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Safety Culture, Training, Understanding, Aviation Passion: The Impact on Manual Flight and Operational Performance

Karlene Kassner Petitt

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This Dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. David Esser, Ph.D, and has been approved by the members of the dissertation committee. It was submitted to the College of Aviation and was accepted in partial fulfillment of the requirements for the
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ABSTRACT

Researcher: Karlene Kassner Petitt

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The objective of this study was to understand pilots' proclivity toward automation usage by identifying the relationship among pilot training, aircraft and systems understanding, safety culture, manual flight behavior, and aviation passion. A survey instrument titled Manual Flight Inventory (MFI) was designed to gather and assess self-reported variables of manual flight behavior, aviation passion, safety culture perception, pilot training, and pilot understanding. Demographic data and automation opinion-based questions were also asked to fully understand pilots' thoughts on automation, safety culture, policies, procedures, training methodologies and assessment measures, levels of understanding, and study techniques. Exploratory Factor Analysis (EFA) was utilized to identify underlying factors from the data, followed by confirmatory factor analysis (CFA) to confirm the factor structure. Structural Equation Modeling (SEM) was utilized to test the relationships between the variables. All hypotheses were significant; however, four of the thirteen hypotheses were not supported due to a negative relationship. The significant predictors of manual flight were identified to be pilot understanding, pilot training, aviation passion, and safety culture. Pilots' understanding of the aircraft operating systems was determined to have the greatest influence over a pilot's decision to manually fly. Aviation passion was identified as the second largest influencing factor. Pilot training had the greatest influence over pilot understanding, and safety culture presented the greatest influence over pilot training. Results identified that safety culture was negatively impacting pilot training, and pilot training had a negative influence over pilots' decision to manually fly. The contributions of this research have identified the significance of safety culture as associated with Safety Management Systems (SMS) as an influencing factor over pilot training and resultant operational performance. Pilot understanding is a direct result of pilot training, and current training practices are negatively influencing the decision for manual flight. Therefore, a solution to the industry problem—operational confusion (understanding), as well as guidance versus control (Abbott, 2015), and the lack of hand flying skills and monitoring ability (OIG, 2016)—can now be addressed by improving training practices. Future research and recommendations were provided.

DEDICATION

I dedicate this work to the thousands of pilots worldwide who participated in this research, and to those who are courageous enough to use these results to create positive change.

When this work began, I was required to acquire 1,599 surveys. I was told that was impossible. At the most I would get 300, maybe 350. Eight months later I had 7,492 surveys. The significance of this number identifies that pilots worldwide care about the safety of the industry. Comments received from these pilots have further identified concern with the trajectory and ensuing safety of where this industry is going. The hope is that this research will be used for betterment of this industry to make positive steps for the future to ensure safe travel for all.

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CHAPTER I

INTRODUCTION

Air France Flight 447, Colgan Air Flight 3407, Asiana Flight 214, and UPS Flight 1354 were a series of catastrophic accidents attributed to pilot error due to inadequate skill. However, critical analysis of these accidents revealed problems beyond skill to include lack of systems and aircraft understanding, as well as incorrect operational procedures (BEA, 2012; NTSB, 2010; NTSB, 2014a; NTSB, 2014b). While automation was designed to improve safety, pilot training may not be keeping up with technological growth, leaving pilots without a thorough understanding of aircraft systems and operational procedures that may be resulting in pilots' reluctance to manually fly their aircraft without the autopilot and autothrust (Young, Fanjoy & Suckow, 2006). Whereas the option to disengage the autothrust and autopilot remains in the pilot's control, component failure may cause unintended disengagement requiring manual flight proficiency. Thus, pilots should be able to manage the aircraft in all modes of operation from Level 0 (no autopilot, autothrust, and flight director) to a fully automated and managed aircraft of Level 4. Pilots should also have competency beyond rote memorization of aircraft limitations, to a level of knowledge where they possess a complete understanding of instrument displays, system operations, and operational procedures in order fully realize situation awareness (SA) (Endsley, 2001). *SA* is defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 2001, p. 5). While research has identified that technology improves visualization in the glass cockpit aircraft, this technology could also be a contributory factor of reduced skills in the ability to scan. There is concern that if the automation were to fail and pilots were required to fly on standby instruments, they may have problems maintaining control within required speed, heading, and altitude control of ten knots, ten degrees, and 100 feet respectively (Young, Fanjoy & Suckow, 2006).

The Next Generation Air Transport System (NextGen) is underway, where satellite-based systems will replace ground-based systems for air traffic management (Curtis, Jentsch, & Wise, 2010). Continued technological advancement will necessitate that pilots taxi utilizing moving maps, execute satellite-based landing procedures, and assume responsibility for aircraft separation (FAA, 2016; Krois, Piccione, & McCloy, 2010). With increased complexity and additional responsibilities, reduced SA will create an environment susceptible to human error. Krois, Piccione, and McCloy (2010) purport, "Major changes in NextGen flight decks provide new opportunities for error as well as a change in the nature and frequency of existing error patterns" (p. 705). History has also shown that any time new technology is introduced, an area of instability develops associated with a learning curve, creating an environment ripe for catastrophe (Salas, Maurino, & Curtis, 2010). If pilots do not have a solid understanding of their aircraft and procedures, possessing both cognitive and physical skills, the added complexity of NextGen may increase instability with additional technological distractions (Darr, Ricks, & Lemos, 2010). NextGen pilots will also have fewer opportunities to manually fly, due to regulatory pilot-managed separation and automated arrivals (Darr, Ricks, & Lemos, 2010; FAA, 2016). A paradigm shift is underway where manual flight skills may become archaic due to NextGen yet will remain essential for safe operations when systems fail (FAA, 2016). Thus, the necessity for pilots to understand and manage the automated aircraft, with or without the autopilot and autothrust, and perhaps without the flight director engaged, remains a key issue in merging automated aircraft into the NextGen automated environment with human operators (Casner, Geven, & Williams, 2013; Franks, Hay, & Mavin, 2014; Geiselman, Johnson, & Buck, 2013; Haslbeck, Ekkerhart, Onnasch, Huttig, Bubb, & Bengler, 2012; Kole, Healy, & Fierman, 2010; Moll, 2012).

The Federal Aviation Administration's (FAA) chief scientific and technical advisor for the flight deck human factors group identified flight skill loss and mode awareness to be industry problems, but also included issues dealing with operational confusion (understanding), as well as guidance versus control (Abbott, 2015). The Office of Inspector General (OIG) further identified pilots' lack of hand flying skills and monitoring ability to be industry issues (OIG, 2016). However, these industry concerns should be of no surprise, in that an FAA human factors task force reported similar issues in 1996, where pilots showed weaknesses in "understanding, automation/mode awareness, and insufficient knowledge and skills" (FAA, 1996, pp. 23-24). The human factors task force also reported heightened concern with both "the quality and quantity of automation training" (FAA, 1996, p. 33). Nineteen years after that 1996 report was presented to the human factors committee, the chair of that committee spoke of those exact industry concerns at the 2015 Flight Safety IASS conference (Abbott, 2015). Recommendations from that FAA (1996) safety report went unaddressed, and today flight skill loss, due to automation reliance and complacency, continues to grow as an industry concern (Abbott, 2015; Curtis et.al., 2010; FAA, 1996; Franks, Hay, & Mavin, 2014; Geiselman, Johnson, & Buck, 2013; Haslbeck et al., 2012; Moll, 2012).

Research has identified that unheeded concerns contained within that 1996 FAA report were contributing factors to numerous accidents, incidents, and thousands of events resulting from pilot error (FAA, 2013d). An FAA sponsored working group (WG) examined 46 major incidents and accidents, 734 Aviation Safety Reporting System

(ASRS) reports, 9,155 Line Operations Safety Audits (LOSA), and interviewed numerous pilots, and identified insufficient understanding of aircraft systems, overuse of automation, and flight skill loss, associated with training, to be contributing factors to pilot error (FAA, 2013d). In response to the concern for flight skill loss, the FAA released a safety alert to encourage manual flight (FAA, 2013a). Despite the FAA directive, it appears that pilots may be reluctant to manually fly their aircraft; therefore, flight skill loss has become an industry issue (OIG, 2016). This reluctance to fly may be diminishing pilots' skills as a result of and/or contributing to the lack of confidence.

The nature of long-haul flying has created additional challenges for pilot competency and performance in that technology enables aircraft to stay aloft for many hours. Long-haul flights therefore demand multiple pilots due to the length of flight time; yet, with only one flight segment every other day, only one of the three to four pilots have the opportunity for a takeoff or landing event to maintain currency (FAA, 2008). Reduced vertical separation minimums (RVSM) require autopilot usage enroute (FAA, 2015b), and the typical airline pilot is said to manually fly less than two-minutes per flight (Lowy, 2011). As opposed to domestic flying, many long-haul pilots also visit a simulator every 90-days, per Federal Aviation Regulation (FAR) 121.439, in lieu of flying, yet only meet minimum requirements during this currency event to make them legal. Many FAA approved training programs require pilots to train themselves at home, allow the classroom portion of training to be an instructor review of the electronic test, followed by a computer assessment of pilots' systems knowledge versus a traditional oral exam to assess understanding, followed by simulator sessions that only allow the pilot to experience an event once (FAA, 2017a). However, in order to learn, pilots must not only have aptitude, but they must also have the ability to practice through repetition, receive feedback, and feel confident that the level of performance they achieve will ensure a safe operation (English & Visser, 2014; Hattie & Timperley, 2007; Huddleson & Rolfe, 1971; Johnson, & Fowler, 2011). A pilot must experience success to feel confident. Without repetition to a continued set of successful attempts, doubt will prevail, leaving the pilot with diminished confidence (Johnson & Fowler, 2011). General aviation flight activity may also impact a pilot's decision to disengage automation during flight associated with work, in that the pilot's passion may transfer to the job with greater interest resulting in self-directed learning. Safety culture, policy, and training methodologies may impose additional factors that impact pilot behavior concerning manual flight.

Within the advanced qualification program (AQP), a *train to proficiency* program introduced in 1990, pilot training has shifted from individual performance assessment to crew-based performance assessment (Helmreich, Merritt, & Wilhelm, 1999). Under AQP guidelines, airlines have realized an economic benefit by reducing the training footprint. However, training assessment effectiveness has been an ongoing concern and may still be in question (Nemeth, 2015). This raises the question as to how AQP training has impacted pilots' aircraft systems and operational understanding, confidence, monitoring skills, and willingness to manually fly. The first step in finding a solution to these industry problems—flight skill loss, lack of mode awareness and confusion (Abbott, 2015); lack of hand flying and monitoring skills (OIG, 2016); and lack of aircraft understanding and overuse of automation (FAA, 2013d)—is to understand how current training practices, pilots' understanding, safety culture, and passion, may impact performance and pilots' reluctance to manually fly. NextGen will increase pilots' responsibility, adding more complexity and creating opportunities for error (Curtis, Jentsch, & Wise, 2010). However, safety management systems (SMS) are designed to evaluate the environment, assess hazards, mitigate risk, and capture errors (FAA, 2013b; Stolzer & Goglia, 2015). In the middle of these two spectrums of safety, NextGen and SMS, pilot performance becomes an integral part of the entire system.

Significance of the Study

This research identified that safety culture is influencing pilot training with a negative impact on operational performance. The results identified that current training practices are negatively influencing the decision for manual flight, and further identified the importance of pilots' understanding of their aircraft is essential to their decision to manually fly. Therefore, a solution to the industry problems—operational confusion (understanding), as well as guidance versus control (Abbott, 2015), the lack of hand flying skills and monitoring ability (OIG, 2016)—can now be addressed by improving training practices.

Statement of the Problem

Industry reports supported by academic literature indicate that pilots may not understand aircraft systems, lack flight skills due to automation dependence, and have ineffective monitoring skills; all of which could be a direct result of safety culture, pilot training and associated levels of understanding, and aviation passion with resultant impact on the decision to manually fly.

Purpose Statement

The purpose of this research was to examine the relationships among training methodologies, pilots' aircraft understanding, safety culture, aviation passion, and manual flight, in order to address industry concerns of automation dependence, confusion, lack of mode awareness, and flight skill loss. The strongest predictors of automation, meaning the events impacting a pilot's decision to manually fly, could therefore be utilized for empirical research at a later date.

Current industry reports have identified performance issues in modern-day glass cockpit aircraft to include loss of manual flight skills, inability to read the flight mode annunciator, and lack of understanding, which have resulted in accidents, incidents, and safety reports. Whereas current literature has identified automation challenges to include trust and reliability, complacency, display and integrated systems design, confidence, and situation awareness, a gap in the research appears to exist as to what factors impact pilots' performance and proclivity toward automation usage, and if automation usage is impacting performance. In addition, while much research has been conducted on safety culture, a gap in the research exists as to how safety culture may impact a pilot's willingness to manually fly, pilot training, and aircraft understanding.

Research Questions

The overarching research question is—does pilot training, aircraft understanding, aviation passion, and safety culture, impact a pilot's decision as to the level of automation usage? Moreover, in what extent do these factors impact each other? Likewise, could demographics such as age, gender, geographic location, flight hours, type of aircraft, or general aviation flight impact pilots' performance associated with the level of automation utilized?

Aviators' performance has become an industry problem, but factors impacting this performance have yet to be determined. In this research, the level of performance identifies how the aviator chooses to operate the aircraft indicated by the level of automation selected. The FAA appears to have recognized the relationship between manual flight and pilot proficiency because the agency recommended that pilots should manually fly their aircraft (FAA, 2013a). Yet, despite this recommendation, the OIG reported pilots continue to lack hand-flying skills and lack monitoring ability—where manual flight is a skill that speaks directly to pilot understanding of the aircraft they are operating (OIG, 2016). Pilots' unwillingness to manually fly has been identified as an industry problem, but the specific reasons for this unwillingness to manually fly have yet to be identified or acknowledged. A survey instrument—Manual Flight Inventory (MFI)—was developed, tested, and validated to conduct this research. MFI is a survey instrument designed to assess self-reported variables with a measurement tool that had not been previously validated or previously utilized, thus considered new scale development.

In that this research was based upon new scale development, exploratory factor analysis (EFA) was utilized to extract underlying factors among selected input variables in the analysis. After EFA was run, hypotheses were formed. A confirmatory factor analysis (CFA) measurement model was then built and tested. Structural equation modeling (SEM) was utilized to test the relationships between factors in order to better understand the underlying correlations that could influence pilot behavior where manual flight and a variety of variables are concerned. The MFI survey was developed to better understand these relationships to assist the industry to be better equipped to both comprehend and solve the problem, in addition to providing a theoretical contribution, adding to the body of knowledge.

Delimitations

Multiple factors could impact a pilot's willingness to manually fly; however, this research focused only on pilot training, pilots' systems understanding, safety culture, aviation passion, and the level of automation usage. This study targeted airline, charter, and corporate/fractional pilots, worldwide, in multiple aircraft types. Pilot instructors and check airman were allowed to participate, despite that these training professionals should have higher levels of understanding than the average line pilot. Pilots employed in single pilot operations were not utilized due to a single pilot operation may necessitate higher automation usage to reduce workload to a manageable level. Pilots who have retired or were between jobs within the previous 12 calendar months were allowed to participate, in that many active pilots sit reserve and may not fly during the year and many receive recurrent training on an annual basis. The pilots who were retired or between jobs within a year were perceived to still have enough recent experience and perception of past behavior. Pilots who were in the middle of training with a new company, or on a new aircraft type, were requested to respond with answers based upon their most recent aircraft in which they had experience. To ensure pilots' opinions were based upon their experience and not a perception of what they thought may be the case, the questions were designed to be non-conditional. For example, a domestic pilot was not requested to state their opinion on the perception of utilizing automation at the end of a long-haul flight that they never experienced. Each automation opinion-based question was designed to allow the pilot the ability to answer based upon their experience and frame of reference. This research was not intended to study pilots within an individual country or a specific operator but designed to be a broad view of the worldwide pilot population, therefore demographic data was collected based upon general geographic locations.

Limitations and Assumptions

A potential limitation of this study was the lack of a perfect sampling frame due to expansive worldwide operations, which necessitated relying upon nonprobability sampling. Therefore, the sample was primarily located through social network systems

(SNS)—virtual platforms where pilots connect and communicate—with a hybrid of snowball sampling, respondent drive sampling, and purposive sampling.

This sample could also express a higher passion for aviation, and therefore would be more apt to be motivated for self-directed learning than a pilot whose only interest was the perception of a large paycheck. However, many pilots also connect to these sites for the sole purpose of shifting jobs and searching for better career opportunities, thus participation could be career-motivated versus passion driven. Posting a survey link on the open Internet also has the risk of anyone who has access to potentially taking it. Informational messages were utilized to engage potential participants. These potential participants were directed to another site that provided more information and articulated the purpose of the research. Precautions were taken to never post the survey link to any SNS public forum, but to send potential participants to two sites to further explain the purpose of the research and the qualifications to participate. Potential participants were directed to go to the researcher's blog that would identify qualifications and request help for survey fulfillment from qualified participants. Potential participants were then directed to a website that reiterated qualifications and further explained the purpose, history, declaration of anonymity, and provided the survey link.

The researcher is a part of the target population, is an author with a public domain, and is active on SNS. A perceived limitation of this research could be the inability to separate the researcher's scholarly work with that of personal opinions, aviation activity, publications, and blogging activity due to the internet. While there is no indication, research or otherwise, that would indicate this would be the case, protections were taken to design the survey questions in a manner that a public profile would not influence how the participants would respond. To separate the industry related issues and opinions from the survey, a survey link was never connected to an aviation industry statement.

Pilot personality profiles have been identified with low Neuroticism 60% (13% high); Conscientious was at 58% high (7.5% low); Extrovert scale was 42% high (23% low); Openness was 29% high (37% low); and Agreeableness was 27% high (32% low) (Makarowski, Smolicz, & Plopa, 2016; Fitzgibbons, Davis, and Schutte, 2004). This research indicates that pilots are emotionally stable extroverts who are highly conscientious and hold strong opinions. While these statistics fall within the normal distribution, the data indicate that a greater percentage of pilots may not to be open to new ideas or agreeable. Therefore, the assumption was made, due to the pilot personality, that pilots would not be swayed by opinions of another, but more than willing to stand up for their belief system. Research further identified political opinions on Twitter noted as *opinion leadership* regarding influence of political participation and found that Twitter identified with significantly impacting a persons' *involvement* in the political processes; however, utilizing Twitter did not necessarily support a person's *engagement* (Park, 2013).

Both online and paper surveys were utilized to avoid potential limitation of one methodology versus the other. Query and Wright (2003) conducted a combination of online and paper surveys for older adults and reported no discernable differences between data collection formats. Thus, there was no reason to expect that the pilot population would have different results between paper and online surveys. The primary assumption was that the pilots would tell the truth when taking the survey. There was also the assumption that those taking the online survey are in fact who they claim to be, and therefore part of the target population. As with any survey, self-reported data could be subject to accuracy bias in that the surveyed pilots may have an inflated self-perception. Research indicates that pilots may also remember successes more than failures, thus inaccurately overestimating their own abilities (Bénabou & Tirole, 2002; Compte & Postlewaite, 2004). This inaccurate assessment is not dependent upon educational level. In a study of judges and college professors, there was no difference in overestimation, in that 94% of college professors surveyed believed they were better than their colleagues (Gilovich, 1991, as cited in Bénabou & Tirole, 2002); and 90% of federal judges viewed they were above average as compared to their peers (Guthrie et al., 2001, as cited in Compte & Postlewaite, 2004). Therefore, the pilot may indicate a higher level of knowledge, ability, or performance than he or she may actually have. However, reporting higher than actual ability could be equally, or more, prevalent during an interview due the respondent's embarrassment in reporting low knowledge and performance ability to the interviewer versus a computer or paper survey. In an attempt to eliminate accuracy bias, a number of efforts were taken to include emphasis upon anonymity, clearly defined goals, and survey question structure. Pilots' names, and the name of their employer, were not asked; therefore, performance was not linked to the pilot or company. A detailed explanation as to the purpose of this research was provided to promote participation. Survey questions were designed in a manner to assist the pilot respondent in answering the question without forcing the pilot to select one extreme or another. Then tests were conducted to assure validity and reliability. Despite the precautions to encourage participants to respond honestly, the limitation of assessing the level of pilots' understanding, without an actual test to determine knowledge, could be reflective of pilots' over confidence of their knowledge more so than their actual understanding. *Confidence* was removed as a factor due to potential high cross-loading with the factor labeled *Understanding*. However, the factor Understanding responses could be reflective of confidence versus actual knowledge.

The greatest overall limitations could be due to (a) demographics of a worldwide sample associated with misunderstood questions due to language barriers, (b) company and manufacturer mandates dictating automation usage, and (c) the vast number of potential situations that would impact a pilot's decision to manually fly. First, while English is the required language of pilots worldwide, there is a potential for a conceptual misunderstanding of the questions due to English being the second language for many participants. Second, each company and aircraft manufacturer may also have a variety of automation mandates, beyond government regulations, that may leave the pilot without a choice for manual flight. Third, the combination of potential reasons a pilot may choose automation over manual flight are far too many to capture in this survey instrument, as the increased length of adding these additional questions would have greatly increased the risk of survey fatigue. Moreover, asking questions with multiple combinations of possibilities, that are type of flying dependent, would be asking pilots to guess and respond to something they may not have experienced. Eliminating these types of questions that may not pertain to everyone enabled the pilots to answer based upon their actual experience.

Definitions of Terms

Adaptive expertise Adaptive expertise is where understanding and contextual-based knowledge, combined with motivation for problem solving, creates adaptive and flexible strategies for unexpected events (Bohle, Stalmeijer, Konings, Segers, & Van Merrienboer, 2014).

Aeronautical Decision Making (ADM) ADM is "a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances" (Federal Aviation Administration, 1991, p. 4).

AvGeek "An AvGeek is someone who is passionate about aviation and that passion can be shown in countless ways" to include photography, aviation club participation, reading aviation magazines and books, flying home simulators, and/or owning aircraft models (Brown, 2013, par. 4).

Aviation passion Passion is defined as "a strong inclination toward an activity that people like, find important and which they invest their time and energy" (Vallerand et al., 2008, p. 1), whereas aviation passion is a passionate connection to aviation.

Aviation Safety Action Program (ASAP) ASAP is a pilot self-reporting program to encourage pilots to report information for system improvement without fear of disciplinary action (FAA, 2004b). The ASAP reports are directed to the pilots' airline.

Aviation Safety Reporting System (ASRS) The ASRS is a voluntary program that receives and analyzes incident reports that describe unsafe events and potential hazards from "pilots, air traffic controllers, dispatchers, cabin crew, maintenance technicians, and others" to improve safety (NASA, 2015, p. 4). This report is submitted to NASA.

Automaticity When a pilot's knowledge is at the level where he or she does not have to think about what to do, the response is automatic *(*Casner, Geven, & Williams, 2013*)*.

Automation For the purpose of this study, automation refers to a fully engaged auto-flight system, where the autopilot and authothrust are both engaged, and aircraft control is determined by parameters programed into the computer by the pilots, or with pilot mode control panel intervention as required per ATC commands (OIG, 2016).

Automation dependence For the purpose of this study, automation dependence is a pilot's reliance on both the autopilot and autothrust (Parasuraman & Wickens, 2008).

Cognitive architecture Cognitive architecture is the framework representing the mind's structures and processes, related to working memory, information processing, and long-term memory storage (Sweller, van Merrienboer, & Paas, 1998).

Competency For the purpose of this study, competency is "the consistent application of knowledge and skill to the standard of performance required in the workplace. It embodies the ability to transfer and apply skills and knowledge to new situations and environments" (Franks et al., 2014, p. 132).

Corporate culture Corporate culture is a pattern of behavior stemming from artifacts, espoused values and beliefs, underlying assumptions, and policies and procedures, to include elements of a safety culture, identifying organizational processes (Schein, 2010; Stolzer & Goglia, 2015).

Confidence The pilot's belief that he or she will perform well, know what they are doing, and will succeed at a given action (Johnson, & Fowler, 2011).

Confusion A situation in which people are uncertain about what to do or are unable to understand something clearly; the feeling that you have when you do not understand what is happening, what is expected, etc.; a state or situation in which many things are happening in a way that is not controlled or orderly" (Confusion, n.d., para. 11).

Consciously competent "The crew has the knowledge and skill to cope with the situation but must apply much effort to deal with it" (Besco, 1997, p. 60).

Consciously incompetent "The crew knows what they don't know. This can occur when the crew is aware of the gravity of the problem but is unable to select suitable responses to the perceived situation" (Besco, 1997, p. 59).

Flexible culture "People can adapt organizational processes when facing high temporary operations or certain kinds of danger, shifting from the conventional hierarchical mode to a flatter mode" (Stolzer & Goglia, 2015, p. 28).

Flight skill loss For the purpose of this paper, flight skill loss refers to the reduction in manual flying skills.

Flight training Training in a simulator or aircraft, other than ground training.

Fly-by-wire The term used for an aircraft where electronic signals provide input to flight control surfaces versus cable driven control (Airbus, 2003).

Flight Operational Quality Assurance (FOQA) FOQA is a voluntary safety program that collects digital performance data during flight operations, enabling participating airlines to share de-identified data to identify operating trends in order to improve performance (FAA, 2004a).

Full autoflight Full autoflight indicates that both the autopilot and autothrust are engaged, and the aircraft is being flown per pilot programmed commands without mode control panel interventions (FAA, 2016; OIG, 2016).

Full manual flight For the purpose of this research, full manual flight is where the pilot manually flies the aircraft without the authothrust, autopilot, and flight director engaged (OIG, 2016).

Glass cockpit A flight deck with integrated electronic instrument displays versus analog digital flight instruments termed round-dial.

Harmonious passion Harmonious passion is passion internalized into the individual's identity, where they are highly motivated and dedicated, and this passion is in harmony with their life (Kocjan, 2015).

Informed culture "Those who manage and operate the system have current knowledge about human, technical, organizational, and environmental factors that determine the safety of the system as a whole" (Gain, 2004, p. 4).

Initial flight training Initial flight training is defined as qualification and is the training program administered to a pilot new to an aircraft, under the airline's approved program (FAA, 2017a).

Just culture "A just culture refers to a way of safety thinking that promotes a questioning attitude, is resistant to complacency, is committed to excellence, and fosters both personal accountability and corporate self-regulation in safety matters" (Gain, 2004, p. 4).

Knowledge For the purpose of this study, knowledge includes both declarative knowledge (factual knowledge the pilot has about the aircraft operating, annunciation, and navigation systems) and procedural knowledge (pilots know how to perform the company's standard operating procedures), pertaining to the aircraft and flight operations.

Learning culture "Continuous improvement is a characteristic of a learning culture that enables proactive risk management through process improvement" (Yantiss, 2011, p. 169).

Legacy carrier A legacy carrier is an airline that had an established route structure prior to the Deregulation Act of 1978 (Wensveen, 2011).

Level 0 automation For the purposes of this paper, level 0 automation is manual flight, without any automation engaged (Aldana, 2013).

Level 1 automation For the purposes of this paper, level 1 automation indicates that only the flight director is engaged, and the flight is being flown without autothrust or the autopilot and is considered manual flight for LOSA observations (FAA, 2013d).

Level 2 automation For the purposes of this paper, level 2 automation indicates that the flight director and the autothrust are both engaged, yet the autopilot is disengaged, which is also considered manual flight per the OIG (OIG, 2016).

Level 3 automation For the purpose of this paper, level 3 automation indicates that the flight director, autothrust, and autopilot are all engaged—termed full autoflight—yet performance parameter interventions are available to the pilot, also termed tactical autoflight (OIG, 2016).

Level 4 automation Level 4 automations is a fully automated aircraft, with the flight director, autothrust, and autopilot engaged, and the aircraft is being flown per programmed commands without mode control panel interventions—the concept of NextGen operations (Aldana, 2013; FAA, 2016; OIG, 2016).

Line Check Safety Audit (LCSA) "LCSA is an event in which a check airman occupying the jump seat observes a flight crew in the operation of an aircraft" (Esser, 2005, p. 8).

Line Operational Evaluation (LOE) "LOE is an evaluation of individual and crew performance in a flight simulation device conducted during real-time. LOE is primarily designed in accordance with an approved design methodology for crewmember evaluation under an AQP" (FAA, 2004b, p.iii).

Line Oriented Flight Training (LOFT) "LOFT is conducted as a line operation and allows for no interruption by the instructor during the session except for a non-disruptive acceleration of uneventful enroute segments" (FAA, 2004b, pii). A LOFT can either be an initial qualification LOFT, or a recurrent LOFT.

Line Operations Safety Audit (LOSA) "LOSA is an event in which a trained individual occupying the jump seat observes a flight crew in the operation of an aircraft" (Esser, 2005. p. 8).

Manual flight For the purpose of this research, manual flight is where the pilot manually flies the aircraft without the authothrust and autopilot engaged (OIG, 2016).

Mode Awareness "Awareness of aircraft configuration and auto flight system modes. The latter includes such aspects as current and target speed, altitude, heading, AP/FD armed/engaged modes and the state of flight management system (FMS) data entries" (Airbus, 2007, p. 1).

Network driven sampling A term utilized in this research to identify a non-random sampling method that is a hybrid of purposive sampling, snowball sampling and respondent driven sampling, where the researcher is a member of population that does not have a sampling frame, and relies upon recruitment methods of purposive sampling, respondent driven sampling, and snowball sampling.

NextGen The Next Generation Air Transport System, where satellite-based systems will replace ground-based systems for air traffic management (Curtis, Jentsch, & Wise, 2010).

Obsessive passion Obsessive passion stems from the need for social acceptance and self-esteem, where the individual's identity becomes the driving force for the passion, more so than the enjoyment (Kocjan, 2015).

Purposive sampling "A type of nonprobability sampling in which the units to be observed are selected on the basis of researcher's judgment about which ones will be the most useful or representative" (Babbie, 2013, p. 128).

Recency training A recency event is a simulator training event where a pilot performs three takeoffs and landings, within 90-days, to maintain currency per Federal Aviation Regulation (FAR) 121.439 (GPO, 2015).

Recreational flight A pilot flies an aircraft on their days off, not for hire, but for enjoyment.

Recurrent simulator training Recurrent simulator training is an FAA mandate where pilots will receive an approved number of simulator days, per airline, for training and evaluation, conducted on either a sixth month, nine month, or annual cycle (GPO). A typical example for a cycle could be every nine months the pilot will spend two, four-hour sessions in the simulator (day-one and day-two). The first day is training, the second day is checking.

Reserve system An airline operating system where pilots are paid to standby, on call, in the event they are needed to fly.

Respondent driven sampling Respondent-driven sampling (RDS), combines "snowball sampling" (getting individuals to refer those they know, these individuals in turn refer those they know and so on) with a mathematical model that weights the sample to compensate for the fact that the sample was collected in a non-random way (Volz et al., 2012).

Reporting culture A culture where reporting safety related information is both encouraged and rewarded (Stolzer & Goglia, 2015).

Safety culture "The shared values, action, and behaviors that demonstrate a commitment to safety over competing goals and demands" (FAA, 2013b, p. 9). A positive safety culture includes five subcultures—reporting culture, a just culture, a flexible culture, an informed culture, and learning culture (Stolzer & Goglia, 2015).

Safety management systems (SMS) "SMS is the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. It includes systematic procedures, practices, and policies for the management of safety risk" (FAA, 2016, A-2).

Situation awareness "The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 2001, p. 5).

Snowball sampling Snowball sampling is "a technique for finding research subjects. One subject gives the researcher the name of another subject, who in turn provides the name of a third, and so on" (Atkinson & Flint, as cited in Baltar & Brunet, 2012, p. 60).

Social networking site A social networking site (SNS) is a "web-based service that allow individuals to construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view and traverse their list of connections and those made by others within the system" (Boyd & Ellison, as cited in Baltar & Brunet, 2012, p. 58).

Stall "Aerodynamic loss of lift caused by exceeding the critical angle of attack" (GPO, 2010, p. 2361).

Standard operating procedures Airline specific operating procedures, that ensure all pilots will perform the same processes and procedures in the flightdeck.

Startle Factor An unexpected event resulting in an unconscious response (Casner, Geven, & Williams, 2013; Landman, Groen, Van Paassen, Bronkhorst, & Mulder, 2017).

Stick pusher "A device that, at or near a stall, applies a nose down pitch force to an aircraft's control columns to attempt to decrease the aircraft's angle of attack" (GPO, 2010, p. 2361).

Systematic reflection "A learning procedure during which learners comprehensively analyze their behavior and evaluate the contribution of its components to performance outcomes" (Ellis, Carette, Anseel, & Lievens, 2014, p. 68).

Tactical autoflight Tactical autoflight indicates that both the autopilot and auto thrust are engaged, but the aircraft is pilot managed with heading, speed, and altitude interventions (FAA, 2016; OIG, 2016).

Targeted sampling "Targeted sampling includes an initial ethnographic assessment in order to identify the networks that might exist in a given population" (Baltar & Brunet, 2012, p. 60).

TPO "TPOs are statements of performance, conditions, and standards established at the task level," written as AQP directives of training (FAA, 2017a, p. 17).

Unconsciously competent "Unconsciously competent occurs with overlearning in that the knowledge or skill is applied without conscious thought" (Besco, 1997, p. 60).

Unconsciously incompetent "The crew is unaware that they do not know something or that they cannot do something. In other words, the crew doesn't know what they don't know" (Besco, 1997, p. 58).

Understanding Understanding is a pilot's ability, beyond knowledge-based facts and memorized procedures, to know why procedures are accomplished and to identify and understand instrument display indications, enabling the pilot to manage the aircraft during full automation usage (Level 4) or no automation usage (Level 0), whether the automation was intentionally disengaged, or a component failed, within any given environment.

List of Acronyms

AIC Automation-induced complacency

ADM Aeronautical Decision Making

AFC	Automated Flight Control
AGFI	Adjusted Goodness of Fit Index
ALPA	Airline Pilots Association
AP	Autopilot
AQP	Advanced Qualification Program
ASAP	Aviation Safety Action Program
ASRS	Aviation Safety Reporting System
AT	Autothrust
ATP	Airline Transport Pilot Certificate
AVE	Average Variance Extracted
BEA	Bureau of Economic Analysis
CA	Captain
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMIN/df	Minimum Discrepancy/Degrees of Freedom
CR	Construct Reliability
CRM	Crew Resource Management
CLT	Cognitive Load Theory
EFA	Exploratory Factor Analysis
EICAS	Engine Indication and Crew Alerting System
ESSAI	Enhanced Safety through Situation Awareness Integration in Training
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FD	Flight Director

FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMS	Flight Management System
FO	First Officer
FOQA	Flight Operational Quality Assurance
GFI	Goodness of Fit Index
GPO	Government Publishing Office
IRB	Institutional Review Board
LCSA	Line Check Safety Audit
LOE	Line Operational Evaluation
LOFT	Line Oriented Flight Training
LOSA	Line Operation Safety Audit
MFI	Manual Flight Inventory
MSA	Measure of Sampling Adequacy
NextGen	Next Generation Air Transport System
NFI	Normal Fit Index
NSTB	National Safety Transportation Board
OIG	Office of Inspector General
PF	Pilot Flying
PM	Pilot Monitoring
RMSEA	Root Mean Square Error
SA	Situation Awareness
SNS	Social Networking System
WG	Working Group

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

Relevant literature reviewed included six primary subject matter areas: industry concern, pilot performance referencing how they operate the aircraft in relation to the level of automation, pilot confidence, aircraft understanding, training methodologies, safety culture, and aviation passion. Sub-categories expanded upon automation challenges, beliefs and perceptions, trust, complacency, equipment failure, manual flight, pilot error, situation awareness, decision-making, experience, advance qualification program (AQP), learning, cognition, pilot debrief, feedback, self-assessment, training assessment, safety management systems (SMS), and safety culture. While this literature review is not exhaustive, it provides a representative sample of critical research within each area. A summary of the following literature review is presented in Appendix A.

