5.86	2.729	6	3.0
Questions 4 - CF4	4.21	2.545	4	3.0
Questions CF1 & CF4 Combined	4.21	2.658	4	3.0
Questions CC2 & CC3 Combined	5.80	2.743	6	3.0
Likelihood to Interject to Preserve Safety				
Questions 1 - CF1	4.09	2.742	4	3.0
Questions 2 - CC2	5.72	2.910	6	3.0
Questions 3 - CC3	5.97	2.811	6	3.0
Questions 4 - CF4	3.94	2.554	4	3.0
Questions CF1 & CF4 Combined	4.02	2.648	4	3.0
Questions CC2 & CC3 Combined	5.84	2.861	6	3.0

Note. Questions 1-4 n = 261. Questions 1 & 4 and 2 & 3 combined n = 522.

[a] Values represent the average of all responses on an 11-point Likert scale.

[b] Mean values represent pilot's responses that the specified COF would improve safety.

General trends in the data can be seen by contrasting the combined data for each of the six safety and behavior markers. Observable differences can be seen in pilot perceptions of the three markers of safety relative to the three subordinate pilot behavior markers. Pilots appeared to have much stronger perceptions of the advantages of the CAPT-CAPT COF when subordinate pilot behaviors were considered than when general flight safety markers were considered. Additionally, pilot perceptions that the CAPT-FO COF enhanced safety were initially strong but declined in favor of the CAPT-CAPT COF, as respondents progressed through the survey. The greatest responses in favor of the CAPT-FO COF were in the first two survey questions, and the belief that the CAPT-FO COF would improve safety or subordinate behavior declined for the *inter-cockpit communications, flight safety*, and *correct captain errors* questions, increasing for the *enforce standard operating procedures* questions before declining again for the *interject to preserve safety* questions.

Another general trend is noticeable when comparing individual COF answers. Referencing Table 14, CF1 and CC2 questions utilized the COF terminology, and questions CC3 and CF4 utilized plain language. It is notable that, for each of the six safety markers, pilot perceptions that the CAPT-CAPT COF increased safety was higher when plain language was used compared to when COF terminology was used. It is also notable that pilot perceptions that the CAPT-FO COF resulted in greater safety were higher when COF terminology was used relative to when plain language was used in all but one safety marker (*correct captain errors*). Finally, both the SD and IQR data indicate that pilot’s responses became less disbursed as they progressed through the survey as both the SDs and IQRs reduced.

Testing for the differences between means was completed using both MS Excel and SPSS software. The means of each of the matched-paired questions were compared using a repeated measures *t*-test. Data collected from questions CF1 and CC2 and data from questions CC3 and CF4 were compared for differences in the means. This pairing compared questions asked using the same question format (COF terminology or plain language), eliminating variance in the data resulting from question format. Additionally, responses utilizing the COF terminology and plain language question formats were combined for each level of COF (CAPT-CAPT and CAPT-FO), and the means of these combined data were also compared for differences. The results of the repeated measure *t*-tests are provided in Table 15. A discussion of these results for each of the six markers of safety and subordinate pilot behavior is provided in the following paragraphs.

Table 15

Between COF Repeated Measures t-Test Results

	CAPT-CAPT	CAPT-FO			95% CI		Cohen's
Safety/Behavior Marker	M(SD)		t [a]	p	LL	UL	d [e]
Flight Deck Teamwork							
CF1 & CC2 (COF Terminology) [b]	4.90(2.950)	5.60(3.142)	-2.066	.020	-1.356	-0.033	-0.128
CC3 & CF4 (Plain Language) [b]	5.29(3.118)	5.13(2.994)	0.480	.316	-0.511	0.840	0.030
Combined [c, d]	5.10(3.038)	5.36(3.075)	-1.105	.135	-0.733	0.220	-0.048
Inter-Cockpit Communications							
CF1 & CC2 (COF Terminology) [b]	4.77(2.842)	5.16(2.932)	-1.209	.114	-1.018	0.244	-0.075
CC3 & CF4 (Plain Language) [b]	5.23(2.981)	4.98(2.845)	0.775	.220	-0.39	0.895	0.048
Combined [c, d]	5.00(2.918)	5.07(2.887)	-0.293	.385	-0.517	0.382	-0.013
Flight Safety							
CF1 & CC2 (COF Terminology) [b]	5.03(3.029)	5.04(3.101)	-0.022	.491	-0.693	0.678	-0.001
CC3 & CF4 (Plain Language) [b]	5.63(3.079)	4.72(2.961)	2.687	.004	0.244	1.580	0.166
Combined [c, d]	5.33(3.066)	4.88(3.033)	1.855	.064	-0.027	0.931	0.081
Correct CAPT errors							
CF1 & CC2 (COF Terminology) [b]	6.02(2.796)	3.92(2.796)	6.830	<0.001	1.494	2.705	0.423
CC3 & CF4 (Plain Language) [b]	6.15(2.779)	4.05(2.640)	6.994	<0.001	1.514	2.701	0.433
Combined [c, d]	6.09(2.785)	3.98(2.717)	9.782	<0.001	1.681	2.526	0.428
Enforce compliance with SOPs							
CF1 & CC2 (COF Terminology) [b]	5.73(2.761)	4.20(2.770)	5.107	<0.001	0.939	2.118	0.316
CC3 & CF4 (Plain Language) [b]	5.86(2.729)	4.21(2.545)	5.738	<0.001	1.082	2.213	0.355
Combined [c, d]	5.80(2.743)	4.21(2.658)	7.664	<0.001	1.181	1.995	0.335
Interject to Preserve Safety							
CF1 & CC2 (COF Terminology) [b]	5.72(2.901)	4.09(2.742)	5.330	<0.001	1.027	2.230	0.330
CC3 & CF4 (Plain Language) [b]	5.97(2.811)	3.94(2.554)	6.982	<0.001	1.455	2.598	0.432
Combined [c, d]	5.84(2.861)	4.02(2.648)	8.674	<0.001	1.414	2.241	0.380

Note. One tail significance values presented. *t*-Critical = 1.969. Mean values represent the average of all responses that the specified COF would improve safety measured on an 11-point Likert scale. Desired p value for significance ≤ .05. [a] The df for individual matched-pair questions = 260, for combined data = 521. [b] n = 261. [c] Combined data represent COF terminology & Plain Language data combined for the specified COF. [d] n = 522. [e] Effect sizes defined as: 0.2 = small; 0.5 = medium; 0.8 = large (Field, 2013).

Flight Deck Teamwork

As indicated by the higher mean values for the CAPT-FO COF then the CAPT-CAPT COF for the combined data, pilots perceived that the CAPT-FO COF improved flight deck teamwork. Within the individual questions, pilot perceptions appeared to be influenced by question terminology, with pilots preferring the CAPT-FO COF when the question used COF terminology and CAPT-CAPT COF when plain language was used. The data on the impact of COF on flight deck teamwork were not significant.

Inter-Cockpit Communications

Data for inter-cockpit communications were also mixed, with pilots again perceiving the CAPT-FO COF as improving inter-cockpit communications when the question used COF terminology and CAPT-CAPT when the question used plain language. It is notable that, while the negative combined *t*-statistic indicated pilots still had a higher preference for the CAPT-FO than the CAPT-CAPT COF, pilot preference for the CAPT-FO COF was 5.4% lower than their preference for the CAPT-FO COF from the first question regarding flight deck teamwork. While the reduced preference for the CAPT-FO COF was an early trend in the data, the combined data indicated that pilot perceptions still favored the CAPT-FO COF. The combined data for this safety marker were again not significant.

Flight Safety

Pilots were asked for their perceptions of the impact of COF on overall flight safety. Data for this question followed the same general trend as the first two questions with pilots perceiving the CAPT-FO COF as improving flight safety when the question used COF terminology and CAPT-CAPT when the question was asked using plain language. The early trend in the reduced preference for the CAPT-FO COF continued for this marker of safety to the point that more pilots perceived the CAPT-CAPT COF as improving overall flight safety as indicated by the now positive combined *t*-statistic. While this question produced the highest mean differential in favor of the CAPT-CAPT COF of the three flight safety markers, the results for the impact of COF on flight safety were still not significant.

Correct Captain Errors

The second series of three questions related to subordinate pilot behaviors on the flight deck. The first of these questions asked pilots their perceptions of whether subordinate pilots would be more likely to correct captain errors as a function of COF. The data indicate pilot perceptions were that subordinate pilots would be more likely to correct captain errors in the CAPT-CAPT COF. Responses were consistent regardless of the question format, and the data were significant with a small-moderate effect size.

Enforce Standard Operating Procedures

Pilots were asked their perceptions of whether subordinate pilots would be more likely to enforce standard operating procedures as a function of COF. The data indicate pilot perceptions were that subordinate pilots would be more likely to enforce standard operating procedures in the CAPT-CAPT COF. Responses were consistent regardless of the question format, and the results were significant with a small-moderate effect size.

Interject to Preserve Safety

Pilots were asked their perceptions of whether subordinate pilots would be more likely to interject to preserve safety as a function of COF. The data indicate pilot perceptions are that subordinate pilots would be more likely to interject to preserve safety in the CAPT-CAPT COF. Responses were consistent regardless of the question format, and the results were significant with a small-moderate effect size.

Categorical Data on Subordinate Pilot Behavior

This research was focused on better understanding pilot perceptions of the impact of COF on flight safety, specifically how subordinate pilot behavior impacts flight safety. In addition to the normal matched-pair question strategy discussed earlier, three additional questions which did not utilize an 11-point Likert scale were asked for each of the three subordinate pilot behavior research questions. These three questions replaced the 11-point Likert scale format with four categorical responses which asked pilots to choose which COF they thought would improve subordinate pilot behaviors. These additional categorical questions were designed to not only eliminate any potential confusion related to COF terminology or definitions, but also any confusion related to the Likert scale. These categorical questions can be reviewed in Appendix B, Questions 32, 37, and 41. For these three categorical questions, respondents were asked whether they believed the FO/SIC would be more likely to take the action specified to preserve safety if they were: (a) qualified as CAPT (CAPT-CAPT COF), (b) qualified as FO (CAPT-FO COF), (c) would be unaffected by the FO/SIC’s qualifications, and (d) not sure how the FO/SIC’s qualifications would impact their willingness to take the specified action. Graphs of the responses received from these three questions are provided in Figures 14, 15, and 16.