Industry Concern

As long as humans continue to build and operate aircraft, human error will be an integral component of research, design, development, and training (Sheridan, 2010). The history of aviation safety has evolved from an equipment focus to integrating human factors, and is progressing into the organization as a whole with aviation SMS. Much has been learned through research by analyzing accident investigations and pilot safety reports, which have driven safety efforts. Yet, despite known concerns, history repeats with aircraft accidents, incidents, and safety reports attributed to issues that have transcended the decades—automation dependency, confusion, limited knowledge, communication errors, mode awareness, flight skills, and inadequate training (FAA, 1996; FAA, 2013d). In the wake of the automated glass flight deck aircraft, an FAA human factors safety report identified pilots' weaknesses in aircraft understanding and automation mode awareness due to inadequate knowledge and skill, and further expressed concern for weak automation training with both quality and quantity of training (FAA, 1996). Close to two decades later, similar performance issues prevail despite advanced automation and AQP training methodologies (Abbott, 2015; FAA, 2013; OIG, 2016).

Industry efforts have been made to address performance issues. As the result of the Colgan Air, Flight 3407, crash during arrival into the Buffalo-Niagara International Airport, the Airline Safety and Pilot Improvement Act of 2009 was introduced into Congress, yet never passed the Senate (Civic Impulse, 2016). The act, however, introduced regulatory change to increase flight hours for the airline transport pilot (ATP) certificate to 1,500 hours, which was subsequently adopted into regulation in 2010 (FAA, 2013c). However, where experience was once valued and identified by the number of flight hours a pilot acquired, automated aircraft flight hours have been questioned as to the quality of experience associated with performance due to automation usage (Harris, 2012). In example of flight hours not supporting performance enhanced experience, the pilots in a series of catastrophic airline crashes—Air France Flight 447, Colgan Air Flight 3407, Asiana Flight 214, and UPS Flight 1354—were anything but novice, as these pilots' combined experience exceeded 50,000 flight hours (BEA, 2012; NTSB, 2010; NTSB, 2014a; NTSB, 2014b; Palmer, 2013). While these accidents were attributed to pilot error due to inadequate skill, critical analysis revealed problems beyond skill to include lack of systems and aircraft understanding, and incorrect operational procedures (BEA, 2012; NTSB, 2010; NTSB, 2014a; NTSB, 2014b). Legislation followed the Airline Safety Act of 2009, resulting in the Airline Safety and Federal Aviation Extension Act of 2010 (GPO, 2010). Regulatory implementation of NTSB recommendations toward pilot performance, to include stall training, upset recovery training, remedial training programs for performance deficiencies, stick pusher training, and weather training, became public law (GPO, 2010). An FAA 2019 simulator mandate will require training to include manually flown arrivals and departures, slow flight, loss of reliable airspeed, and recovery from bounced landings (OIG, 2016). Current legislation and regulatory mandates have focused on flight training pertaining to simulator training, yet did not address knowledge training or assessment measures to ensure understanding (GOP, 2010). Despite this legislation, a preponderance of research has identified pilot confusion and lack of understanding to be causal factors of inadequate performance resulting in accidents, incidents, or pilot safety reports (Bent & Chan, 2010; Besco, 1997; Endsley & Jones, 2012; FAA, 1996; FAA, 2013d; NTSB, 2010; NTSB, 2014a; NTSB, 2014b; OIG, 2016; Ross & Tomko, 2016; Sherman, Helmerich, & Merritt, 1997; Wise, 2011; Young, Fanjoy, & Suckow, 2006). The Air France Flight 447 crash is a poignant example of hull loss attributed to pilots' inability to fly their aircraft with degraded levels of automation (BEA, 2012), yet the pilots' lack of understanding of the Airbus A330 operating systems may have attributed to the crash (Palmer, 2013). Air Transat Flight 236 presents yet another accident where pilot confusion created a total fuel loss condition, with a subsequent dual engine failure in an Airbus A330 (FAA, 2015c).

Flight skill loss due to pilot dependence upon automation presents an additional concern. Yet, current flight training requirements do not provide guidance, nor do they mandate manual flight performance or requirements to practice in the simulator, nor is the pilot required to demonstrate manual flight performance in the aircraft with a training professional to assess performance (FAA, 2017a). However, the FAA has expressed consideration to mandate instances where pilots would be required to manually fly with passengers, despite never having demonstrated proficiency in the aircraft with a training professional (Abbott, 2015). In response to the flight skill loss concern, the FAA released a safety alert that encouraged pilots to disengage the autopilot and autothrottle, to manually fly the aircraft in order to maintain manual flying skills (FAA, 2013a). However, flight skills extend beyond manual flight to operational performance of aircraft management, that incorporate both knowledge and procedural performance. An FAA working group (WG) further reported operational performance concerns due to insufficient aircraft systems knowledge, procedures, and understanding the aircraft condition, where pilots may have difficulty when failures occur and there are no written procedures or guidance, resulting in the flight crews' inability to respond properly (FAA, 2013d).

Industry concerns have also indicated that pilots are not manually flying the aircraft, which has subsequently resulted in flight skill loss, in addition to their lack of aircraft understanding and problems with guidance and control (OIG, 2016). While pilot error has been attributed to 70-90% of aviation accidents, pilot error is not an isolated causal factor (Airbus, 2007). An accident is rarely due to one event, but a chain of events that necessitates a system analysis. Besco (1997) further argues:

> If the problem can be judged to lie exclusively in the head and heart of an unworthy flight crew, then no one in the system needs to be responsible for changes and improvements. False comfort is gained when the irresponsible pilot is the only threat. (p. 54)

The capabilities of commercial aviation have shifted to where technology has enabled aircraft to remain airborne for extended periods of time, requiring multiple pilots due to crew duty limitations, yet only one pilot will receive the experience of a takeoff and landing per flight segment (FAA, 2008). Due to reduced vertical separation minimums (RVSM), where automated aircraft are able to pass within 1,000 feet at altitude, autopilot usage is mandated, which further limits the opportunity for a pilot to manually fly the aircraft (FAA, 2015d). Regulations and company requirements also exist for automation usage during low visibility approaches. The pilot's lack of ability to manually fly the aircraft will continue to increase due to NextGen operations, further reducing manual flight opportunities (Curtis, Jentsch, & Wise, 2010). The concern for pilot error in automatic aircraft versus analog aircraft was expressed by Naidoo and Vermeulen (2014) when they argued that human errors made in a modern aircraft were more likely to end in an accident due to an input-output effect that becomes a compounded chain of events. The Air France, Flight 447, crash is an example of a compounded chain of events (BEA, 2012). Therefore, understanding automation challenges of complex highly automated aircraft become essential.

Automation challenges. With the advent of glass cockpit and fly-by-wire technology, airliner operation has shifted to where pilots no longer fly with skill, but manage systems with knowledge application (Harris, 2012). Automated aircraft represent the core of aircraft operations today, where human factors and aircraft design integrate to achieve efficient information-processing displays in order to improve safety (Curtis, Jenstsch, & Wise, 2010). However, automation interface is more than an autoflight system display, but flight control functionality. Disengaging the autopilot, flight director, and autothrust does not necessarily remove all computer control in a fly-by-wire aircraft, yet at the same time disengagement is considered manual flight (Airbus, 2003; Rosay, 2015). When a pilot manually operates a fly-by-wire aircraft, depending upon the level of computer failures or level of automation selected, computers assist behind the scenes controlling surface movements to provide more efficiency, thus removing the pilot from traditional flight control management thought processes (Airbus, 2003; Rosay, 2016). Whereas pilots once *flew* an aircraft with a yoke, in a cockpit, connected to a cable that directly controlled flight control surfaces, today a pilot *manages* a fly-by-wire aircraft with a control stick, or yoke, that sends a command from a flight deck, through wires to computer actuators that move control surfaces to achieve computer desired performance, per the pilot's command. Early fly-by-wire aircraft were designed to be *harmonized* in order to meet certification requirements, but continuing requirements demand fly-by-wire technology to reduce weight, as well as the reduction of maneuver capabilities to prevent control loss, which in turn prohibits additional control actions (Lelaie, 2012). While improving passenger comfort, this technology has resulted in increased complexity of flight control computers. This added complexity, however, creates more confusion for operating crews (Ross & Tomko, 2016).

Confusion extends beyond operations to what constitutes manual flight, as there is a taxonomy difference between the OIG and the FAA. Line operation safety audit (LOSA) defines manual flight as related to vertical, lateral, or speed deviations, and power settings, indicating both autothrust and autopilot are disengaged, yet the flight director is not mentioned (FAA, 2013d). The OIG (2016) identified manual flight with only the autopilot disengaged, with the autothrust and flight directors engaged. However, *full manual flight* indicates no automation—autoflight, autothrust, or flight directors. *Full autoflight* indicates that the autopilot, autothrust, and flight director are engaged, and the aircraft is being flown per pilot programmed commands without mode control panel interventions—the concept of a NextGen operation (FAA, 2016; OIG, 2016). Tactical autoflight indicates that the autopilot, autothrust, and flight director are engaged, but the aircraft is pilot managed with heading, speed, and altitude interventions. Current operations dictate the use of both types of automation usage—full autoflight and tactical. In current operations, aircraft are programed for full autoflight with a departure, route, and arrival, yet tactical autoflight is utilized during Air Traffic Control (ATC) interventions.

The focus of automation research, however, has revolved around flight deck displays of a glass cockpit and integrated system designs versus the traditional round-dial aircraft with limited discussion on flight control operations and understanding the added complexity of the fly-by-wire system (Curtis, Jenstsch, & Wise, 2010; Ferris, Sarter, & Wickens, 2010; Naidoo & Vermeulen, 2014; Parasuraman & Riley, 1997). When integrated displays are lost, the crew may be left with minimal operational understanding. The Air France Flight 447 crash indicates that aircraft management may not depend solely upon mode awareness but a deeper understanding as to what the displayed information (or absence of) may be indicating and how to manage the systems to achieve flight management goals. Beyond understanding aircraft displays, automation challenges include pilot perceptions, trust, and complacency, in addition to technology related to the levels of automation and equipment failure.

Beliefs and perceptions. Early research focused on behaviors and attitudes toward automation usage and reliance. While Parasuraman and Riley (1997) reported performance was not necessarily connected to the individual's expectations or automation reliability, pilots were initially reluctant to fully utilize automation and defaulted to manual flight (Curry, 1985). Compte and Postlewaite (2004) identified success of accomplishing a task be dependent upon the perception of that success. Therefore, as pilots' confidence increased in their ability (or perception of that ability), automation use increased and ultimately resulted in automation dependence (Parasuraman & Riley, 1997). A challenge for researchers became the difficulty in readily understanding why pilots were reluctant to disengage their automation and manually fly their aircraft by simply asking. In the search for automation perceptions, Funk et al. (1999) identified pilots' lack of understanding, poor attention, limited knowledge, mode awareness issues, and problems managing an automation surprise to be resultant from automation complexity. Naidoo and Vermuelen (2014) later assessed pilot perceptions of automation and identified five automation issues to include: (a) lack of understanding, (b) automation function may not be transparent, (c) pilot overconfidence in the automation, (d) poorly designed equipment, and (e) inadequate training. While Funk et al. (1999) identified aircraft complexity to be causal of automation problems, Naidoo and Vermuelen (2014) identified that complexity was not necessarily the issue, but inadequate training of the complex aircraft. Overconfidence and complacency have also been associated with automation complexity—in that the greater the confidence in automation, the pilots may become more complacent (Bailey & Scerbo, 2007). However, Parasuraman, Molloy, and Singh (1993) argued that overconfidence, while it may be a predictor of behavior, does not necessarily dictate complacency, in that a higher workload due to weather, distractions, or fatigue could be contributory factors as to pilots' reliance upon equipment during task-saturated situations. While automation usage due to situational factors may be the reason pilots opt to use higher levels of automation at times, the question might be asked if situational usage would create reliance and complacency or if a higher level of trust in automation versus personal ability caused dependency.

Trust. Trust in automation has also been identified as a determinant of automation usage—the more trust the pilot has in the automation, the more likely the pilot is to use it (Ferris, Sarter, & Wickens, 2010; Parasuraman & Riley, 1997). Whereas early automation research attempted to understand why pilots were reluctant to fully utilize the automated equipment (Curry, 1985), the challenge shifted to understanding pilots' over-reliance on automation usage (Ferris, Sarter, & Wickens, 2010). Trust continues to be a significant factor in automation usage. Due to high reliability of current technology, elevated trust may result in pilots with greater trust in the equipment than they have in their ability to manually to fly (Ferris, Sarter, & Wickens, 2010; Parasuraman & Wickens, 2008).

Complacency. A variety of operational concerns exist with automation usage, from over-involvement with automation at the sacrifice of primary flight situation awareness (SA), lack of understanding, over-reliance, and complacency (Young, Fanjoy, & Suckow, 2006). Bailey and Scerbo (2007) reviewed the history of automation-induced complacency (AIC) and identified that higher equipment reliability led to higher complacency. However, while the FAA has encouraged pilots to manually fly (FAA, 2013a), pilots continue to be automation dependent and reluctant to manually fly their aircraft, which has impacted performance and resulted in flight skill loss (OIG, 2016). Monitoring challenges also continue to plague automation usage and complacency, yet Casner and Schooler (2014) identified the innate difficulty of maintaining continued focus on highly reliable equipment. Despite the difficulty in maintaining continued vigilance and focus, pilots' cognitive state of trust in automation will influence their choice in levels of automation and associated automation dependence (Parasuraman & Wickens, 2008).

Levels of automation. Casner and Schooler (2014) conducted pilot awareness measurement testing to better understand the relationship between levels of automation and airline pilots' task-related and task-unrelated thought patterns. Results identified that higher levels of aircraft automation enabled pilots to shift attention to a higher-level flight related thought processes pertaining to flight operations, yet during a high automation and low task environment, pilots' minds wandered beyond the flight. Challenges with lack of understanding as how to operate the automation in attempt to solve programming issues shifted pilots' attention toward operational concerns which then further removed attention from the overall flight, lowering SA (Casner & Schooler, 2014). Kaber and Endsley's (2004) research identified that better SA was present during intermediate levels of automation versus higher levels. However, Kaber and Endsley (2004) argued that while a fully automated aircraft removes the pilot from direct control, which may result in lower SA, the benefit of high automation is that cognitive overload will be reduced, supporting improved information processing, which in turn will enable pilots to better manage the overall operation.

Equipment failure. Strauch (2016) argued that errors in numerous accidents were, in part, due to system designers' inability to identify and acknowledge the impact of pilots' interaction with automation, the pilots' expertise, and the type of automated systems training. Degani, Barshi, and Shafto (2013) analyzed Air Transat Flight 236—an Airbus A330 that lost both engines due to a fuel leak. Degani et al. (2013) attributed the pilots' reaction to the absence of integrated information within the engine, absence of fuel parameters, missing indications from traditional planes such as a yoke tilt with fuel out of balance, and purported that fuel available at *each* waypoint was hidden within the computer, as contributing factors. These authors blamed the equipment failure, due to pertinent information embedded within the flight management system, as the causal factor of the accident (Degani et al., 2013). The FAA further attributed the cause of this accident, in part, to the fuel leak itself, and recommended warning systems to alert the crew to an increase in fuel burn rate (FAA, 2015c).

The Air Transat Flight 236 incident presents a poignant example of a mishandled event after a system failure attributed to confusion, distraction, and lack of understanding. The pilots of Air Transat Flight 236 became distracted due to low oil temperature, low oil quantity, and high oil pressure; where the fuel imbalance warning, designed to activate at 6,000-pound difference between wings, was the crew's first indication of a fuel leak (FAA, 2015c). The crew from the Transat Flight performed a fuel balancing procedure from memory and failed to check the total fuel prior to opening crossfeed valves (enabling fuel to flow from one tank to the other), as directed per Airbus procedures, and proceeded to dump the remaining fuel out the engine leak (FAA, 2015c). The pilots' reaction (startle factor) to the unexpected event (automation surprise) has been identified as one of the most difficult challenges in training (Casner et al., 2013; Jackman, 2012). Lack of mode awareness is an industry concern indicating pilots are unaware of a system change, automation degradation, or decrease in performance (FAA 2013a). The inability to identify excessive fuel loss on an Airbus A330 indicates lack of system display awareness, as total fuel is always displayed on the engine page during cruise, despite researchers suggesting the fuel information was buried deep within the computers (Airbus, 2003; Degani, Barshi, & Shafto, 2013). Lack of systems understanding with low oil temperature and high oil pressure related to low fuel, led to distraction, whereas information was available to identify a fuel leak, primarily 6,000 pounds of missing fuel on the total fuel indicator (FAA, 2015c).

While it may not be possible to train for every potential situation, pilots must be trained to identify failures, manage the aircraft performance, and possess tools and skills for intervention strategies (FAA, 2013d). Equipment is fallible, and when it fails, pilots should have the knowledge, awareness, and ability to fly the aircraft to safety. Figure 1 displays the reasons of human error after an equipment failure event.

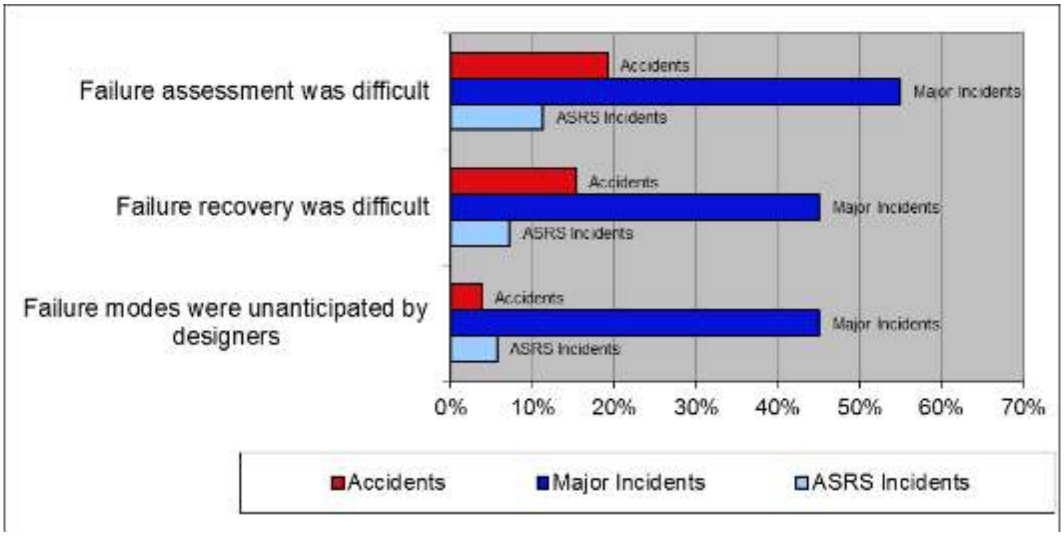


Figure 1. Human error after equipment failure. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

Failure identification, failure recovery, and unanticipated events were associated with automation failure. Yet, highly reliable, technologically advanced aircraft, combined with low pilot error rates, have generated challenges in legitimizing predictive models to gauge the difference between conditional pilot consequential errors, or consequential errors attributed to technology (Wickens, Sebok, Gore, & Hooey, 2012).

Research has focused on automation side effects in areas concerning complacency, bias, surprise, and mental models resulting in cognitive skill decline impacting SA (Strauch, 2016). Skill degradation is a concern that perhaps may be misunderstood, in that one must begin with skills prior to losing them, and current training methodologies may be leaving pilots short on understanding and knowledge in the automated aircraft, without adequate time available to practice flight skills (Wise, 2011). Current training may be resulting in pilots' reluctance to manually fly their aircraft with resultant flight skill loss, thus impacting multiple aspects of performance (OIG, 2016).

Performance

Pilot performance and human factors have been the core of research for decades, and the Aviation Safety Reporting System (ASRS) has provided the FAA with data identifying causal factors. Yet incidents continue to occur with thousands of ASRS reports submitted annually, reaching the millionth report submitted in 2012 (Connell, 2012). Human error has contributed to numerous accidents where fatigue, cognitive overload, communication problems, and information processing have resulted in faulty decision-making (Helmreich, 2000, p. 781). While decision-making can be directly connected to performance, Besco (1997) identified "knowledge, skills, attitudes, systems environment and obstacles" as essential elements of performance (p. 55). Performance tied to automation encompasses an extensive range of research to include manual flight, pilot error, situation awareness, decision-making, and pilot experience. Pilot performance in this research is identified by how the pilot chooses to operate the aircraft and associated levels of automation, but will not be measured. However, results of performance—how pilots operate the aircraft and automated systems—will be identified in relation to pilot error, accidents, major incidents, and ASRS, as reported in the FAA working group's final report of performance-based operations (FAA, 2013d).

Manual flight. Despite an FAA safety alert recommending pilots should manually fly their aircraft (FAA, 2013a), performance assessment continues to identify that pilots are experiencing flight skill loss due to lack of manual flight (OIG, 2016). Airline pilots have both opportunity and ability to disengage the automation, yet the question as to pilots' reluctance to do so has gone unaddressed in current research. Human error has also been a consistent factor in aviation accidents since the onset of flight and has directed a focus on cognitive architecture to increase safety through improved human performance (Gluck, 2010). Cognitive architecture is the framework representing the mind's structures and processes, related to working memory, information processing, and long-term memory storage (Sweller, Van Merrienboer, & Paas, 1998). Human error extends beyond mode awareness issues and automated flight confusion, to include manual aircraft handling errors (OIG, 2016). The type of errors as identified by the WG include:

- Manual operation is difficult after transition from automated control;
- Crew coordination problems;
- Training is inadequate;
- Behavior of automation, based on pilot input or other factors, may not be apparent to pilots;
- Understanding of automation is inadequate;
- Inadequate knowledge;
- Cross-verification. (FAA, 2013d p. 32)

Figure 2 depicts the percentages of manual handling errors where manual flight was identified as a contributing factor in an excess of 60% of all accidents and 30% of major incidents reviewed (FAA, 2013d).

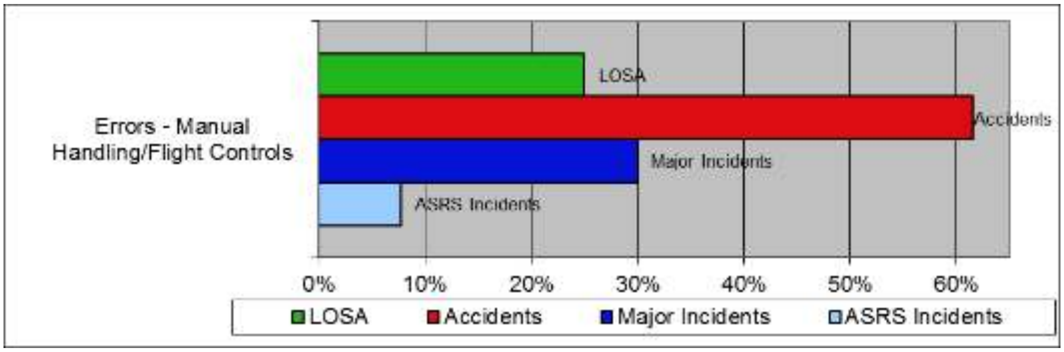


Figure 2. Errors: Manual handling flight controls. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

LOSA, Flight Operations Quality Assurance (FOQA) data, and Aviation Safety Reporting System (ASRS) and Aviation Safety Action Program (ASAP) reports may provide adequate indicators of pilot procedural knowledge (FAA, 2013), and Line Check Safety Audits (LCSA) would explain FOQA results (Esser, 2005). However, LOSA, FOQA, LCSA, ASAP, and ASRS data do not ascertain declarative knowledge, cannot assess hand flying performance if the pilots are utilizing automation, nor do they indicate why pilots are not hand flying, let alone the pilots' level of confidence in knowledge and ability.

Pilot error. Pilot error and flight skill loss have become an industry concern due to reliance on automation and lack of manual flight practice (Franks, Hay, & Mavin, 2014; Geiselman, Johnson, & Buck, 2013; Haslbeck et al., 2012; Moll, 2012). Research identified that flight skill retention in automated aircraft was determined to remain relatively intact without consistent performance, yet degradation of cognitive ability necessary for manual flight was apparent (Casner, Geven, Recker, & Schooler, 2014; Hendrickson, Goldsmith, & Johnson, 2006). However, Casner et al., (2014) suggest that pilots who pay attention to flight performance enroute, with the automation engaged, will perform better with identifying system failures, aircraft tracking, and position awareness, more so than ignoring the automated flight performance. Thus, automation usage in itself is not performance debilitating but contingent upon pilot awareness. Helmreich (2000) identified that proficiency errors accounted for about 70% of consequential errors, whereas decision-making errors and communication errors accounted for over 40% and 10% respectively, as depicted in Figure 3. Helmreich (2000) further reported that proficiency errors identified a need for technical training that may necessitate more ground school training to educate pilots on systems understanding, whereas decision-making and communication errors identified a need for team training, representative of simulator LOFT training. As identified, 30% more consequential errors than decision-making errors and 60% more than communication may indicate a necessity to increase technical training, identifying the necessity to improve ground school.

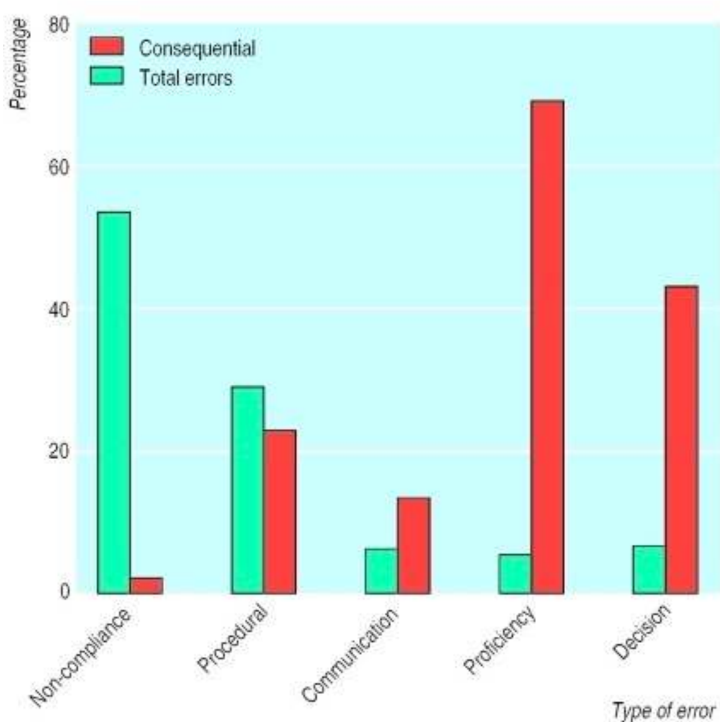


Figure 3. Decision making errors. Reprinted from “On error management: Lessons from aviation,” Helmreich, 2000, Education and debate.

Situation awareness. Endsley (2001) defined situation awareness (SA) as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (p. 5). Inadequate situation awareness (SA) has been attributed to 52% of all accidents (Airbus, 2007), and thus is a focus of aviation human factors research. If data transfer to the long-term memory does not occur, the result is an overloaded working memory that will prohibit both learning and memory formation, in addition to reducing SA (Endsley, 1995; Maurino, 2000; Wickens, 2002; Wickens, Gordon-Becker, Liu, & Lee, 2004). The automated aircraft is an integral element of the innate limitation of the working memory due to susceptibility of capacity overload as a result of large amounts of complex information, which in turn reduces situation awareness (Endsley, 1995; Wickens, 2002). Technological advancement enables highly complex machines to remain at altitude for extended periods of time, requiring longer periods of automation monitoring, further decreasing pilot performance in that sleep deprivation and mental fatigue add to cognitive overload (Gonzalez, Best, Healy, Kole, & Bourned, 2011). Dehydration associated with long flights, further negatively impacts cognitive function and memory (Lindseth, Lindseth, Petros, Jensen, & Caspers, 2013). Accounting for the complexity of the automated aircraft, fatigue, dehydration, the addition of inclement weather, system failures, or unexpected events may therefore impinge upon an already overloaded working memory, further reducing SA (Endsley, 2010).

Automaticity has been noted to be essential for airline pilots to improve SA, as lack of automaticity may limit pilots' decision-making ability (Endsley, 2010). Automaticity indicates a pilot's knowledge is at the level where he or she does not have to think about what to do and the response is automatic *(*Casner, Geven, & Williams, 2013*)*. Besco (1997) is an advocate in support of over-learning to the point where the pilot becomes *unconsciously competent*, in that the pilot performs tasks without conscious thought, a level of performance essential for aircraft operations. However, apprehension for automaticity has not gone unnoticed with a concern for reduced SA due to a perceived inability to transfer task at hand duties to conscious thought, necessary to adapt to changes in the environment (Banbury, Dudfield, Hoermann, & Soll, 2007). While routine expertise may lead to quick and immediate reactions, that could be likened to rote memorization, performance in a changing environment demands a deeper level of understanding that will be adaptable to unique situations (Smith, Ford, & Kozlowski, 1997). Smith et al. (1997) argued that adaptive expertise requires precise knowledge, in both quality and content, to be structurally organized in the memory, as well as required for metacognitive skills necessary for *planning, monitoring,* and *memory*. Bohle, Stalmeijer, Konings, Segers, and van Merrienboer (2014) further discussed the elements of adaptive expertise where understanding and contextual-based knowledge, combined with motivation for problem solving, created more adaptive and flexible strategies for unexpected events, whereas routine expertise is limited with a new experience.

The answer as to when immediate processing due to automaticity would help or hinder situation awareness and ensuing performance, lies in the distinction between rote memorization versus knowledge based understanding, and routine expertise versus adaptive expertise (Bohle et al., 2014; Casner, Geven, &Williams, 2013; Smith, Ford, & Kozlowski, 1997; Wise, 2011). Unconsciously competent would be likened to automaticity and adaptive expertise, different from rote memorization that would be associated with routine experience. Where automaticity and adaptive expertise improve performance during novel situations, rote memorization would result in limited understanding and memorized procedures that may not transfer to the aircraft beyond events practiced and anticipated in the simulator (Casner, Geven, &Williams, 2013). Rote memorization does not guarantee the pilot understands the automatic response, whereas knowledge-based automaticity and adaptive expertise imply a deeper level of understanding. Research further identified that pilots with a more developed information processing ability and working memory improved their situation awareness and performance with higher levels of automation; whereas the reverse was true for pilots with lower levels of information processing ability and working memory (Jipp & Ackerman, 2016). Yet, during periods of high workload, higher levels of automation usage have been identified to improve situation awareness (Endsley, 2010). However, when mental workload is increased due to lack of understanding of complex aircraft systems, operations, or interpreting the automation, higher levels of automation will reduce situation awareness if the pilot is mentally overloaded (Vidulich & Tsang, 2015).

Enhanced Safety through Situation Awareness Integration in Training (ESSAI), a European research project, assessed the impact of SA in relation to airline accidents and incidents, and reported that flight crews improved SA with ESSAI training, beyond FAA approved LOFT scenarios *(*Banbury, Dudfield, Hoermann, & Soll, 2007). LOFT, an AQP requirement, was developed to integrate Crew Resource Management (CRM) as a risk mitigation process of pilot error based upon communication strategies (FAA, 2017a). However, ESSAI training showed improvements above LOFT training in cognitive efficiency*,* automaticity *and* interpersonal dynamics subscales*, and* improved judgment assessment, increased flexibility with a changing environment, and improved memory for routine performance (Banbury, Dudfield, Hoermann, & Soll, 2007). Whether automation improves or reduces situation awareness is dependent upon the pilot's cognitive ability and the level of overload under a given situation (Bohle et al., 2014; Casner, Geven, & Williams, 2013; Endsley, 1995; Jipp & Ackerman, 2016; Maurino, 2000; Wickens, 2002; Wickens et al., 2004). Cognitive overload is not isolated but also susceptible to multiple and changing environmental factors that could impact decision-making (Endsley, 2010; Lindseth et al., 2013; Gonzalez et al., 2011).

Decision-making. Two different cognitive processing styles have been identified with decision-making—analytical and non-analytical. Analytical processing was noted to be slower, more elaborative, required more cognitive effort, and derived more conscious ability; whereas non-analytical was quicker, took less cognitive effort, and is often accomplished without a conscious effort (Reber, Ruch-Monachon, & Perrig, 2007). Captain Sullenberger's decision to land in the Hudson River, due to his perception of the inability to make a runway, was not based upon analytical calculations, but an implicit knowledge, based on extensive experience (NTSB, 2009). Reber et al., (2007) conducted research into intuitive problem solving and identified that implicit knowledge was based upon unconscious perception, related to perception structure, learning, decision-making, and problem solving.

Information processing is a key component of decision-making when a pilot must choose between choices, where the process includes both environment assessment and *cue seeking,* the process of searching the environment for cues pertinent to the situation (Vidulich, Wickens, Tsang, & Flach, 2010). Without adequate SA—a lack of perception of the environment, lack of comprehension or understanding of what is being observed or experienced, and projection into the future—the pilot may be challenged to make informed decisions (Endsley, 2001). Decision-making represents the third stage in

Wickens' human information processing model (HIP), after stimuli and perception, and is followed by execution and feedback, whereas the decision is determined by understanding the situation and all elements relative to that situation (Wickens et al., 2004). Without adequate knowledge, understanding, or experience, decisions may be based on (a) satisficing, where the pilot takes the first available option (Sheridan, 2010b); (b) a naturalistic decision based on feeling of familiarity (Sheridan, 2010); or (c) heuristics, a mental shortcut associated with cognitive overload (Vidulich et al., 2010). While experience has been identified as an essential component of both problem solving and decision-making, Vidulich et al. (2010) clarified that experience must be in the context of deliberate practice versus routine performance.

Experience. "The level of practice and training, as measured by daily flying practice and elapsed time since initial flight training, has a significant influence on airline pilots' fine-motor flying skills" (Haslbeck & Hoermann, 2016, p. 539). In addition to frequency and time, the frequency of when and how knowledge is used has also been identified as a key factor in pilot performance, with recommendations to address these issues during training to ensure pilots' knowledge had not decreased (Besco, 1997). Long-haul pilots experience fewer opportunities for repetition and practice of manual flight skills, and automated aircraft provide limited opportunities for knowledge application beyond procedural knowledge by both long-haul and short-haul pilots. There is also no requirement for knowledge assessment during pilot recency, or recurrent training events beyond rote memorization of limitations or memory items, and no requirements for repetition or practice of manual flight skills (FAA, 2017a; GPO, 2015). Competency requires (a) practice via repetition (English & Visser, 2014), (b) feedback as to the success and/or failure of the pilot's performance (Hattie & Timperley, 2007), and

(c) confidence that performance will result in a safe outcome (Johnson, & Fowler, 2011). Repetition for performance cannot be overstressed as it leads to unconscious competency, a state where overlearning, automaticity, and adaptive expertise improve situation awareness and overall performance (Besco, 1997; Bohle, 2014; Endsley, 2010; Wickens et al., 2004).

Repetition and practice are necessary to take a pilot from novice to expert, yet the transition to expert could take up to ten years of practice (Strauch, 2016). However, current AQP mandates do not require pilots to see most Terminal Proficiency Objective (TPO) events more than once in the simulator, and many pilots may go years, if ever, prior to experiencing the actual event (FAA, 2017a). TPOs are the "statements of performance, conditions, and standards established at the task level" written as AQP directives of training (FAA, 2017a, p. 17).

The nature of long-haul flying and aircraft complexity has also created unique challenges for pilot competency and performance. Long-haul flights demand multiple pilots due to the length of flight time; yet, only one pilot conducts the takeoff and landing event, preventing three of the four pilots the opportunity to gain experience or maintain currency (FAA, 2008). Reduced vertical separation minimums (RVSM) require autopilot usage enroute, thus further eliminating opportunities for manual flight (FAA, 2015d). As opposed to domestic flying, many long-haul pilots also visit a simulator every 90-days, per Federal Aviation Regulation (FAR) 121.439, to obtain three takeoffs and landings, yet meet only minimum requirements during this currency event to make them legal to fly. Thus, pilots have little opportunity during training or line flying to work toward higher levels of expertise. Performance is based on proficient operating skills in a simulator, thus the only place to gain expertise is on the flight line (Strauch, 2016).

However, flight line operations utilize a fraction of the functionality of highly automated aircraft under normal operations. Therefore, pilots are challenged with the ability to gain a level of confidence in systems knowledge and operations beyond the minimum without experiencing operations in the simulator (Sherman et al.,1997). An Airbus Industries senior vice president of engineering stated, “FMC’s may offer too many possibilities and be too complex, with the result that many pilots rely on only 20% of the software features” (Hughes, 1995, as cited in Sherman et al.,1997, p. 312).

Company policy could also be impacting pilot experience by mandating automation usage. However, an assumption that operators demand higher levels of automation usage for fuel efficiencies could be a misunderstanding. While automation usage could maximize fuel efficiencies during enroute flight segments, decision-making regarding cruise altitudes, speed, descent planning, gear and flap extension, speedbrake usage, and the ability to fly an on-profile approach, will all impact fuel efficiencies that are in control of the pilot regardless of the level of automation. One missed approach due to poor planning will cost thousands in added fuel expense.

Flight hours in automated aircraft do not improve aircraft systems knowledge, and they do not increase pilot performance when an unanticipated event occurs (Casner et al., 2013). As reported, a typical pilot spends less than two-minutes per flight segment manually flying (Lowy, 2011). While the Federal Aviation Regulation (FAR) 121.439 requires pilots to have three takeoffs and landings in 90 days to maintain currency (GPO, 2015), some pilots may go many months without ever seeing the inside of the flight deck of an actual aircraft due to a reserve system. Despite the three takeoffs and landings requirement in 90 days, there are also no requirements for normal operations to conduct a pre-flight, practice in-flight operational procedures (normal, abnormal, or emergency), perform navigation tasks, or fly a takeoff or descent profile during a recency event (GPO, 2015). In addition, there is no requirement to demonstrate operational competency beyond takeoffs and landing proficiency that may be performed with the autopilot and autothrust engaged, or systems knowledge assessment (GPO, 2015). However, mandates that require manual flight during initial flight training for departures and arrivals are required to be in effect by 2019, yet there are no requirements for recency training, indicating this may be a one-time event (GPO, 2010; OIG, 2016). Performance based upon greater operational experience should theoretically increase confidence, but how confidence impacts operational performance cannot be overlooked.

Confidence

Confidence that corresponds with competence is related to operational success and resultant safety, and is critical to operational safety and efficiency (Hattie & Timperley, 2007; Johnson & Fowler, 2011; Kern, 1998). The WG found an over-reliance in automation attributed to numerous accidents, incidents, and ASRS reports and further reported that pilots' overconfidence in automation, presented in Figure 4, was a contributing factor to one-quarter of the accidents reviewed. The WG associated overconfidence with automation to the pilots' lack of confidence in their own ability, suggesting that they displayed greater comfort in utilizing the automation than taking manual control, which resulted in an accident, major incident, or ASRS incident (FAA, 2013d).

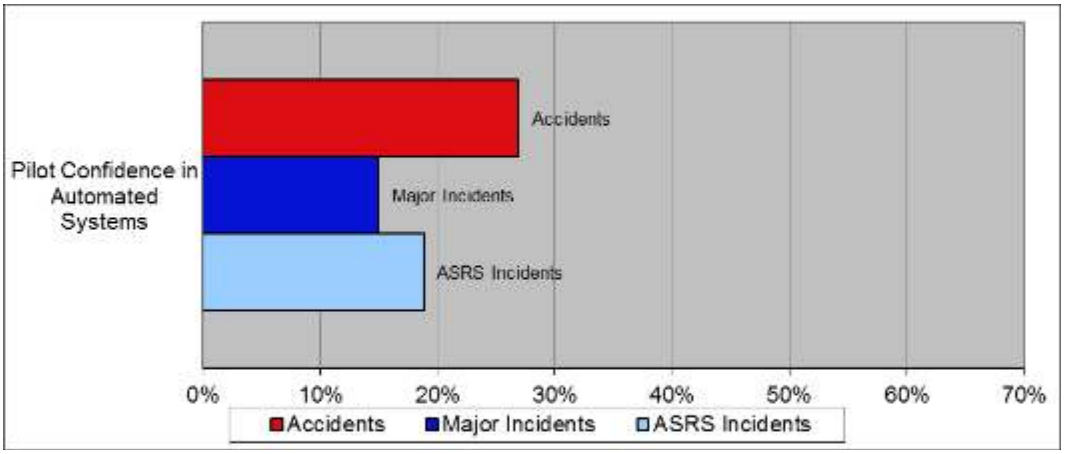


Figure 4. Pilot confidence in automated systems. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

Confidence has not only been associated with performance but is an integral component of the learning process, where the pilot must feel confident that the level of performance they achieve will ensure a safe operation (Johnson & Fowler, 2011). The pilot personality is one that innately exudes confidence. Cuevas (2003) suggests that due to this greater confidence level, pilots can deal more effectively with higher amounts of stress than less confident individuals. However, if a pilot does not understand the operation of their aircraft, the added stress and associated reduction in confidence may impact their ability to perform and willingness to manually fly the aircraft.

Whereas confidence is essential to positive performance, overconfidence may push pilots into more risky behavior, with a feeling of infallibility (Bénabou & Tirole, 2002; Stewart & John, 2006). Thus, training programs should focus on teaching pilots to control the aircraft, not falsely taking them to a level of overconfidence, which is defined as a high-risk employee trait (Stewart & John, 2006). Corroboration in research further identified that "People tend to attribute positive experiences to things that are permanent and to attribute negative experiences to transient effects" (Seligman, 1990, as cited in

Compte & Postlewaite, 2004, p. 1541). Thus, a pilot who passes a check ride may attribute success to their ability, whereas one that fails the checking event may blame the simulator not being representative of the aircraft, blame the supporting pilot for errors made, or the instructor's lack of ability—transient experiences. Past successes are predictive of future success, whereas failures have no predictive impact, yet success and failure may shift a pilot's level of confidence without substantiated performance to support that belief system (Compte & Postlewaite, 2004). Confidence also impacts the operator's decision to utilize automation. When pilots trust the automation more so than their own ability, they tend to become more dependent upon automation, whereas if pilots have higher confidence in their ability than automation, they are more apt to disengage the automation and manually fly (Parasuraman & Wickens, 2008). Pilots' confidence in their ability further influences their decision-making and reactions during anticipated and actual experiences with the environment (Bandura, 1982). Self-efficacy is identified as the individual's belief in their ability to create the desired results. The greater the pilots' perceived self-efficacy, the greater their performance as well as their persistence to succeed (Bandura, 1982).

A study of United Kingdom glass-cockpit pilots' attitudes with automation identified that pilots generally believed they had "a good level of understanding of the aircraft and its systems and they felt that automation increased their confidence as a pilot" (McClumpha, James, Green, & Belyavin, 1991, p. 111). However, McClumpha et al., (1991) further identified that despite pilots' confidence on understanding systems, the lack of awareness and lack of aircraft understanding may only become apparent during a catastrophic failure.

Chapman, Lane, Brierley, and Terry (1997) performed a study on multidimensional theory of cognitive (mental) anxiety, somatic (physical) anxiety, and self-confidence with Tae Kwon-Do athletes during competition. Results indicated that the best performers had higher self-confidence scores and lower cognitive and somatic anxiety scores than the lower performers. Another key point of this study was that 63% of the athletes were correctly predicted as winners based upon their scores, with self-confidence the highest factor. Fischer and Budescu (2005) utilized 1,200 decision-based questions and studied confidence, performance development, and the correlation between both. Findings identified that confidence: (a) develops gradually, (b) does not develop at the same rate as performance, (c) develops "at a diminishingly increasing rate that depends, at least in part, on the nature of the task," and (d) develops as a function of positive and negative feedback (p. 50). Fischer and Budescu (2005) state, "In real-life confidence often serves as a proxy for, or a predictor of expertise, performance, and competency" (p. 51). Beyond confidence in operational performance, pilots' confidence in a belief they understand the aircraft systems may be overestimated as to their actual understanding in they may be operationally proficient, yet unconsciously incompetent (Besco, 1997).

Understanding

The WG analysis reported a knowledge deficiency, in some capacity, attributed to over 40% of the accidents and 30 % of major incidents they reviewed, and LOSA narratives identified that flight path errors were due to knowledge deficit and automation usage (FAA, 2013d). Figure 5 depicts the percentage of accidents, incidents, and ASRS reports associated with threats due to lack of knowledge.

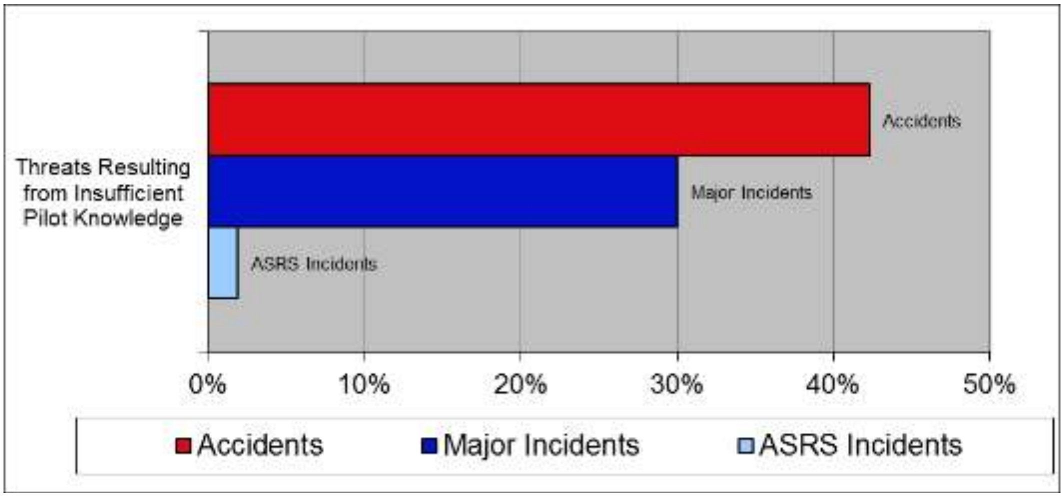


Figure 5. Threats from insufficient knowledge. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

Since the 1996 human factors team report, equipment and procedural changes have addressed mode awareness and flight management computer (FMC) operation, yet lack of understanding as to what the displayed information indicates and operational programming errors continue to be industry issues (FAA, 1996; FAA, 2013d; OIG, 2016). If pilots do not have a solid understanding of their aircraft, with both cognitive and physical skills, the added challenges of NextGen, where satellite-based systems will replace ground-based systems for air traffic management, may increase that level of instability with added distractions and increased workload (Curtis et al., 2010; Darr et al., 2010; FAA, 2016). History shows that when new technology is introduced, an area of instability develops, associated with a learning curve, generating an environment open for catastrophe (Salas et al., 2010). Figures 6 and 7 depict the percentage of programming and mode selection errors within the flight path management system report (FAA, 2013d).

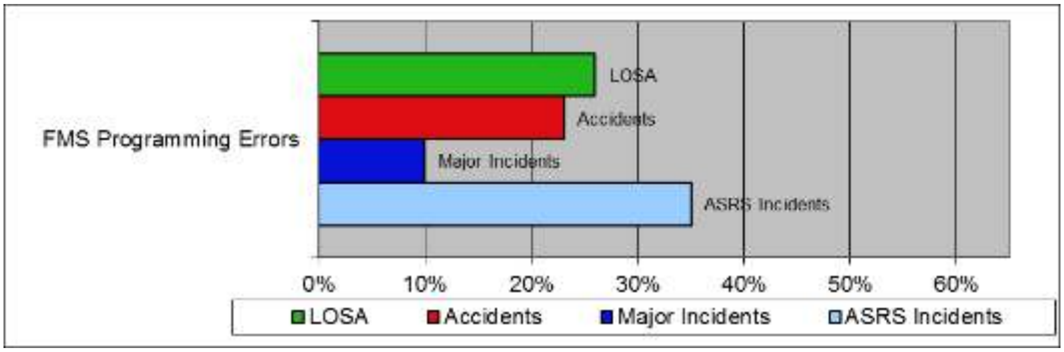


Figure 6. FMS programming errors. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

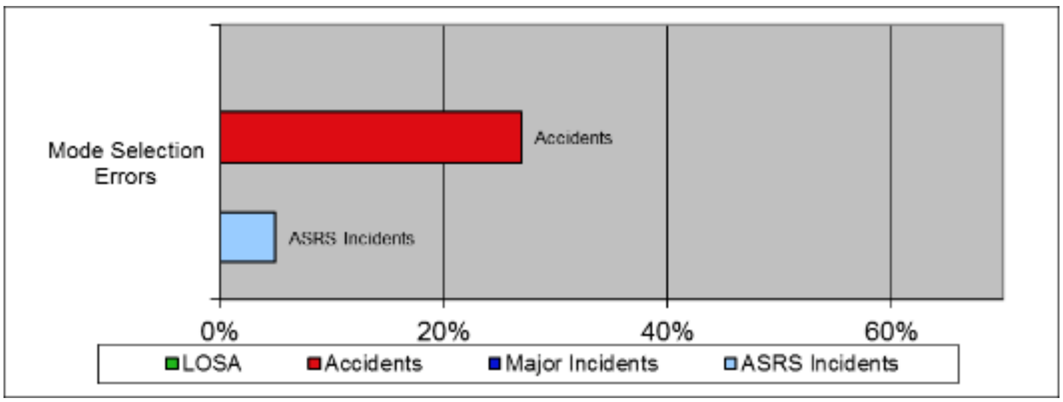


Figure 7. Mode selection errors. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

Ross and Tomko (2016) investigated 336 ASRS incident reports between June 2009 and May 2014 with a focus on pilot confusion, utilizing Rosenthal, Chamberlin, and Matchette's (1993) research identifying confusion as two types. Type 1 was based on cognitive function, where the pilot did not understand the experience, whereas Type 2 was based upon behavior that resulted in confusion, such as reading a wrong checklist and confusing the other pilot (Rosenthal et al., 1993; Ross & Tomko, 2016). The implication of these studies was that in 1993 pilots were "1.32 times more likely to report

Type 1 than Type 2 confusion, whereas the current results indicated reports of Type 1 increased to 1.96 times more likely than Type 2", indicating that lack of understanding, where pilots are more overall confused, has increased more so than driven confusion (Ross & Tomko, 2016, p. 1302). In 1993, pilots reported confusion as a contributing factor in 1 of 10 aviation safety reports (Ross & Tomko, 2016). AQP training focused on CRM and communication to eliminate pilot error (FAA, 2017a), yet, two decades later confusion has become the most reported factor in aviation accidents and incidents (Ross & Tomko, 2016). Ross and Tomko (2016) presented extensive research on multiple characteristics of confusion to include: confusion is cognitive-based, associated with feelings of uncertainty; appraisal-based reacting to, and in conflict with, the environment; subjective involving knowledge and understanding; and that confusion is an authentic emotion and a subjective experience.

Lack of understanding may be an overlooked characteristic leading to confusion, where confusion is defined as, "A situation in which people are uncertain about what to do or are unable to understand something clearly, and the feeling that you have when you do not understand what is happening, what is expected, etc." (Confusion, n.d., para.11). Besco (1997) examined the underlying reasons for lack of understanding and identified knowledge inadequacy related to whether or not the knowledge had been acquired in the first place, how often the knowledge was used, if the pilot received feedback as to their level of knowledge, and issues related to training such as, training curriculum relevance, learning methodologies, compatibility with the organization, and the pilot's aptitude toward learning. To assess pilot knowledge, Besco (1997) recommended eight questions to identify if the pilot was unconsciously incompetent, lacking awareness of the experience:

1. What are the observable facts concerning crew knowledge?
2. Could the crew comprehend the situation that was occurring?
3. Could the crew select a reasonable strategy from a set of strategies?
4. Was the crew aware of all reasonable alternatives?
5. Did the crew know how to choose alternatives?
6. Was the crew aware of the consequences of the available alternatives?
7. Did the crew have knowledge to carry out the chosen strategy?
8. Could the crew assess the system response to the chosen strategy? (p. 58).

Wise (2011) conducted a descriptive study to assess airline pilot knowledge at a major airline that operates the Boeing B747-400, Boeing B757, and B767 aircraft—all automated, glass cockpit aircraft. The sample included 321 pilots, and results indicated that *two thirds* of those pilots were below an 80% knowledge level, with very few demonstrating proficiency greater than the 90% level after training, and more than half the pilots exhibited substandard performance with mode awareness and changes in automation (Wise, 2011). These findings of limited knowledge and weakness in identifying mode changes parallel challenges at the time of this research, with lack of understanding and confusion (IG, 2016). Parasuraman and Riley (1997) argued that if pilots understood how the automation worked, they would have a greater ability to use it correctly. Dismukes, Berman, and Loukopoulos (2007) also identified inadequate training and guidance resulting in insufficient knowledge and experience, as causal factors in 19 airline accidents. Endsley and Jones (2012) expanded upon factors that contribute to the lack of understanding with automated systems, to include system complexity, interface design, and substandard training.

The problem with reduced understanding of what the automation is doing, even when the system is operating normally, is that it diminishes SA. Without knowledge and understanding it would be difficult, if not impossible, for a pilot to comprehend the situation of what is happening (Level 2 SA) in order to project the situation into the future (Level 3 SA), thus reducing performance (Endsley & Jones, 2012). Pilots worldwide may be deficient in knowledge of the aircraft they fly, which under normal operations may manifest in a safe outcome; however, when the unusual occurs, the unexpected event may instigate an inappropriate reaction (Casner, Geven, Recker, & Schooler, 2014; Dahlstrom, Dekker, van Winsen, & Nycy, 2008). The Air France Flight 447 accident presents yet another poignant example of confusion and lack of systems and performance knowledge, where the crew's inappropriate response indicated the pilots were consciously incompetent, aware of the gravity of the situation, yet unable to solve the problem (BEA, 2012; Besco, 1997). However, Pons, and Dey (2015) argue that Air France Flight 447 crashed as a result of cognitive processes contrary to lack of knowledge. Yet, cognitive overload and working memory challenges have been attributed to knowledge transfer and long-term memory, impacting knowledge acquisition (Endsley, 1995; Maurino, 2000; Wickens et al., 2004). Research further indicates that the majority of pilots may not fully understand complete FMC functionality and operational modes, recommending the solution to focus on training (OIG, 2016; Sherman et al., 1997). Pilots' understanding of aircraft systems and operations may be a direct result of poor or inadequate pilot training.

Training

A preponderance of research and accident investigations attributed automation-related pilot errors, in part, to inadequate training (BEA, 2012; Bent & Chan, 2010; FAA, 2013d; NTSB, 2010; NTSB, 2014a; NTSB, 2014b; Sarter &Woods, 1998; Wise 2011; Young et al., 2006). Bent and Chan (2010) further identified *sub-optimal training* as one of the two most significant flight hazards, with the other being a shortage of experienced personnel. Yet, corporate pressure to shorten training program footprints, while pilots train themselves at home as cost saving measures have become the industry norm (Dahlstrom et al., 2008). Young et al., (2006) identified yet another industry norm to be a reduction in automation and flight management system (FMS) training due to organization concern with financial resources.

Airlines created standard operating procedures (SOP) where training was designed to ensure that all pilots would perform the same processes and procedures in the flight deck. Safety is a crew event, not two pilots operating in isolation; yet, numerous accidents have been attributed, in part, to individual pilots not following SOPs. While Giles (2013) attributed the lack of following SOPs to be a choice, causal factors as to why pilots ignored SOPs pose the question as to whether it was a pilot's conscious choice not to follow SOP or a result of a cognitive overload with minimal system and operational understanding due to training inadequacies (FAA, 2013d; OIG, 2016).

Training and flight experience affect cognitive abilities, which further impact SA (Endsley, 1995), and how pilots are trained will impact learning capacity. Reducing factors that induce overload and restructuring information in a way that will enable pilots to formulated thoughts and assimilate previous knowledge could improve learning and performance (Kalyuga, 2009; Paas, Renkl, & Sweller, 2004). Figure 8 presents multiple areas identified by the FAA working group where training was a contributing factor in accidents, incidents, and ASRS incidents. Whereas non-automation training (manual flight) resulted in the highest number of accidents, automation training was second, followed by inadequate basic training.

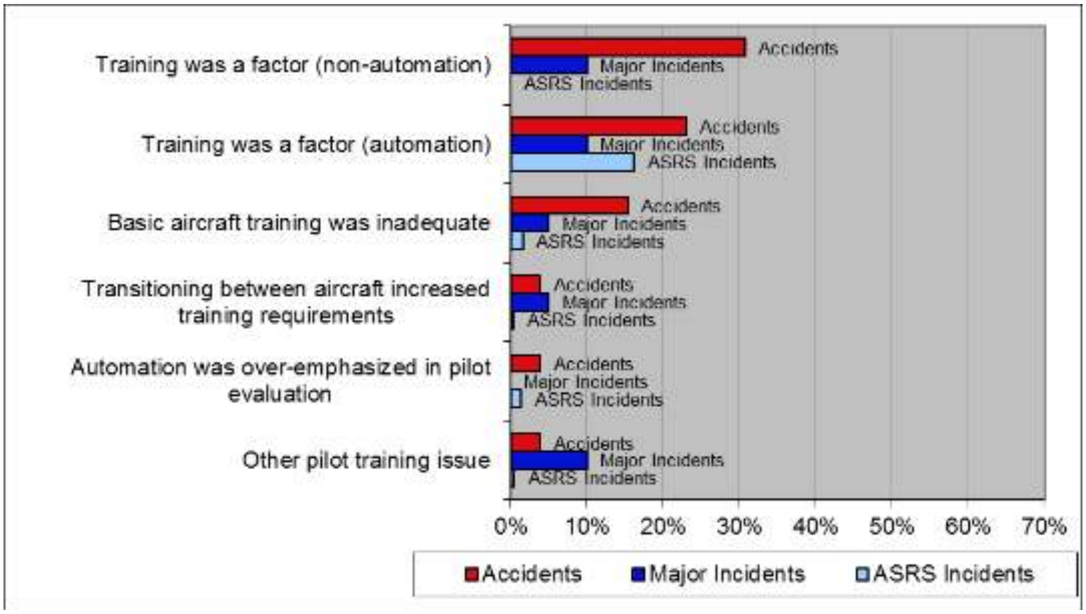


Figure 8. Accidents, incidents, and ASRS incidents. Reprinted from "Operational use of flight path management systems: Final report of the performance-based operations," FAA, 2013d, Aviation Rule Making Committee / Commercial Aviation Safety Team Flight Deck Automation Working Group.

Jamieson and Vicente (2005) identified mode awareness issues to be a byproduct of automation, and that confusion in understanding automation functionality was due to lack of a mental representation of how the systems operated. Automation complexity has increased the necessity of training needed to master the automation; however, financial resources have yet to fulfill the requirement (Strauch, 2016). The OIG (2016) reported that the FAA is lacking in many areas of training mandates, in that there are no processes in place to confirm airline pilots received automation and monitoring training, how often the pilots manually flew, if they were proficient at manual flight, and there were no processes in place to assess monitoring skills. The FAA has, however, mandated upset recovery training, manually flown arrival and departures, slow flight, loss of reliable airspeed, and recovery from stall and bounced landing training (OIG, 2016). Beyond manually flown departures and arrivals, the focus of this pilot training mandate has shifted training from ensuring proficiency with primary flight skills and performance to acceptance that flight control errors may occur when the automation fails, and thus the industry is focused on training the pilot *how to* recover once the abnormal condition manifests. Modern day automated aircraft are designed with protections to avoid unusual flight characteristics such as stalls, overbanking, and excessive speed (Airbus, 2003), yet if automation fails and the pilot has no flight skills to fall back upon, the pilot may put the aircraft into an unusual condition that necessitates this type of trained escape maneuver (OIG, 2016). Retention of this training may be in question if this is a one-time event during initial aircraft training, and the pilot may not experience such an event until the end of their career. Notwithstanding, cognitive performance requires practice and repetition for the pilot to remain proficient (Casner et al., 2014).

Pilot training has shifted from a pilot-centered focus to a crew-based focus, yet the concept of learning may not have been highlighted in this industry change (FAA, 2017a). Learning, in part, is dependent upon cognition, repetition, assessment, and feedback. A critical view into pilot training may provide better understanding as to pilot deficiencies with mode awareness and operational programming errors (FAA, 1996; FAA, 2013d; OIG, 2016).

AQP. Airlines have realized an economic benefit to reduce pilot training with the advanced qualification program (AQP), meeting personally designed TPO goals (Adamski & Doyle, 2005). AQP is a train to proficiency program that mandates inclusion of CRM, LOFT, and line operational evaluation (LOE) scenarios. AQP simulator training must be aircraft specific; include indoctrination, qualification, and continuing qualification (CQ) programs; training and evaluation for instructors and examiners; replicate normal flight operation; include a normal crew compliment; collect proficiency data; and utilize a full flight simulator (FAA, 2017a). Under AQP, pilot training shifted from individual training and performance assessment to crew-based performance, where line-oriented training processes enable crews to manage the aircraft while improving team and communication skills (Helmreich et al., 1999).

AQP is a voluntary program, yet when implemented is expected to exceed minimum training standards and demands a full commitment from the airline (FAA, 2017a). Within the AQP structure, pilot training is a proficiency-based concept focused on an entire system perspective versus individual training components. AQP shifted training and testing of specified maneuvers, procedures, and knowledge, toward this crew-based philosophy requiring specific tasks, knowledge, and skills associated with seat position, incorporating CRM, and designed by the respective airline (FAA, 2017a). However, Hendrickson et al., (2006) presented concerns that under this proficiency concept, training would only be proficiency based and focused on training efficiency, not on improved understanding and performance, at the expense of skill decline.

Current training practices have enabled airlines to cancel traditional ground-schools, where pilots no longer come together in a classroom environment with an instructor and fellow classmates to learn aircraft operating systems. Under AQP, airline flight operations management are authorized to enable pilots to teach themselves aircraft systems and computer operations via at-home training programs (FAA, 2017a). This training process resides under the assumption that a pilot will acquire correct systems understanding, and when an inflight emergency arises, the pilot will have accurate knowledge to deal with it. If inflight information is not understood or the pilot experiences cognitive overload, the pilot may make decisions based upon heuristics, a mental shortcut. While heuristics are purported to provide positive outcomes, this process may not lead to the best decision (Vidulich et al., 2010). An accident such as Air France Flight 447 presents a case where the wrong decision to pull the stick aft at altitude did not create a positive outcome (BEA, 2012). Another concern with the at-home methodology is that beginners do not have the knowledge and ability to determine what information is important and what is not relative to a given situation (Endsley, 2006, as cited in Strauch, 2016). Knowles, Swanson, Holton, and Ellwood (2011) argued that for self-directed learning to be effective, it should not be an isolated event, but requires a team to include teachers, mentors, and peers. Yet, under many approved AQP programs, pilots are expected to teach themselves aircraft systems without an instructor to facilitate questions and without peers or support personnel, which may be leaving pilots short on understanding. Wise (2011) identified current training practices to be problematic when he states,

> The pilots just cannot be given a manual and then be expected to memorize the contents in order to transfer the knowledge to a practical application. Without meaningful reasoning for the pilots to understand the concepts, procedures, or tasks, the pilots only obtain rote knowledge level abilities without knowing how to apply the training content. (p. 151.)

Learning. Learning occurs when systems knowledge and procedures move from the working memory into the long-term memory, in order to become available for recall (Wickens et al., 2004). Information processing and knowledge acquisition are key aspects of learning, where competency defines knowledge application (Franks et al., 2014). In order to learn, pilots must not only have aptitude to learn, but they must also have the ability to practice through repetition, receive feedback, and feel confident that the level of performance they achieve will ensure a safe operation (English & Visser, 2014; Hattie & Timperley, 2007; Huddleson & Rolfe, 1971; Johnson, & Fowler, 2011). Yet, a disparity between initial pilot training (where the pilot learns a new aircraft) and effective line operations (once on the flight line) may exist in terms of managing the automated aircraft (Dekker, 2000, as cited in Harris, 2012). Training that lacks repetition and feedback in complex aircraft may directly impact understanding (knowledge), performance (manual flying), and pilot confidence in automated aircraft. Matton, Raufaste, and Vautier (2013) argue that pilots cannot learn skills with only explicit instruction and declarative knowledge acquisition, and purport that flight skills depend upon multiple environmental, physiological, and aircraft cues acquired through repetition.

Adult learning identifies that pilots' experience, reflection upon that experience, real world application of training elements with problem centered training, where motivation is internal versus external, improves learning (Conti, 2009). However, Wise (2011) identified that airline training has been taught utilizing a behavioristic approach, which encompasses a teacher-centered focus with limited student involvement. This process opposes the construct of learner directed, adult learning (Conti, 2009). Whereas pilot-centered training, aligned with adult learning practices, focuses on metacognitive concepts emphasizing self-evaluation and improves learning. Many airlines utilize computer-based training (CBT) to teach pilots aircraft systems; however, research indicates that CBT focuses on declarative knowledge only versus how that knowledge will be applied to the operation, and contradicts adult learning theory (Wise, 2011). Wise (2011) identified problems with CBT in that the design had no foundation in adult learning principles, and training included rote memorization of acronyms which may be leaving pilots short on understanding.

Cognition. Cognition is required for learning as well as sustained performance, yet when working memory is overloaded with too much complex, illogical information, data do not transfer to long-term memory, which prohibits memory formation (Endsley, 1995; Maurino, 2000; Wickens et al., 2004). Cognitive Load Theory (CLT) suggests the reduction of causal factors for overload and restructuring information in a manner where pilots are able to formulate thoughts associated with previous knowledge would improve information processing and memory formation (Kalyuga, 2009; Paas, Renkl, & Sweller, 2003).

Automated glass cockpit and fly-by-wire aircraft are highly complex equipment, and training manuals present tremendous amounts of unfamiliar information. The pilot is required to read, comprehend, transfer, and retain that information in long-term memory for practical application at a later date. Pilots are also expected to learn, retain, and transfer this knowledge from an at-home, train-yourself program, without support or clarification. Literature identifies pilot confusion and lack of understanding to be causal factors of inadequate performance that has resulted in accidents, incidents, and pilot safety reports (Bent & Chan, 2010; Besco, 1997; Endsley & Jones, 2012; FAA, 1996; FAA, 2013d; NTSB, 2010; NTSB, 2014a; NTSB, 2014b; OIG, 2016; Ross & Tomko, 2016; Sherman, Helmerich, & Merritt, 1997; Wise, 2011; Young, Fanjoy, & Suckow, 2006). Current industry performance may be an indication that training methodologies could be problematic (OIG, 2016). Yet, FAA mandates have not addressed current training processes, where the first stage of skill development is declarative knowledge acquisition (Vidulich et al., 2010). Nonetheless, declarative knowledge without associated understanding is likened to rote memorization leading to poor SA. Endsley (2010) argues that success of training processes is dependent upon pilots' experience, closeness to the new information, perseverance, and the availability of resources. Learning impacts pilots' SA in that when an unexpected event occurs, and confusion disables the pilot from understanding the meaning of that experience, the pilot is unable to project the status into the future, which decreases decision-making ability, impacting the safety of the flight (Endsley, 2010).

Pilot debrief. Systematic reflection, where pilots analyze and evaluate behavior relating to performance, requires feedback on both the outcome—success or failure—and how to improve the process (Ellis et al., 2014). The power of the flight crew debrief has been the focus of much research and is instrumental in how pilots learn from human error (Allen, Jones, & Sheffield, 2010, Morris & Moore, 2000; Ron, Lipshitz, & Popper, 2006, as cited in, Ellis et al., 2014). Learning also depends upon how the debrief was conducted per the outcome of the event. If the checkride was a success, the debrief should only focus upon errors made throughout the event to maximize learning, yet after a failed experience, the focus must also include what the pilot did correctly (Ellis et al., 2014). Ellis et al. (2014) further argued the necessity to accurately assess the experience for learning to occur and reported that pilots would become more accountable for their behavior if they became responsible to their success and failures during the learning process. The pilot debrief contains elements of both feedback and self-assessment.

Feedback. Feedback is an essential component of learning (Hattie & Timperley, 2007). Literature supporting pre and post-briefs indicates that effective feedback should be task-focused versus person-oriented, to include self-critiques that are participatory in nature and where individuals were willing to accept feedback from others (Esser, 2005).

Training that lacks repetition and feedback in complex aircraft may directly impact understanding (knowledge), performance (hand flying), and pilot confidence. Cognitive skills must be utilized and practiced often, despite initial learning, to maintain competency (Casner et al., 2014). Not only are practice and repetition necessary components of competency, but also essential to learning in creating automaticity and adaptive expertise (Bohle et al., 2014; Casner et al., 2013). However, learning requires more than practice, it requires reflection upon that practice to improve performance (Mavin & Roth, 2014b). Mavin and Roth (2014a) further identified the power of video as a tool utilized during a pilot debrief with the flight instructor and seat support pilot an integral part of the debrief. Learning is not an isolated event. When students observe their performance utilizing a video, and self-assessment and reflection are done with an instructor and peers, maximum performance gains will be realized (Mavin & Roth, 2014b).

The length of a training session, in addition to the debrief, may also impact learning performance. Flight training simulator lessons have historically been conducted in four-hour sessions, yet Mavin and Roth (2014b) identified that a four-hour session left the pilots fatigued and less apt to remember what happened during the training event, contrary to effective reflection. A three-hour session, however, found the pilots were more amicable to discussing the training session in detail, due in part to less fatigue and more timely memory of events, which may indicate that shorter simulator sessions, with extended debrief, to include videos, may support improved learning performance (Mavin & Roth, 2014b). The pilot debrief provides an opportunity for feedback which has been linked to improved performance, whereas Besco (1997) purports that the benefits of feedback in aviation training have been the most undervalued benefit, denying the pilot an opportunity for self-assessment.