Figure 14

Pilot Responses for Categorical Question - Correct Captain Errors

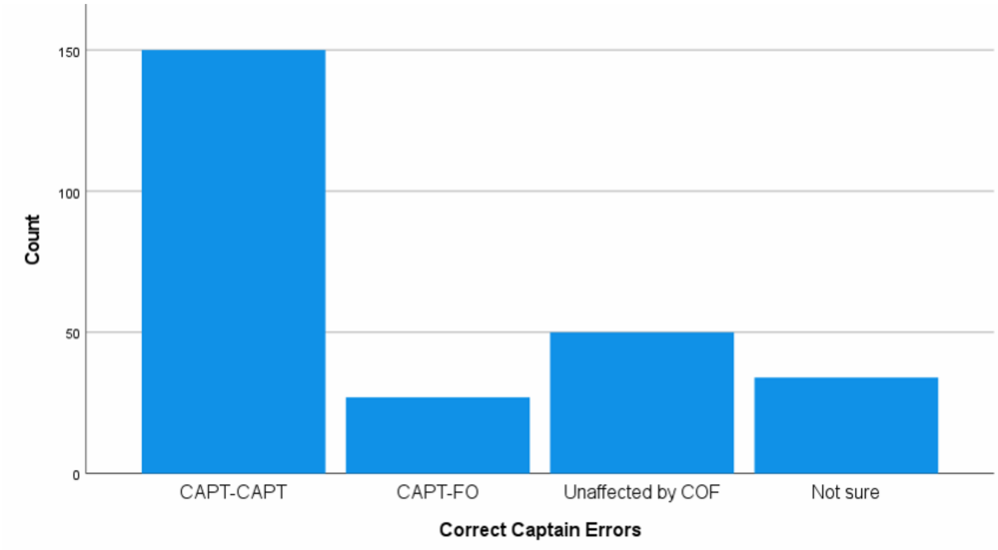


Figure 15

Pilot Responses for Categorical Question - Enforce SOPs

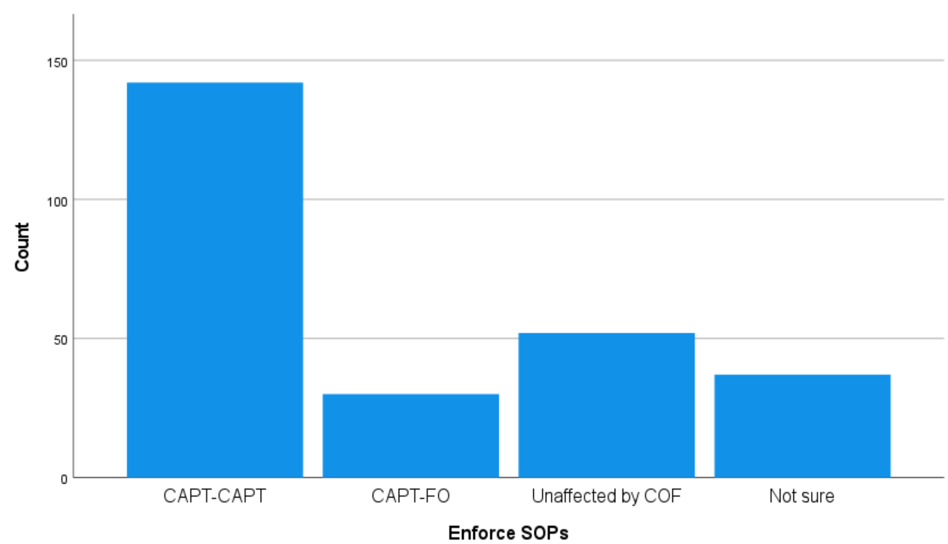
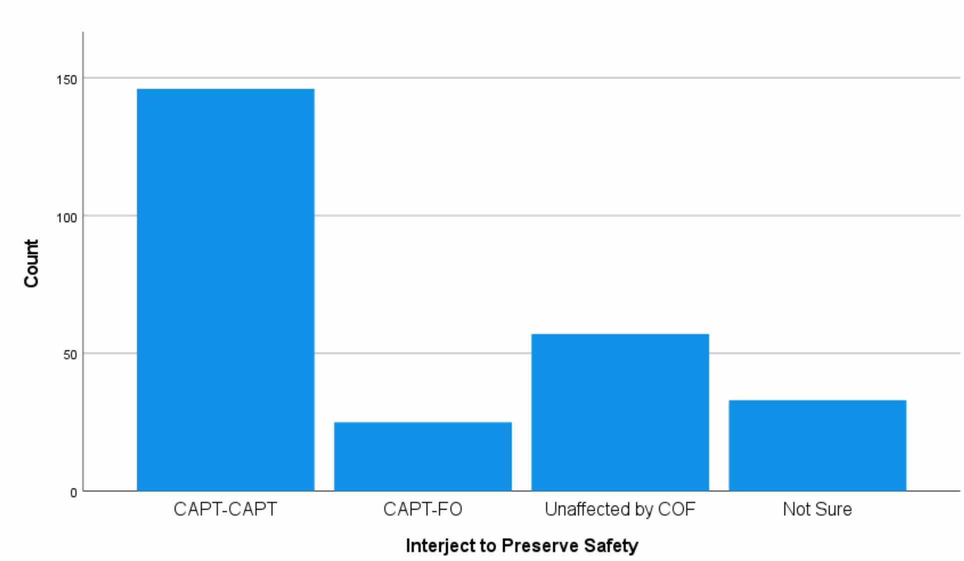


Figure 16

Pilot Responses for Categorical Question - Interject to Preserve Safety



The data received from these three categorical questions were consistent with the data received from the match-pair questions for the specified subordinate pilot behavior; pilots appeared to have a strong belief that the CAPT-CAPT COF would be more likely to result in subordinate pilots taking the specified action then for the CAPT-FO COF. Is it worth noting that more pilots believed that subordinate pilot behavior would be unaffected by COF than believed the CAPT-FO COF would improve the likelihood that subordinate pilots would take the specified action. For the *correct captain errors* and *interject to preserve safety* questions, more pilots were unsure of COF's impact on subordinate pilot behavior than believed the CAPT-FO COF would improve subordinate pilot performance. A summary of this data, the results of the Chi-squared goodness-of-fit tests, and the significance of the results are provided in Table 16.

Table 16

Categorical Data and Chi-Squared Goodness-of-Fit Testing

Research Question - Likelihood Subordinate Pilot will:	Pilot Responses				Chi-Squared	
	CAPT-CAPT	CAPT-FO	No Difference	Unsure	Statistic	Significance
Correct Captain Errors	150	27	51	33	153.5	p < .001
Enforce SOPs	143	39	52	37	126.1	p < .001
Interject to Preserve Safety	145	26	58	32	137.3	p < .001

Note. n=261. Testing assumed equal distribution of perceptions, with an expected distribution of 65.3 for each of the four response options.

The data from all three of the subordinate pilot behavior questions which collected categorical data on pilot perceptions of COF indicated pilots believed subordinate pilots would be more likely to take the specified action in the CAPT-CAPT COF. Responses were consistent with the Likert data collected, and the results were significant.

Experience as a Covariate in Pilot Perceptions of COF

The potential that pilot experience could be a confounding variable in pilot perceptions of COF was considered during the construction of the survey. Pilot experience is typically measured by the number of hours a pilot has logged at the controls of an aircraft (Certification of pilots, flight instructors, and ground instructors, 14 C.F.R. § 61, 2021). Section A of the survey collected four measures of flight experience: (a) total flight hours, (b) PIC flight hours, (c) SIC flight hours, and (d) flight hours in the preceding 12 months. To determine whether pilot experience impacted pilot perceptions of COF, an ANCOVA analysis using SPSS software was performed which included total flight hours as a potential covariate. The results of this ANCOVA are presented in Table 17.

Table 17

ANCOVA of Pilot Perceptions of COF Controlled for Total Flight Time

Level of COF	Type III Sum of Squares	df	F	Significance	Partial Eta Squared
Flight Deck Teamwork					
Primary Effects	267.762	1	20.762	<.001	.074
Interaction Effects	510.205	1	39.395	<.001	.132
Error	3354.339	259			
Intra-Flight Deck Communication					
Primary Effects	233.581	1	19.530	<.001	.070
Interaction Effects	381.276	1	31.879	<.001	.110
Error	3097.682	259			
Fight Safety					
Primary Effects	379.912	1	27.142	<.001	.095
Interaction Effects	484.690	1	34.627	<.001	.118
Error	3625.302	259			
Correct CAPT/PIC Errors					
Primary Effects	656.425	1	57.875	<.001	.183
Interaction Effects	269.087	1	23.725	<.001	.084
Error	2937.618	259			
Enforce SOPs					
Primary Effects	339.813	1	30.310	<.001	.105
Interaction Effects	136.776	1	12.200	.001	.045
Error	2903.741	259			
Interject for Flight Safety					
Primary Effects	593.413	1	53.923	<.001	.172
Interaction Effects	316.232	1	28.736	<.001	.100
Error	2850.243	259			

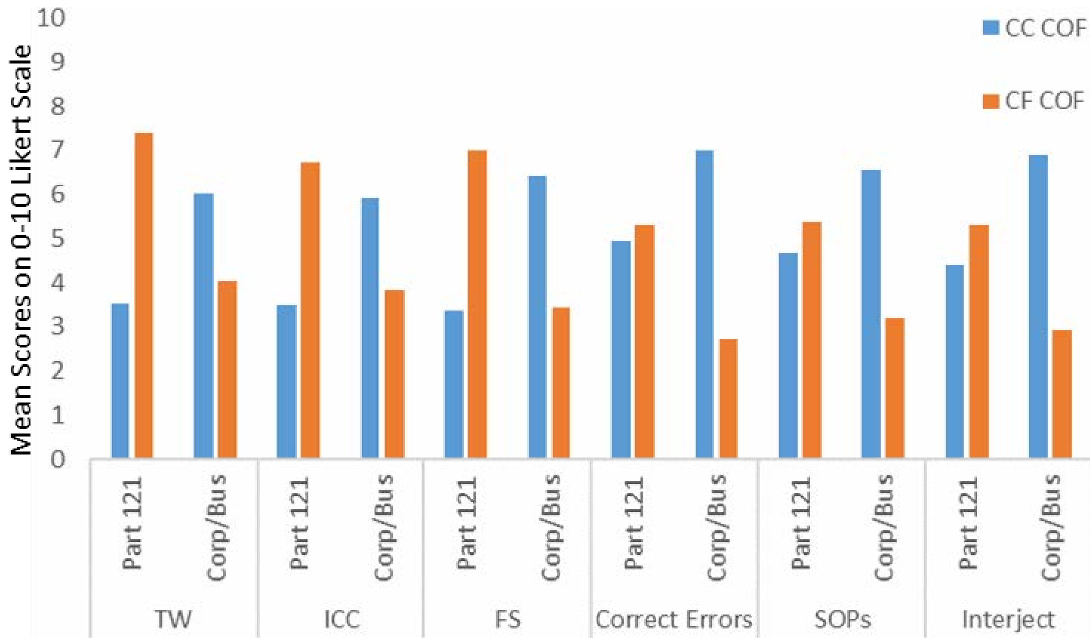
The results of the one-way repeated measures ANCOVA revealed that there were both significant main effects and interaction effects for pilot's perception of COF when controlled for flight hours. While the impact of controlling for flight hours varied for each of the six research questions and for the impact of the interaction of flight hours and pilot perceptions of COF, the results were significant for all six research questions and for all interaction effects. Comparing the results in Table 17 with the results in Table15 indicate the improvement in the significance of the findings when the results were controlled for flight experience.