Self-assessment. Historically, aviation safety has been judged by the lack of accidents. However, pilots may also view their personal performance based upon safely landing at destination versus whether or not boundaries of safety were reached, and without means to assess their knowledge or level of performance in order to improve. Automated aircraft provide extensive latitude for safety, meaning there is a great deal of room for error as automation is a safety net that minimizes consequences of pilot performance. Therefore, pilots have the opportunity to perform and respond to mismanaged arrivals, poor decision-making, and lack of SA without resulting in a consequential event, whereas continual success may create erroneous mental models of adequate performance (Dismukes, 2010). While self-assessment is an integral part of effective learning, pilots must possess the resources to accurately measure performance in order to adjust their self-assessments (Sitzmann, Ely, Brown, & Bauer, 2010). Esser (2005) purports that assessments should not only provide continuous feedback that identifies individual progress and areas for improvement but should also be based upon an established level of performance, with self-assessment an essential component. Self-assessment extends to assessing performance in daily operations; however, under AQP, the training itself should be assessed (FAA, 2017a).

Training assessment. An integral component of training, an AQP mandate is the requirement to ascertain training effectiveness through data collection in addition to crewmember, instructor, and evaluator assessment (FAA, 2017a). Johnson and Goldsmith (2016) identified the fundamental connection between training and assessment as a dual role in effective training.

> The quality of training can be no better than the quality of the data used to assess the training. This relationship between training and assessment is the fundamental core of AQP. Under AQP it is not sufficient to simply train. It must be demonstrated that the training ensures proficiency, and this can only be accomplished with quality assessments that tell us precisely what aspects of the curriculum and training are working and what components are not. (p. 19)

Safety control systems are designed around processes to gather data in order to improve safety. The primary reason for a data acquisition in the data management process is designed to establish a systematic quality control system to ensure the efficacy of pilot training and qualification processes that foster continual improvement (Air Transport Association's Data Management Focus Group, 1998). The AQP guide provides an outline for how training and assessment data should be utilized:

- Provide assurances of proficiency levels.
- Establish expectations and determine variations from those expectations.
- Assess instructional quality.
- Validate training assumptions.
- Analyze effectiveness of instructors and evaluators.
- Provide instructor and evaluator feedback.
- Refine the training and/or measurement process.
- Indicate where training changes are needed.
- Validate alternative training technologies.
- Provide common grounds for sharing of information between carriers.
- Provide a quantitative means for CRM assessment. (FAA, 2017a, pp. 2-3)

Despite data collection requirements and guidelines on how to collect good data, adequate measurement to determine training effectiveness has eluded the industry (Nemeth, 2015). Pilot performance, as identified by accidents, incidents, and ASRS may be better indicators of training effectiveness than current AQP data collection processes during simulator training events and electronic reviews (BEA, 2012; FAA, 2013d; NTSB, 2010; NTSB, 2014a; 2014b; OIG, 2016). Training assessment has been an ongoing challenge; however, until recently, little research existed on effective simulator training evaluation measures, yet effective evaluation is the only way to determine training program effectiveness, and is worth the financial investment (Banbury et al., 2007). Roth (2015) conducted research to investigate airline pilot assessment methods and expressed concerns.

> Examiners did not perceive and process all relevant facts (attributes) of an event, which mediated how they rated the performance that could be seen… There is therefore mounting evidence that in the flight examiners' workplace, assessment is based on categorization, which can be mathematically modeled using fuzzy logic. (Roth & Mavin, 2015, as cited in Roth, 2015, p. 223)

Accepted training assessment processes do not necessarily substantiate that learning has taken place in the form of understanding and retention, with the capability to transfer that knowledge to the aircraft (Walcott, & Phillips, 2013). Quality pilot training is a proactive safety strategy, which is dependent upon policy, risk management, safety assurance, and safety promotion—all elements of an SMS (Stolzer & Goglia, 2015). The AQP guide was designed to assist training and assessment with safety assurance and safety promotion, the focus of SMS, where corporate culture may be the key to success.

Safety Culture and SMS

Corporate culture is a pattern of behavior stemming from artifacts, espoused values and beliefs, underlying assumptions, policies, and procedures, to include elements of a safety culture, identifying organizational processes (Schein, 2010; Stolzer & Goglia, 2015). The Federal Aviation Administration (FAA) defines safety culture as, "the shared values, actions, and behaviors that demonstrate a commitment to safety over competing goals and demands," and comprises five sub cultures—reporting, just, flexible, informed, and learning (FAA, 2013b, p. 9). Safety culture is therefore the essence of the corporation's culture in that behaviors, values, beliefs, and how the organization does business relative to safety and associated processes that include communication, reporting, flexibility, information sharing, and improvement strategies. Therefore, safety culture is inclusive in the corporate culture and is the essence of the organization's culture. Safety culture emphasis lays on communication in a flexible, blame free, accountable environment that encourages reporting safety concerns, where management has both the knowledge and ability to support the system's overall safety goals focused on continual improvement (Patankar & Sabin, 2010: Reason, 1997; Stolzer & Goglia, 2015; Torres, 2008). An airline's safety culture establishes the foundational support of a successful safety management system (SMS) (Woo, 2015). SMS is defined as:

> An organization-wide comprehensive and preventive approach to managing safety. An SMS includes a safety policy, formal methods for identifying hazards and mitigating risk, and promotion of a positive safety culture. An SMS also provides assurance of the overall safety performance of your organization. (FAA, 2015b, para. 2)

SMS risk mitigation and safety assurance are designed to improve overall organizational performance in preparation for NextGen (Stolzer & Goglia, 2015). Thus, the FAA mandated all U.S. airlines to have an SMS in effect as of January 2018 (FAA, 2015a). SMS importance extends beyond regulatory compliance, but also makes logical business sense in comparison to the costs associated with an accident (Stolzer & Goglia, 2015). However, in order to be effective, SMS demands a positive safety culture—reporting culture, just culture, flexible culture, informed culture, and learning culture (Stolzer & Goglia, 2015). Thus, SMS implementation will be in name only without a positive safety culture. Corporate culture also plays a key role in pilots' performance beyond espoused values, corporate rules, and written procedures, in that the unwritten rules are what often guide behavior and impact performance (Roughton & Crutchfield, 2014). Corporate culture therefore extends to performance in that *how* the airline culture behaves and transcends to employee performance standards.

> If the informal, unwritten motto of the people in an organization is "the best way to advances in this organization is to shut up and not make waves", the entire professional force will eventually lower their personal performance standards. (Besco, 2004, p. 160)

Deviation from standard operating practices (*normalization of deviance)* may become the normal practice when the organization encourages or pushes operating limits (Besco, 2004). Just as SMS demands safety assurance, maximizing safety efforts require performance monitoring and improvement measures as well as feedback and recognizing positive performance to ensure operational efficiency with maximized safety efforts (Mager & Pipe, 1997; Stolzer & Goglia, 2015). Goh (2003) further stressed the importance of a learning organization that encourages employees to improve their knowledge, to experiment and try novel methods of problem solving and search out feedback. Bent and Chan (2010) identified that many airlines, at best, meet regulatory requirements, yet compliance does not necessarily mean to the highest standards. The process of only meeting minimal regulatory compliance diminishes hazard identification and risk mitigation processes required for SMS (Roughton & Crutchfield, 2014).

The evolution of airline safety resembles SMS processes of hazard identification and risk mitigation, supported by an informed and learning culture (Adamski & Doyle, 2010; Gesell & Dempsey, 2011; Patankar & Sabin, 2010). Human factors research drove the creation of CRM, AQP, threat and error management (TEM), and LOSA in an attempt to reduce pilot error and improve safety (Patankar & Sabin, 2010). CRM, originally termed cockpit resource management, became the first regulatory mandate to teach crewmembers interpersonal and communication skills in order to reduce pilot error (Helmreich et al., 1999). CRM was not a one-time fix but an evolutionary process during the 1990s that encompassed five stages expanding over a decade to include theory, teamwork emphasis, team expansion, AQP, and TEM (Helmreich et al., 1999). AQP required CRM training in the form of LOFT and LOE scenarios (FAA, 2017a). This shift in training moved individual-based performance focus to crew-based performance (Helmreich et al., 1999). TEM was designed to assist pilots in identifying operational threats in order to mitigate risk (Helmreich, Klinect, & Wilhelm, 2001; Mathew & Thomas, 2004). The understanding was that errors would occur; however, if pilots' awareness expanded to potential threats, pilots would then become prepared for those events that would otherwise have been unexpected (Helmreich et al.,1999; Merkt, 2010).

LOSA created the platform for trained observers to monitor performance on actual flights, document threats, and record scores based upon pre-established behavior criteria (Leva, Cahill, Kay, & McDonald, 2010). However, multiple issues have created a concern with the efficacy of LOSA to include lack of feedback for improvement, inability to identify the entire chain of events, inability to assess pilots' understanding of the aircraft and operations, how TEM was connected to the LOSA process to mitigate risk, and failure of data to improve operational processes (Leva et al., 2010). The aviation industry is moving to more proactive safety measures, somewhat likened to TEM with risk mitigation, but extended beyond the flight deck to the entire corporation, where SMS demands entire organizational processes to proactively look at operational practices, identify threats, and mitigate risk, where communication is essential and becomes an integral part of every organization's safety culture not only to comply with FAA mandates but for improved organizational safety (FAA, 2015a; Stolzer & Goglia, 2015).

The Continental Express Flight 2574 (NTSB, 1992) and ValueJet Flight 592 (NTSB, 1997) accidents were attributed to corporate culture, which began the shift to an aviation organizational safety culture, where management revised attitudes, beliefs, actions, norms, rules, and acceptable levels of risk moved forefront (Mearns & Flin, 1999).

> Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes, and be

> rewarded in a manner consistent with these values. (Wiegmann, Zhang, Von, Thaden, Sharma, & Mitchell, 2002, p. 8)

To exemplify a safety culture attitude, a CEO at a major airline asserted that every employee was required to report anything not right in his operation, but despite that assertion of a reporting culture, 15 Air 21 whistle blower actions (Wendell H. Ford Aviation Investment and Reform Act for the 21st Century) have been filed against this airline, due to retaliation of employees reporting safety violations from 2008 to 2018, and 42 recorded court cases of alleged harassment (FOIA, 2018).

An effective SMS also requires the organizational safety culture to facilitate line employees' ability to implement SMS principles in daily operational duties while the organization assesses performance. However, Chen and Chen (2012) identified that a gap may exist between employee involvement, corporate assessment, and proactive response. American Airlines Flight 587, an Airbus A330 that crashed due to incorrect rudder response during a wake turbulence encounter presents an example of this gap. This crash was attributed to incorrect training; however, numerous documents surfaced years after the crash that identified an incorrect process in upset recovery training had been a known training issue (Fraher, 2015). Yet, due to lack of communication and information sharing required with informed, reporting, and learning cultures, essential to a safety culture, this information was never addressed until after the accident.

The FAA continues to balance safety and economics. Early technology was improved upon to reduce systems failure and adapt human factors into design. Yet, human error resulting in communication problems prompted the safety side of the FAA to create CRM, while the economics side developed AQP (FAA, 2017a). Under AQP, the combination of communication training was incorporated into the LOFT and LOE scenarios to improve performance, while at the same time enabled airlines to decrease the amount of training, and subsequently a new generation of automated accidents occurred due to lack of understanding, confusion, mode awareness, and flight skill loss (FAA, 1996). Economics are driving NextGen, and the FAA is proactively working toward safer skies with proactive measures via safety culture and SMS mandates, yet accidents, incidents, and ASRS continue due to lack of understanding, confusion, mode awareness, and flight skill loss (FAA, 2013d). Safety culture is the foundation of SMS, which will facilitate a safer environment for NextGen operations (FAA, 2015b; FAA, 2016; Stolzer, Halford, & Goglia, 2015); however, a gap may exist between safety culture, SMS, NextGen, and training, resulting in ongoing performance issues. The Evolution of Aviation Safety, shown in Figure 9, displays industry change related to accidents, program development, and the future of aviation associated with risk mitigation and training to improve safety, preparing for a NextGen and SMS future (Petitt, 2015a). Each accident was due, in part, to lack of understanding.

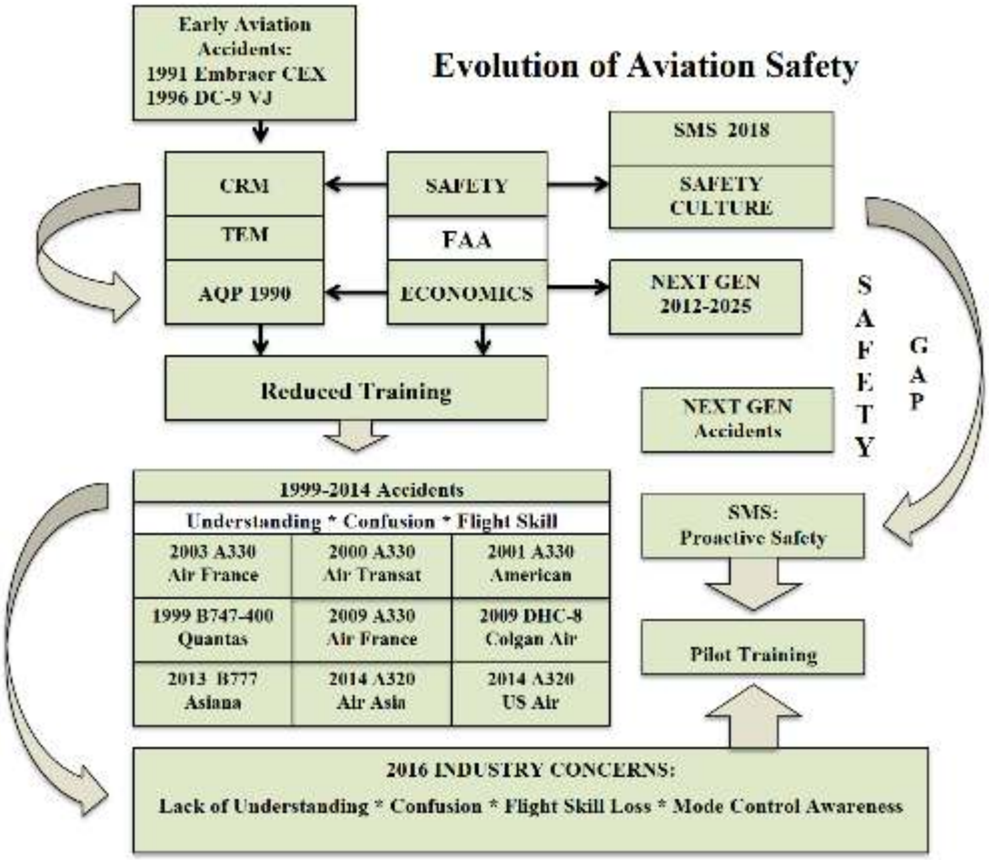


Figure 9. Evolution of aviation safety. Adapted from Petitt K. K. (2017). Structural redesign of pilot training and the automated aircraft. *International Journal of Aviation Systems, Operations and Training.*

Experts predict an increase in the accident rate to an unacceptable level from 2020-2025, due to added complexity of air-based systems (Patankar & Sabin, 2010). With the added complexity of the NextGen environment, human error in automated aircraft is likely to increase if pilots are not properly trained to achieve deeper understanding of aircraft operations (Skitka, Mosier, Burdick, & Rosenblatt, 2000). While corporate culture impacts performance in multiple ways, unethical culture can negatively impact employee engagement and lead to potential burnout; whereas the greater an employees' perception of cultural ethics, the greater work engagement (Huhtala, Tolvanen, Mauno, & Feldt, 2015). Engagement has been noted to be similar to passion in a sense that strong motivation to engage in work activities, such as learning a new aircraft, is indicative of an authentic self and an aspect of performance (Kocjan, 2015).

Aviation Passion

Passion has been associated with an individual's strong involvement in a favorite activity and is defined as, "a strong inclination toward an activity that people like, find important and which they invest their time and energy" (Vallerand et al., 2008 p. 1). When passion is focused on aviation, that individual may be termed an AvGeek. An Avgeek is defined as "someone who is passionate about aviation and that passion can be shown in countless ways," to include photography, aviation club participation, reading aviation magazines and books, flying home simulators, or owning aircraft models (Brown & Moore, 2013, par. 4). An Avgeek is not necessarily a pilot, but if the pilot were to be an Avgeek, their passion toward aviation could be carried into the job with a potential for increased performance.

Two types of passion exist: harmonious passion and obsessive passion. Harmonious passion is the essence of an Avgeek, where the passion is internalized into the pilot's identity, the individual is highly motivated and dedicated, and the passion is in harmony with their life (Kocjan, 2015). Astakhova (2014) describes harmonious activity to be fulfilling, gratifying, and fun-filled where the passionate person experiences enjoyment. While Kocjan (2015) likened passion to engagement, Schaufeli, Taris, and Van Rhenen (2008) and Vallerand et al., (2003) characterize the difference between harmonious passion and engagement, in that the passionate person identifies with their passion, and work engagement represents the person's feeling toward work. Ho, Wong, and Lee (2011) purport work engagement is similar to job passion when personal identification and satisfaction with the job exist. An aviation passion that is combined with the job of flying could create a harmonious passion that is both representative of job satisfaction and personal passion, creating increased work engagement.

People with harmonious passion have been reported to have better work performance, whereas those with job passion feel more identification and satisfaction, enhancing the desire to perform well because there is a personal meaning and love for the job (Ho, Wong, & Lee, 2011). When a pilot is passionate about aviation, in addition to enjoyment, the pilot's self-concept within that passion becomes their identity (Ho, Wong, & Lee, 2011).

Ho, Wong, and Lee (2011) clarified that harmonious passion exists because the individual loves the job characteristics, not because they have to do the work for social approval, whereas obsessive passion, based on identity, can lead to feelings of superiority and importance. Kocjan (2015) reported that obsessive passion stems from the need for social acceptance and self-esteem, where the identity of what a pilot means becomes the driving force for the passion, more so than the enjoyment. Harmonious passion was identified to be a positive force on performance, as opposed to obsessive passion (Vallerand, 2008).

Elements of passion in regard to focus and immersion versus absorption depend upon intentional concentration and the quality of effort, whereas the pilot with greater harmonious passion should have greater absorption manifesting into higher levels of performance (Ho, Wong, & Lee, 2011). Ho, Wong, and Lee (2011) further identified that attention did not necessarily increase performance, and suggested this could be due to job complexity, greater challenges, and higher demands, all which are associated with highly automated aircraft.

Shaufeli et al., (2008) identified that work engagement increased performance related to passion based on three dimensions—first the individual must be dedicated, resilient, with the ability to persevere despite problems. Second, they must be inspired, proud, enthusiastic, and realize the significance and challenges of their work; and third they must be engrossed and absorbed in what they are doing. Motivation, engagement, and many years of deliberate practice, identified as deliberate engagement, are essential to improving performance (Ericsson, 2008; Vallerand et al. 2008).

Despite the difference between harmonious passion and obsessive passion, positive performance in an aircraft could be realized with either type of passion due to the amount of dedication and engagement in the job, be it pure enjoyment or the need for identity. However, a culture that promotes both engagement and harmonious passion will require performance feedback necessary for increased, permanent wellbeing, and improved performance (Schaufeli et al., 2008). Engagement tied to passion of an Avgeek may be where the worker immerses themselves into their job and could be the answer to improved performance; whereas the disengaged pilot is not motivated and will detach from the job and be less motivate to self-study and learn beyond what is being provided in training (Kocjan, 2015).

Data Collection Research

Social network system (SNS). From first quarter 2010 to first quarter 2018, Twitter had 336 million active users (Statista, 2018) connected via the Internet that has over three billion users (Davidson, 2015). The use of the Internet has become an extremely effect tool to identify many target populations that cover the globe, that would not otherwise have been possible. These Internet venues are termed SNS. Boyd and Ellison, as cited in Baltar and Brunet, (2012) define SNS as:

> Web-based service(s) that allow individuals to construct a public or semi-public profile within a bounded system, articulate a list of other users with whom they share a connection, and view and traverse their list of connections and those made by others within the system. (p. 58)

Access to participants via SNS is an increasing form of locating research participants versus traditional data gathering methods, with positive results. King, O'Rourke, and DeLongis (2014) utilized Facebook and found gathering data directly into electronic databases was rapid, cost-effective, and enabled bypassing traditional and professional associations, in addition to the immediacy that enabled participants to access the survey per their schedule, an essential feature for commercial pilots who may have irregular flight schedules. Grant-Muller et al., (2015) reported the benefits and increased role of data collection via social media in the transport sector, viewing this process as opportunistic and efficient when data was needed in a timely manner. Paper surveys were available to eliminate potential bias based on computer-generated survey data only. However, Grieve, Witteveen, and Tolan, (2014) studied the difference between online versus offline data collection with pen and paper, and identified online results were comparable in terms of internal reliability with construct relationships. Data collection during disaster relief also realized advantages with face validity due to immediacy and the ability to survey in a timely manner, and Spence, Lachlan, and Rainear (2016) further purport that SNS was a better option of gathering data because they believe existing research has been conducted with *random* but *flawed* samples.

SNS recruiting has been identified as a worthwhile option when there is no available list of the population (Spence, Lachlan, & Rainear, 2016), such in the case of pilots worldwide. In support of online data collection, Greive, Witteveen, and Tolan

(2014) revealed that an online methodology missed less data, showed greater disclosure with sensitive material, and bivariate correlations identified similar patterns, despite online or traditional data collection methodology. Greive, Witteveen, and Tolan (2014) further argued that online data collection was not only more representative but was more diverse, that it may provide greater quality data, and suggested that people may be more apt to take a survey on line, if they were so inclined, and more apt to provide authentic responses. One concern Greive, Witteveen, and Tolan (2014) proposed was that the findings with searching qualified subjects via Facebook may not necessarily be generalized; however, they also reported that socially value-laden measures showed higher degrees of confidence, and that overall the difference with online data collection versus traditional methodology was minimal.

SNS has proven to be an effective means for data collection when research necessitates non-probability sampling (Babbie, 2013; Sibona & Walczak, 2012; Vogt, Gardner, & Haeffele, 2012; Woodley & Lockard, 2016). Types of non-probability sampling include purposive or judgmental sampling, snowball sampling, and respondent driven sampling. Network driven sampling is a term utilized in this research to reflect a hybrid data collection process that combines elements of snowball sampling, respondent driven sampling, and purposive sampling.

Best Practices. For effective SNS recruitment, messages must be specific to the targeted market, but target marketing is more favorable to distinct groups such as the target population in this study (Aaker & Brumbaugh, 2000; Dubicki, 2007). “Messages need to be both informative and persuasive… also need to capture the patron’s attention–graphics grab the reader’s attention better than text, and slogans or catchy phrases are even more memorable” (Dubicki, 2007, p. 11). Groves and Dipko (2004) reported that survey respondents participation increased by as much as 40% if the topic interested them versus not, and the response rate included, in part, the manner in which the survey request presented the topic. Industry related tweets that grabbed the reader's attention, aligned with the concept of social exchange theory, where success with recruitment strategies was due to participants taking the survey based upon perceptions of what they would receive in return (Sibona & Walczak, 2012). Sibona & Walczak (2012) further identified the necessity to openly support *group values* and validate that the participants were making a difference by taking the survey (Sibona & Walczak, 2012). A qualitative study further identified trust as vital and interpersonal communication essential to internet research (Dziubaniuk, 2014). Persuasion is acceptable, whereas undue influence is not (Barton, Eggly, Winckles, & Albrect, 2014). While coercion is never allowed due to undue influence, Barton et al. (2014) articulated the difference between persuasion and undue influence, reporting bioethicists' definition of undue influence occurs if the participants were not properly informed of the research and lacked understanding of what they were doing when they signed the informed consent.

Nonprobability sampling. Nonprobability sampling is a methodology utilized when there is no sampling frame, and participants are not on a master list (Babbie, 2013). Palinkas et al. (2015) presents research utilizing multiple approaches with purposeful sampling and identifies the effectiveness of hybrid designs. Network Driven Sampling (NDS) is a hybrid of snowball sampling, respondent driven sampling, and purposive sampling that focuses on the target population (Babbie, 2013; Vogt, Gardner, & Haeffele, 2012; Sibona & Walczak, 2012; Woodley, & Lockard, 2016). NDS was utilized to mitigate bias while utilizing SNS, by focusing on the target population (Babbie, 2013; Vogt, Gardner, & Haeffele, 2012; Sibona & Walczak, 2012; Woodley, & Lockard, 2016).

Purposive sampling. Purposive (judgmental sampling) is, "A type of nonprobability sampling in which the units to be observed are selected on the basis of researcher's judgment about which ones will be the most useful or representative" (Babbie, 2013, p. 128). The target population was identified and the judgement to select as many members of that population directed targeting subjects within that population via SNS. Sibona and Walczak (2012) identified the challenges of recruiting and determined the use of Twitter was extremely effective in purposive sampling methods. Recommendations to increase response rate via Twitter included adopting social exchange theory, where the participants actions of taking the survey were based upon what they thought they would receive in return (Sibona & Walczak, 2012). Sibona and Walczak (2012) further identified a necessity of a relationship between the researcher and participants to be based on trust. If the given target population queried had access to a researcher's profile on SNS and where able to identify her as part of the community, participants may be more likely to participate due to that connection. In addition to the aforementioned recommendations, participants should also feel value that their opinion matters, should be validated that they are part of a group that is making a difference, and due to social propensity where people like to help another in need, asking for help would encourage support, all of which should improve the response rate (Dillman, Smyth, & Christian, 2008).

Snowball sampling. Snowball sampling is a type of convenience sampling that has been identified as an effective method of contacting target populations that may otherwise be difficult to access due to size, hidden populations, or subject sensitivity (Vogt, Gardner, & Haeffele, 2012; Woodley & Lockard, 2016). Snowball sampling was effectively utilized in a doctoral research project where the experiences of black female faculty in higher education located in New Mexico were studied, which otherwise would have been difficult, if not impossible, to locate this unique population (Woodley, 2014). Kahan and Al-Tamimi (2009) utilized snowball sampling to effectively recruit hard to find Middle Eastern-American young adults, and Temple and Brown (2012) utilized snowball sampling when they recruited cannabis users, which otherwise may not have been possible. However, while snowball sampling is not without concern, snowball sampling has been proven necessary to gather data in certain studies. Woodley and Lockard (2016) reported concerns pertaining to snowball sampling to include selection bias, subjects' diversity, and validity.

Respondent driven sampling. Respondent driven sampling (RDS) is a chain-referral method where the respondents are incentivized to act as an agent on behalf of the researcher versus providing names to the research. Similar to snowball sampling but with a mathematical model to compensate non-random sample collection, respondent driven sampling is also based upon hidden populations that have no sampling frame, where anonymity is essential within the group, often because of illegal behavior (Heckathorn,1997). RDS was developed by Heckathorn (1997) for a drug abuse HIV study, and while this method of data collection has become extensively used in the public health sector for drug and sexual tendency research, there is ample opportunity to utilize concepts of RDS in other areas. RDS is also beneficial when anonymity is essential due to the criticality of concerns for repercussions of reporting performance related issues and identifying organizational culture. RDS recruitment methods have also been effectively moved to the internet enabling minimum resources to gather a larger sample of the population quickly (Wenjert, Cyprian, & Heckathorn, 2008).

To address deficiencies of chain-referral models, mapping the targeted population has been utilized to recruit subjects from a variety of areas, to ensure participants will be from different areas versus one (Heckathorn,1997). The concept of mapping could be utilized to create a list of worldwide airlines and operators to contact potential respondents from each airline, in addition to company type—airline, charter, and corporate or fractional. Heckathorn (1997) further identified that RDS is an incentive driven method in that those who recruit participants to assist would receive double incentives—one incentive to participate and another to recruit. Despite the option of financial incentives, the results of participants volunteering to recruit other participants versus providing names could improve efficiency over snowball sampling by reducing workload. Slganik and Heckathorn (2004) remind researchers that RDS is a sample of convenience with associated bias, similar to snowball sampling, and suggest the strength of RDS is found within exploratory research.

Summary

In 1942 military pilots were provided manuals, learned aircraft systems and procedures on their own, and then showed up to the aircraft to learn how to fly (Stromberg, 2016). Now, decades later, airline pilots learn aircraft systems and procedures on their own via a flash drive and then learn how to fly in a simulator (FAA, 2017a). The same process exists, albeit with different technology.

Industry concern. Modern day aircraft create a complex conundrum between improving safety through advanced technology with improved efficiency and reliability in order to reduce pilot error. However, the added complexity has increased opportunities for pilot confusion, lack of understanding, complacency, and dependence, all of which have led to pilot error. A direct consequence of automation usage is flight skill loss, and automated aircraft have created issues with complacency and mode awareness challenges. Industry concerns point to training, while AQP data collection and training assessment have been an ongoing industry challenge that may be an integral part of performance issues.

Performance. Automation dependency has been identified as an insidious culprit taking pilot skills while at the same time inducing complacency. While high levels of automation usage can both improve and reduce situation awareness, an in-depth understanding of aircraft systems and operations may improve operational performance. Trust in equipment is also a determining factor in the level of automation usage. Where the pilot places trust for highest performance (the pilot or automation) may determine the level of automation used. There is a direct connection between performance and causal factors of accidents and incidents. Passion and engagement improve performance, whereas a disengaged pilot will become detached and non-motivated, negatively impacting performance.

Accidents and incidents. Aviation accidents are rarely attributed to one causal factor. Confusion, limited knowledge, communication, mode awareness, lack of flight skills, and training concerns continue as causal factors attributing to airline accidents, incidents, and ASRS. Flight skill loss appears to be attributed to pilot dependence and over-usage of automation. Yet pilots have the ability and opportunity to disengage the autopilot, autothrust, and flight directors for most departures, arrivals, and areas outside RVSM airspace, yet many are reluctant to do so or are prohibited by corporate culture and company regulations. Airline accidents and incidents will continue to drive legislation.

Legislation. Current FAA legislation has implemented stall training, upset recovery training, remedial training, stick pusher training, weather training, and requirements for manually flown arrivals and departures, slow flight, loss of reliable airspeed, and recovery from bounced landings. However, no legislation exists to address whether or not instructors are able to effectively conduct and/or evaluate the 2019 FAA training mandates, or how airline management is to evaluate those instructors. Legislation to improve declarative knowledge with deeper understanding of systems and aircraft operations, or training that improves learning, has yet to be addressed.

Learning. Training for unexpected events continues to be a difficult challenge, yet how pilots learn has become a science unto itself, with focus on feedback, repetition, and confidence. Feedback and self-assessment in a pilot debrief are necessary for effective learning, as are adult learning techniques. While SA may not be a learned trait, per se, training, cognitive ability, and experience all impact SA, thus SA becomes a byproduct of learning. Improved situation awareness is essential in aircraft operations because it enables better decision-making. Yet, corporate culture and a training environment must support employee involved learning, establish policy, manage risk, assure safety, and promote safety.

Corporate culture and SMS. Corporate culture impacts employee performance, inside and outside the flight deck. Whereas a safety culture defines corporate culture, a positive safety culture is the foundation of an SMS. The FAA has mandated all U.S. airlines implement SMS, a proactive safety management system designed to mitigate risk, establish policy, and provide safety assurance and safety promotion. Applying SMS principles to pilot training may reduce industry issues and improve pilot performance. An unethical culture can negatively impact employee engagement, whereas the greater an employees' perception of cultural ethics, the greater work engagement. Passion and work engagement are closely related.

Literature gap. The gap in the current literature consists of unanswered questions as to why pilots are not manually flying their aircraft and what is causing a lack of understanding, confusion, and mode awareness issues, and if lack of understanding, confusion, and mode awareness are influencing pilots' unwillingness to manually fly. In current generation glass aircraft, manual flight does not dismiss the requirement of understanding operational modes or avoid the need to understand the data on the moving maps and instrumentation, as information does not disappear with the autopilot and autothrust disconnected. The pilot must understand and manage copious amounts of information. Manual flight means that the pilot must be able to manually control the aircraft and at the same time understand pitch, path, and speed modes in relation to performance required for the flight regime, as well as associated guidance for navigation and approach modes of operation. In a fly-by-wire aircraft, computers are still controlling some aspect of the aircraft and providing computer driven information to flight control surfaces during manual flight. Therefore, learning which buttons to push by rote memorization takes far less cognitive effort than manual flight, and perhaps less training, too. If the pilot does not understand the functionality of the automation or the information presented, disengaging the automation will only add to cognitive overload as the pilot will have to manage the aircraft in an unfamiliar system, within a dynamic environment.

While improved understanding would naturally increase confidence, whether or not lack of systems understanding is the attributing factor to lack of confidence associated with manual flight is open for question. Training practices such as lack of manual flight in a simulator, lack of repetition, or lack of demonstrating the ability of manual flight with a training professional in the aircraft could diminish confidence and create the reluctance to disengage the automation. Ample research identifies multiple factors of automation dependency; however, automation does not control the pilot. Unless corporate policy, or FAA regulations, mandate automation usage, the pilot has a choice. Thus, a question exists as to why pilots are choosing to not disengage the automation, despite FAA recommendations (FAA, 2013a). The question must also be asked if regulatory and corporate policy could be hindering crew performance. A great deal of literature identifies how people learn, yet that literature appears to be in conflict with approved training methodologies to include flash drive, train-at-home ground schools, and simulated events that are experienced once, without repetition, under the AQP program. Industry officials have identified the problem—pilots' lack of flight skills, lack of monitoring ability, and exhibit confusion in the aircraft—and this performance problem has been identified as an attributing factor to accidents and incidents. Yet, there is a gap in research as to why pilots are unwilling to manually fly, pilots' level of understanding and how that level impacts operational performance, and in what capacity training practices may be leaving pilots deficient in confidence to manually fly their aircraft.

Data collection. To fill the literature gap and fully understand why pilots may not be flying their aircraft and lack understanding necessitated a worldwide sample. In that a master list containing airline, corporate, fractional, and charter pilots worldwide does not exist, SNS was utilized to capture a sample of that population that would be representative of the entire population.

CHAPTER III

METHODOLOGY

In order to address industry problems, fill the literature gap, and add to the body of knowledge regarding automation dependence, confusion, lack of mode awareness, and flight skill loss, the Manual Flight Inventory (MFI) survey was constructed and utilized to gather data concerning pilots' understanding, proclivity toward automation usage, training practices, safety culture, and aviation passion. Participants were commercial pilots from airlines, corporate and fractional operators, and charter flight departments worldwide who fly international and/or domestic, long and/or short-haul operations, with a required crew compliment of two or more pilots. Survey data were cleaned, meaning the data were analyzed and fixed if identified as invalid, imputed, and divided into three datasets— training, validation, and test—in order to cross-validate. Imputation was the process to "replace the unobserved score with some estimated value (Byrne, 2010, p. 290). Three models were built, and each model was evaluated with each dataset utilizing descriptive statistics and exploratory factor analysis (EFA), a multivariate statistical method to extract underlying factors (dimensions) among the selected input variables in the study. Confirmatory factor analysis (CFA) was then used to identify the relationships between latent variables and constructs. Three CFA models were tested with cross-validation similar to the EFA process, utilizing all three datasets. Analysis and comparison as to the best model fit was determined, and the full dataset was tested on the final CFA model. Hypotheses were formed, and SEM was utilized to test path analysis in order to accept or not accept the hypotheses.

Research Approach

The MFI survey was developed by querying FAA designees and industry professionals as to their assessment of manual flight issues; analysis of current training methodologies, NTSB reports and FAA standards; and this information was combined with a thorough literature review. The researcher was able to synthesize this information due to a foundation of practical experience and authored the survey instrument. After the survey instrument was developed, eight subject matter experts performed extensive analysis of the survey instrument prior to implementation. The MFI was utilized to gather data on pilots' understanding of aircraft and flight management systems, manual flight tendencies, training, aviation passion, and safety culture. A multivariate statistical method, exploratory factor analysis (EFA), was utilized to extract underlying factors (dimensions) among these selected input variables in the analysis. These dimensions represent factors that are inter-correlated among the survey items. The MFI was assessed, tested, and a pretest was conducted with EFA and CFA. Then data for the complete study was collected and EFA, CFA, and SEM were conducted.

Factor analysis. EFA and CFA are types of factor analysis that were both utilized in this research. EFA was conducted with SPSS (a statistical software program) to determine the strength of variables, convergence, reliability, and the discriminant value to ensure constructs were distinct. Current research purports, "EFA is preferable at the beginning phase of scale development because there may be unanticipated, but substantively meaningful factors influencing subsets of items or unanticipated cross-loadings" (Flora & Flake, 2017, p. 82). CFA was conducted with AMOS (a statistical software program) and is utilized when "the researcher has some knowledge of the underlying latent variable structure (Byrne, 2010, p. 6). Therefore, initial research was performed with EFA followed by CFA. Observations of theoretical constructs that cannot be observed directly are considered latent variables or factors (Byrne, 2010). Examples of latent variables have been identified in behavioral sciences such as psychology to be self-concept and motivation, or within education, verbal ability and teacher expectancy (Byrne, 2010). Byrne identified that factors related to observable variables could make measurement possible with factor analytic modeling, if the observed variables were produced by the latent constructs. Statistical modeling in exploratory factor analysis explains how observed items and latent variables are related to one another (Byrne, 2010). Factor analysis is a statistical concept that originated from the *common factor model* stating that, "each indicator in a set of observed measures is a linear function of one or more common factor and one unique factor" (Brown & Moore, 2013, p. 361).

Criterion used for factor analysis. The factor extraction method used for this study was the maximum likelihood (ML) technique. ML has the reputation of being the most commonly used factor analysis procedure (Brown & Moore, 2013; De Winter & Dodou, 2011; Hair et al., 2010; Williams, Onsman, Brown, 2010).). Maximum likelihood factor analysis (MLFA) also generates a factor solution that will best emulate the underlying population (De Winter & Dodou, 2011). In addition, results with ML are not dependent upon data distribution (Costello & Osborne, 2005; Fabrigar et al., 1995). ML has desirable statistical properties, making it the basis for most developments in factor analysis and related methods (Tinsley & Brown, 2010). The ML extraction technique, used in EFA, corresponds with IBM's AMOS (Analysis of Moment Structures) CFA estimation method as the default factor estimation**.** Another consideration in factor analysis is the axis rotation methodology to clearly segment the identified factors. Factor rotation used in this study was oblique rotation because the study assumed there would be a meaningful correlation between the extracted factors. In addition, *oblique rotation* utilizing *Promax* rotation has an advantage of being fast and simple (Abdi, 2003). Factor analysis also has strict multivariate assumptions that if violated could increase the likelihood of a Type I error as well as reduce the power of the analysis (Tinsley & Brown, 2000). A Type I error being the incorrect rejection of a null hypothesis (De Veaux, Velleman, Bock, 2010). Multiple assumptions of factor analysis were considered prior to running factor analysis, in order to determine the appropriate use of the model. Factor analysis assumptions included: (a) sample size, (b) input variable inter-correlation, (c) measure of sampling adequacy, (d) explanation of total variance, (e) factor loading, (f) reliability measurement, (g) convergent validity, and (h) discriminate validity (Hair et al., 2010; Williams, Onsman, Brown, 2010).).

Design and procedures. Observed data were gathered with the Manual Flight Inventory (MFI) survey, developed and validated for the purpose of this research. This survey instrument was created to assess pilots' declarative and procedural knowledge, their proclivity toward automated flight, identify their passion for aviation, assess training practices, and query pilot perceptions of training and safety culture. The MFI survey was developed based on a thorough literature review and in consultation with extensive subject matter experts. Survey design was based upon best practices recommended by Ruel, Wagner, and Gillespie (2016) and Wise, Abbott, Wise, and Wise (2010). Constructs were conceptually defined, and questions were written as variables of each construct. Demographic and background information queries were written in multiple choice and dichotomous questions. Eight subject matter expert (SME) volunteers, representative of the population, assessed the survey instrument to ascertain clarity, directness, understanding, and context, in addition to identifying construct and variable relationships, and an inter-rater reliability analysis was conducted. The survey and questions were edited and re-evaluated. This process continued until no more changes were required. The survey was pretested and analyzed with EFA, followed by a CFA measurement model analysis. Sample size for both the pretest pilot study with EFA and CFA, and the full dataset with EFA, CFA, and the full SEM was determined and dependent upon the number of latent and observable factors, effect size, statistical power, and probability level (Cohen, 1988; Westland, 2010). Table 1 represents an overview of the scale development, data collection, and the methodological process.

Table 1

Scale Development, Data Collection, and Methodological Process

Design and Procedure Overview	
Step 1	Conceptually define constructs based on literature review.
Step 2	Develop questions to measure variables associated with each construct, and format demographic and background data for the survey: Manual Flight Inventory (MFI).
Step 3	SMEs review the survey to assess understanding, directness, clarity, context, and construct allocation.
Step 4	Conduct inter-rater reliability test.
Step 5	Edit MFI and evaluate as necessary.
Step 6	Finalize survey.
Step 7	Conduct pilot study.
Step 8	Perform EFA for Pilot study with SPSS to include: maximum liklihood extraction, oblique rotation Measure of Sampling Adequacy (MSA), Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity, and validation of extracted factors with discriminant validity and convergent validity, and inter-item reliability with Cronbach's Alpha.
Step 9	Extract variables per results and build the measurement model based upon extractions and Perform CFA with AMOS and evaluate.
Step 10	Collect full data sample required.
Step 11	Clean data, test for randomness with MCAR Test, and conduct multiple imputations.
Step 12	Split Data into three random sets: Training, Validation, and Test.
Step 13	Build EFA Model 1 with training dataset removing communalities lower than .3, one by one.
Step 14	Perform: maximum liklihood extraction, oblique rotation Measure of Sampling Adequacy (MSA), Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity, and validation of extracted factors with discriminant validity, and convergent validity, inter-item reliability with Cronbach's Alpha, and Harman's single factor test.
Step 15	Build EFA Model 2 removing communalities lower than .3 in groups of two or three
Step16	Repeat step 14 with model 2.
Step 17	Build EFA Model 3 removing factor loading lower than .3, one by one.
Step 18	Repeat step 14 with model 3.
Step 19	Run all three models with all three datasets and full dataset and compare models.
Step 20	Utilize all three models after factors have been extracted to perform CFA with AMOS, with all three datasets.
Step 21	Compare models Chi-Square, AIC and BIC, and select best model.
Step 22	Test for reliability, validity, common latent factor test, and model fit.
Step 23	Test five assumptions: Normality, linearity, multicollinearity, homoscedasticity and independence of errors.
Step 24	Run CFA with full data set.
Step 25	Perform SEM with full data set.
Step 26	Assess hypotheses

Scale development and pre-testing. The researcher utilized acquired aviation experience combined with a literature review associated with automation dependence, confidence, manual flight, training, understanding, aviation passion, and safety culture to develop conceptual definitions for fives constructs—manual flight (MF), pilot understanding (PU), pilot training (PT), safety culture (SC), and aviation passion (AP). While empirical research related to confidence was identified in the literature review, confidence was not a construct due to potentially high cross-loading with the factor pilot understanding.

Twenty-six SEM questions (Q6 - Q31) were written to represent each construct. Hair et al. (2010) recommended a minimum of three questions per construct for strength. However, Young and Pearce (2013) suggest that a factor containing two variables would be deemed reliable if the variables were "highly correlated with each another ($r > .70$) but fairly uncorrelated with other variables" (p. 80). A proactive measure to ensure the minimum number of variables remained after factor extraction was to ask five or more questions per construct, in the event variables were removed due to cross-loading or low-loading issues.

The survey design ensured the questions were simple, direct, specific, with no *double-barreled* questions, that ask two questions in one (Ruel et al., 2016; Wise et al., 2010). Ruel et al. (2016) advised to avoid abbreviations, slang, ambiguity, and double negative questions, and recommendations were heeded. A seven-point Likert scale was utilized for the SEM opinion and operational based questions, which enabled pilots to answer knowledge-based questions on a level from extremely unlikely to extremely likely versus an absolute. The assumption was if the pilot absolutely knew the systems question, they would select extremely likely (7). However, anything below extremely likely would indicate doubt in absolute knowledge. The odd number of selections was intended to prevent a forced choice that an even number scale would create. Inasmuch as there are many options such as aircraft type, the option to select *other* was provided for those questions that did not have a comprehensive list. To simplify demographic data and assist with further anonymity of the airline, corporate location data was limited to nine geographic areas versus all countries. Based upon results with the pilot study, categorization and questions were reordered to place the SEM questions first in the survey due to potential survey fatigue. Those respondents that did not finish the survey but completed the SEM questions were utilized for the factor analysis. The SEM questions were not grouped together per construct; however, the remaining questions pertaining to manual flight, training, experience, and perceptions of automation usage were grouped in categories. One grouping of dichotomous questions pertained to the participant's opinion on automation regarding perception of safety despite the cautions on dichotomous questions in that "questions rarely have two possible answers" (Ruel et al., 2016, p. 58). The question, "Is autopilot usage safer than manual flight?" would fall within that warning. The answer is difficult to answer yes or no because it depends upon many variables—mental fatigue, physical fatigue, overall flying experience, experience of fellow crewmembers, experience of the active arrival or location, cognitive ability, inter crewmember tension or conflict, life stress, pilot age, weather, location of flight, time of flight, time of crewmember's break, quality of crew rest, passenger issues, recency of training, length of flight, circadian rhythm, or any combination of these variables, or others. However, to include the response *it depends,* it was assumed the results would include all participants selecting *it depends* on every question— because it does. Thus, participants were asked these questions without any variables other than is it or is it not safer, strictly based upon their opinion. Formatting the pages with the online survey was also important, in that only three to four questions were presented on each page. This assisted the participant in moving to the next page without the feeling of taking a long time to complete a page, creating a perception that the survey was moving quickly. Aviation related motivational quotes were placed at the end of each category to engage the participant to see what was next, and an indication of progress half way through was presented and updated with each segment until the end of the survey, in order to inform the participant of time remaining to encourage them to finish versus quit, close to completion.

Research questions were written, and the survey was developed, then both the survey and a survey assessment form were provided to eight aviation subject matter experts (SMEs) representative of the target population, to take, assess, and evaluate the survey per Gaskin's (2017a) recommendation on survey assessment measures. SMEs represented the target population—airline, corporate/fractional, and charter flight department pilots, some were retired with a vast amount of experience. SMEs included: (1) retired airline captain with 38-years of flying experience with a 30 career airline pilot career overlapped with 22 years as an Air Force pilot, who is type-rated on the A330, B747-200, B737, C-141, T38, and T41, with flight engineer experience on the B747 and B727 aircraft, and has flown a variety of light aircraft and gliders; (2) an airline captain who retired early to pursue opportunities with Boeing flight operations, who is type-rated on B787, B777, B747-400, B767, B757, B737, DC9, MU300, BE400, and DA20 aircraft; (3) first officer for an international airline with experience from nine airlines, and instructing experience on the B747-400, who is type-rated on the B747-400, B767, B757, B737, ATR42/72, ERJ-170/190, and A320, and flies general aviation aircraft on his days off; (4) retired airline captain currently flying corporate, charter operations, and general aviation, and type-rated on the B777, B747-400, B747-200, and B757 aircraft; (5) retired captain with 51-years of instructional experience, 41-years as part 121 director of training, currently flies charter, and is type-rated on the A320, B777, B747-400, B767, B757, B737, B727, BE-300, C-650, DA-50, DC10, DC9, DC3, and LR-45; (6) retired captain with heavy Boeing experience, chief pilot, and flight operations director, type-rated on the B747-200, B747-400, B767, B757, B737, and SIC on EA500, and currently flies gliders; (7) Corporate flight operations manager, corporate pilot, PhD in Aviation with dissertation on safety management systems, and type-rated on the T-38/C, OV-10A, F-16/C, HS-125, G-IV, DA-50, DA-2EASy, and DA-7X; and (8) retired airline captain with 34-years line experience on Boeing heavy aircraft, 17-years management experience, director of training at an international airline, and 11 years instruction and training program development, type-rated on the F-8, B757, B747-200, and curriculum development on the B747-8. Of the eight SMEs, five received initial flight training in general aviation, one Air Force, one Navy, and one Marine, and all SMEs have flown domestic and international operations.

Part one of the survey analysis form queried opinions on the first half of the survey concerning demographics and background information for readability and content the SMEs identified as important and to test the timing of the survey. Part two of the assessment form was utilized to assess the variable questions on four measures: (1) understanding, (2) directness, (3) clarity, and (4) context (Ruel, Wagner, & Gillespie, 2016). Questions were reworded if the SME participants overall experience was a challenge with reading the passage. The questions were clarified if the SME participants were not sure how to answer a particular question. The questions were reworded if the SME participants took too long thinking about how to answer a question. Finally, if the SME participants could not answer because the answer was dependent upon something else, then the context of the question was addressed. The overall assessment on four measures was based upon overall consensus among the raters. Part three of the survey assessment form was used to determine if the questions measured what they were intended to measure. Each SME participant was provided a list of constructs with definitions and then asked to identify which question belonged to which construct. Based on Gaskin's (2017a) recommendation, eight raters were utilized requiring >70% consensus to be deemed adequate to proceed. This evaluation and editing process continued until no corrections were necessary. Inter-rater reliability was assessed after the raters performed their respective evaluations. After the survey instrument was complete, a pilot study was conducted to pre-test the MFI survey instrument to detect potential problems prior to surveying all participants.

Pilot study. A pilot study was conducted to test the reliability and validity of the survey instrument. Survey data were gathered for the pilot study in order to pretest the MFI survey instrument. A great deal of discussion has transpired as to the correct number of participants for a pilot study. MacCallum, Widaman, Preacher, and Hong (2001) purport "that if communalities are high, recovery of population factors in sample data is normally very good, almost regardless of sample size, level of over determination, or the presence of model error," and determined a sample size as small as 60 to be adequate (p. 636); whereas, Hertzog (2008) suggested utilizing 10% of the anticipated sample size. Gorsuch (1983) suggested a minimum of 100 participants for a pilot study, which was supported by Kline (1994) who also added an additional recommendation that the respondent to variable ratio should be 2:1 (Ke, 2001). Cattell (1978) recommended a ratio range of respondent to variable of 3:1 to 10:1 (as cited in MacKenzie, Podsakoff, & Podsakoff, 2011). Ultimately, the minimum number for the pre-test and the full SEM was based upon the number of latent and observable factors, effect size, statistical power, and probability level, utilizing Soper's (2017b) online calculator. This decision selected created a requirement for the highest number of participants of all suggested methods because the larger the sample size, the stronger the results (Hair et al., 2010).

Considering this was new scale development, meaning this measurement tool has not been previously validated, SPSS was utilized to perform EFA to confirm the strength of variables, convergence, reliability, and discriminant validity to ensure constructs were distinct. According to Hair et al. (2010) and Williams (2012), EFA requirements should include sample size criteria, input variable inter-correlation, and measures of sampling adequacy, explanation of total variance, factor loading, reliability measures, and convergent and discriminate validity. EFA was performed with SPSS on a pilot test with 113 participants, based upon the criteria of maximum likelihood (ML) factor extraction and the axis rotation utilizing the oblique rotation methodology and eigenvalues > 1 to determine the amount of variance. Measure of sampling adequacy (MSA) was determined prior to factor extraction by Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity. Chi-square estimation determined the goodness of fit. Validation of extracted factors was tested for discriminant validity, convergent validity, and inter-item reliability with Cronbach's Alpha. Due to the low validity testing of Pilot Training, the PT factor was removed to improve the strength of the model. The CFA model was built with four factors, run, and the proposed MFI first-order CFA model, with a sample size of 113, showed satisfactory assessment of model specification, model identification, construct validity, and the validity of the measurement model to proceed with the full research. The survey instrument was modified per the pilot test results. Due to the large sample size collected, the Pilot Training factor was included in the final research, and the original 5 factor model was utilized for the full research. The assumption that the large sample size would address validity issues of the Pilot Training factor was confirmed.

Full research. Soper's calculator, based upon Westland's formula, was utilized to determine minimum sample size and identified to be 1,599 responses (Soper, 2017b; Westland, 2010). However, due to the large sample size utilized for the SEM—5,661 after filtering and imputation—the data was able to be randomly split into three groups at approximately 33% each: training dataset (1,831); validation dataset (1,887); and test dataset (1,943). Three EFA models were then built with the training dataset to gain a better picture of the emerging factors. A meaningful relationship requires a shared variance to be above .3 (Nandy, 2012). Therefore, factors with low commonalties of less than .3 were removed. The commonalities in the first model were removed one at a time. This process continued until all commonalities were .3 or greater. In the second EFA model, the commonalities were also removed based on the <.3 criteria, but this time they were removed two and three at a time. Whereas the first two models were built by removing variables with low commonalities, the third EFA model was built utilizing factor loading—anything less than .3 on the pattern matrix was removed, one by one. After the <.3 factor loadings were removed, the construct was assessed to determine average loading of all variables. If it appeared a variable with a factor loading of a low .4 (despite meeting the .3 criteria) would lower the overall average of the construct below the required .5, the low variable was also removed to avoid negatively impacting convergent validity. Variables in two of the models were inversely recoded due to negative values.

All three models were assessed for construct reliability, convergent validity, and discriminant validity. The validation dataset and test dataset were both subsequently utilized on the three models and were compared to determine the best model. Harman's single factor test was conducted to identify common method bias, meaning the amount of variance related to the measurement method was tested versus variance in the model (MacKenzie & Podsakoff, 2012). Utilizing EFA without rotation, all variables were loaded onto a single factor, and if the variance of the new factor was less than 50%, no bias existed (Podsakoff et al., 2003). CFA followed, and a similar process with split data for cross-validation was performed to determine the best model fit. A number of variables were covaried on each of the models, and some variables were removed. The final model selection was run with the entire dataset, and then two additional runs were conducted with the same dataset for further model re-specifications by covarying variables.

Population/Sample. The target population included commercial pilots from airlines, corporate and fractional operators, and charter flight departments worldwide who fly international and/or domestic, long and/or short-haul operations, requiring a crew compliment of two or more pilots. Pilots who had retired or were between jobs within the previous 12 months and met specified qualifications were able to participate. A sample of this population was utilized to draw inferences about the entire population. Social network systems (SNS) such as Facebook, Twitter, and Linkedin were utilized to identify the target population. The SNS target population was utilized in a variety of manners to expand the sample size. The hybrid method of nonprobability sampling was the most efficient method of gathering a broad sample due to the size of the target population, the vast geographic displacement of participants, the sensitivity of questions concerning flight performance and level of understanding, in combination with the distinct fact that pilots belong to a community with access to each other, yet not located on one central database.

Sample size. Soper (2017a) utilized a formula developed by Westland (2010) to determine adequate sample size and created a priori sample size calculator. The formulas utilized for this calculator follow.

Error function:

$$\operatorname{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt.$$

Lower bound sample size for a structural equation model:

$$n = \max(n_1, n_2)$$

where:

$$n_1 = \left\lceil 50\left(\frac{j}{k}\right)^2 - 450\left(\frac{j}{k}\right) + 1100 \right\rceil$$

$$n_2 = \left\lceil \frac{1}{2H}\left(A\left(\frac{\pi}{6} - B + D\right) + H + \sqrt{\left(A\left(\frac{\pi}{6} - B + D\right) + H\right)^2 + 4AH\left(\frac{\pi}{6} + \sqrt{A} + 2B - C - 2D\right)}\right) \right\rceil$$

$$A = 1 - \rho^2$$

$$B = \rho \arcsin\left(\frac{\rho}{2}\right)$$

$$C = \rho \arcsin(\rho)$$

$$D = \frac{A}{\sqrt{3 - A}}$$

$$H = \left(\frac{\delta}{z_{1-\alpha/2} - z_{1-\beta}}\right)^2$$

where *j* is the number of observed variables, *k* is the number of latent variables, ρ is the estimated Gini correlation for a bivariate normal random vector, δ is the anticipated effect size, α is the Sidak-corrected Type I error rate, β is the Type II error rate, and *z* is a standard normal score.

Normal distribution cumulative distribution function (CDF):

$$F(x; \mu, \sigma^2) = \frac{1}{2}\left[1 + \operatorname{erf}\left(\frac{x - \mu}{\sigma\sqrt{2}}\right)\right],$$

where μ is the mean, σ is the standard deviation, and *erf* is the error function. (Soper, 2017a)

Soper's calculator was utilized with an effect size of .1, a statistical power of .8, and probability level of .05 to determine minimum sample size for the model structure pretest, and then again to determine the sample size for the EFA, CFA, and full SEM (Soper, 2017b; Westland, 2010). With five constructs and the initial 26 variables, a sample size of 113 participants was collected to validate the model structure. A minimum of 1,599 participants were required to conduct the SEM. However, to increase the strength of the SEM, the minimum survey count was exceeded in order to split the data for cross-validation.

Network Driven Sampling (NDS). As of January 31, 2015, there were 154,438 airline transport pilot certificates (ATP) and 101,164 commercial pilot certificates (FAA, 2016). Social Network Systems (SNS) was utilized to sample this expansive and worldwide population. Multiple methods were utilized, termed Network Driven Sampling (NDS) to include Facebook, Twitter, and LinkedIn in order to create a more representative sample. Multiple methods were necessary to maximize data collection due to the unique processes and functionality between each of the various SNS in order to create a more representative sample.

Sampling bias. A bias concern resides when the subjects are hand-chosen because they may be non-representative of the population, with further concern that those selected by snowball sampling or respondent driven sampling would choose others based upon personal bias (Baltar & Brunet, 2012; Heckathorn, 1997; Woodley & Lockard 2016). SNS enabled the researcher to invite potential participants "apparently" representative of the population within each network, not those based upon previous personal relationships that would create bias. SNS identifies potential participants' qualifications such as their work history, current aircraft flown, current organization, photos of their aircraft, name, type-ratings, and other identifying information to indicate they would be representative of the population. Connections were also made with potential participants within the aviation community circle, that were not personally known, by requesting a connection, followed by a survey request. For example, when (who is a LinkedIn member) corporate pilot, captain, or first officer was typed into the *search with filters* box, a list of corporate pilots, captains, or first officers populated, respectively. A connection request to those specific pilots who randomly populated from the search was made. If the connection request was subsequently accepted, a request to participate in the survey, by providing a link to the website that explained the purpose of the research, was made, with a request they share the website link with their colleagues, which hosted the survey link. While those colleagues would be acquaintances of the pilot asking them, and perhaps friends, they would also be representative of the population due to their current employment status. To perform the pilot study, 113 qualified participants were personally contacted and requested to complete the survey in order to test the reliability and validity of the instrument. This selection process included bias, in that half of those participants were known to the researcher from associated venues, and many were friends. The other half were internet acquaintances from social media venues. Participants were intentionally sampled from a variety of airlines and SNS venues to ensure the pretest sample was more generalizable. They were not selected by *how* they might respond, only selected because they *would* respond. Another bias in selecting friends for an aviation safety study is that many friendships may be built because people are likeminded, therefore data could realize similar results. To further assist with reducing this bias, data collection was extended beyond acquaintances.

Sampling selection and diversity. The criticism of nonprobability sampling and diversity exists in the written definition of *hidden, marginalized, or hard to reach populations,* whereas the concern is this process limits the generalizability of the study (Heckathorn, 1997; Woodley & Lockard, 2016). However, while the selected population for this research is not hidden, pilots are known and vast, covering the world, they are not contained on a master list. While random selection from an airline list would appear to increase generalizability due to a random selection methodology, this would not be generalized to the larger population due to airline specific training, equipment, and corporate culture. In an attempt to address the generalizability issue and diversity, SNS was not limited to the geographic limitations of traditional snowball sampling and RDS reliant upon personal relationships as the first step. SNS contains contacts for the representative population, while not inclusive, provided a means to access this population when the pilots were not personally known. SNS protections are also in place that a person cannot directly solicit any person on a SNS system (short of openly posting a link to an open forum for anyone to see) unless each party agrees to a connection that enables direct communication. A potential benefit this researcher experienced during the SNS data collection process is that she has thousands of connections within LinkedIn, Twitter, and Facebook and was better able to apply elements of respondent directed sampling. Babbie (2013) also recommended an interviewer to wear similar clothing as the respondents for effective interviewing strategies to help with a subliminal connection to encourage participation. Therefore, potential participants who viewed credentials, prior to accepting a connection to communicate, were better able to identify with the researcher in that they wore the same clothing—a pilot uniform. In addition, the target SNS was varied between LinkedIn, Twitter, and Facebook, with each group similarly connected, but perhaps for a different type of connection, which could bias who took the survey and potentially impact internal validity. For example, LinkedIn represents more of a business connection; Twitter could be business, passion, and entertainment; and Facebook would be more associated with social circles of family, friends, coworkers, and passion.

Sampling selection and validity. Validity concerns with generalizability of the study also identified that external validity would be higher if surveys were provided randomly to participants versus being provided to friends (Baltar & Brunet, 2012). SNS includes a worldwide population, with pilots who fly a variety of aircraft, work for a variety of operators such as airlines, corporate or fractional, and charter who are either a captain or first officer and accessing them would greatly improve generalizability of the study. While snowball, respondent driven, and purposive sampling could be initiated on a friendship basis, the utilization of SNS expanded the population to beyond known friends or acquaintances. The survey was provided directly to the target population who were connected, via SNS, whereas SNS participants were located worldwide, work for multiple organizations, fly a variety of aircraft, and are not deemed as friends, but are connected due to a particular passion, job, or interest. SNS enabled a broad spectrum of participants beyond the friendship-based concern, to be accessed in order to initiate network driven marketing.

Social Network Systems (SNS). In order to gather an adequate representative sample of the worldwide population in a timely manner, SNS was utilized to identify qualified participants. As part of the target population, the researcher was connected to thousands of pilots via SNS such as Linkedin, Twitter, and Facebook. Furthermore, her participation in aviation groups such as Flight Safety, AOPA, NAFI, Eurocontrol, International Society of Women Airline Pilots (ISA +21), and ninety-nines (99s), and maintaining connections to pilots from both domestic and international aviation venues further supported network driven sampling efforts. The initial sample response, prior to cleaning, was 7,487. This large number of pilots was unknown to the researcher on a personal basis, yet were bounded within an SNS and included in the population being studied. An assumed bias was that aviation venue contacts may have a greater aviation interest beyond work, and that passion could transfer to the job resulting in more self-directed learning that could impact understanding, confidence, and manual flight tendencies. Thus, the passion aspect of aviation was assessed in the survey instrument, and a broad sample was selected beyond aviation venues. Alternatively, it could be assumed that many of these pilots could be connected to these aviation sites to improve their career positions and may not have an extra passion. In an effort to reduce this potential bias, participants connected to SNS were asked to provide the survey to their colleagues in order to extend the survey to qualified participants not associated with SNS. Sharing the survey with colleagues could appear to induce more bias in the form of purposive introduction, however, the pilots are simply sharing with those who are qualified, and not for any other selection process; therefore, all pilots should be equal despite how they were selected.

The primary difference in this study from Facebook recruiting methods from earlier research was that only qualified participants, representative of the population, were directly contacted on FB and LinkedIn, and a target specific search with hashtags was utilized on Twitter to identify the population within the bounds of the SNS system. Target specific means that all efforts to recruit participants were focused only on the target population. This increased the internal validity of the study with more control as to whom was taking the survey.

To address concerns of knowing who was taking the survey, King, O'Rourke, and DeLongis (2014) suggested protections to include monitoring IP protocols and cross mailing addresses and to identify reporting countries. In an attempt to eliminate the ability for participants to complete the survey more than once, protections were added into the data collection site which prevented the survey from being repeated from the same computer and search engine. However, in that no financial rewards were provided to participate, this further reduced motivation of anyone attempting to take the survey a second time. The survey site also enabled the participant who was kicked off or ran out of time to reinitiate the survey at the point they previously stopped.

Social media has been successful in Facebook and Twitter recruiting, but not without concern of openly posting the survey link on the internet. This research addressed participant motivation to identify what would entice the target population versus all others, to improve internal validity. When rewards are provided for participation, the reward itself could motivate non-qualified participants into taking the survey. Therefore, the participants in this study were not provided an extrinsic reward, but it was assumed the intrinsic value of being involved within their industry would be motivation enough, while at the same time removing the potential of nonqualified participants from taking the survey. Qualified participants as identified on SNS were contacted either directly via SNS or notified with informational messages that would only be engaging to the target population, providing more control and knowledge that the participants taking the study were in fact qualified to do so. The elimination of monetary rewards further reduced motivation for non-qualified individuals to take the survey. SNS has enabled people to connect, engage, and share information worldwide, and provided the opportunity to connect with individuals in the target population that would otherwise be an un-accessible group. Pilots who engage in social media have private access to their personal accounts. This population is visible via SNS; however, they can only send personal communication after a connection is made. Therefore, contacting a qualified participant via SNS, with a personal connection, name, and occupation listed, provided a better indication that the pilot was the person taking the survey, than Facebook open recruiting methodologies that have been proven successful, which improved internal validity (Grant-Muller et al., 2015; Greive, Witteveen, & Tolan, 2014; King, O'Rourke, & DeLongis, 2014; Spence, Lachlan, & Rainear, 2016).

For ease of communication, a URL (PetittAviationResearch.com) assisted with presenting the research information, qualifications, and displayed the survey link. Additional precautions were taken to make the domain private, by purchasing protections that were touted to increase security by preventing hacking and establishing protections from stalkers. A private one-page website (Appendix B) was designed specifically for this research that explained the history of the research, the purpose, qualifications to participate, anonymity, and provided a link at the bottom of the page that connected the potential participant to the electronic informed consent and the survey instrument (Appendix D). Business cards were made with the link to the website in order to ensure every participant received the same brief as to the purpose of the study, and those cards were provided to pilots at aviation venues, on an airplane, or walking through a terminal, which enabled participants to access the link at a later time. An aviation blog was utilized to provide aviation posts to elicit participation from pilots and provided a link to the research website. This process created great efficiency in the survey dissemination process. Each SNS was used sequentially and assessed as to the effectiveness of each.

Twitter process. The data collection process began with an attempt to identify and place qualified participants of 28,000+ Twitter followers into a group. Twitter was extremely problematic in that effectively the only way to make that happen would have been to start at the most recent connection and not shutdown the computer until the job was complete. However, Twitter froze within the first hundred selections, and each time the program reopened, it would start at the most recent connection. Thus, there was no systematic way to begin where the researcher left off. However, many pilots were previously categorized in an aviation group, and more were added as they connected during the data collection process. This list enabled access to send a direct message to those qualified participants. Sending direct messages enabled control of who received the request versus tweeting the research link on the open internet. However, this too became problematic because Twitter blocked a *cut and paste* after 4-5 messages were sent. Twitter was effective to disseminate links to the to the informational blog post that contained the website link where the purpose of the research was reiterated in order to gain access to the survey link. This process of creating multiple steps, links, and websites to reach the survey link may have lost potential participants due to an element of intentionally induced hassle. However, the effort was conducted to retain an element of control on Twitter to assist in ensuring that the potential participants knew precisely the purpose of the research prior to reaching the survey link. A hashtag (#) is a Twitter search methodology than enables Twitter members to specifically search items of interest and see those particular messages, whereas those uninterested would not see the message unless they happened to be watching, real time, the Twitter member who posted the tweet. Due to the hashtags such as #Aviation, #Safety, and #Pilots with aviation messages that highlighted current aviation events or issues, aviation communities who viewed those tweets and read the blog posts connected with the researcher in order to provide contact information for aviation groups, unions, airlines, and associations, resulting in successful snowballing.

Facebook process. Facebook (FB) notifies participants of friends' birthdays in an email. Therefore, six months prior to data collection, the research began compiling a master list from the birthday email notifications of qualified participants. A master list of qualified participants was made and utilized to send a personal request to visit the informative website and, if interested and qualified, to take the survey. Each time a private message on FB was sent, others who were connected to both that person and the researcher were viewed, and those qualified applicants were added to a list and a request sent. The process of randomly looking at friends of friends to see who was not connected, but qualified, was also followed by a connection request. However, the 5,000-friend limitation on FB hindered that process. FB did not limit the number of personal messages that could be sent at a time and was extremely effective when requesting help from friends on Facebook who were not qualified participants but knew qualified participants.

LinkedIn process. LinkedIn was the most efficient and effective of all SNS venues with data collection of a broad sample from a worldwide population. LinkedIn allowed categorization of qualified participants who were current contacts in alphabetical order, which enabled sending messages and keeping track of who a message was sent to, but most importantly provided the ability to pick up where the researcher left off the day prior. After 920 current qualified LinkedIn contacts were sent a request, filters such as captain, first officer, and corporate pilot were input, enabling a connection request sent to those demographics. When the potential participant accepted the connection, they were subsequently sent a message thanking them for the connection with a request to take the survey and were provided a link to the website that articulated the purpose of the research and provided the survey link. The message also requested they share it with their colleagues. When participants acknowledged they would take the survey, they were personally thanked for their efforts. The ability to randomly find qualified applicants without knowing them reduced the friendship based bias concern. In an attempt to further improve upon the generalizability, a website that listed 149 world airlines (SeatGuru, 2018) was utilized. This list was not all inclusive as U.S. air freight operators, one U.S. regional airline, and a fractional airline that were known, but not on the list, and were subsequently added. However, this list was a solid representation of world airlines, and those operators that were not on the list were included. Then, 154 company names were typed into the filter on LinkedIn, one by one. The names that populated within each organization did not have any apparent order, as they were not alphabetized or listed by position. Up to 100 requests were sent to qualified participants from each organization, dependent upon how many qualified applicants populated on the company list. Some organizations did not have 100 available. This was extremely effective in that if the pilot recipient responded shortly thereafter with acceptance, indicated the participant was actively engaged in LinkedIn, and a request to visit the website was sent. Some users sign up for social media sites they rarely visit, therefore there was no way to determine if the selected participant wan inactive on the site versus non participatory. Utilizing the list of airlines and LinkedIn with purposive sampling enabled contact with thousands of qualified applicants, many who stated they would share the research with their colleagues.