The Impact of Oversampling Business/Corporate Pilots

For the sample group, 48.3% of respondents reported they were employed in the airline industry, and 51.7% reported they were employed in business/corporate aviation. These numbers are inconsistent with BLS industry data of 67.3% and 32.7% for airline pilots and business/corporate pilots, respectively. The impact of this non-representative sample of pilots with respect to the distribution of pilot jobs by industry sector was initially thought to likely result in a higher preference for the CAPT-CAPT COF because of the higher prevalence of this COF in the business/corporate aviation sector. To support this contention, respondent data were segregated by current industry, and the mean responses of pilots for each COF were computed by industry sector. For comparison purposes, these mean values are presented in Figure 17.

Figure 17

Pilot Perceptions of COF by Industry Sector



Note. The CC acronym stands for CAPT-CAPT, and CF for CAPT-FO.

As shown in Figure 17, Part 121 pilots strongly favored the CAPT-FO COF for each of the three questions related to the markers of safety with large differences between the means of their perceptions of the CAPT-FO and the CAPT-CAPT COFs. However, their perceptions in favor of the CAPT-FO COF were lower for the three questions on subordinate pilot behavior, as indicated by the smaller difference between the means for the final three questions. Conversely, business/corporate pilots indicated they perceived the CAPT-CAPT COF would result in improved safety performance for the three safety markers, and their perceptions in favor of the CAPT-CAPT COF increased for the three subordinate pilot behavior questions.

An ANOVA was conducted on this data to determine whether the differences between pilot perception of COF based upon industry sector were significantly different. The results of this analysis are shown in Table 18.

Table 18

One-way ANOVA of Pilot Perceptions of COF by Industry Sector

Level of COF	Type III Sum of Squares	df	F	Significance	Partial Eta Squared
Flight Deck Teamwork					
Primary Effects	69.869	1	5.293	0.022	.010
Interaction Effects	1052.012	2	39.848	<.001	.133
Error	6850.982	519			
Intra-Flight Deck Communication					
Primary Effects	19.854	1	1.642	0.201	.003
Interaction Effects	843.948	2	34.905	<.001	.119
Error	6274.379	519			
Fight Safety					
Primary Effects	2.299	1	0.177	0.674	.000
Interaction Effects	1337.735	2	51.536	<.001	.166
Error	6735.917	519			
Correct CAPT/PIC Errors					
Primary Effects	875.252	1	80.131	<.001	.134
Interaction Effects	618.281	2	28.302	<.001	.098
Error	5668.926	519			
Enforce SOPs					
Primary Effects	462.663	1	44.762	<.001	.079
Interaction Effects	473.792	2	22.919	<.001	.081
Error	5361.431	519			
Interject for Flight Safety					
Primary Effects	608.465	1	59.465	<.001	.102
Interaction Effects	689.824	2	377.912	<.001	.114
Error	5346.417	519			

Note. Part 121 pilots may be referred to as Airline Pilots.

This difference in perceptions between these industry sectors for all six survey questions was found to be statistically significant, $p < .001$. The equally divided preference between COF by industry sector likely contributed to the lack of statistically significant results and the low effect sizes for the three markers of safety when all pilot groups were combined (see Table 15). When their data were aggregated, the nearly equal numbers of business/corporate and Part 121 pilots offset each other in their preferences for COF, and their preferences were for the COF most prevalent in their respective industry. However, the shift toward the CAPT-CAPT COF in both pilot groups as they proceeded longitudinally through the survey was evident by the reduced mean differentials in favor of the CAPT-FO COF for Part 121 pilots and larger differentials in favor of the CAPT-CAPT COF for business/corporate pilots. This shift in favor of the CAPT-CAPT COF likely resulted in statistically significant results for the questions regarding subordinate pilot behavior. Thus, the data on preference for COF based upon industry sector explains why the results for the three markers of safety lacked statistical significance, and the three on subordinate pilot behavior were significant; Part 121 pilot’s preference for the CAPT-FO COF reduced as they moved longitudinally through the survey, and business/corporate pilot’s preferences for the CAPT-CAPT COF increased as they completed the survey.

The strong influence pilot sector has on pilot preference for COF underscores the importance of having the pilot sample representative of the population of commercial and airline-transport rated pilots to maintain external validity. The results of the hypothesis testing for each of the three hypotheses on subordinate pilot behaviors were significant and with medium effect sizes. However, the over representation of business/corporate pilots in the sample group combined with the strong influence of industry sector on the results indicate that the generalizability of these results to the population of commercial and airline transport-rated pilots may be limited.

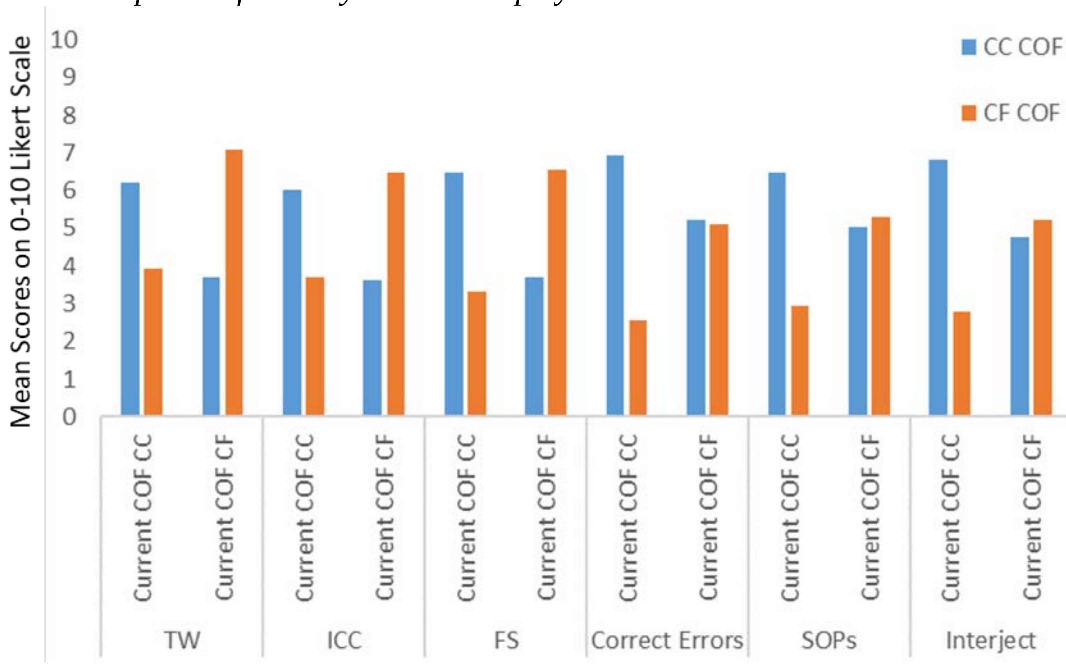
While external validity may have some limitations, the strong influence of pilot sector on perceptions of COF is a data point worth noting, and the trend toward the CAPT-CAPT COF by both pilot groups is also worth noting. The results indicate that pilots in the business/corporate sector strongly prefer the CAPT-CAPT COF and perceive it as improving both flight safety and subordinate pilot performance. Part 121 pilots perceive the CAPT-FO COF as improving flight safety, but their perceptions were less strong that the CAPT-FO COF resulted in improvements in subordinate pilot behaviors. The polarization of pilot's perceptions of COF by industry sector is a result that will be further discussed in Chapter 5.

The Impact of Oversampling CAPT-CAPT COF

Because of the novel nature of this research, there were no industry or government data available to determine whether the sample group was representative of the population of commercial and airline-transport rated pilots regarding the COF utilized by their current employer. As indicated in Table 12, survey responses indicated that 51.7% of respondents reported the CAPT-FO COF was utilized by their current employer, and 46.4% of respondents reported the CAPT-CAPT COF in use. These results are inconsistent with the results expected based upon BLS data that 67.3% of pilot jobs are held by airline pilots where the CAPT-FO COF is almost universally employed, and 32.7% are held by business/corporate pilots where the CAPT-CAPT COF is more prevalent. The sampling distribution of COF utilized by the respondent's current employer is similar to the sampling distribution of pilot jobs by industry sector (48.3% for Part 121 pilots and 51.7 for business/corporate pilots), a distribution that was also inconsistent with BLS industry data. It was thought that this oversampling of pilots currently in the CAPT-CAPT COF could potentially increase preferences for the CAPT-CAPT COF. To assess this potential impact, respondent data were segregated by current employer COF and the mean responses for each COF computed. These mean values are presented in Figure 17.

Figure 18

Pilot Perceptions of COF by Current Employer COF



Note. The CC acronym stands for CAPT-CAPT, and CF for CAPT-FO.

The impact of current employer COF was also assessed using an ANOVA to determine whether the differences between pilot perception of COF based on current employer COF were significantly different. The results of this analysis are shown in Table 19.

Table 19

One-way ANOVA of Pilot Perceptions of COF by Current COF Experience

Level of COF	Type III Sum of Squares	df	F	Significance	Partial Eta Squared
Flight Deck Teamwork					
Primary Effects	47.829	1	3.629	0.057	.007
Interaction Effects	1102.383	5	16.729	<.001	.139
Error	6800.610	516			
Intra-Flight Deck Communication					
Primary Effects	1.816	1	0.150	0.699	.000
Interaction Effects	863.083	5	14.239	<.001	.121
Error	6255.244	516			
Fight Safety					
Primary Effects	0.002	1	0.000	0.99	.000
Interaction Effects	1187.858	5	17.803	<.001	.147
Error	6885.794	516			
Correct CAPT/PIC Errors					
Primary Effects	83.149	1	7.507	0.006	.014
Interaction Effects	571.912	5	10.327	<.001	.091
Error	5715.295	516			
Enforce SOPs					
Primary Effects	47.612	1	4.588	0.033	.009
Interaction Effects	483.326	5	9.315	<.001	.083
Error	5354.897	516			
Interject for Flight Safety					
Primary Effects	61.460	1	5.851	0.016	.011
Interaction Effects	615.762	5	11.723	<.001	.102
Error	5420.479	516			

Note. The CC acronym stands for CAPT-CAPT, and CF stands for CAPT-FO.

The similarities of this data with the data presented in Table 18, the data on pilot perceptions of COF based upon industry sector, is worth noting. The differences in the means for pilots currently utilizing the CAPT-FO COF were strongest for the three markers of safety and decreased for subordinate pilot behavior. In fact, the results for the *correct captain errors* question indicated that more pilots currently using the CAPT-FO COF believed that subordinate pilots would be more likely to correct captain errors in a

CAPT-CAPT COF, the only time pilot perceptions were opposite their current employer COF. Consistent with the by-industry data, pilots currently utilizing the CAPT-CAPT COF strongly favored the CAPT-CAPT COF for each of the three question groups related to the markers of safety, and their preference for this COF increased for the questions related to subordinate pilot behaviors. The difference in pilot perceptions based upon current COF supports the contention that the oversampling of pilots currently utilizing the CAPT-CAPT COF limits the generalizability of these results to the population of commercial and airline transport-rated pilots.

Reliability and Validity Testing Results

Reliability testing was completed by comparing the responses to the matched-pair questions. As shown in Table 13, the matched-pair design utilized two questions for each level of COF, one utilizing COF terminology (CAPT-CAPT and CAPT-FO), and one utilizing plain language. This design afforded the opportunity to assess reliability by comparing the within COF data for internal consistency. Table 20 provides a summary of the results of this reliability testing.

Table 20

Within COF Reliability Testing

Safety/Behavior Marker	COF Terminology M(SD)	Plain Language M(SD)	Cronbach's Alpha [a]	Corrected Item Correlation
Flight deck teamwork				
CAPT-CAPT COF	4.90(2.950)	5.29(3.118)	0.817	.691
CAPT-FO COF	5.60(3.142)	5.13(2.994)	0.849	.739
Inter-Cockpit Communications				
CAPT-CAPT COF	4.77(2.842)	5.23(2.981)	0.895	.811
CAPT-FO COF	5.16(2.932)	4.98(2.845)	0.884	.793
Flight Safety				
CAPT-CAPT COF	5.03(3.029)	5.63(3.079)		
CAPT-FO COF	5.04(3.101)	4.72(2.961)	0.905	.827
Correct CAPT errors				
CAPT-CAPT COF	6.02(2.796)	6.15(2.779)	0.889	.801
CAPT-FO COF	3.92(2.796)	4.05(2.640)	0.916	.847
Enforce compliance with SOPs				
CAPT-CAPT COF	5.73(2.761)	5.86(2.729)	0.923	.858
CAPT-FO COF	4.20(2.770)	4.21(2.545)	0.923	.859
Interject to preserve safety				
CAPT-CAPT COF	5.72(2.901)	5.97(2.811)	0.952	.909
CAPT-FO COF	4.09(2.742)	3.94(2.554)	0.921	.856

Note. n=261. Mean values represent the average of all responses that the specified COF would improve safety measured on an 11-point Likert scale. [a] Cronbach's alpha greater than 0.70 indicates acceptable levels of internal consistency and reliability (Field, 2013).

As indicated in Table 20, the values of Cronbach's alpha for both levels of the independent variable exceeded 0.70, indicating a high level of reliability. The Cronbach's alpha results were also supported by the corrected item correlation values greater than 0.40. With these results, no further analysis of reliability was performed.

Drost (2011) recommends assessing construct validity by examining discriminant and convergent validity. Convergent validity should be assessed by a convergence, or consistency of responses, across different measures of the same thing, in this case questions related to the same COF. Divergent validity should be assessed by testing for divergence between measures and manipulations that are related but which are conceptually distinct, in this case questions related to different COFs. The matched-pair design allowed for these assessments by use of a multitrait-multimethod correlation matrix. A bivariate correlation between the match-pair questions was performed using SPSS. Before the correlation was executed, a combined value for each respondent's data was created using the SPSS transform function. The responses for both the COF terminology and plain language question formats for each of the six research questions were used to generate the correlation table presented in Table 21. Convergent validity was assessed by comparing similar question pairs, CF1 and CF2 to CF1 and CF2 between the three questions related to flight safety and the three questions related to subordinate pilot behavior. All correlations were positive and greater than 0.75, indicating acceptable convergent validity. Divergent validity was assessed by comparing dissimilar question pairs, CF1 and CF2 to CC1 and CC2 both within and between the three questions related to flight safety and the three questions related to subordinate pilot behavior. All correlations were negative and less than -0.55, indicating moderate but acceptable discriminant validity. The critical correlation value was determined to be 0.1051 using the Pearson's Correlation Tables at df of 259 and p = .05. All correlations, including the total correlations, exceeded the critical value.

Table 21

Construct Validity Testing

		Teamwork		Inter-cockpit Com		Flight Safety		Capt. Errors		Enforce SOP		Interject for Safety		
		CF1 & CF2	CC1 & CC2	CF1 & CF2	CC1 & CC2	CF1 & CF22	CC1 & CC22	CF1 & CF2	CC1 & CC2	CF1 & CF2	CC1 & CC2	CF1 & CF2	CC1 & CC2	Totals
TW CF1 & CF2	Pearson Correlation	1.00												
	Sig. (1-tailed)													
TW CC1 & CC2	Pearson Correlation	-.623**	1.00											
	Sig. (1-tailed)	0.000												
ICC CF1 & CF2	Pearson Correlation	.809**	-.566**	1.00										
	Sig. (1-tailed)	0.000	0.000											
ICC CC1 & CC2	Pearson Correlation	-.557**	.836**	-.621**	1.00									
	Sig. (1-tailed)	0.000	0.000	0.000										
FS CF1 & CF2	Pearson Correlation	.807**	-.591**	.799**	-.567**	1.00								
	Sig. (1-tailed)	0.000	0.000	0.000	0.000									
FS CC1 & CC2	Pearson Correlation	-.559**	.776**	-.541**	.785**	-.667**	1.00							
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000								
CPERS CF1 & CF2	Pearson Correlation	.638**	-.470**	.668**	-.453**	.689**	-.505**	1.00						
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000							
CPERS CC1 & CC2	Pearson Correlation	-.410**	.516**	-.432**	.555**	-.441**	.618**	-.594**	1.00					
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
SOP CF1 & CF2	Pearson Correlation	.630**	-.471**	.643**	-.452**	.646**	-.467**	.768**	-.490**	1.00				
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000					
SOP CC1 & CC2	Pearson Correlation	-.378**	.584**	-.385**	.616**	-.413**	.624**	-.468**	.696**	-.536**	1.00			
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
INTJT CF1 & CF2	Pearson Correlation	.644**	-.486**	.637**	-.445**	.666**	-.478**	.774**	-.518**	.807**	-.473**	1.00		
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
INTJT CC1 & CC2	Pearson Correlation	-.446**	.571**	-.460**	.630**	-.489**	.638**	-.568**	.765**	-.522**	.809**	-.526**	1.00	
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
Totals	Pearson Correlation	.362**	.284**	.358**	.343**	.331**	.320**	.331**	.323**	.348**	.422**	.358**	.357**	1.00
	Sig. (1-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Note. Symbol ** indicates correlation is statistically significant. Critical correlation value for df(259) at $p = .05$ is 0.0151.

Hypothesis Testing Results

Mean values of pilot's perceptions of whether COF would improve each of the six safety and subordinate pilot behavioral markers were computed using pilot responses to survey questions measured on an 11-point Likert scale. These mean values were then compared for differences between the two levels of COF using paired-sample *t*-test analysis techniques. A discussion of the hypothesis testing results is provided for each hypothesis in the following paragraphs.

H_1: Flight Deck Teamwork

A paired-samples *t*-test was conducted to evaluate whether pilots perceived a difference in flight deck teamwork as a function of COF. There was not a statistically significant increase in pilots' perceptions of teamwork for the CAPT-CAPT COF (M = 5.10, SD = 3.04) compared to the CAPT-FO COF (M = 5.36, SD = 3.00), t = -1,11, p >.05 (one-tailed). The mean differential between CAPT-CAPT and CAPT-FO COFs was -0.26, and the Cohen's *d* statistic (-.048) indicated a small effect size. The null hypothesis associated with this research question stated:

> Pilots will perceive that flight deck teamwork is not improved in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceived flight deck teamwork was not improved in a CAPT-CAPT COF. Additionally, the results were not statistically significant at the $p < .05$ level.

H_2: Intra-Flight Deck Communication

This research question asked pilots their perceptions of the impact COF would have on intra-flight deck communication. A paired-samples *t*-test was conducted to evaluate whether pilots perceived a difference in intra-flight deck communications as a function of COF. There was not a statistically significant increase in pilots' perceptions of intra-flight deck communications for the CAPT-CAPT COF (M = 5.00, SD = 2.92) compared to the CAPT-FO COF (M = 5.07, SD = 2.89), t = -0.293, p >.05 (one-tailed). The mean difference between COFs was -0.07, and the Cohen's d statistic (-.013) indicated a small effect size. The null hypothesis associated with this research question stated:

> Pilots will perceive that intra-flight deck communications are not improved in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceived flight deck communication was not improved in a CAPT-CAPT COF. Additionally, the results were not statistically significant at the p < .05 level.

H_3: Fight Safety

The third research question asked pilots their perceptions of the impact COF would have on flight safety. A paired-samples t-test was conducted to evaluate whether pilots perceived a difference in flight safety as a function of COF. There was not a statistically significant increase in pilots' perceptions of flight deck safety for the CAPT-CAPT COF (M = 5.33, SD = 3.07) compared to the CAPT-FO COF (M = 4.88, SD = 3.03), t = 1.86, p >.05 (one-tailed). The mean difference between COFs was -0.45, and the Cohen's d statistic (.081) indicated a small effect size.

These results are worth noting because the markers of safety investigated in research questions one and two are generally considered components of safety (Chidester et al., 1990). However, the pilots participating in this study did not perceive the impact of

COF on flight safety in a manner consistent with how they responded to questions related to the two components of safety. Additionally, the mean differential and *t*-statistic were the largest of the three research questions focused on safety. While the significance level is greater than the .05 threshold level used to establish statistical significance, it was just 0.01 over this threshold indicating that the pilots sampled in this study perceived the CAPT-CAPT COF as improving safety, but just below the level needed to establish statistical significance. The null hypothesis associated with this research question stated:

> Pilots will perceive that flight safety is not improved in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceived flight safety may be improved by the CAPT-CAPT COF, but the results were not statistically significant at the $p < .05$ level.

H_4: *Willingness to Correct CAPT/PIC Errors*

This research question asked pilots their perceptions of the impact COF would have on FO/SIC crewmembers' willingness to correct CAPT/PIC errors. A paired-samples *t*-test was conducted to test for differences in pilots' perceptions for this variable. There was a statistically significant increase for the CAPT-CAPT COF ($M = 6.09$, $SD = 2.79$) compared to the CAPT-FO COF ($M = 3.98$, $SD = 2.72$), $t = 9.78$, $p <.001$ (one-tailed). The mean difference between COFs was 2.11, and the Cohen's *d* statistic (.428) indicated a small-medium effect size. Additionally, pilot responses to the questions asking pilots to explicitly indicate which, if any, COF was more likely to result in subordinate pilots correcting captain errors using categorical responses indicated pilots perceived the CAPT-CAPT COF as the more likely to do so, responses which were significant, $\chi^2(3) = 153.5$, $p < .001$. The null hypothesis associated with this research question stated:

> Pilots will perceive that there is not a higher likelihood the FO/SIC will correct captain errors in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceived the FO/SIC is more likely to correct captain errors in a CAPT-CAPT COF than in a CAPT-FO COF. Additionally, the results were statistically significant at the $p < .05$ level.

H_5: Willingness to Enforce SOPs

The fifth research question asked pilots their perceptions of the impact COF would have on FO/SIC crewmembers' willingness to enforce SOPs. A paired-samples *t*-test was conducted to test for differences in pilots' perceptions for this variable. There was a statistically significant increase for the CAPT-CAPT COF ($M = 5.80$, $SD = 2.74$) compared to the CAPT-FO COF ($M = 4.21$, $SD = 2.66$), $t = 7.66$, $p <.001$ (one-tailed). The mean difference between COFs was 1.61, and the Cohen's *d* statistic (.335) indicated a small-medium effect size. Additionally, pilot responses to the questions asking pilots to explicitly indicate which, if any, COF was more likely to result in subordinate pilots enforcing standard operating procedures using categorical responses indicated pilots perceived the CAPT-CAPT COF as the more likely to do so, responses which were significant, $\chi^2(3) = 126.1$, $p < .001$. The null hypothesis associated with this research question stated:

> Pilots will perceive that there is not a higher likelihood the FO/SIC will enforce compliance with SOPs in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceived the FO/SIC is more likely to enforce compliance with SOPs in a CAPT-CAPT COF than in a CAPT-FO COF. Additionally, the results were statistically significant at the $p < .05$ level.