Aviation blog. *Flight to Success* (Petitt, 2018d), written by the researcher, is an aviation blog dedicated to providing industry issues, aviation education, supporting aviation professionals, and promoting aviation events. This blog has proven instrumental in survey response for numerous aviation studies in masters and doctoral research projects, where posts were written with a link to the respective surveys, and subsequent Tweets with hashtags on Twitter and postings on Facebook and LinkedIn messages advertising the post with industry related hashtags resulted in successful data collection (Petitt, 2015b; Petitt, 2018a; Petitt, 2018b; Petitt, 2018c). The *Flight to Success* blog was utilized to provide the link to Petitt Aviation Research on multiple posts throughout the data collection to communicate the research, address industry issues, provide updates on the survey count, thank pilots for their participation, and request the aviation community to continually share the link. Messages via Twitter, FB, and LinkedIn were effective means of encouraging pilots to read the blog posts. The blog then served as a means to explain the research, identify qualifications, and posted the link to the research site that once again explained the history, the purpose, qualifications, and anonymity and provided the survey link. The blog, as did LinkedIn, displayed the researcher's profile, that may have assisted in data collection in part due to her being a member of the community. This blog had 3,184,700 views as of June 8, 2018, and 21,238 in the month of May 2018. The results of readership may be due, in part, to effective marketing strategies that included tweets, FB posts, and LinkedIn messages that followed marketing best practices. A reference to the research was included at the bottom of those posts, with direction to the website that explained the context of that research and requirements to participate. The associated tweets and blog posts identified and supported group values, identified that participants were making a difference in the aviation industry, had an opportunity to impact safety, and were supporting an aviation future for the next generation of pilots, with a purpose to visit the blog. The shared group values of this target population were utilized to create effective and efficient recruitment efforts. The researcher carefully evaluated each statement in comparison to the research questions and identified that none of the recruiting statements would in any manner influence *how* the participant could answer the questions, only capture their attention to visit the blog. Survey questions were based upon the participant's personal practice, company policy, operational decisions, and individual demographics. When utilizing persuasive tweets, it became essential to ensure there was no undue influence to encourage participants to take the survey. Therefore, protections were taken by connecting recruiting tweets on Twitter and FB posts directly to the blog post, not to the survey link. At the end of the blog post, the reader was provided the requirements for the survey and provided yet another link to the website. Once the reader went to the website, they were provided the purpose of the research, history, and requirements to participate, with the link to the survey at the bottom of the page.

Data Collection Device

To address the concern that a computer driven survey may identify a bias for pilots without computer access, the survey was provided in both a paper and electronic format. Paper surveys were provided to pilots, face to face, and occurred with random contact at the airport or professional functions. Only thirty-four paper surveys were received, as pilots felt more comfortable taking a card and doing the survey on line. The electronic survey was made available via a website, and the link to that website was distributed with business cards, sent to qualified participants via SNS and provided to a variety of pilots and aviation organizations—all representatives of the population being studied for effective network driven sampling.

Survey instrument description. Multiple-choice questions were utilized to ascertain specifics concerning training, background information, opinions on automation, and demographics, whereas Likert questions were asked to ascertain manual flight tendencies, knowledge, training, aviation passion, and safety culture. In that surveys may have a tendency for bias, due to some participants overestimating their ability (Bénabou & Tirole, 2002; Compte & Postlewaite, 2004), a seven-point Likert scale was written to assist in eliminating some of that bias by enabling pilots to answer knowledge-based questions on a level of extremely unlikely to extremely likely, versus a dichotomous response. It was considered that pilots may be more likely to falsely answer if given a *yes or no* option related to understanding. If provided an actual test question, the assumption was the pilot would look up an answer they did not know. In addition, due to the variety of aircraft flown, an actual test was not feasible. Thus, the Likert scale, and design of the questions, provided the opportunity to answer an opinion to their assumed level of knowledge versus an exact answer, with the assumption the pilot would be less likely to falsely overstate their knowledge. A pilot may not feel compelled to state they absolutely knew the answer to a question, if they were not absolutely sure, and had the opportunity to select a lower level, but high enough without feeling inadequate. However, unless the pilot was not absolutely sure—extremely likely—that he or she understood the aircraft systems, indicated by level six or below, that response may identify a lack of understanding. A missed approach is a time critical event, and the pilot must have absolute knowledge. Potential concern as to the assessment of actual knowledge versus an over-confidence of knowledge that may not exist remains for discussion.

Multiple efforts were made to reduce non-response bias potential, in that the survey was designed to ensure clarity, context, understanding, and directness and was tested with eight subject matter experts, followed by an inter-rater reliability test. A few adjustments were made to the survey after the pretest, such as moving the SEM questions from the end of the survey to the beginning, removing the section for comments, adding the fractional operator option, and minor adjustments to the non-SEM questions. The timing was estimated to be 10-15 minutes and averaged 13 minutes. However, comments from some international participants, with English as the second language, indicated they took much longer, and at times up to 30-40 minutes. Progress updates, and motivational quotes were included in an attempt to reduce survey fatigue and encourage the participants to continue reading. The participants were also assured anonymity with their identity and their respective company, which assisted in gaining participation. However, dozens of comments were sent via LinkedIn and emails regarding detailed information from their airline regarding safety, manual flight, industry concerns, corporate culture, and a variety of operational issues. These participants sent comments with trust that their identity would remain anonymous while presenting this information, due to fear of retaliation, but accepted the content could be utilized in the discussion to provide a broader picture.

Variable constructs are presented in Table 2. Associated operational definitions with sources are presented in Table 3.

Table 2

MFI Variable Constructs Identified

Construct	Construct Label	Construct Input
Manual Flight	MF	Survey Variables MF_1 - MF_5
Pilot Understanding	PU	Survey Variables PU_1 - PU_5
Pilot Training	PT	Survey Variables PT_1 - PT_6
Safety Culture	SC	Survey Variables SC_1 - SC_5
Aviation Passion	AP	Survey Variables AP_1 - AP_5

Table 3

MFI Construct and Operational Definitions

Construct	Operational Definitions	References
Manual Flight	Manual flight is where and when the pilot makes the decision to manually fly the aircraft without the autothrust and autopilot engaged. The flight director may or may not be engaged during manual flight.	FAA, 2013d: OIG, 2016
Pilot Understanding	Pilot understanding is the pilot's ability to know why procedures are accomplished, and to identify and understand instrument display indications, flight management computer operations, and aircraft system operations in both emergency and normal operations.	Besco, 1997; Ross & Tomko, 2016
Pilot Training	Training activities that support learning and performance to include feedback, repetition, and methodologies for understanding systems and processes versus rote memorization, in both the classroom, simulator, and on the aircraft.	Ellis, Carette, Anseel & Lievens, 2014; English & Visser, 2014; FAA, 2006; Kalyuga, 2009; Matton, Raufaste, & VAutier, 2013; Paas, Renkl, & Sweller
Aviation Passion	Aviation passion includes (but not limited to): aviation club participation, aviation based social circles, recreational flight, reading aviation magazines and books, and/or purchasing aviation products. This passion is also internalized into the pilot's identity, in harmony with their life, where flying is fulfilling and gratifying.	Astakhova, 2014; Brown, 2013; Koejan, 2015

Safety Culture	Safety culture includes a reporting culture, just culture, learning culture, flexible culture, and informed culture. Reporting safety related information is both encouraged and rewarded, a questioning attitude is valued in an environment that is resistant to complacency, committed to excellence, where proactive risk management promotes continuous improvement, and flexibility enables empowerment to exceed regulatory compliance, and leadership has knowledge about human technical factors to support safety.	Gain, 2004; Schein, 2010; Stolzer & Goglia, 2015: Yantiss, 2011

Conceptual definitions for latent and observable variables of manual flight, understanding, pilot training, safety culture, and aviation passion, with associated questions are as follows.

Manual flight. Manual flight (MF) was identified by the pilot's inclination to hand fly the aircraft, as to where and when the pilot was willing to disconnect the automation and to what levels. There are multiple combinations of automation usage between the autopilot, autothrust, and flight director. However, as defined for this research, manual flight was considered flight without the autopilot and autothrust. This series of questions was designed to ascertain where the pilot was inclined to disengage the automation and to what level.

Manual flight questions.

MF_1 In day VFR weather conditions, how likely are you to disengage *both* the autopilot and autothrust prior to beginning the arrival phase?

MF_2 In day VFR weather conditions, how likely are you to disengage *both* the autopilot and the autothrust on final approach *prior to* 1000 feet?

MF_3 In day VFR weather conditions, how likely are you to disengage *both* the autopilot and the autothrust on final *below* 1000 feet and *prior to* 200 feet before touchdown?

MF_4 How likely are you to keep the autothrust engaged *until after* touchdown?

MF_5 In day VFR weather conditions, how likely are you to fly *without any* automation engaged (no autopilot, no autothrust, *and* no flight director) during the course of the flight?

Pilot understanding. Pilot understanding (PU) is a latent variable defined by the pilot's ability, beyond knowledge-based facts and memorized procedures, to understand why procedures are accomplished and how to manage the aircraft without direction, and to identify and understand instrument display indications. This series of questions was designed to ascertain the pilots' opinion of their knowledge of aircraft systems during inflight operations.

Pilot understanding questions.

PU_1 How likely is it that you understand *all* functionality of the flight management system (FMS) on your aircraft? If no FMS, leave blank.

PU_2 How likely is it that you could pass a systems oral on your current aircraft without any studying or preparation first?

PU_3 If your aircraft is on final approach (fully configured) without the autopilot and autothrust engaged, and you execute a missed approach at 200 feet, how likely are you to know all the items displayed in the flight mode annunciator (FMA) during the missed approach? If no FMA, leave blank.

PU_4 If your aircraft lost one or more of its hydraulic systems, and the Engine Indicating and Crew Alerting System (EICAS) or something similar (if installed) and in-flight reference manuals or written procedures were *not available*, how likely are you to know what to do?

PU_5 If an emergency were to occur, beyond knowing *what* to do by following a directed procedure, how likely are you to know *why* most emergency procedures are written?

Pilot training. Pilot training (PT) is a latent variable defined as the activities that will support learning to include feedback, reflection, repetition, and understanding versus rote memorization. This series of questions was designed to ascertain how the pilot was trained and elements of pilots' perceptions of their respective employer's training program.

Pilot training questions.

PT_1 During your employer's pilot training (ground school), how likely is it that a pilot will receive feedback to ensure clarity of aircraft systems operations?

PT_2 How likely is it that during your initial checkout, on your current aircraft, the systems training (ground school) was based on rote memorization versus in-depth understanding?

PT_3 How likely is it that during your initial checkout, on your current aircraft, the procedures training in the simulator was based on rote memorization versus in-depth understanding?

PT_4 During your initial operating experience (in-flight pilot training) on your current aircraft, how likely was it that your instructor encouraged you to disengage both the autopilot and autothrust?

PT_5 During your initial checkout, or your current aircraft, how likely were you to repeat event sets multiple times, during simulator training, until you felt comfortable?

PT_6 How likely was it that your pilot training (simulator) debriefing sessions included self-assessment and reflection, in conjunction with your instructor's comments?

Safety culture. A positive safety culture includes five subcultures—reporting culture, just culture, flexible culture, informed culture, and learning culture (Stolzer & Goglia, 2015). *Safety culture is a latent variable* to include reporting culture where reporting safety related information is both encouraged and rewarded (Stolzer & Goglia, 2015); *just culture* is where the organization "promotes a questioning attitude, is resistant to complacency, is committed to excellence, and fosters both personal accountability and corporate self-regulation in safety matters" (Gain, 2004, p. 4); flexible culture is where organizational processes are adapted to unforeseen events and shift from a hierarchical mode to a flatter mode to achieve improved safety with the ability to exceed regulatory compliance (Stolzer, Halford, & Goglia, 2011); an informed culture, where, "Those who manage and operate the system have current knowledge about human, technical, organizational, and environmental factors that determine the safety of the system as a whole" (Gain, 2004, p. 4); and a learning culture is where proactive risk management promotes continuous improvement (Yantiss, 2011). *Culture is identified by behavior that stems, in part, from* beliefs and underlying assumptions, and can be most readily assessed by querying perceptions of those within that environment as to their belief systems (Schein, 2010). This series of questions was designed to ascertain safety culture to include, reporting culture, just culture, learning culture, flexible culture, and informed culture.

Safety culture questions.

SC_1 How likely is it that employee suggestions are taken into consideration by your employer?

SC_2 How likely are you to critique and report any aspect of your employer's training program if you perceive it as substandard?

SC_3 How likely is it that your employer's leadership team in pilot training, involved in program development, has knowledge of how humans learn and is aware of technology to improve learning?

SC_4 How likely are you to agree with the following statement—the best way to have a successful career as a pilot is to keep quiet and not make waves?

SC_5 How likely is it that your employer will *exceed* minimum regulatory compliance?

Aviation passion. Aviation passion (AP) is a latent variable associated with the individual's involvement in an aviation activity beyond the work experience, such as recreational flight, aviation club participation, reading aviation magazines and books, flying home simulators, or purchasing aviation themed products. This passion is also internalized into the pilot's identity, in harmony with their life (Kocjan, 2015), where flying is fulfilling and gratifying (Astakhova, 2014). This series of questions were designed to ascertain the pilots' level of aviation passion.

Aviation passion questions.

AP_1 How likely is it that you will attend an aviation conference or an aviation social event within the next 12 months?

AP_2 How likely are you to acquire aviation themed products? Examples include (but are not limited to) an aircraft model, t-shirt, artwork, or coffee mug.

AP_3 How likely are you to read aviation books or magazines for enjoyment?

AP_4 How likely are you to go to the airport or join a social media site to connect in order to socialize with other aviators?

AP_5 How likely are you to agree with the statement—I feel great pride being a pilot, and it defines who I am?

Multiple choice and dichotomous questions. The FAA has mandated a number of required AQP elements in order to train pilots to proficiency. Specific observable requirements for AQP (that are essential to learning) were queried with dichotomous and multiple-choice questions. Additional questions included whether the operator was AQP certified and if the pilot was given a traditional oral versus an electronic test. AQP is a program that enables operators to train-to-proficiency, providing a flexible means of training. While no training program is the same for each operator under AQP, there remains certain AQP requirements mandated by the FAA (FAA, 2017a). This series of questions was designed to ascertain training elements related to length of briefing times, traditional ground school versus an at home study program, tools utilized such as videos for the debrief, and required elements of crew compliment, that may or may not be in the operators' program, but applicable to learning.

Demographic data. These questions were designed to identify data such as gender, length of time on aircraft, seat position, if they had experience as an instructor, pilots' age, and if the pilots participated in recreational flight for leisure activity.

The pilots were asked which geographical region their organization was based, in order to identify if geographical culture impacted performance. English is the required language of pilots worldwide; therefore, if the pilot participants are operating in the air traffic control (ATC) system, it was assumed they should possess language skills necessary to understand and respond to the questions on the Manual Flight Inventory survey. Regulatory mandates per country should not impact and vary any response to questions asked on the MFI, yet, each airline, even within the United States, has different corporate cultures, policies, and procedures, that varied more so than government regulations. Corporate policy among airlines and regions are discussed, as company mandates appear to impact manual flight decisions more so than personal choice.

Instrument reliability. Construct reliability (CR) was checked to determine the extent to which the latent constructs were homogenous in their measurements, and CR values were required to be >.7 (Hair et al., 2006). In order to identify the consistency between test items being measured with similar responses, Cronbach's alpha was utilized to measure the scale reliability (Kline, 2011). The design of the MFI survey instrument, the specificity of questions, and SME evaluative assessment process assisted in reliability of the instrument to support external reliability and the ability to repeat this study with similar findings.

Instrument validity. To measure construct validity, the sample size was large enough to assess model fit, factor loadings, and convergent and discriminant validity. Convergent validity assessed the degree of which two or more measures of the same construct were correlated, and discriminant validity determined whether or not the factors were distinct and uncorrelated, both of which are types of construct reliability. A factor correlation matrix was utilized to display the correlation coefficients between the factors on the EFA to test for discriminant validity. With discriminant validity, the EFA extracted factors were not to exceed the correlation coefficient of ±0.70 per Gaskin

(2017). In addition, the factor correlation matrix was required to have no bivariate correlations coefficients greater than .70, indicating extracted factors were distinct, and discriminant validity was achieved. Hair et al. (2010) established a three-category factor loading of ±.30 minimal, ±.40 important, and above ±.50 practically significant. Convergent validity was achieved if the variables did not converge.

Construct validity was based upon distinct relationships between variables, whereas content validity measured the scope of meanings within a particular concept (Babbie, 2013). Internal validity showed that the intended variables to be measured were actually what was measured and were dependent upon the design of the questions and subject matter experts' assessment. Utilizing commercial pilots who fly for an airline, charter, and corporate or fractional worldwide, in both international and/or domestic operations that include long and/or short-haul operations, achieved external validity by increasing the generalizability of the study.

Treatment of the Data

Paper survey data were input into an external data collection site and combined with electronic responses, then all data were extracted from that external data collection site. Data were treated anonymously in that names were not collected with the surveys, nor was employer information collected. The data were cleaned, analyzed for missing responses, filters built, and imputed. The data was split into three sets: training, validation, and test and used on three different EFA models and three different CFA models. EFA was run, and tests were conducted with SPSS. CFA was run with AMOS. SEM was run with AMOS, and hypotheses were evaluated. Data were analyzed and displayed for a visual depiction.

Data preparation. Data were reviewed evaluating missing responses, and the decision to filter eight variables was made. Missing data were analyzed to ensure percentages were not excessive and occurred in a random fashion. The data were imputed, and a clean set prevailed. Due to the large sample size, the data was randomly split into three groups at approximately 33% each, for cross-validation. Three EFA models were built, and SPSS was utilized to ensure the strength of the items, convergence, reliability, and the discriminant value to determine if the constructs were distinct for each model. The models were compared, and CFA was conducted in a similar fashion to confirm the relationship between the latent and observed variables in order to verify that the constructs represented the variables. Normality was established, as non-normality could affect variances and covariance tests (Byrne, 2010). The 113 pretest participants' survey data were not included in the final EFA, CFA, and SEM analysis.

Filtering process. Data were cleaned, and frequency tables for each individual question were analyzed to ensure only seven points existed, and the number of missing variables were reviewed. A filter was then created to remove participants who left eight of the 26 questions blank. The decision to remove participants who left six questions blank (Q6_MF_1; Q7_M11_MF_2; Q22_PT_4; Q26_MF_5; Q27_MF_4; Q29_MF_3) was based upon an assumption the questions were left blank due to the inability to answer because the equipment was not available. These questions were based upon autopilot and autothrust usage and were essential to the manual flight (MF) and pilot training (PT) constructs. Upon further evaluation, two additional SEM questions were problematic (Q7_PU-1; Q25_PU_3) in that the question recommended to be left blank if the pilot did not have the equipment, therefore those participants who left those particular questions blank were also assumed to not have the equipment and were removed from the dataset. Thus, a filter was created to remove participants who left the aforementioned questions blank. After the data were filtered, the frequencies were checked for each variable to confirm everything was within a 1-7 per the Likert scale.

Missing data. Data were analyzed for the number of missing variables to determine randomness and identify total percentage of missing values and percentage of missing variables. Hair et al. (2006) purports if missing data are 10% or less for an individual participant, it could be ignored as long as the missing data occurred in a non-specific random fashion, with the total number of missing variables less than 30%, and total missing values less than 5% (Tabaschnick & Fiddell, 1983). After the number of missing values was determined not to be a factor, an MCAR (*Missing Completely At Random)* test was utilized to ensure the missing data occurred in a random fashion. After determining that missing data occurred in a random fashion, the data were imputed to replace the missing values. The multiple imputation utilized was a linear regression approach to predict the missing values. The data were imputed six times and averaged the missing values. After the data were imputed, it was compared to the mean identifying the same number. The imputed values were input into the data creating a clean set with no missing variables.

Assessment of the measurement model. To validate the measurement model (the relationship of the indicator variables to its respective latent variable) critical assessment of individual path estimates (significance and size), construct validity (reliability measure, convergent validity, and discriminant validity), model fit, and diagnostic test of the standardized residual covariances were conducted. Eigenvalues represent the amount of variance by a single factor, and only factors with *eigenvalues**

greater than 1 should be considered significant, disregarding the others (Hair et al., 2010). Kaiser (1965) established criterion of the *eigenvalue > 1 Rule*. However, Hair et al (2010) recommended the cumulative percentage of variance should be greater than .50 to consider good estimates in identifying the number of factors extracted from the dataset.

Inter-correlation among input variables. A correlation matrix was used in the factor analysis process to display relationships between individual variables (Williams, Onsman, Brown, 2010).). Correlation coefficients over ±.30 are identified to be good indicators of factorability (Tabachnick & Fidell, 2007).

Measure of sampling adequacy. Prior to factor extraction, several tests were conducted to assess the suitability of the respondent data for factor analysis to include the *Kaiser-Meyer-Olkin* (KMO) Measure of Sampling Adequacy, and the Bartlett's Test of Sphericity (Williams, Onsman, Brown, 2010).). Williams (2012) recommended that a KMO index above 0.50 was suitable for factor analysis, and Hair et al. (2006), stated, "values above .50 for either the entire matric or an individual variable indicate appropriateness" (p. 103).

Factor loadings. Factor loadings are the correlation of the input variables within each extracted factor (Hair et al., 2010). Hair et al. (2010) established factor loading criteria to be considered acceptable for factor structure interpretation with the range from ±.30 to ±.40 and loadings of ±.50 or greater to be considered practically significant.

Path estimation. Factor loading estimates can be statistically significant but still too low to qualify as good items. As such, standardized regression estimates below 0.50 were considered low loadings and were addressed in this study (Hair et al., 2010).

Model fit statistics. Goodness of fit will measure how well the model "reproduces the covariance matrix among the indicator variables" (Hair et al., 2006, p.

708). Modification indices (MI) identify cross factor loadings or covariance errors. Model fit statistics that were checked include:

- GFI (goodness of fit): >.90 to .95 is good, 1 is a perfect fit.
- AGFI (GFI adjusted for degrees of freedom): >.90 to .95 is good, 1 is a perfect fit.
- NFI (normal fit index): >.95 is acceptable, 1 is a perfect fit.
- CFI (comparative fit index): >.95 is acceptable, 1 is a perfect fit.
- RMSEA (root mean square error): <.05 good fit.
- CMIN/df (minimum discrepancy/degrees of freedom): Good = 0, and 1-2 acceptable. (Hair et al., 2006)

Descriptive statistics. Quantitative data were gathered from the MFI survey in reference to demographic data such as age, flight hours, seat position, and geographical location, and mean, mode, skewness, standard deviation, and kurtosis were analyzed and displayed by means of histograms and a chart for a visual depiction.

Reliability and validity testing. Validation of the extracted factors was a three-step process of the extracted factors to include testing for discriminant validity, convergent validity, and reliability.

- Discriminant validity refers to the "degree to which two conceptually similar concepts are distinct" (Hair et al., 2006, p. 137).
- Convergent validity "assesses the degree to which two or more measures of the same concept are correlated" (Hair et al., 2006, p. 137).
- Construct reliability (CR) refers to the "measure of reliability and internal consistency of the measure variables representing a latent construct" (Hair et al., 2006, p. 771).

Discriminant validity determined if the constructs were distinct from the other constructs (Hair et al., 2006). Discriminant validity testing was accomplished by comparing the AVE with the squared correlation estimates to each path. The AVE must be higher than the square correlation of the path to identify discriminant validity (Hair et al., 2006). Convergent validity determines whether or not the indicators converge. Cronbach's alpha in SPSS was used to confirm reliability. The average variance extracted (AVE) should be ≥ .5 which identifies that indicators converged as they should. High construct reliability (CR) indicates good reliability, and values should be >.7 (Hair et al., 2006). Whereas AVE is a measure of convergent validity, Malhotra and Dash (2011) state, "AVE is a more conservative measure than CR. On the basis of CR alone, the researcher may conclude that the convergent validity of the construct is adequate, even though more than 50% of the variance is due to error" (Malhotra & Dash, 2011, p.702).

Assumptions. Prior to performing the SEM, three assumptions were tested to include normality, linearity, and independence of errors.

Normality. Normality was graphically checked by analyzing histograms for distribution, boxplots for outliers, and Q-Q plot line to determine if observations hugged the line. Skewness and Kurtosis value within +/- 1 is ideal, and +/- 2 is acceptable (Warner, 2013). Skewness and Kurtosis ratio test determined the standardized scores threshold by dividing the value by the standard error, which created a standardized value. By standardizing the value, the threshold for standardized scores could be applied. A standard value of 0.05 equaled a threshold of +/- 1.96 or 2.0, and three standard deviations had a standard value of 0.10 equal to +/- 2.56 or 3.0, to be considered normal. Kolmogorov-Smirnov, a test of normality, was conducted, with desirable results to be close to zero; however, the Kolmogorov-Smirnov test of normality is sensitive to large samples, meaning it is difficult to pass with a large sample. Ideally there should be a non-significant observation; however, a sample size >1,000 is more than likely to get a significant test, as the formula EN=n(i)/N includes the population size (Chakravarti, Laha, & Roy, 1967). The process of data transformation versus dropping cases that were slightly over three was utilized in order to not lose the value of those individual cases. Data transformation methods, mathematical techniques, utilized to assist in standardizing normality by four methods were Log 10, square root, inversed, and squared, and the greatest enhancement was utilized. Each of the factors were standardized with an attempt to capture the data points that were greater than two or three. There are two types of outliers—potential and influential. Potential are acceptable, but influential could distort and negatively impact the results. Univariate normality was also assessed, but based upon the multivariate model, multivariate normality was more important to achieve.

Linearity. To have a meaningful regression analysis, the expectation is that the factors from EFA to CFA have a meaningful linear relationship. Linearity estimates if there is a linear relationship between variables. The Pearson Correlation was examined to identify if a linear relationship exists. The correlation should be either -1 as a negative relationship or +1 as a positive correlation, avoiding 0 which indicates no correlation. Anything between .25 and > .3 is considered medium size relationship, and >.5 is considered a large relationship. With a large sample, any effect detected will provide a significant relationship.

Independence of errors. This test will confirm that the residuals are not correlated with previous errors, with the goal to have errors independent from each other. Errors should occur in a random fashion. Systematic errors, or correlated errors, would indicate a problem with the model. Mahalanobis distance was utilized to detect outliers. Mahalanobis d-squared "measures the distance of cases from the means(s) of the predictor variable(s) (Field, 2013, p. 307).

Common method bias. Common method bias can occur due to rater characteristics, item characteristics, item context, or measurement context (Podsakoff et al., 2003). Rater characteristics are often attributed to social desirability response. Item characteristic could also be a social desirability response or interpretation of the question, but also placement of the question with item context effects, as related to other items in the survey (Wainer & Kiely, 1987). Measurement context identifies the context or situation of survey analysis. To test and then control for common method bias, a Common Latent Factor (CLF) was utilized in AMOS, where a path to each variable was created and constrained to zero in order to identify bias. The five factors and items associated with those factors, along with the CLF was imputed into the data, creating a new dataset. Adjusting for the CLF due to known bias assisted in avoiding a Type I error or rejecting a null hypothesis that is true.

Hypothesis testing. Hypotheses were written with two themes as the result of the EFA. The first identified the direct response of each construct upon the other taking into consideration the other factors. Direct response hypotheses were written as multivariate hypotheses versus univariate with the assumption that each factor within the model will impact the relationship to some extent. The questions revolving around the hypotheses are what is impacting pilots' willingness to manually fly, what is impacting understanding, and what impacts pilot training. A mediation hypothesis was also tested, where one construct predicts another yet may be mediated by another construct, whereas the original univariate relationship exists. Figure 10 presents the path model for the mediation process.

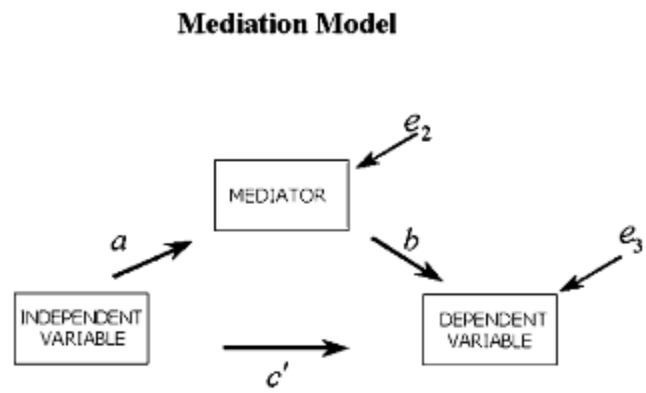


Figure 10. Mediation path model. Mediation path model adapted from MacKinnon, D. P., Fairchild, A. J., & Fritz, M.S. (2007). Medication analysis. Annual Review of Psychology. 58(1), p. 595.

Direct response hypotheses:

$H_{1A:}$ Pilots' aircraft understanding positively influences willingness to manually fly, controlling for pilot training, aviation passion and safety culture.

$H_{2A:}$ Training positively influences willingness to manually fly, controlling for pilot understanding, aviation passion, and safety culture.

$H_{3A:}$ Aviation passion positively influences pilots' willingness to manually fly, controlling for pilot training, safety culture, and understanding.

$H_{4A:}$ Safety culture positively influences pilots' willingness to manually fly, controlling for pilot training, aviation passion, and understanding.

$H_{5A:}$ Safety culture positively influences pilot training, controlling for manual flight, aviation passion, and understanding.

$H_{6A:}$ Aviation passion positively influences pilot training, controlling for manual flight, safety culture, and pilot understanding.

H_{7A} Pilot understanding positively influences pilot training, controlling for aviation passion, manual flight, and safety culture.

H_{8A} Manual flight positively influences pilot training, controlling for aviation passion, understanding, and safety culture.

$H_{9A:}$ Safety culture positively influences pilot understanding, controlling for manual flight, aviation passion, and pilot training.

$H_{10A:}$ Aviation passion positively influences pilot understanding, controlling for manual flight, safety culture, and pilot training.

H_{11A} Pilot training positively influences pilot understanding, controlling for aviation passion, manual flight, and safety culture.

H_{12A} Manual flight positively influences understanding, controlling for aviation passion, pilot training, and safety culture.

Mediation hypothesis.

$H_{13A:}$ Safety culture positively influences pilot training, which influences a pilot's willingness to manually fly.

The SEM model was utilized to better understand the relationship between the latent variables and to examine the hypothesis in order to determine whether or not to accept or reject the hypotheses. Modification indices were checked to determine cross loadings, and paths and variables were removed per the model fit statistics results. Hair et al. (2010) identified that factor loading estimates could be statistically significant but still too low to qualify as good items, such that standardized regression estimates below 0.50 would be considered low loadings. Hair et al. (2010) also proposed to use the average of the standardized regression, and the squared multiple correlation estimates of items within each construct as an approximation of convergent validity. Thus, average standardized regression estimated values greater than .50 and average squared multiple correlation greater than .30 would both indicate adequate convergent validity. P-values were identified as significant at .001. Results determined acceptance of hypotheses.

Ethical and IRB considerations. Ethical considerations were applied with the subjects and their associated employer and within the scientific community. Primary assurance was made that no harm would come to the participants either physically or psychologically. A consent form was signed prior to participants conducting the survey, to enable utilization of their information in this research. The survey was not deemed harmful because anonymity was assured. Participants' names were not gathered, and employers were not identified. Survey data were de-identified from the pilot and their respective geographical location and will remain anonymous. Pilots who provided additional comments will remain anonymous. An Institutional Review Board (IRB) application was submitted prior to data collection, to ensure that human rights were protected (Appendix E) and IRB exemption (Appendix C).

Summary

New scale development measured latent constructs of manual flight, aircraft understanding, training, aviation passion, and safety culture to understand the relationship between constructs to address industry concerns of automation dependence, confusion, lack of mode awareness, and flight skill loss. SEM was selected for this research because it simultaneously provided a combination of regression and factor analysis that assisted to better understand how latent variables influence other latent variables. A challenge with SEM was more than the required large sample size, but the fact a worldwide pilot population is a vast group not represented on a master list dictated nonrandom sampling methods. The nonrandom sampling methods included elements of snowball sampling, respondent driven sampling, and purposive sampling, referred to in this research as network driven sampling. Utilizing SNS with a hybrid data collection process proved an effective data collection. LinkedIn was the most effective of SNS due to functionality, efficiency, and the ability to invite qualified participants from countries, airlines, corporations, and fractional airlines worldwide, that would not have otherwise been possible. A variety of steps were utilized to address challenges with SNS and random sampling to include: recruiting via multiple venues of SNS; combining aspects of purposive sampling, snowball sampling, and respondent driven sampling; utilizing an effect size of one to increase the minimum required size; efforts to expand the sample to multiple airlines and flight operations worldwide while randomly selecting potential applicants from each list as a representative sample belonging to LinkedIn; added protections with the survey collection process to prevent multiple entries and hackers; carefully designed and evaluated the survey questions; collected five times the required data to cross-validate and provide more stability of the model; and expanded the research worldwide with airlines, charter, fractional, and corporate pilots in order to provide more generalizability.

The design of a new inventory was essential to narrow the gap between operational practice and current research dealing with aviator performance related to automation usage. EFA was effectively utilized, and the preferred methodology with scale development, followed by CFA and SEM (Costello & Osborne, 2005; Flora & Flake, 2017; Hurley, Scandura, Shriesheim, Brannick, Seers, Vandergerg, & Williams, 1997). Whereas current literature addresses pilot fatigue, automation challenges, situation awareness, safety culture, confidence, and learning methodologies, there continues to be a gap between real world operational problems and current research as to what is impacting performance issues beyond the unwillingness to manually fly.

CHAPTER IV

RESULTS

Chapter IV presents the sequential results of all phases throughout the research process. Survey analysis of the survey instrument, MFI, is first presented followed by pilot testing of the instrument. The data from the pretest of the instrument, termed Pilot Test, was utilized to perform first EFA and CFA, testing for intercorrelation, measures of sample adequacy, AVE, factor loadings, goodness of fit, reliability, and validity testing, and are presented for the four-factor model. The pilot test results for the five-factor path model to include C.R., AVE, MSV, and model fit measures are presented in Appendix I, Tables 11, and 12, respectively. The data treatment for the full sample is presented, followed by three EFA models, with the pilot training factor included, providing three-model comparisons with the five-factor model, followed by three CFA models with comparisons, and the selection process of the final model. Testing for intercorrelation, measures of sample adequacy, AVE, factor loadings, goodness of fit, reliability, and validity testing for the final model were performed. Common Method Bias was tested, and the results are presented. Prior to performing the SEM, five assumptions were tested to include normality, linearity, multicollinearity, homoscedasticity, and independence of errors. Hypotheses testing was included for thirteen hypotheses. SEM results and Automation opinion-based results are displayed in Appendix F and Appendix G, respectively.