H_6: Willingness to Interject for Flight Safety

The sixth and final research question asked pilots their perceptions of the impact COF would have on FO/SIC crewmembers' willingness to interject to maintain flight safety. A paired-samples *t*-test was conducted to test for differences in pilots' perceptions for this variable. There was a statistically significant increase for the CAPT-CAPT COF ($M = 5.84$, SD = 2.86) compared to the CAPT-FO COF ($M = 4.02$, $SD = 2.65$), $t = 8.67$, $p < .001$ (one-tailed). The mean difference between COFs was 1.82, and the Cohen's *d* statistic (.380) indicated a small-medium effect size. Responses to the questions asking pilots to explicitly indicate which, if any, COF was more likely to result in subordinate pilots interjecting to preserve safety using categorical responses indicated pilots perceived the CAPT-CAPT COF as the more likely to do so, responses which were significant, $\chi^2(3) = 137.3$, $p < .001$. The null hypothesis associated with this research question stated:

> Pilots will perceive that there is not a higher likelihood the FO/SIC will interject to maintain flight safety in a CAPT-CAPT COF relative to CAPT-FO.

The results indicate that pilots perceive FO/SIC pilots are more likely to interject to maintain flight safety in the CAPT-CAPT COF than the CAPT-FO COF. Additionally, the results were statistically significant at the $p < .05$ level.

Summary

This chapter provided information on the results of both the pilot study and the main study of the impact of COF on pilots' perceptions of safety and subordinate pilot behavior. For the main study, 450 responses were obtained from the population of active commercial and airline-transport rated pilots using non-probability sampling techniques, 261 of which provided usable data. All respondents held either an airline-transport or commercial pilot certificate, and only one respondent held only a commercial pilot certificate. The average age of the respondents was 50.4 years old, and the average flight time of the respondents was 12,264 flight hours. Respondents reported that 46.0% were currently employed in the business/corporate sector of the aviation industry, and 42.1% employed in the airline industry. Respondents also reported that 46.4% were currently employed in positions which utilized the CAPT-CAPT COF, and 51.7% were currently employed where the CAPT-FO COF is utilized.

The data indicated that pilots did not perceive the CAPT-CAPT COF as improving flight safety in the following areas: (a) flight deck teamwork, (b) inter-cockpit communications, and (c) flight safety. Data received for these areas produced mixed results regarding which COF would improve safety, with pilots believing the CAPT-FO COF would improve safety in the first two areas, and the CAPT-CAPT COF improving overall safety. However, no results for these three markers of safety produced statistically significant results. Therefore, for each of these three markers of safety, the null hypotheses were accepted, and the alternative hypotheses were unsupported by the data.

The data did indicate that pilots perceived the CAPT-CAPT COF would improve subordinate pilot behavior in the follow areas: (a) willingness to correct CAPT/PIC errors, (b) willingness to enforce SOPs, and (c) willingness to interject to maintain flight safety. Data received for these indicators of subordinate pilot behavior indicated that pilots perceive the CAPT-CAPT COF would improve subordinate pilot's ability / willingness to take the specified actions to preserve safety. The results for these three measures of subordinate pilot behavior produced statistically significant results, and all had small-medium effect sizes. For each of these questions, the null hypotheses were rejected and the alternative hypotheses that the CAPT-CAPT COF would improve subordinate pilot behavior were supported by the data and retained.

Chapter V: Discussion, Conclusions, and Recommendations

This research investigated pilot's perceptions of COF's impact on flight safety and subordinate pilot behavior. An online survey measured pilot perceptions of COF through their responses to 27 questions. Twenty-four questions measured pilot perceptions about which of two COFs, the CAPT-CAPT or CAPT-FO, would result in improved safety and subordinate pilot behaviors on an 11-point Likert scale. Three additional questions did not use the Likert scale but rather asked pilots to choose the COF they believed would improve subordinate pilot performance from four categorical choices. Responses to these survey questions were collected over a four-week period. There were 450 total responses received, but only 262 were initially considered usable data. One additional response was excluded from the analysis because of missing data, resulting in 261 responses used in the analysis.

The execution of the data collection phase of the project was consistent with the research proposal. The survey proved effective in collecting pilot perceptions of COF while also providing information on the validity and reliability of the survey itself. Additionally, the data obtained were of sufficient quality to provide meaningful results and valid conclusions.

Data indicated that there was no statistical difference between pilots' perceptions of the impact of COF on three markers of safety: (a) cockpit teamwork, (b) inter-cockpit communications, and (c) flight safety. However, pilot perceptions of COF were statistically significant when asked about subordinate pilot behavior, with pilots indicating they believed the CAPT-CAPT COF was more likely to result in subordinate pilots acting to: (a) correct captain errors, (b) enforce compliance with SOPs, and (c) interject to preserve flight safety. Responses received on subordinate pilot behavior and measured on an 11-point Likert scale were consistent with the categorical responses received for the same questions.

This chapter will provide an expanded discussion of the knowledge gained from this research. The results introduced in Chapter 4 will be contextualized, and the conclusions and recommendations that can be drawn from those results will be introduced. It will also provide the recommendations for additional research which can be used to further our understanding of COF's impact on flight safety and subordinate pilot behavior. To provide the full context of the results obtained, both the strengths and limitations of the findings will be discussed.

Discussion

A survey was designed to measure pilot's perceptions of COF. The survey employed a matched-pair design and both Likert scale and categorical responses. The matched-pair design and the use of both Likert and categorical responses provided data on both the reliability and validity of the survey itself. The reliability and validity of this new survey was acceptable, as indicated by the high value for Cronbach's alpha and that the correlation coefficients exceeded the critical correlation value (see Tables 20 and 21).

While the COF construct was a new term introduced for the first time in this research, the respondents seemed to understand the concept and were, as previously discussed in Chapter 4, able to apply this new construct effectively in their responses. This is at least partially explained by the fact that, although this construct has not been the subject of prior investigations by the aviation research community, the COF construct currently exists in aviation. Pilots with experience in either military aviation or business/corporate aviation have likely flown in an environment where the subordinate pilot had qualifications equal to the PIC, the definition of the CAPT-CAPT COF. Also, the airline industry has a very structured organizational framework where the CAPT-FO COF is almost universally employed (Gann, 1961; Hopkins, 1982). Therefore, while the concept of COF and the definition of the two levels of COF are a novel area of research, it is not a novel concept for professional pilots.

Participant Demographics

The sampling strategy utilized an online survey and non-probability sampling techniques. The strengths of this design were: (a) low costs associated with the research, (b) the ability to reach many pilots in a short time and with minimal effort, (c) the ability to reach a broad range of pilots, (d) consistency in the delivery and presentation of the survey, and (e) reduced opportunity for the research team to introduce bias into the results (Wolf, et al., 2016). The primary weakness of this sampling technique was the inability to ensure the sample was representative of the target population (Wolf, et al., 2016). To reduce the threat to external validity posed by the non-probability sampling techniques, the plan to recruit respondents employed multiple techniques designed to reach a broad range of professional pilots. Additionally, a relatively large sample size was obtained as an additional technique to reduce the threat to external validity. To measure the impact of these strategies on external validity, demographic data on the population of commercial and airline-transport rated pilots, when available, were compared to the demographics of the sample of pilots who participated in the study. As reported in Chapter 4, the sample of pilots used in this study approximated the population of commercial and airline-transport rated pilots in the following areas: (a) age, (b) gender, and (c) certificates held. However, the sample of pilots used in this study did not approximate the population in the following categories: (a) currently employed industry sector, and (b) current employer COF.

Summary of Hypothesis Testing

Mean values of pilot's perceptions of the impact of COF on each of the six safety and subordinate pilot behavioral markers were computed using pilot responses to survey questions. For questions which utilized the Likert scale format, the mean values were compared for differences between the two levels of COF using paired-sample *t*-test analysis techniques. For questions utilizing categorical responses, differences between the two levels of COF were tested using chi-squared goodness-of-fit techniques. Statistical significance was determined at the $p < .05$ level. If the probability of type one errors was < .05, the null hypothesis was rejected and the alternative hypothesis retained. A discussion of the hypothesis testing results, including whether the null and alternative hypotheses were accepted or rejected, is provided for each hypothesis in the following paragraphs.

H_1: Flight Deck Teamwork. Pilots perceived flight deck teamwork was not improved in a CAPT-CAPT COF. The results were not statistically significant at the $p <$ .5 level. Therefore, the null hypothesis is retained; the alternative hypothesis was not supported by the data.

H_2: Intra-Flight Deck Communication. Pilots perceived flight deck communication was not improved in a CAPT-CAPT COF. The results were not statistically significant at the $p < .05$ level. Therefore, the null hypothesis is retained; the alternative hypothesis was not supported by the data.

H_3: Fight Safety. Pilots perceived flight safety may be improved by the CAPT-CAPT COF, but the results were not statistically significant at the $p < .05$ level. Therefore, the null hypothesis is retained; the alternative hypothesis was not supported by the data.

H_4: Willingness to Correct CAPT/PIC Errors. Pilots perceived the FO/SIC is more likely to correct captain errors in a CAPT-CAPT COF than in a CAPT-FO COF. The results were statistically significant at the $p < .05$ level. Therefore, the null hypothesis is rejected; the alternative hypothesis was supported by the data and retained.

H_5: Willingness to Enforce SOPs. Pilots perceived the FO/SIC is more likely to enforce compliance with SOPs in a CAPT-CAPT COF than in a CAPT-FO COF. The results were statistically significant at the $p < .05$ level. Therefore, the null hypothesis is rejected; the alternative hypothesis was supported by the data and retained.

H_6: Willingness to Interject for Flight Safety. Pilots perceive the FO/SIC is more likely to interject to maintain flight safety in the CAPT-CAPT COF than the CAPT-FO COF. The results were statistically significant at the $p < .05$ level. Therefore, the null hypothesis is rejected; the alternative hypothesis was supported by the data and retained.

Three Markers of Safety

Results for the three questions which asked for pilot perceptions of the impact of COF on the three markers of flight safety were not statistically significant. The responses for the first of these three safety markers, flight deck teamwork, indicated that pilots believed the CAPT-FO COF would result in improved teamwork relative to the CAPT-CAPT COF. The preference for the CAPT-FO COF was the strongest for the first question, and preferences for both the CAPT-FO and CAPT-CAPT COF decreased from the first to the second question. However, while preferences for the CAPT-FO COF continued to decrease for the third and all subsequent questions, preferences for the CAPT-CAPT COF increased by 6.6% for the third question and 14.3% for the fourth question. The increased preference for the CAPT-CAPT COF resulted in more pilots preferring the CAPT-CAPT COF by question number three, and preferences in favor of this COF remained significantly higher than the preference for the CAPT-FO COF for all subsequent survey questions.

Order Effects. One potential explanation for this reduction in pilot preference for the CAPT-FO COF as respondents moved longitudinally through the survey was that they became more familiar with the COF construct and the definitions of the two levels of COF as they answered additional questions. This effect, often referred to as the order effect (Schuman & Presser, 1996; Krosnick & Alwin, 1987), could explain the consistent reduction in the respondents' preferences for the CAPT-FO COF and the simultaneous increase in preferences for the CAPT-CAPT COF.

One technique that is effective for mitigating order effects is to randomize the presentation of questions (Schuman & Presser, 1996). Utilizing this technique was considered during construction of the survey. However, due to the identical nature of the survey questions, randomizing the order of the questions was thought to pose a greater threat to survey reliability than the threat posed by order effects. As stated in Chapters 3 and 4, a matched-pair question design was utilized which asked pilots four questions for each of the six markers of safety and subordinate pilot behavior. This matched-pair design utilized two sets of paired questions identical in wording except for the words used to describe COF, which were reversed between the question pairs to indicate a preference for the CAPT-CAPT COF in one question and the CAPT-FO COF in the next. Making the order in which the matched-pair questions were presented identical across the six markers of safety and subordinate pilot behavior made it easier for respondents to provide consistent responses focused on the impact of COF. If the questions were randomized, it was thought that respondents would need to carefully review each question to ensure proper understanding, something some respondents, given the identical nature of the matched-pair design, may not have been able or willing to do repeatedly over the course of 27 questions. Because of this, randomizing the order of the questions was thought to pose a greater threat to reliability than the threat posed by order effects (Schuman & Presser, 1996). Also, the potential of respondents tending to increase preference for one level of COF as they became more familiar with the COF construct was thought to be an additional source of data indicating pilot preference for a specific COF. Pilots tending to perceive one COF as more likely to improve safety as they became more familiar with the COF construct was considered a potential data point itself.

Based upon the shift in pilot preferences for COF as they became more familiar with the COF construct, pilots perceived the CAPT-CAPT COF as more likely to improve safety and subordinate pilot behavior. It is interesting to note that the final question of the three markers of safety (the third overall question) asked pilots their perception of the impact of COF on overall flight safety, and their responses to this question were the first area where pilots indicated a preference for the CAPT-CAPT COF. The statistical testing for this final question, while still not significant ($p = .06$), was the nearest to a statistically significant result for any of the three questions on the markers of safety, and pilot perceptions for all subsequent questions indicated a preference for the CAPT-CAPT COF which were statistically significant.

Potential Question Ambiguity. One potential explanation for the lack of statistically significant results for the three markers of safety was the design choice to ask pilots to provide their perceptions on questions considered to be markers or indicators of safety. This survey design choice may have presented pilots with questions that were ambiguous in nature. Certainly, pilots provided more conclusive responses to the questions related to subordinate pilot behavior, an area where they could project themselves into the role of the subordinate pilot and quantify their answers based upon past experiences. Pilot perceptions on the impact of COF for the three indicators of safety were not significant, but their responses neared the threshold for statistical significance when asked directly for the impact of COF on safety instead of asking for the impact of COF on indicators of safety. Additionally, perceptions of the impact of COF on subordinate pilot behavior, including the impact of COF on whether subordinate pilots would be more likely to interject to preserve safety, were significant and with small to medium effect sizes. It is possible that respondents had difficulty quantifying their perceptions to the more ambiguous questions related to the indicators of safety, a problem that was not present in the questions related to subordinate pilot behavior.

Subordinate Pilot Behavior

Results for the three questions asking for pilot perceptions on the impact of COF on subordinate pilot behavior were statistically significant with effect sizes that neared the medium level. Additionally, preference for the CAPT-CAPT COF was consistent for all questions related to subordinate pilot behavior. It is worth noting that, as discussed in

Chapter 2, Crew Resource Management training programs were created in part as a response to the failures of subordinate pilots to correct captain errors and interject to preserve safety (Helmreich, et al., 1999). Survey respondents gave mixed results for questions on whether one COF would result in improved flight deck teamwork, inter-cockpit communication, and overall flight safety. However, they gave statistically significant responses when asked whether they believed having the subordinate pilot on a more level status with and with equal qualifications to the superordinate pilot would likely result in subordinate pilots correcting captain errors, enforcing SOPs, and interjecting to preserve safety.

Other Predictors of COF

Experience was thought to have a potential impact on pilot perceptions of COF because of the impact it potentially has on both pilot qualifications (CAPT or FO) and their willingness to embrace a new organizational framework. It was thought that more experienced pilots would exhibit more resistance to any potential change in the flight deck organizational system. Resistance to change is a rational response when change could be characterized as a loss (Dent & Powley, 2003), and the CAPT-CAPT COF, where pilots share more equally in both the authority and responsibilities of the PIC position while having equal qualifications could easily be perceived as a loss by pilots qualified as captains within the CAPT-FO COF. This pre-study supposition, while not related to the study’s goal of measuring pilot’s perceptions of how COF impacts flight safety and subordinate pilot behavior, and therefore not translated into a research question, was found to have a statistically significant effect on pilot’s perception of COF, (see Table 17).

Two additional factors not considered during the study design process were found to have a significant effect on pilot perceptions of COF: present industry sector and present employer COF. These two factors were initially analyzed to assess the potential impact of the oversampling of business/corporate pilots relative to airline pilots, specifically whether the oversampling would adversely impact external validity. If these factors had a weak effect on pilots' perceptions of COF, than it could be said that the oversampling of these two characteristics may also have had a minor impact on external validity. However, as indicated in Tables 18 and 19, both additional factors were found to have a statistically significant effect on pilots' perceptions of COF with medium effect sizes. It is likely that these two variables were capturing the same effect, the preference for the COF more prevalent in their current sector of aviation. This result was an unintended outcome of this study, an outcome which indicates the polarization of pilot's opinions in favor of the COF utilized in their current industry sector. This study was unable to answer the question of why pilots have such strong preferences for the COF dominant in their industry sector, but it potentially reveals this preference, a preference that was more pronounced in business/corporate pilots than in Part 121 pilots. These results tend to support Dent and Powley's (2003) research into resistance to change and perceived loss.

Because of the strong impact these two factors have on COF, any future research in this area should consider controlling for these effects by using probabilistic sampling techniques to ensure the sample used is representative of the population of commercial and airline-transport rated pilots with respect to industry sector.

Industry Impact

Despite significant attempts to train first officers on how to overcome barriers that inhibit their ability to correct captain errors, commercial aviation continues to see events where monitoring and challenging failures adversely impact aviation safety (NTSB, 2011a). These events provide evidence that attempts to train crewmembers to overcome these barriers have not fully achieved the objectives envisioned by early CRM pioneers. Even though aviation continues to observe first officer resistance to the mitigation strategies designed to increase their challenging / monitoring skills (Dismukes, et al., 2007; NTSB, 1994), no prior research was discovered that was designed to investigate whether hierarchical organizational structures are the root cause of this resistance. This research investigated whether COF may be a potential root cause in both subordinate pilot behavior and its concomitant contribution to flight safety. This sample of commercial and airline transport-rated pilots indicated that they believed organizational framework has an impact on subordinate pilot performance. Past research supports the findings that organizational framework has an impact on crew performance and teamwork (Lukinaitė & Sondaitė, 2017; Reason, 1990; Wiegmann & Shappell, 2001; Wriston, 2007), although this past research did not specifically investigate the impact different organizational frameworks have within the multi-crew flight deck environment. This study attempted to address this gap in the literature. The knowledge gained through this study may provide the impetus for additional research designed to determine whether pilot perceptions, as measured in this study, are in fact predictors of pilot behaviors, specifically subordinate pilot behaviors.

Conclusions

This study investigated the impact of organizational framework on flight safety and subordinate pilot behavior. Its scope was limited to studying commercial and airline transport pilot perceptions of whether COF influenced safety and subordinate pilot behavior by world events, the COVID-19 virus. The inability to conduct in-person interviews or employ an experimental design greatly influenced the decision to utilize a research design that employed an online survey and non-probabilistic sampling techniques. While these limitations did impact the research design, they did not prevent the successful execution of the study.

The data indicate that this sample of commercial and airline-transport pilots believed COF has a significant impact on subordinate pilot behavior, and that the CAPT-CAPT COF was more likely to result in subordinate pilots correcting captain errors, enforcing SOPs, and interjecting to preserve flight safety. Further, when given the opportunity in the three categorical questions to respond that COF *had no impact* on subordinate pilot behaviors (i.e., FOs were no more likely to correct captain errors, enforce SOPs, or interject to preserve safety based upon the COF employed in the cockpit), only 19.5%, 19.9%, and 22.2% respectively chose that response. Similarly, when the same three categorical questions also gave pilots the opportunity to respond that they *were unsure* whether COF impacted subordinate pilot behavior, only 12.6%, 14.2%, and 12.3% respectively chose that response. This compares with 67.8%, 69.7%, and 65.5% of pilots selecting either the CAPT-CAPT or CAPT-FO COF as more likely to produce improvements in the same three categorical questions. Thus, pilots strongly indicated they perceived COF had an impact on subordinate pilot behaviors, and when given the opportunity to equivocate about their perceptions of COF, few pilots indicted that they were either unsure or did not believe that COF had on impact on subordinate pilot behaviors.

Theoretical Contributions

This study investigated pilot's perceptions of the impact of COF on safety and subordinate pilot behavior. While the external validity of the study may have some limitations, theoretical validity is a more effective measure of the importance of the findings of this study because of the investigative nature of the research. Theoretical validity is defined as the degree to which theoretical explanations developed from the study fit the data. Theoretical validity is especially important when investigating new or original concepts (Cohen, et al., 2017). While external validity may be limited, the theoretical validity of this research was strengthened by the new contributions to the body of knowledge in the following areas: (a) pilots perceive COF as a factor contributing to the willingness of subordinate pilots to correct captain errors, enforce SOPs, and interject to preserve safety, (b) pilots perceived the CAPT-CAPT COF as more likely to result in subordinate pilots correcting captain errors, enforcing SOPs, and interjecting to preserve safety, (c) pilot perception of COF is strongly influenced by the industry sector in which the pilot is employed, and (d) pilot perception of COF is strongly influenced by the COF utilized by their present employer.

This new knowledge may explain the observation made by the NTSB (2011, p. 4) in the accident report involving an Avions de Transport Régional (ATR) 42 when they commented, "Thirteen years after the FAA issued AC 120-51C [mandating CRM training], the NTSB continues to investigate accidents where one pilot does not question the actions or decisions of another pilot." The CRM training programs introduced in the 1980s were designed to train captains to encourage FOs to take action to preserve safety and FOs to be more assertive. However, this research indicates that current CRM training programs failed to address the potential root cause that is preventing FOs from being more assertive to preserve safety. The results of this study support the hypothesis that pilots perceived COF as a potential contributor to subordinate pilot willingness to take action to preserve safety. This is a potential contributor to flight safety that has not been investigated before.