Survey Instrument Analysis

Inter-rater reliability. Rater demographics identified that five of the eight raters are currently retired, which is approximately 62.5% of the rater participants, and three raters reported they are currently active pilots, which amounts to 38.0 % of the sample data. All eight raters are male (*n* = 8), and each rater reported they have been or are current flight instructors (100.0%). Seven of the eight raters reported they were a captain (CA) (86.5 %), and one rater was a first officer (FO) (12.5 %). Average age of the raters is *M* = 60.25 (60 years old) with the youngest age reported at 25 years of age and the oldest reported age at 73. Case summaries revealed the observed median score in each of the 26 Manual Flight Inventory (MFI) survey items correctly corresponded to the study's assumed five factors. An intraclass correlation was conducted to determine if there was an absolute agreement between the eight raters in the overall assessment of the survey items and to test whether the raters correctly assigned the inventory that corresponds to the five theoretical factors of the Manual Flight Inventory scale, as presented in Table 4. The results indicated a significant and adequate measure of absolute agreement between the eight raters, *ICC* = .986, 95% C.I. [0.976, 0.993], *p* < .001.

Table 4

Intraclass Correlation Coefficient Between Raters

	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0		F Test with True Value 0[b]	
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Average Measures	0.986	0.976	0.993	56.985	25	175	0.000

There was sufficient evidence to support the study's assumption that the scores between the eight raters were in absolute agreement and statistically significant with >70% consensus, based on Gaskin's (2017) recommendation, and deemed adequate to proceed.

Pilot Test

The pilot test was conducted to test the reliability and validity of the survey instrument. Soper's calculator was utilized with an effect size of .1, a statistical power of .8, and probability level of .05 to determine minimum sample size for the model structure pretest, and the resulting number satisfied the minimum of greater than 100 (Soper, 2017b; Westland, 2010). With five constructs and 26 variables, a sample size of 113 participants was the minimum required. The study's sample size, n = 115, was therefore deemed appropriate for an EFA study. The maximum likelihood (ML) factor extraction method was used for the study. Oblique factor rotation was used because the study assumed there would be a meaningful correlation between the extracted factors. A meaningful inter-correlational relationship existed across the indicator variables.

Prior to factor extraction, several tests were utilized to assess the suitability of the respondent data for factor analysis to include the *Kaiser-Meyer-Olkin* (KMO) Measure of Sampling Adequacy and the Bartlett's Test of Sphericity (Williams; 2012). The *KMO* value for the study achieved an acceptable rating, and the Bartlett's test of Sphericity revealed a significant test. A meaningful relationship between the input variables and the respective indicator variables was identified.

The factor analysis extraction method identified four dimensions—Safety Culture, Pilot Understanding, Aviation Passion, and Manual Flight. Of the 26 input variables selected for factor extraction, 17 showed adequate factor loading to their respective factors. In terms of model fit of the extracted factor model (EFA), the goodness of fit resulted with a non-significant outcome, an indication that the four extracted factor model adequately fit the pilot data. Measure of model fit using the *chi-square* estimation indicated a parsimonious fit of the model at the *EFA* stage. A confirmatory factor structure of the Manual Flight Inventory (MFI) measurement model was built with four latent constructs to include Manual Flight (MF), Pilot Understanding (PU), and Safety Culture (SC), and Aviation Passion (AP), along with their respective indicator variables and measurement error terms. Model identification was achieved, which identified the theoretical possibility for the SEM program to derive a unique estimate of every model parameter (Kline, 2011). The model identification was over-identified, meaning the model will more likely provide a meaningful estimation of the hypothesized CFA model.

To validate the measurement model (the relationship of the indicator variables to its respective latent variable) critical assessment of individual path estimates (significance and size), construct validity (reliability measure, convergent validity, and discriminant validity), model fit, and diagnostic test of the standardized residual covariances were conducted. The unstandardized and standardized regression estimates of the individual paths of the proposed first-order factor structure model identified that two of variables had a medium sized effect, whereas the other 15 indicator variables had large effect sizes. Construct validity has three main parts to include construct reliability of items within each of the four constructs, convergent validity, and discriminant validity (Hair et al., 2010). The average standardized regression estimates in each of the four factors of MFI were greater than .50, and the average squared multiple correlation in each of the factors was greater than the .30, an indication of large effect sizes. Overall, although the path estimates of the indicator variable showed significant results at $p < .001$ and mostly have an observed large effect size, there were issues to be considered since convergent validity was not assumed. In terms of discriminant validity, both AVE and maximum shared variance (MSV) were used to conduct distinctiveness of the four factors. Each of the four

MSV values were less than their respective AVE values, and thus discriminant validity was achieved. Model fit measures also identified an excellent and good fit in all measures meeting the following standards in Table 5:

Table 5

MFI Pilot Test Model Fit Measures

Measures	Acceptable Thresholds	Observed Model Fit
CMIN/df	<3.0*	1.275
CFI	>.95 Excellent; >.90 Traditional; > .80 Permissible*	0.937
GFI	>.95 Excellent; >.90 Traditional; > .80 Permissible*	0.883
AGFI	>.80*	0.840
SRMR	<.05 Good Fit; .05-.08 Adequate Fit, >.10 Poor fit*	0.076
RMSEA	<.05 Good Fit; .05-.10 Moderate, >.10 Poor fit*	0.049
PCLOSE	1=Perfect	0.507

*Hu and Bentler (1999)

The pilot test for the proposed MFI first-order four-factor CFA model showed satisfactory assessment of model specification, model identification, construct validity, and the validity of the measurement model. However, due to the large sample size collected, the five-factor model was utilized for the full sample EFA and CFA, followed by the SEM. All SEM questions from the MFI survey were retained for the full analysis, as were the additional questions. Changes were made to the survey that include: (1) moving the SEM questions forward in the survey to capture the SEM data in the event of survey fatigue, and (2) the option for comments was removed.

Full Sample Demographics

The initial data download included 7,490 surveys spanning the globe with graphic results displayed in Figures 18 through 22.

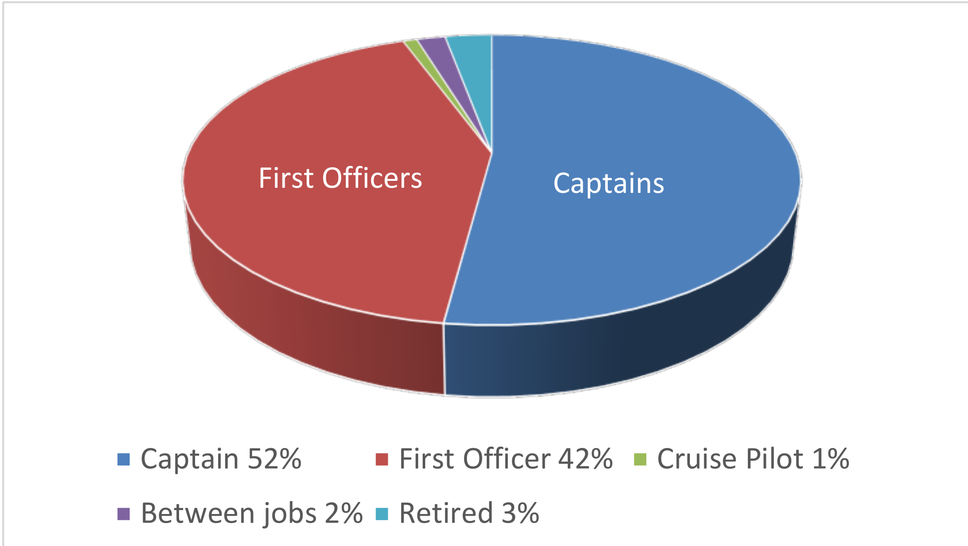


Figure 18. MFI seat position questions, full data sample, identifying 52% of participants were Captains, 42% first officers, 1% cruise pilots, 2% between jobs, and 3% retired.

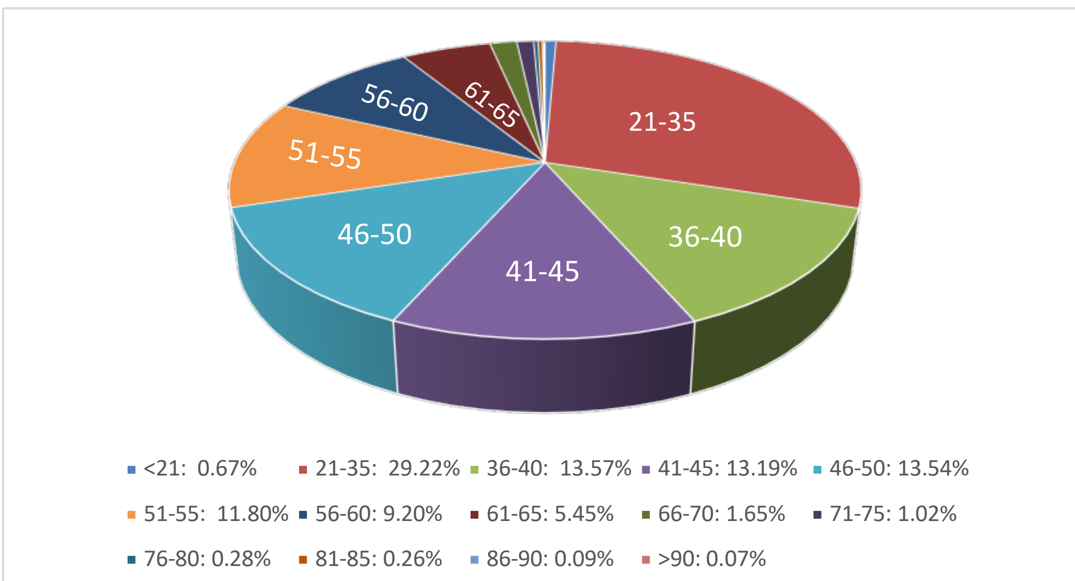


Figure 19. MFI age question, full data sample, identifying the percentage of age range of the demographics. The greatest percentage were ages 21-35 at 29%, with the next three categories, 36-40, 41-45, and 46-50, were similar at 13-13.5%.

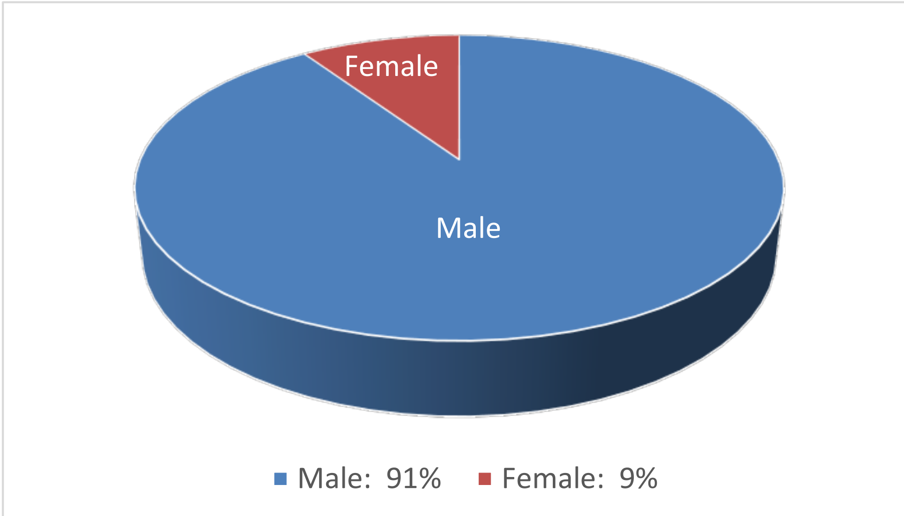


Figure 20. MFI gender questions, full data sample, identifying that 91% of the population were men in relation to 9% female pilots.

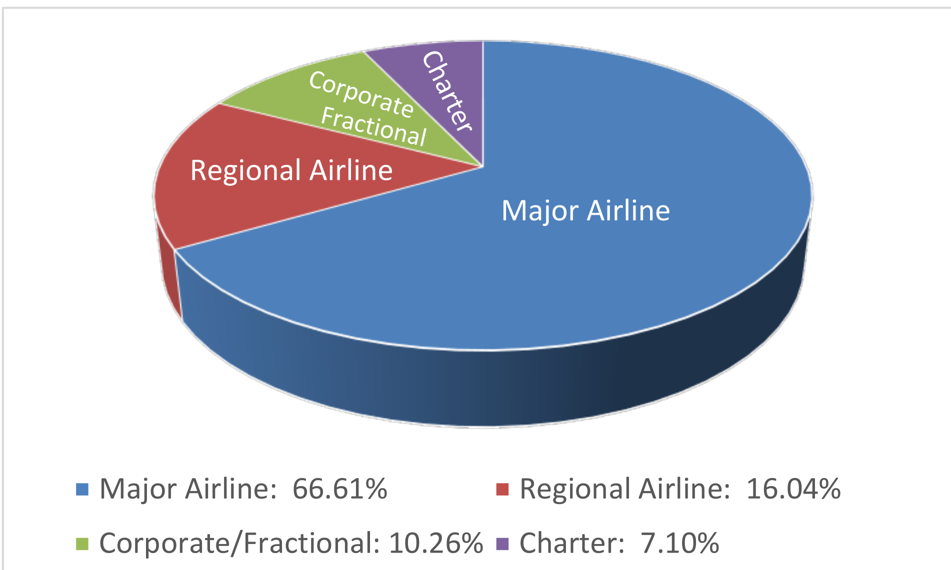


Figure 21. MFI most current employer question, full data sample, displaying that close to 70% of the demographic were employed at an airline, 16% regional, 10% fractional/corporate, and 7% charter operation.

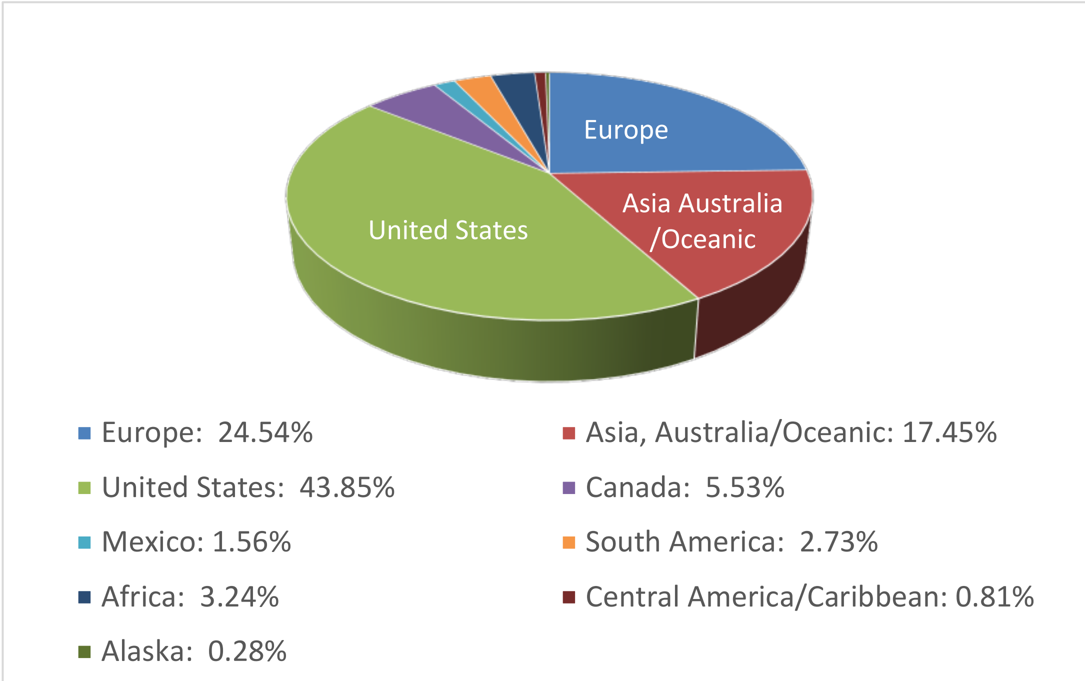


Figure 22. MFI corporate headquarters location question, full data sample, identifying 44% participants were from the United States, 24.5% were from Europe, and 17.5% were from Asia, Australia/Oceanic.

Operating experience. Operating experience is depicted in Figures 23 through 27. Operating experience includes instructor and check airman experience, if any, total flight time, type of flight time in the previous 12 months, type of aircraft flown, to include flight deck and trim type, typical number of daily cycles, to include long or short haul, and type and time since initial flight training.

Figure 23. MFI instructor/check airman experience and total flight time questions, as identified by the full data sample.

Figure 24. MFI recreational and employment flight hours questions from the full data sample in the previous 12 months.

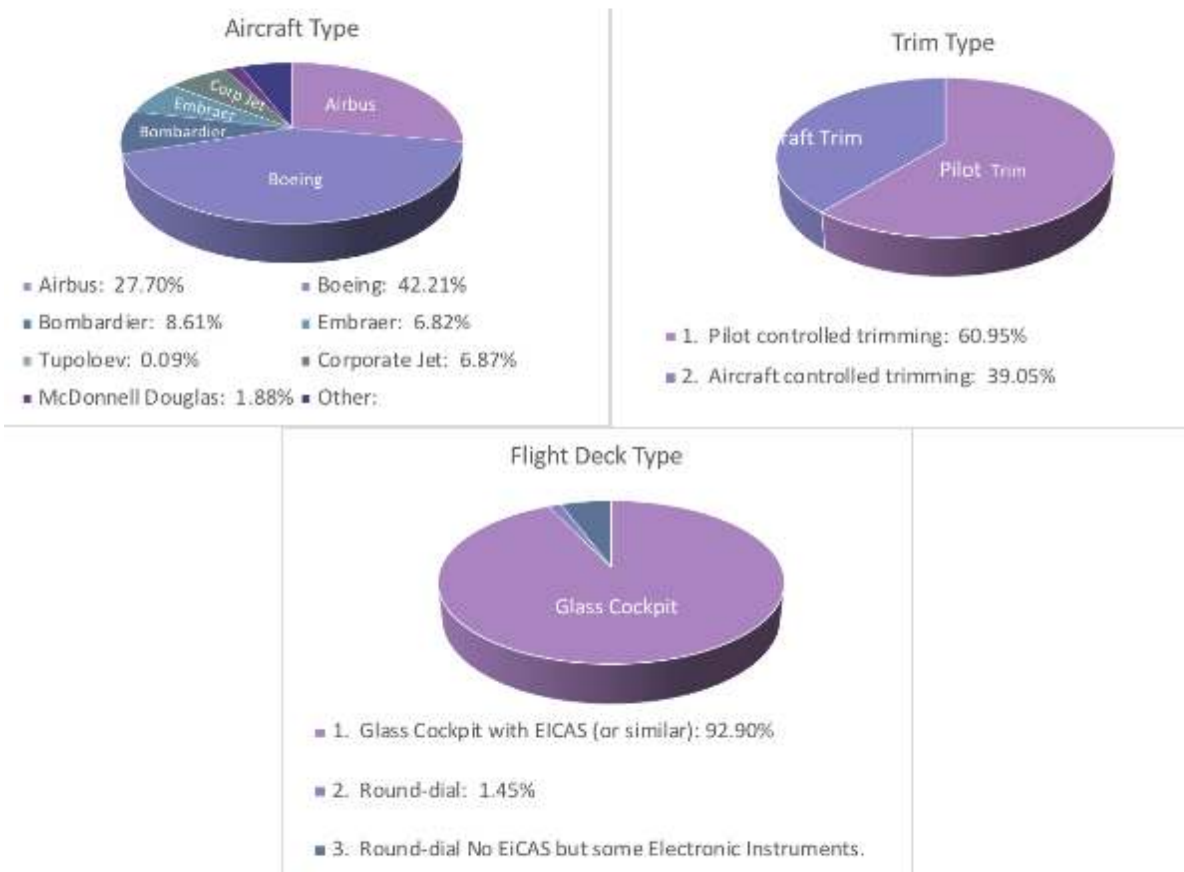


Figure 25. MFI type of aircraft, flight deck, and trim, questions from the full data sample.

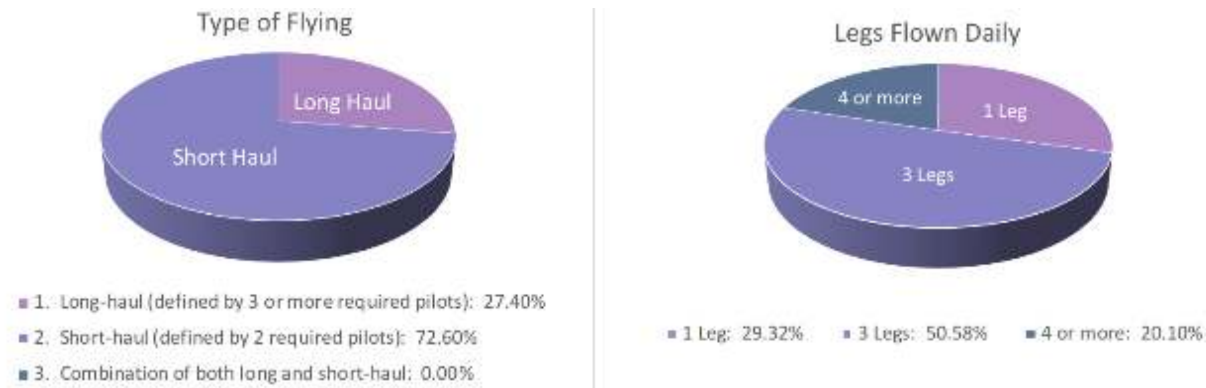


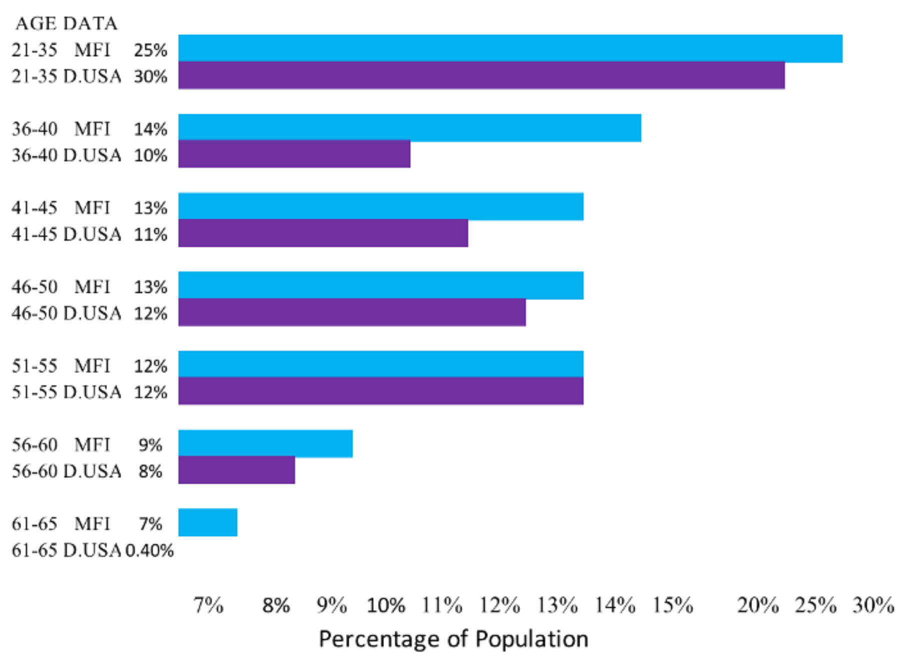
Figure 26. MFI type of employment flying and legs flown daily questions, from the full data sample.

Figure 27. MFI primary flight training and time since initial training was conducted questions, from the full data sample, identifying that the 43% of the demographic were general aviation pilots, and 68% experienced training within the previous 5 years.

Demographic comparison. In order to determine the representativeness of the sample to the population, demographic comparisons were evaluated in two categories. Age (DataUSA, 2018a) and gender statistics (DataUSA, 2018b) from 2016 were compared to the population in the MFI survey, 2018. Table 6 represents the age comparison where both the MFI and USA category from 21-35 represented the highest percentage at 29% and 25%, respectively. Category 36-40 was 14% MFI versus 10% USA, 41-45 was 13% MFI versus 11% USA, category 51-55 were both 12%, 56-60 was 9% MFI versus 8% USA, and 61 to 65 was 7% MFI to .4% USA. Despite that DataUSA statistics was two years earlier, it becomes difficult to adjust an age increase comparison assumption over the two-year period in that aviation is a career that enables pilots to join the career at any age below the mandatory retirement, as well as allows them to exit the career early.

Table 6

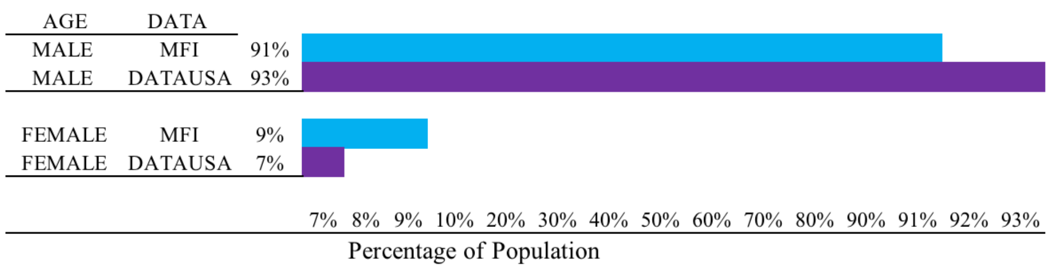
MFI Data Comparison Age with DataUSA 2016 Data



The gender demographic presented in Table 7 displays the comparison of the female population of the MFI survey to be 9% to the USA data of 7%. The 2% increase could be due to activities to increase female pilots in this workforce (Petitt, 2015). The age and gender demographic comparisons from the MFI survey with DataUSA identify the data closely approximated the 2016 statistics population and is closely representative of the survey population.

Table 7

MFI Data Comparison Gender with DataUSA 2016 Data



Full Sample Data Treatment

The initial data download included 7,490 surveys. Data were reviewed evaluating missing responses and eliminated respondents that had more than 70% missing data. Eight variables were filtered, meaning any respondents who left the following eight questions blank were removed from the dataset: SEM—Q6_MF_1; Q7_PU1; Q11_MF_2; Q22_PT_4; Q25_PU_3; Q26_MF_5; Q27_MF_4; and Q29_MF_3. Missing data were analyzed to ensure percentages were not excessive and occurred in a random fashion. The dataset was imputed, and a clean set prevailed to include 5,661 responses. Due the large sample size, the data was randomly split into three groups at approximately 33% each, for cross-validation.

Filtering process. Data were cleaned and frequency tables for each individual question were analyzed to ensure only seven points existed, and the number of missing variables were reviewed. A filter was created to remove participants who left eight of the

26 questions blank. After the data was filtered, the frequencies were checked for each variable to confirm everything was within a 1-7 per the Likert scale and looked normal.

Missing data. Data were analyzed for the number of missing variables to determine randomness and identify total percentage of missing values and percentage of missing variables. Hair et al. (2006) purports if missing data is 10% or less for an individual participant, it could be ignored as long as the missing data occurred in a non-specific random fashion, with the total number of missing variables less than 30% (Hair et al., 2006) and total missing values less than 5% (Tabaschnick & Fiddell,1983). Figure 28 represents the number of missing variables to be very low at .168%.

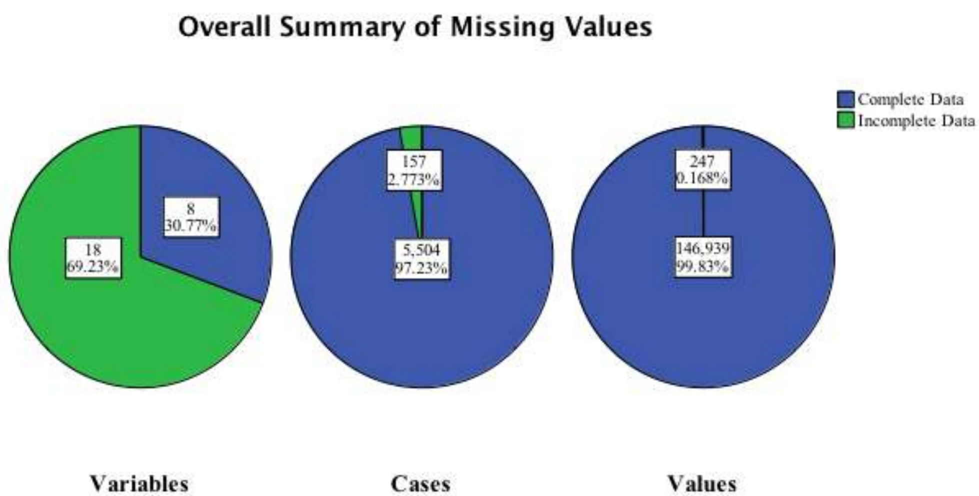


Figure 28. MFI percentage of missing variables, as presented with depiction of missing variables, number of cases with missing variable, and percentage of total missing variables.

Missing variable patterns in Figure 29 identified there were no patterns. The visual in the bottom right of the figure is related to the missing data on two sequential questions, 30 and 31; however, no patterns exist.

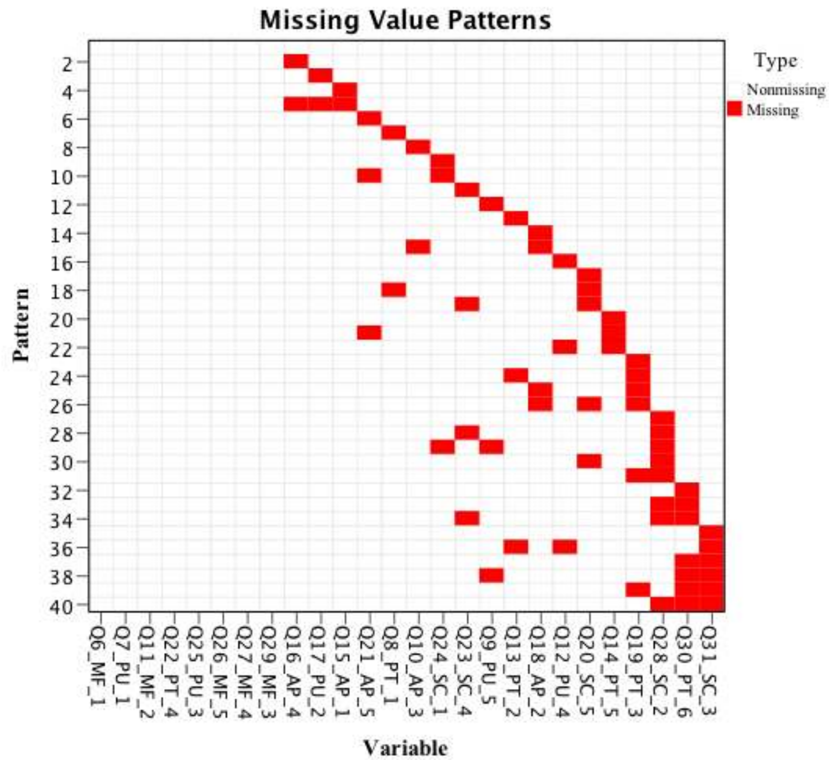


Figure 29. MFI missing value patterns, reflecting a block of missing responses on questions 30 and 31.

An MCAR test (*Missing Completely At Random)* was utilized to ensure the missing data occurred in a random fashion. This test resulted in non-significance at .988, meaning there was no non-random occurrence. Acceptable level is <5% variable levels and <30% for missing values (Hair et al., 2006; Tabaschnick & Fiddell, 1983).

Imputing data. Multiple imputations were utilized with a linear regression approach that predicted missing values and replaced them. The data was imputed six times and averaged the missing values, which then replaced the missing values in each of the variables. SEM questions, Survey questions 6 through 31, retained 5,661 valid cases.

Dataset division. Due to the large sample size—5,661 after filtering and imputation—the data was randomly split into three groups at approximately 33% each: training dataset (1,831); validation dataset (1,887); and test dataset (1,943). Table 8 presents the total number of participants in each dataset. The training dataset was utilized to build three EFA models, and all datasets were utilized on each model.

Table 8

MFI Cross-Validation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Training Data Set	1831	32.3	32,3	32,3
	Validation Data Set	1887	33.3	33.3	65.7
	Test Data Set	1943	34.3	34.3	100.0
	Total	5661	100.0	100.0	

Full Sample EFA Model Comparison

Three EFA models were then built with the training dataset to gain a better picture of the emerging factors, utilizing the original five factors. All three models were analyzed with each dataset in addition to the full dataset. A meaningful relationship requires a shared variance to be above .3 where a shared variance is a correlation r, and .30 is considered medium correlation indicating that there is a relationship (Nandy, 2012). Factors with low commonalties well below .3 were removed in the first two models. The commonalities in the first model were removed one at a time. This process continued until all commonalities were close to, or greater than .3. In the second EFA model, the commonalities were also removed based on the <.3 criteria, but this time they were removed two and three at a time. Whereas the first two models were built by removing variables with low commonalities, the third EFA model was built utilizing factor loading—anything less than .3 on the pattern matrix was removed, one by one. After the <.3 factor loadings were removed, the construct was assessed to determine average loading of all variables. If it appeared a variable with a factor loading of a low .4

(despite meeting the .3 criteria) would lower the overall average of the construct below the required .5, the low variable was also removed to avoid negatively impacting convergent validity. Variables in two of the models were inversely recoded due to negative values. The process continued until three models resulted.

Inter-correlation among input variables. Correlation coefficients over ±.30 were identified to be good indicators of factorability (Tabachnick & Fidell, 2007). Table 14, Appendix I: Inter-item Correlation Matrix, displays the correlation matrix for the first EFA model constructed with the full dataset. Correlation coefficients that are above the ±.30 threshold are significant at a .001 significance level. The correlation matrix identifies there are meaningful inter-correlational relationships that exist across the indicator variables compared.

Measure of sampling adequacy. Prior to factor extraction, several tests were utilized to assess the suitability of the respondent data for factor analysis to include the *Kaiser-Meyer-Olkin* (KMO) Measure of Sampling Adequacy and the Bartlett's Test of Sphericity (Williams; 2012). Williams (2012) recommended that a KMO index above 0.50 is suitable for factor analysis, and Hair et al. (2006) confirms that values above .50 is appropriate for an individual variable or the entire matric (p. 103). *KMO* value for the three models are .755, .737, and .745, respectively, well above the criterion set by Williams, and achieved an acceptable rating under Hair's guidelines. The study's sample size also met the required measure of sampling adequacy for factor analysis. Bartlett's test of Sphericity revealed a significant test with $p < .001$ on all three models identified in Table 9. A meaningful relationship between the input variables and the respective indicator variables exists with all three models. Therefore, the null hypothesis that the residual covariance is proportional to an identity matrix is rejected.

Table 9

MFI KMO and Bartlett's Test Model Comparison with Test Data

Model 1			Model 2			Model 3		
Kaiser-Meyer - Olkin Measure of Sampling Adequacy		0.755	Kaiser-Meyer - Olkin Measure of Sampling Adequacy		0.737	Kaiser-Meyer - Olkin Measure of Sampling Adequacy		0.745
	Approx	8200		Approx	7302		Approx	7694
Bartlett's Test of Sphericity	df	153	Bartlett's Test of Sphericity	Df	120	Bartlett's Test of Sphericit y	df	136
	Sig.	0		Sig.	0		Sig.	0

Extracted factors. The factor analysis extraction method of each model retained all five dimensions—Safety Culture, Pilot Understanding, Aviation Passion, Manual Flight, and Pilot Training. Each dataset and the total dataset were run on all three models. Of the 26 input variables selected for factor extraction, 18 input variables showed adequate factor loading to their respective five factors in model 1, 16 input variables in model 2, and 17 input variables in model 3. Table 10 reveals the comparison of the three models and the identification that model 2 represents a slightly better model, with an average common variance (communality) of .344 which is above the required .30 threshold established by Hair (2010). The decision to retain factors slightly below .30 was based upon the EFA process being exploratory, where more stringent guides were utilized in the CFA.