Practical Contributions

The operational implications of the results of this study are somewhat limited due to the limited scope of this investigation. However, this investigation has revealed a new area of investigation for the aviation research community to determine whether pilot perceptions, as indicated in this study, are accurate predictors of subordinate pilot behavior. If future research finds that COF has a significant impact on subordinate pilot behavior and flight safety, then the industry may need to consider changing the COF that is dominant in the airline industry. This type of change would be exceedingly difficult because it would require a cultural change, and as discussed in Chapter 2, implementing cultural change can be challenging. This type of cultural change may be too difficult for an existing carrier because of existing hierarchical organizational structures. The true practical application of this new approach to how flight-deck crewing is managed would be with new entrant air carriers. New entrants do not have the hierarchical organizational systems in place that established carriers typically have, and this could allow them to establish the COF that offers the greatest safety potential. The findings from this research indicate that pilots in the CAPT-CAPT COF have strong preferences for that COF, believing that not only does this COF result in improved safety but also improved subordinate pilot behavior. In addition to the potential improvements in safety that the CAPT-CAPT COF may provide, a new entrant carrier may also be better able to attract pilots who are eager to function as the PIC far sooner than they may be able to in the CAPT-FO COF.

Limitations of the Findings

The sampling strategy utilized an online survey and non-probability sampling techniques. The primary weakness of this sampling technique was the inability to ensure the sample was representative of the target population (Wolf et al., 2016). To reduce the threat to external validity posed by the non-probability sampling techniques, the plan to recruit respondents employed multiple techniques designed to reach a broad range of professional pilots. However, the sample of pilots used in this study did not approximate the population in the following categories: (a) currently employed industry sector and (b) current employer COF.

As discussed earlier, the oversampling of business/corporate pilots resulted in a sample which may have been non-representative of the population of commercial and airline-transport rated pilots. Given the strong influence industry sector had on pilot perceptions of COF, the external validity of the results of this study may have some limitations. However, theoretical validity, a potentially more effective measure of the importance of the findings of this study, was strengthened by the new contributions to the body of knowledge in the following areas: (a) pilots perceive COF as a factor contributing to the willingness of subordinate pilots to correct captain errors, enforce

SOPs, and interject to preserve safety, (b) pilots perceived the CAPT-CAPT COF as more likely to result in subordinate pilots correcting captain errors, enforcing SOPs, and interjecting to preserve safety, (c) pilot perception of COF is strongly influenced by the industry sector in which the pilot is employed, and (d) pilot perception of COF is strongly influenced by the COF utilized by their present employer.

Recommendations

In the paragraphs that follow are a series of recommendations designed to both validate the research findings achieved in this study and to further the understanding of this new construct. While the importance and potential impact of making changes in the framework of how cockpits are organized should not be understated, it is worth recognizing that the remarkable improvements in flight safety introduced in Chapter 1 have been achieved primarily within the CAPT-FO framework, the COF that is almost universally utilized within the airline industry. Pilot perceptions of the impact of COF on safety and subordinate pilot behavior are important, but it is also important to understand that perceptions are not reality. Any recommendations to change the organizational framework used in aviation must take into consideration the impact such a recommendation could have on not only subordinate pilot behavior, but also superordinate pilot behavior, an area not addressed by this research.

It is incumbent on researchers not to overstate the significance of their findings. It is also imperative that any recommendations for change be grounded in the knowledge that implementing the recommended change is both necessary and beneficial. This research has opened the door to a new area of research which may prove to be beneficial, but additional research is needed before the beneficence of any change in COF can be determined. Therefore, the recommendations that follow focus exclusively on the additional research necessary to determine whether pilot perceptions of COF are an accurate predictor of subordinate pilot behavior and therefore flight safety. Should the additional research recommended below produce results consistent with the findings of this study, then recommendations regarding changes to COF may be warranted.

Recommendations for Future Research Methodology

Any future research in this area should consider the following:

- Due to the powerful influence industry sector has on pilot perceptions of COF, either probabilistic sampling techniques should be employed to ensure the sample is representative of the population of commercial and airline-transport pilots or the study delimited to only one of these sectors.
- Avoid using what potentially may be ambiguous indicators of safety in future survey construction. Developing scenario-based questions which pilots can project themselves into may produce more significant results.
- Solicitation of respondents for online surveys can be highly effective, but online sites can be focused on one segment of the pilot population. Utilize multiple sites to obtain a representative sample of the target population.
- Respect forum rules when soliciting respondents. Forum members can be ruthless on survey requests, so researchers should be prepared for a hostile reception from some forum members. This hostile reception should be expected even if you follow the forum’s rules, and failing to follow forum rules may produce even stronger reactions. However, a constructive engagement with those objecting to your request for participation can

diffuse some hostility while indicating to other more moderate forum members the seriousness of your research effort.

Recommendations for Future Research

CRM training programs, industry safety practitioners, and aviation researchers continue to focus on subordinate pilot behavior as key to improving safety. This research, while limited in scope, is a tentative step into an area which has the potential to improve subordinate pilot behavior and thereby improve aviation safety.

Below are the research recommendations which are needed to further our understanding of COF as a potential contributor to flight safety. They provide not only a recommendation for future research, but the order in which this research should proceed.

1. A replication of this study which employs probabilistic sampling techniques.
2. Experimental research employing a simple flight simulation device where COF can be controlled and manipulated, and subordinate pilot behavior measured to determine whether COF impacts subordinate pilot behavior.
3. Experimental research employing a full flight simulation device where COF can be controlled and manipulated, and subordinate pilot behavior measured to determine whether COF impacts subordinate pilot behavior.

A parallel avenue of research would involve the business research community. This research would include the cost impact of a shift to the CAPT-CAPT COF for the airline industry to determine whether there are potential cost savings associated with such a change. Having a less fragmented pilot group may reduce to complexities of crew and training scheduling systems, which may therefore result in operational efficiencies and reduced costs. Making the business case for a change in COF may provide the impetus for change in the same way that aviation safety pioneers made a case for improving safety by demonstrating the potential benefit to financial performance for companies that embraced their concepts.

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Appendix A

Dissertation Proposal Approval Form

Dissertation Proposal Approval Form

EMBRY-RIDDLE
Aeronautical University

Dissertation Proposal Approval Form

Student Name: Robert Allen ID# 2323650

Department of: School of Graduate Studies

Proposed Title: Pilot Perception of Cockpit Organizational Framework's Impact on Flight Safety and Subordinate Pilot Behavior

Committee Approval (Please print names. **State University affiliation if other than ERAU.)

Chairperson: Andy Dattel **University: ERAU

Dept: School of Graduate Studies Signature: Andy Dattel

Member: David A. Esser **University: ERAU

Dept: Aeronautical Science Signature: David A. Esser, Ph.D.

Member: Jennifer Thropp **University: ERAU

Dept: School of Graduate Studies Signature: Jennifer E. Thropp

Member: **University:

Dept: Signature:

External Member: Rich Steckel **Affiliation: St. Louis University

Dept: Flight Science Signature: Richard J. Steckel

Administrative Approval:

Dothang Truong
Program Coordinator

Steven Hampton Digitally signed by Steven Hampton Date: 2021.01.12 12:38:43 -05'00'
Department Chair

Alan Stolzer Digitally signed by Alan Stolzer Date: 2021.01.12 12:33:22 -05'00'
Dean

EMBRY-RIDDLE
Aeronautical University

Your research may require regulatory oversight. Approval from a regulatory oversight committee may be necessary before any research is conducted.

Does the proposal involve research with any human/animal subjects? YES ☑ NO ☐

If "Yes" Indicate date approved and IRB NUMBER: ______________________

Project Number______________________ Date ______________________

If the IRB determines that your project DOES NOT NEED approval, please provide appropriate documentation from that office.

I, Robert Allen, affirm that the research for my doctorate degree will be conducted in agreement with ethical standards at Embry-Riddle Aeronautical University and that my dissertation will be original. I will provide unambiguous attribution for the thought and the words of other scholars eventually appearing in the work. I understand that failure to provide clear credit in this way can result in severe penalties, including separation from the University and revocation of a degree.

I also understand that regulatory oversight for my research may be required and that I should contact the Institutional Review Board for assistance.

____
Student Signature

Appendix B

Survey Instrument

Section A: Demographic and pilot information

1. **Please provide your age:**

   ☐

2. **Please provide your gender:**

☐ **Male**
☐ **Female**

3. **What pilot certificate and class ratings do you currently hold? (Select all that apply.)**

☐ **Commercial pilot single-engine**
☐ **Commercial pilot multi-engine**
☐ **Airline Transport pilot single-engine**
☐ **Airline Transport pilot multi-engine**
☐ **Other (Rotorcraft, glider, any non-US based equivalent certificate, etc. For certificates issues outside the US, please specify certifying country and certificate type below.)**

☐

4. **Please provide your total flight time.**

   ☐

5. **Please provide your total flight time in the last 12 months.**

   ☐

6. **Please provide you total pilot-in-command (PIC) flight time.**

7. **Please provide you total second-in-command (SIC) flight time.**

Section B: Pilot employment and flight department information

8. **Are you now or have you been employed as a pilot within the preceding 12 months?**

- ☐ **Yes**
- ☐ **No**

Note: If your response to question 8 above was "yes", please answer questions 9-14 with reference to your current or most recent pilot employment, then continue to Section C and answer questions 15-41.

If your response to question 8 above was "no", please skip questions 9-14, go directly to Section C and answer questions 15-41.

9. **Please select the industry sector in which you are currently employed as a pilot.**

- ☐ **None**
- ☐ **Business/commercial aviation**
- ☐ **Part 135 scheduled air-carrier operations**
- ☐ **Part 121 scheduled air-carrier operations**
- ☐ **Commercial helicopter operations**
- ☐ **Military aviation**
- ☐ **Other (Please specify below)**

10. **Please select the type operation in which you are currently employed as a pilot.**

- ☐ **Single-pilot operation**
- ☐ **Multi-pilot operation**
- ☐ **Other (Please specify below)**

11. **Please select the responses below that describe all types of operations in which you have been employed as a pilot (select all that apply).**

- ☐ **Single-pilot operation**
- ☐ **Multi-pilot operation**
- ☐ **Other (Please specify below)**

12. **What qualifications do you currently hold as a pilot?**

- ☐ **Single-pilot PIC**
- ☐ **Captain/PIC**
- ☐ **First officer/SIC**
- ☐ **Other (Please specify below)**

13. **What additional qualifications have you held with your present or past employers (select all that apply)?**

- ☐ **Single-pilot PIC**
- ☐ **Captain/PIC**
- ☐ **First officer/SIC**
- ☐ **None**
- ☐ **Other (Please specify below)**

14. If currently employed in a multi-pilot operation, how are crew duties (captain/PIC or first officer/SIC) assigned in your operation?

- ☐ **Fixed, I always function as the captain/PIC**
- ☐ **Fixed, I always function as the first officer/SIC**
- ☐ **Rotated, I am equally likely to function as either captain/PIC or first officer/SIC**
- ☐ **Not currently in a multi-pilot operation**
- ☐ **Other (Please specify below)**

15. If employed in a multi-pilot operation in the past, how were crew duties (captain/PIC or first officer/SIC) assigned? Please mark all that apply.

- ☐ **Fixed, I always functioned as the captain/PIC**
- ☐ **Fixed, I always functioned as the first officer/SIC**
- ☐ **Rotated, I was equally likely to function as either captain/PIC or first officer/SIC**
- ☐ **I was not employed in a multi-pilot operation at a past employer.**
- ☐ **Other (Please specify below)**

Section C: Pilot perceptions on positional assignments and intra-cockpit teamwork

In this section you will be asked for your opinions on how different cockpit organizational frameworks, compared to each other, may impact various crew and safety parameters.

For the purposes of this survey, cockpit organizational framework refers to the system used to make positional assignments within the cockpit (captain/PIC and first officer/SIC) and the resulting composition of the cockpit crew.

A CAPT-FO organizational framework is: a) a crew with one captain and one-first officer, and b) where, regardless of the when they are scheduled, both the roles and seat assignments for these individuals are fixed (the captain always functions as captain, and the first officer always functions as first officer).

A CAPT-CAPT organizational framework is: a) a crew with two captains assigned, and b) where the roles and seat assignments of these crewmembers are rotated (the captain/PIC on one flight will function as first officer/SIC on another flight, and the first officer/SIC on one flight will function as captain/PIC on another flight).

You will be asked to state your opinion on how these different cockpit organizational frameworks may impact various crew and safety parameters relative to each other. It is important that you answer these questions with your beliefs about the question asked.

16. **I believe the CAPT-FO organizational framework would result in improved cockpit teamwork relative to the CAPT-CAPT organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

17. **I believe the CAPT-CAPT organizational framework would result in improved cockpit teamwork relative to the CAPT-FO organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

18. **I believe cockpit teamwork would be improved if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

19. **I believe cockpit teamwork would be improved would be improved if one cockpit member were qualified as captain and the other crewmember were qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

20. **I believe the CAPT-FO organizational framework would result in improved intra-cockpit communication relative to the CAPT-CAPT organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

21. **I believe the CAPT-CAPT organizational framework would result in improved intra-cockpit communication relative to the CAPT-FO organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

22. **I believe intra-cockpit communication would be improved if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

23. **I believe intra-cockpit communication would be improved if one cockpit member were qualified as captain and the other crewmember was qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

24. **I believe the CAPT-FO organizational framework would result in improved flight safety relative to the CAPT-CAPT organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

25. **I believe the CAPT-CAPT organizational framework would result in improved flight safety relative to the CAPT-FO organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

26. **I believe flight safety would be improved if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

27. **I believe intra-cockpit communication would be improved if one cockpit member were qualified as captain and the other crewmember were qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

28. **I believe the likelihood of the FO/SIC correcting Capt/PIC errors would be greater in a CAPT-FO organizational framework than in a CAPT-CAPT organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

29. **I believe the likelihood of the FO/SIC correcting Capt/PIC errors would be greater in a CAPT-CAPT organizational framework than in a CAPT-FO organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

30. **I believe the likelihood of the FO/SIC correcting Capt/PIC errors would be greater if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

31. **I believe the likelihood of the FO/SIC correcting Capt/PIC errors would be greater if one cockpit member were qualified as captain and the other crewmember were qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

32. **I believe the FO/SIC:**

☐ **would be more likely to correct Capt/PIC errors if the FO/SIC were qualified as a captain**
☐ **would be more likely to correct Capt/PIC errors if the FO/SIC were qualified as a first officer**
☐ **likeliness to correct Capt/PIC errors would be unaffected by the FO/SIC's qualifications**
☐ **I am not sure how the FO/SIC's qualifications would impact their willingness to correct Capt/PIC errors.**

33. **I believe the likelihood of the FO/SIC enforcing compliance with standard operating procedures would be greater in a CAPT-FO organizational framework than in a CAPT-CAPT organizational framework (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

34. **I believe the likelihood of the FO/SIC enforcing compliance with standard operating procedures would be greater in a CAPT-CAPT organizational framework than in a CAPT-FO organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

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☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

35. **I believe the likelihood of the FO/SIC enforcing compliance with standard operating procedures would be greater if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)**

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

36. I believe the likelihood of the FO/SIC enforcing compliance with standard operating procedures would be greater if one cockpit member were qualified as captain and the other crewmember were qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

37. I believe the FO/SIC:

- ☐ **would be more likely to enforce compliance with standard operating procedures if the FO/SIC were qualified as a captain**
- ☐ **would be more likely to enforce compliance with standard operating procedures if the FO/SIC were qualified as a first officer**
- ☐ **likeliness to enforce compliance with standard operating procedures would be unaffected by the FO/SIC's qualifications**
- ☐ **I am not sure how the FO/SIC's qualifications would impact their willingness to enforce compliance with standard operating procedures.**

38. I believe the likelihood of the FO/SIC interjecting to ensure flight safety would be greater in a CAPT-FO organizational framework than in a CAPT-CAPT organizational framework. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

39. I believe the likelihood of the FO/SIC interjecting to ensure flight safety would be greater in a CAPT-CAPT organizational framework than in a CAPT-FO organizational framework(Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

40. I believe the likelihood of the FO/SIC interjecting to ensure flight safety would be greater if both cockpit members were qualified as captains. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9-----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

41. I believe the likelihood of the FO/SIC interjecting to ensure flight safety would be greater if one cockpit member were qualified as captain and the other crewmember were qualified as first officer. (Please rate your agreement or disagreement with this statement by selecting a number between 0 and 10 below.)

Strongly Disagree **Strongly agree**

0-----------1-----------2-----------3-----------4-----------5-----------6-----------7-----------8-----------9----------10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

42. I believe the FO/SIC:

☐ **would be more likely to interject to ensure flight safety if the FO/SIC were qualified as a captain**

☐ **would be more likely to interject to ensure flight safety if the FO/SIC were qualified as a first officer**

☐ **likeliness to interject to ensure flight safety would be unaffected by the FO/SIC's qualifications**

☐ **I am not sure how the FO/SIC's qualifications would impact their willingness to interject to ensure flight safety.**

Appendix C

ERAU Human Subject Protocol Exempt Determination Form

Embry-Riddle Aeronautical University
Application for IRB Approval
EXEMPT Determination Form

Principal Investigator: Robert D. Allen

Other Investigators: Dr. Andy R. Dattel

Role: Student **Campus:** Worldwide **College:** Aviation/Aeronautics

Project Title: Pilot Perception of Cockpit Organizational Framework's Impact on Flight Safety and Subordinate Pilot Behavior

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 12/09/2020 **Approval #:** 21-057

Determination: Exempt

Dr. Beth Blickensderfer
IRB Chair Signature: Elizabeth L. Blickensderfer, Ph.D. Digitally signed by Elizabeth L. Blickensderfer, Ph.D. Date: 2020.12.15 15:34:11 -05'00'

Brief Description:

This research proposes to investigate commercial and airline transport pilot's perceptions on whether the system used to determine crew member's positional assignments and flight deck duties may have an impact on subordinate pilot behavior and flight safety. This research will investigate pilot perceptions on whether the organizational systems used in commercial airline, corporate aviation, or military aviation offer advantages which have an impact on subordinate behavior and flight safety. A quantitative-survey research design which employs an online self-administered survey using SurveyMonkey will be utilized.

This research falls under the **EXEMPT** category as per 45 CFR 46.104:

☑ (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (Applies to Subpart B [Pregnant Women, Human Fetuses and Neonates] and does not apply for Subpart C [Prisoners] except for research aimed at involving a broader subject population that only incidentally includes prisoners.)

Appendix D

INFORMED CONSENT

AGREEMENT TO PARTICIPATE IN SURVEY: Pilot Perception of the Impact Cockpit Organizational Framework has on Flight Safety and Subordinate Pilot Behavior

STUDY LEADERSHIP. We are asking you to take part in a research project that is led by Robert D. Allen, a Ph.D. Candidate at Embry-Riddle Aeronautical University Worldwide.

PURPOSE. The purpose of this study is to collect data on active commercial and/or airline transport rated pilot's perception on two different flight deck organizational systems and how those different system may impact flight safety related parameters.

ELIGIBILITY. To be in this study, you hold a commercial and/or airline transport pilot certificate issued under 14CFR 61.5 and be either currently employed as a pilot or employed as a pilot within the previous 12 months.

PARTICIPATION. During the study, you will be asked to complete an online survey regarding your flight experience, age, gender, and current and past pilot employment conditions. You will also be asked your perceptions of how different flight deck organizational systems could impact several key flight safety related parameters.

You are asked to answer each question honestly and with the benefit of your experience as a professional pilot. Your answers are not limited to the conditions currently present in the industry or at your employer; but instead, we ask you to consider the conditions specified in the survey and provide us your perceptions of how these different conditions may impact either your performance, the performance of your fellow aviation professionals, and flight safety in general.

Completion of this survey will take between 20-25 minutes.

RISKS OF PARTICIPATION. The risks presented by subject participation in the study are minimal, with no risks to dignity, rights, health, or welfare for those who participate in this research.

BENEFITS OF PARTICIPATION. There will be no direct benefits from your participation in this research effort. However, your response will assist in this research project, and data from this research may help to enhance flight safety.

COMPENSATION. There is no direct compensation for participation in this research. However, participants who complete the survey will be given the opportunity to enter a drawing for one of three Vanilla Gift Cards valued at $300, $150, and $50. These gift cards serve to both increase participation in the survey and while also expressing our appreciation for assisting in this research project.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time.

RESPONDENT PRIVACY. Your responses to this survey will be anonymous, meaning no personally identifying information other than basic demographic descriptors will be collected. Examples of personally identifiable information which will NOT be collected or retained include your name, email address, pilot certificate number, or physical or home address. Examples of basic demographic descriptors which will be collected or retained include age, gender, flight time, recency of experience, employment status, and certificates held (not certificate numbers). The information collected and retained are limited to information that cannot identify any participant's identity. The survey link and the link for entry into the participation reward drawing are completely independent; no information will be shared between these two sites ensuring there will be no ability to use information from the drawing survey to identify any respondents in the research survey.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact, Robert D. Allen, via email at allenr22@my.erau.edu, or the Research Chairman, Dr. Andrew R. Dattel, at dattela@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179, or via email at teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By clicking "Yes" below, you certify that you agree to participate in this research, that you understand the information on this form, and that any questions you have about this study have been answered.

Further, by clicking "YES" below you voluntarily agree to participate in the study. A copy of this form can be requested at the email contact information provided above.

☐ Yes, I am a commercial and/or airline transport-rated pilot and would like to participate.

Appendix E

EXAMPLE ONLINE FORUM POSTING

Fellow professional pilots, I thought you all might be interested in participating in this survey about the different systems used to organize our cockpits. The study is based upon the informal inputs of pilots from different industry sectors and gives you a chance to state which system you think would work best. It takes about 20 minutes to complete. Plus, after you complete the survey, you will be given a chance to win one of three gift cards ($300, $150, or $50) via a random drawing.

Use the link below to access the online survey. This my second research effort conducted post-retirement; I look forward to hearing your thoughts on what I hope you will find to be an interesting study.

https://www.surveymonkey.com/r/COF-Survey