Table 10

MFI Communalities Model Comparison

Model 1 Test Set *Communalities*[a]	Initial
Q11_MF_2	0.511
Q29_MF_3	0.403
Q6_MF_1	0.384
Q26_MF_5	0.323
RecQ27_MF4	0.244
Q16_AP_4	0.376
Q15_AP_1	0.326
Q10_AP_3	0.348
Q18_AP_2	0.256
Q12_PU_4	0.304
Q9_PU_5	0.319
Q7_PU_1	0.201
Q17_PU_2	0.249
Q31_SC_3	0.395
Q30_PT_6	0.272
Q24_SC_1	0.296
RecQ19_PT3	0.455
RecQ13_PT2	0.444
Average Communality 0.339	

Model 2 Test set *Communalities*[a]	Initial
Q11_MF_2	0.496
Q29_MF_3	0.352
Q6_MF_1	0.381
Q26_MF_5	0.322
Q16_AP_4	0.373
Q10_AP_3	0.342
Q15_AP_1	0.326
Q18_AP_2	0.255
Q31_SC_3	0.394
Q30_PT_6	0.267
Q24_SC_1	0.294
RecQ19_PT3	0.455
RecQ13_PT2	0.442
Q12_PU_4	0.294
Q9_PU_5	0.279
Q17_PU_2	0.232
Average Communality 0.344	

Model 3 Test set *Communalities*[a]	Initial
Q11_MF_2	0.496
Q29_MF_3	0.354
Q6_MF_1	0.383
Q26_MF_5	0.323
Q16_AP_4	0.375
Q15_AP_1	0.326
Q10_AP_3	0.345
Q18_AP_2	0.255
Q31_SC_3	0.395
Q30_PT_6	0.271
Q24_SC_1	0.295
Q12_PU_4	0.303
Q9_PU_5	0.319
Q7_PU_1	0.194
Q17_PU_2	0.248
RecQ19_PT3	0.455
RecQ13_PT2	0.443
Average Communality 0.340	

Table 11 displays a total of five dimensions in each model with eigenvalues greater than 1.0. In model 1 the five factors explain close to 59% of the cumulative variance between the extracted factors, model 2, 62.5%, and model 3, 61 %. All three models are well above Hair's suggested cumulative variance of 50% or greater as a threshold value (Hair, 2010); however, model 2 appears to be the strongest.

Table 11

MFI Total Variance Explained Comparison

Model 1				
Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings
	Total	% of	Cumulative %	Total

		Variance		
1. MF	3.453	19.184	19.184	2.19
2. AP	2.45	13.609	32.793	1.979
3. SC	2.058	11.432	44.224	1.906
4. PU	1.521	8.451	52.676	2.021
5. PT	1.123	6.237	58.913	1.807
Model 2				
Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total
1. MF	3.314	20.714	20.714	1.984
2. AP	2.27	14.185	34.899	1.952
3. SC	1.995	12.472	47.370	1.876
4. PU	1.331	8.32	55.691	1.816
5. PT	1.094	6.836	62.527	1.816
Model 3				
Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total
1. MF	3.422	20.13	20.130	1,872
2. AP	2.279	13.408	33.539	1.753
3. SC	2.001	11.771	45.309	1.514
4. PU	1.497	8,807	54.116	1.496
5. PT	1.11	6.533	60.649	1.356

The scree plot comparison of the three models, Figure 30, identified five extracted factors with the line of the infliction point separating the five significant eigenvalues greater than 1.0 from eigenvalues (below 1.0) that were deemed not significant extracted factors. Models 2 and 3 were more distinct than model 1.

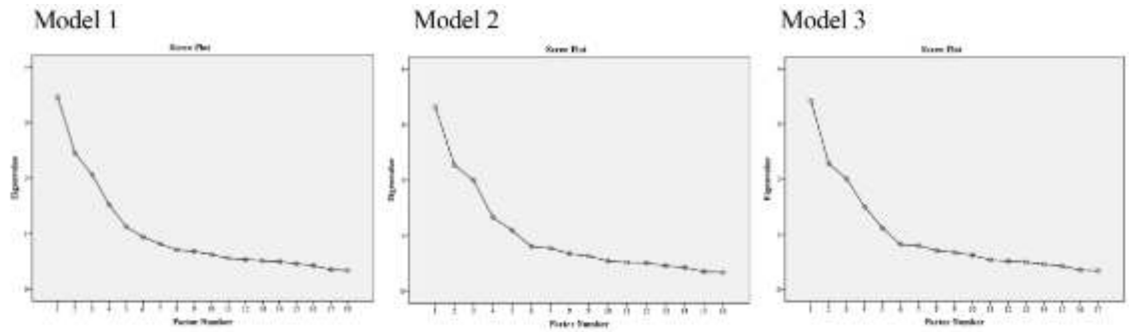


Figure 30. MFI scree plot comparisons with three five-factor models, identifying the variability in data, as identified by the eigenvalues.

Factor loadings. Factor loading is the correlation of the input variables within each extracted factor (Hair et al., 2010). The factor loadings of each input variable to their respective factor or dimensions with the three model comparisons are presented in Table 12. Hair et al. (2010) established factor loading criteria to be considered acceptable for factor structure interpretation with the range from ±.30 to ±.40 and loadings of ±.50 or greater to be considered practically significant. Each of the five extracted factors have a factor loading greater than 0.50, verifying the significance of the factor loadings within each of the structures (factors/dimensions) from the data set. Factor loadings for the three models and each of the five factors are as follows: Safety Culture dimension had factor loadings = 0.657, 0.656, and 0.631; Pilot Understanding dimension had factor loadings = 0.594, 0 .621, and .0573; Aviation Passion dimension had factor loadings = 0.655, 0.652, and 0.640; Manual Fight dimension had factor loadings = 0.693, 0.733, and 0.742; and Pilot Training factor had factor loadings = 0.803, .810, and 0.797.

Table 12

MFI Pattern Matrix Comparison

	Factor				
	Manual Flight	Aviation Passion	Safety Culture	Pilot Understanding	Pilot Training
MODEL 1					
Q11_MF_2	0.859				
Q29_MF_3	0.689				
Q6_MF_1	0.575				
Q26_MF_5	0.519				
RecQ27_MF4	0.514				
Q16_AP_4		0.756			
Q15_AP_1		0.649			
Q10_AP_3		0.646			
Q18_AP_2		0.570			
Q31_SC_3			0.963		
Q30_PT_6			0.512		
Q24_SC_1			0.496		
Q12_PU_4				0.667	
Q9_PU_5				0.633	
Q7_PU_1				0.564	
Q17_PU_2				0.51	
RecQ19_PT3					0.915
RecQ13_PT2					0.690
MODEL 2					
Q11_MF_2	0.883				
Q29_MF_3	0.658				
Q6_MF_1	0.596				
Q26_MF_5	0.529				
Q16_AP_4		0.749			
Q15_AP_1		0.646			
Q10_AP_3		0.644			
Q18_AP_2		0.57			
Q31_SC_3			0.945		
Q30_PT_6			0.522		
Q24_SC_1			0.502		
RecQ19_PT3				0.984	
RecQ13_PT_2				0.635	
Q12_PU_4					0.769
Q9_PU_5					0.582
Q17_PU_2					0.512
MODEL 3					
Q11_MF_2	0.878				
Q29_MF_3	0.651				
Q6_MF_1	0.611				
Q26_MF+5	0.572				
Q16_AP_4		0.735			
Q15_AP_1		0.642			
Q18_AP_2		0.622			

Q10_AP_3	0.559			
Q31_SC_3		0.963		
Q30_PT_6		0.48		
Q24_SC_1		0.45		
Q12_PU_4			0.71	
Q9_PU_5			0.555	
Q17_PU_2			0.537	
Q7_PU_1			0.49	
RecQ19_PT3				0.921
RecQ13_PT2				0.672

Goodness of fit. In terms of model fit of the extracted factor model (EFA), Table 13 displays the goodness-of-fit test comparison of the three models and the training data set. Results identified all three models were non-significant, indicating that the extracted factor model adequately fit the data. Measure of model fit using the *chi-square* estimation indicated a parsimonious fit of the model for each of the three models at the *EFA* stage—model 1: $X^2(73) = 463.971$, $p = 0$; model 2: $X^2(50) = 309.419$, $p = 0$; model 3: $X^2(61) = 357.193$, $p = 0$.

Table 13

MFI Goodness-of-fit Comparison

Model 1 *Goodness-of-fit Test*			Model 2 *Goodness-of-fit Test*			Model 3 *Goodness-of-fit Test*		
chi-square	df	Sig.	chi Square	df	Sig.	chi-square	df	Sig.
463.971	73	0	309.419	50	0	357.193	61	0

Full sample reliability and validity. Validation of the extracted factors was a three-step validation process of the extracted factors to include testing for discriminant validity, convergent validity, and reliability.

Discriminant validity. The factor correlation matrix comparison displays the correlation coefficients between the factors to test for discriminant validity. Table 14 provides the relative measure of strength of the relationship between the five extracted factors in each model. According to Gaskin (2012), validation of the extracted factors should not exceed correlation coefficient of ± 0.70. Gaskin's validation assumption of correlation coefficient less than 0.70 relates to issues with highly correlated factors, which would diminish those factor's individual contributions because highly correlated factors would essentially become a single factor, and discriminant validity would not be achieved. The factor correlation matrix presented shows there was no bivariate correlation coefficient greater than .70 in any of the three models, indicating that each of the extracted factors were distinct and thus achieved discriminant validity.

Table 14

MFI Three Model Correlation Comparison

Model 1

Factor	MF	AP	SC	PU	PT
MF	1	0.144	0.062	0.208	0.034
AP	0.144	1	0.169	0.29	0.076
SC	0.062	0.169	1	0.297	0.411
PU	0.208	0.29	0.297	1	0.399
PT	0.034	0.076	0.411	0.399	1

Model 2

Factor	MF	AP	SC	PU	PT
MF	1	0.154	0.062	0.032	0.239
AP	0.154	1	0.167	0.075	0.293
SC	0.062	0.167	1	0.402	0.302
PU	0.032	0.075	0.402	1	0.337
PT	0.239	0.293	0.302	0.337	1

Model 3

Factor	MF	AP	SC	PU	PT
MF	1	0.164	0.103	0.252	0.098
AP	0.164	1	0.223	0.263	.121
SC	0.103	.223	1	0.293	.389
PU	0.252	.263	.293	1	0.333
PT	0.098	.121	.389	.333	1

Convergent validity. A range from ±.30 to ±.40 is "considered to meet the minimal level for the interpretation of structure," and "loadings of above ±.50 or greater are considered practically significant" (Hair, 2006, p. 128). Factor loadings for each of the five extracted factors in each model, displayed in Table 12, were greater than 0.50, thus resulted in adequate factor loadings greater than expected threshold for all models. Overall, the indicator variables converged with their respective factors, and thus, convergent validity has been achieved.

Reliability: inter-item consistency. Examination of Table 15, the Cronbach's Alpha value of each model and standardized items all indicated values above .70. Overall, the individual items within each dimension achieved a good level of internal consistency, and thus inter-item consistency was achieved.

Table 15

MFI Reliability Statistics Comparison Between Models

Model 1		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.736	.745	118

Model 2		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.734	.741	16

Model 3		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.743	.748	17

Full Sample CFA Model Comparison

A similar process to the EFA model selection process was conducted. Table 16 presents three models compared with each of the datasets, without adjustments, to compare and assess the best model fit. Model 2 depicts a lower chi-square as compared to models 1 and 3, with all three data sets, training, validation, and test-set resulting in

544.583, 543.169, and 559.330, respectively. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were also lower in model 2 for all three datasets. There was no distinct difference between models identifying stability across all datasets.

Table 16

MFI Model Comparisons with Training, Validation, and Test Data

Training Set			
	chi-square	AIC	BIC
1st CFA Model	761.112	853.112	1106.692
2nd CFA Model	544.583	628.583	860.113
3rd CFA Model	613.676	701.676	944.231

Validation Set			
	chi-square	AIC	BIC
1st CFA Model	736.897	828.897	1129.863
2nd CFA Model	543.169	627.934	859.965
3rd CFA Model	586.786	674.786	918.667

Test Set			
	chi-square	AIC	BIC
1st CFA Model	768.488	860.488	1116.799
2nd CFA Model	559.330	643.33	877.353
3rd CFA Model	610.573	698.573	943.74

Table 17 presents three models compared with each of the datasets that include modification adjustments to compare and assess the best model fit after adjustments. Model 2 continues to depict a lower chi-square with each of the models and all three data sets, training, validation, and test-set resulting in 396.571, 396.995, and 424.531, respectively. ACI and BIC were also lower in model 2 for all three datasets as compared to models 1 and 3.

Table 17

MFI Modifications Model Comparisons with Training, Validation and Test Data

Training Set

	chi-square	AIC	BIC
1st CFA Model	610.587	706.587	971.192
2nd CFA Model	396.571	484.571	727.126
3rd CFA Model	465.512	557.512	811.092

Validation Set (1st run Modification index adjusted)

	chi-square	AIC	BIC
1st CFA Model	585.849	681.849	947.901
2nd CFA Model	396.995	484.995	728.876
3rd CFA Model	439.227	531.227	786.193

Test Set (1st run Modification index adjusted)

	chi-square	AIC	BIC
1st CFA Model	626.478	722.478	989.933
2nd CFA Model	424.531	512.531	757.699
3rd CFA Model	475.161	567.161	823.473

Table 18 provides a comparison with the full dataset with the first run of modification indices with each of the three models, comparison with second run of modification indices of models one and two, and the final selection of the second model, third run. Chi-square, AIC, and BIC are 390.003, 472.003, and 744.298, respectively.

Table 18

MFI Full Dataset Model Comparisons 1st, 2nd, and 3rd Run

Full Set (Modification index 1st run)			
1st CFA Model	1566.205	1662.205	1980.990
2nd CFA Model	1021.028	1109.028	1401.247
3rd CFA Model	1156.050	1248.05	1553.552

Full Set (Modification index 2nd run)

	chi-square	AIC	BIC
1st CFA Model	1383.211	1483.211	1815.279
2nd CFA Model	505.548	599.548	911.692
3rd CFA Model			

Full Set (Modification index 3rd run)

	chi-square	AIC	BIC
1st CFA Model			
2nd CFA Model	390.003	472.003	744.298
3rd CFA Model			

Model 2 with third run modification was selected for the SEM. Figure 31 presents the first order confirmatory factor structure of the Manual Flight Inventory (MFI) measure, the five latent constructs include Manual Flight (MF), Pilot Understanding (PU), Pilot Training (PT), Safety Culture (SC), and Aviation Passion (AP), along with their respective indicator variables and measurement error terms, covariances, and the CLF.

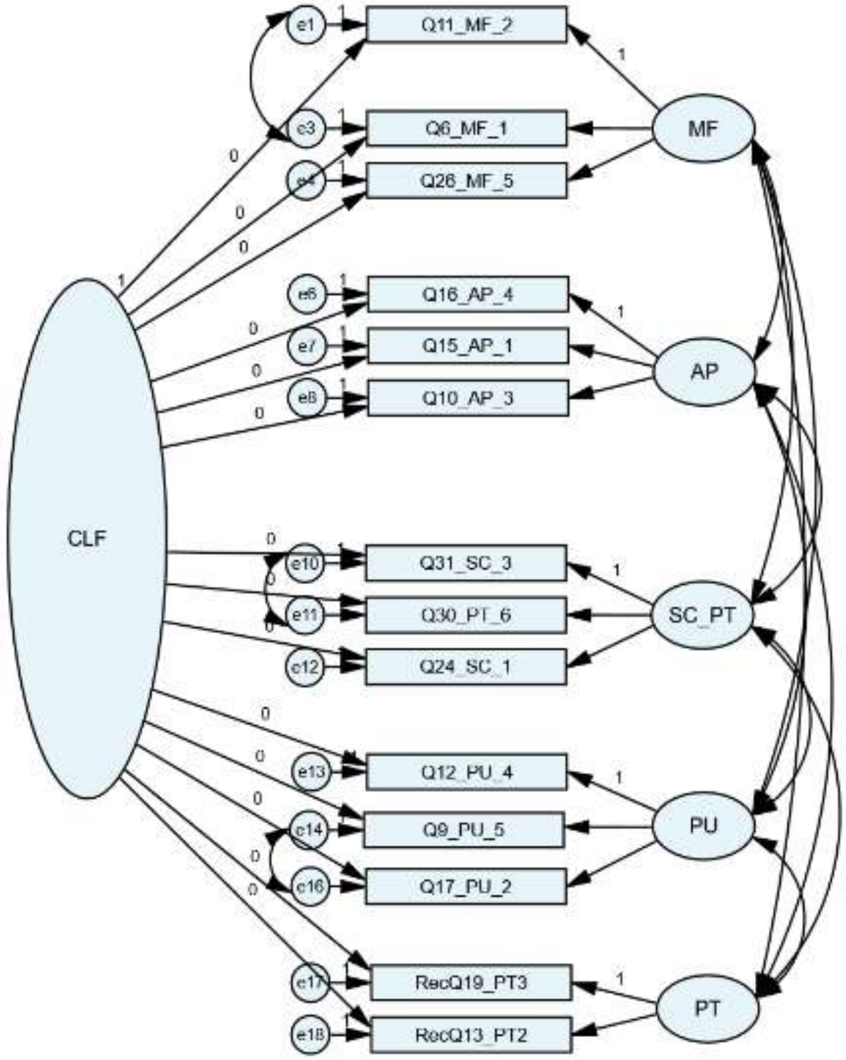


Figure 31. First order confirmatory factor structure. The Manual Flight Inventory (MFI) final model, with Manual Flight, Aviation Passion, Safety Culture, Pilot Understanding and Pilot training factors. Included in the model is the common latent factor weighted to zero.

Manual flight. The factor Manual Flight (MF) retained three variables:

Q_6_MF_1 In day VFR weather conditions, how likely are you to disengage *both* the autopilot and autothrust prior to beginning the arrival phase?

Q_11_ MF_2 In day VFR weather conditions, how likely are you to disengage *both* the autopilot and the autothrust on final approach *prior to* 1000 feet?

Q_26_ MF_5 In day VFR weather conditions, how likely are you to fly *without any* automation engaged (no autopilot, no autothrust *and* no flight director) during the course of the flight?

Pilot Understanding. The factor Pilot Understanding retained three variables.

Q_17_ PU_2 How likely is it that you could pass a systems oral on your current aircraft without any studying or preparation first?

Q_12_ PU_4 If your aircraft lost one or more of its hydraulic systems, and the Engine Indicating and Crew Alerting System (EICAS) or something similar (if installed) and in-flight reference manuals or written procedures were *not available*, how likely are you to know what to do?

Q_9_ PU_5 If an emergency were to occur, beyond knowing *what* to do by following a directed procedure, how likely are you to know *why* most emergency procedures are written?

Pilot Training. The factor Pilot Training retained two variables.

Q_13_ PT_2 How likely is it that during your initial checkout on your current aircraft the systems training (ground school) was based on rote memorization versus in-depth understanding?

Q_19_PT_3 How likely is it that during your initial checkout on your current aircraft the procedures training in the simulator was based on rote memorization versus in-depth understanding?

Safety Culture. The factor Safety Culture retained three variables. Note that one of the three variables is identified as SC_PT, in that this variable loaded onto the SC factor during exploratory factor analysis.

Q_24_SC_1 How likely is it that employee suggestions are taken into consideration by your employer?

Q_31_SC_2 How likely are you to critique and report any aspect of your employer's training program if you perceive it as substandard?

Q_30_ SC_PT_6 How likely was it that your pilot training (simulator) debriefing sessions included self-assessment and reflection, in conjunction with your instructor's comments?

Aviation Passion. The factor Aviation Passion retained three variables.

Q_15_AP_1 How likely is it that you will attend an aviation conference or an aviation social event within the next 12 months?

Q_10_ AP_3 How likely are you to read aviation books or magazines for enjoyment?

Q_16_ AP_4 How likely are you to go to the airport or join a social media site to connect in order to socialize with other aviators?

Descriptive Statistics

Table 19 presents descriptive statistics for the variables that were retained in the final model with 5,561 participants. Data displayed includes Mean, Median, Mode, Standard Deviation, Standard Error of Skewness, Kurtosis, and Standard Error of Kurtosis.

Table 19

MFI Descriptive Statistics Final Model

Variables	N	Mean	Median	Mode	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
Q6_MF_1	5661	3.33	3.00	3	1.804	0.441	0.033	-0.920	0.065
Q9_PU_5	5661	5.31	5.00	6	1.180	-0.993	0.033	1.168	0.065
Q10_AP_3	5561	4.88	5.00	5	1. 582	-0.610	0.033	-0.367	0.065
Q11_MF_2	5661	4.92	5.00	7	1.955	-0.645	0.033	-0.880	0.065
Q12_PU_4	5661	4.99	5.00	5	1.295	-0.721	0.033	0.269	0.065
Q13_PT_2	5661	4.52	5.00	5	1.548	-0.358	0.033	-0.807	0.065
Q15_AP_1	5661	3.78	4.00	3	2.007	0.145	0.033	-1.240	0.065
Q16_AP_4	5661	4.53	5.00	5	1.845	-0.419	0.033	-0.916	0.065
Q17_PU_2	5661	4.54	5.00	5	1.473	-0.497	0.033	-0.379	0.065
Q19_PT_3	5661	4.33	5.00	5	1.492	-0.282	0.033	-0.848	0.065
Q24_SC_1	5561	3.97	4.00	5	1.589	-0.237	0.033	-0.845	0.065
Q26_MF_5	5661	3.20	3.00	1	1.919	-0.481	0.033	-1.037	0.065
Q30_PT_6	5661	5.22	5.00	6	1.450	-1.002	0.033	0.575	0.065
Q31_SC_3	5661	4.59	5.00	5	1.604	-0.533	0.033	-0.437	0.065

Final Model Assessment

Table 20 identifies the model fit measure of the second model, with modification indices, third run, and the full dataset identifying an excellent fit meeting the following standards:

Table 20

MFI Full Dataset Model Fit Measures Final Model

Measures	Acceptable Thresholds	Observed Model Fit
PCLOSE	1=Perfect Fit	1.00
CFI	>.95 Excellent; >.90 Traditional; > .80 Permissible*	0.982
GFI	>.95 Excellent; >.90 Traditional; > .80 Permissible*	0.990
AGFI	>.80*	0.984
SRMR	<.05 Good Fit; .05-.08 Adequate Fit, >.10 Poor fit*	0.024
RMSEA	<.05 Good Fit; .05-.10 Moderate, >.10 Poor fit*	0.030

*Hu and Bentler (1999)

Final model reliability and validity. Validation of the final model was a three-step validation process of the extracted factors to include testing for discriminant validity, convergent validity, and reliability. A construct validity test meets an acceptable level at > .70 as a standard threshold. Table 21 identifies that MF, AP, PU, and PT all exceed the .70 threshold, whereas SC_PT rounded up from .651 was also deemed acceptable. Table 22 revealed that the average standardized regression estimates in each of the five factors of MFI are greater than .50, and the average squared multiple correlation in each of the factors are greater than the .30, as an indication of large effect sizes.

Table 21

MFI Reliability and Validity Final Model

3rd Run

	Construct Reliability	AVE (Convergent Validity)	MSV (Discriminant Validity
Manual Flight	0.732	0.477	0.069
Aviation Passion	0.705	0.446	0.089
Safety Culture PT	0.651	0.390	0.224
Pilot Understanding	0.712	0.453	0.141
Pilot Training	0.779	0.638	0.224

Table 22

MFI Convergent Validity Final Model

	Average Standardized Regression Estimates	Average Squared Multiple Correlation (r2)
Manual Flight	0.658	0.470
Pilot Understanding	0.610	0.384
Safety Culture_	0.631	0.410
Aviation Passion	0.688	0.483
Pilot Training	0.673	0.479

Common Method Bias

Two tests were conducted for common method bias. Harman's single factor test was utilized on the EFA model and common latent factor at the CFA model.

Harman's single factor test. Harman's single factor test was utilized on Model 2 from the EFA comparison to test for common method bias. All variables were loaded onto a single factor and assessed at a 50% level. In that variance of the first factor is 21%, as identified in Table 23, results indicate there was no common bias at the EFA level (Podsakoff et al., 2003).

Table 23

MFI Harman's Single Factor Assessment

Total Variance Explained						
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.316	20.725	20.725	2.48	15.502	15.502
2	2.267	14.171	34.896			
3	1.993	12,459	47.354			
4	1.331	8.321	55.675			
5	1.094	6.836	62.511			

Common latent factor. To test and control for common method bias, a Common Latent Factor (CLF) was utilized in AMOS. A latent factor was added to the CFA model and connected to each item in the model and constrained to zero. The standardized regression weights resulting from the model with the CLF were subtracted from the regression weights of the original CFA model. Table 24 presents results from the zero constrained test that identified bias, and the equal constrained test determined the bias was equally distributed.

Table 24

MFI Common Latent Factor Test

CLF test: Equal Constraints Test				
Full Sample (n-5561)	*X2*	*DF*	*Delta*	*Sig*
	304.089	73	X2(DF=16_= 201.459	0.000
Zero Constrained Model	505.548	89		

CLF test: Equal Constraints test				
Full Sample (n-5561)	*X2*	*DF*	*Delta*	*Sig*
	304.089	73	X2(DF=16_= 201.459	0.000
Equal Constraint Model	569.733	88		

Table 25 presents the difference between the two models, one with a CLF and one without, where common method bias was identified with variables over a .20 delta.

Table 25

MFI Estimates Identifying Common Method Bias

Standardized Regression Weights					
SEM items		Factors	Std Reg Weights with no CLF	Std Reg Weights with CLF	Delta (Difference)
Q11_MF_2	<---	MF	0.646	0.270	0.376
Q29_MF_3	<---	MF	0.436	0.174	0.262
Q6_MF_1	<---	MF	0.716	0.315	0.401
Q26_MF_5	<---	MF	0.720	0.335	0.385

Q16_AP_4	<---	AP	0.742	0.189	0.553
Q15_AP_1	<---	AP	0.689	0.316	0.373
Q10_AP_3	<---	AP	0.567	0.338	0.229
Q18_AP_2	<---	AP	0.514	0.130	0.384
Q31_SC_3	<---	SC_PT	0.690	0.111	0.579
Q30_PT_6	<---	SC_PT	0.470	0.127	0.343
Q24_SC_1	<---	SC_PT	0.688	0.178	0.510
Q12_PU_4	<---	PU	0.587	0.465	0.122
Q9_PU_5	<---	PU	0.730	0.311	0.419
Q17_PU_2	<---	PU	0.697	0.502	0.195
RecQ19_PT3	<---	PT	0.815	0.173	0.642
RecQ13_PT2	<---	PT	0.782	0.217	0.565

Assumptions

Prior to performing the SEM, three assumptions were tested to assess for normality, linearity, and independence of errors.

Normality. Normality is a primary assumption of regression (Kline, 2011). Figures 32 through 36 graphically depict normality of the five factors.

Pilot training. Figure 32 identifies the pilot training graphics. The histogram appears to be bimodal. The bell shape appears flat, with the two high points at less than 3 and great than 4, on a 7-point Likert scale, with a tail skewed slightly to the right. The Q-Q plot identifies most data points hugging the line, with some deviations. The deviations were determined to not be outliers, by observing the box plot.

Figure 32. MFI pilot training diagrams of normality to include a histogram, Q-Q plot, and box plot.

Pilot understanding. Figure 33 displays Pilot Understanding. The tail to the left indicates the curve is negatively skewed, with more selections at Likert selection of 1. There are a few data points not hugging the Q-Q plot line, and the box plot indicates there are outliers on the bottom 25%.

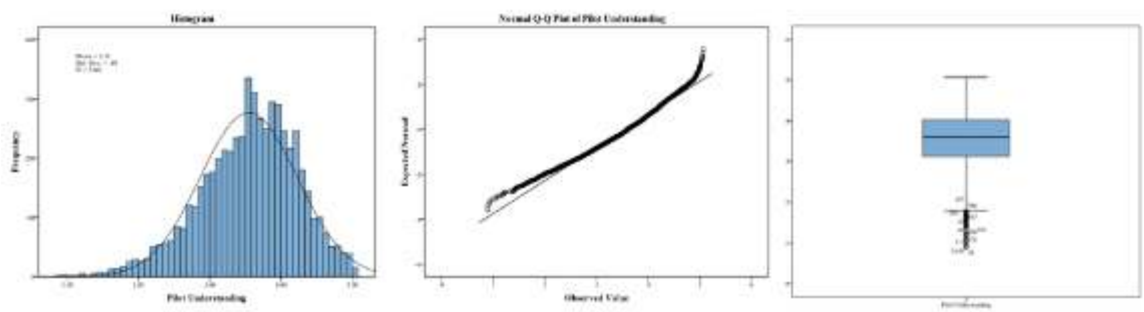


Figure 33. MFI pilot understanding diagrams of normality to include a histogram, Q-Q plot, and box plot.

Safety culture. Figure 34 depicts safety culture with a somewhat normal curve, but with a tail that is negatively skewed. Many data points are hugging the Q-Q plot line with a few deviations. The box plot indicates a few outliers; however, they are close to the whisker.

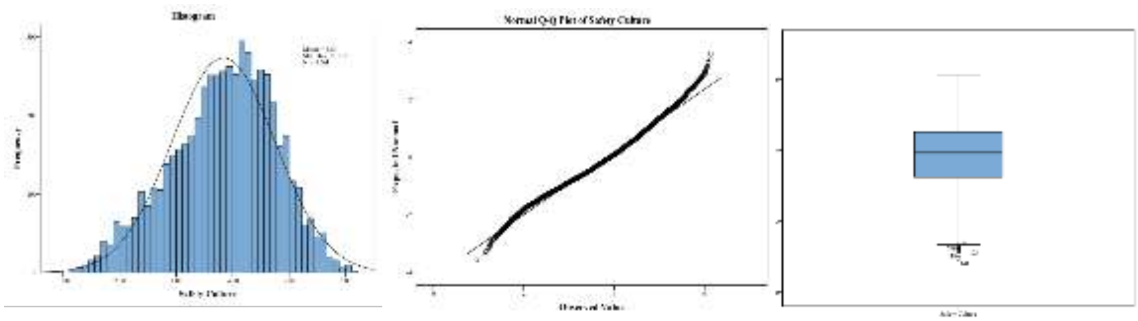


Figure 34. MFI safety culture diagrams of normality to include a histogram, Q-Q plot, and box plot.

Aviation passion. Figure 35 presents Aviation Passion, with a tail to the left, therefore negatively skewed. While there are some deviations from the Q-Q line, most fall on the line. The Box plot identifies no outliers.

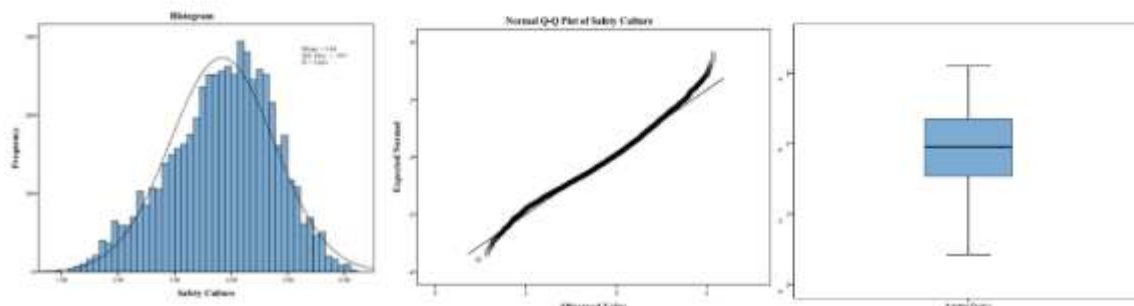


Figure 35. MFI aviation passion diagrams of normality to include a histogram, Q-Q plot, and box plot.

Manual flight. Figure 36 identifies a positive skewness. While many data point hug the Q-Q line, there are large deviations. However, the box plot indicates there are no outliers.

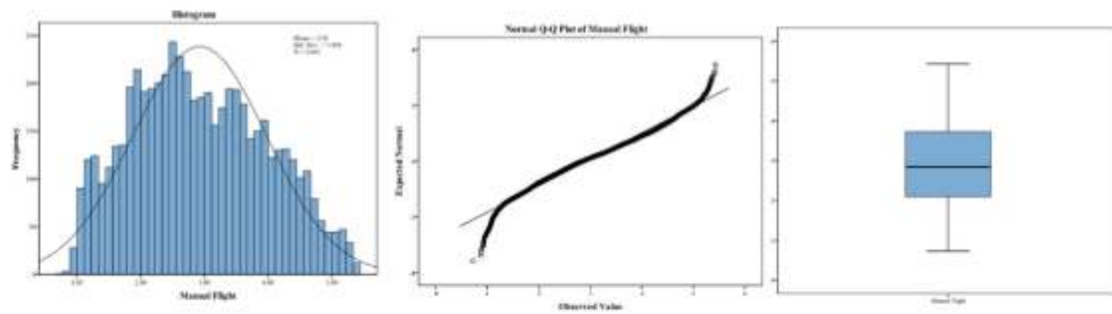


Figure 36. MFI manual flight diagrams of normality to include a histogram, Q-Q plot, and box plot.

Skewness. A Skewness and Kurtosis ratio test was conducted by dividing the Skewness value by the standard error to create a standardized value. By standardizing these values, the threshold for standardized scores could be applied, which is 0.05 = +/- 1.96 or 2.0 and at three standard deviations at 0.10 = +/- 2.56 or 3, with the goal for the score to be within the threshold. Table 26 identifies the Skewness and Kurtosis of the five factors, indicating they are outside the standard thresholds with the following Kurtosis Ratios of Pilot Training -0.568, Pilot Understanding .779, Safety Culture -0.317, Aviation Passion, -0.603, and Manual Flight -0.81. Data transformation was accomplished on Pilot Understanding.

Table 26

MFI Five Factors: Skewness and Kurtosis

Factor	Skewness	Kurtosis	t	Skewness Ratio
Pilot Training	0.285	-0.568	0.033	8.63
Pilot Understanding	-0.497	.779	0.033	-15.06
Safety Culture	-0.319	-0.317	0.033	-9.67
Aviation Passion	-0.179	-0.603	0.033	-5.42
Manual Flight	0.193	-0.81	0.033	5.85

Kolmogorov-Smirnov. Kolmogorov-Smirnov was checked to test for normality and standard distribution. Table 27 displays the Kolmogorov-Smirnov statistic, whereas values close to zero are ideal. While significant, the following statistics indicate they were very close to zero with Pilot Training at .088, Pilot Understanding .046, Safety Culture .039, Aviation Passion .027, and Manual Flight .043, therefore all roughly approximating normality.

Table 27

MFI Test of Normality

	Kolmogorov-Smirnova		
Factor	Statistic	df	Sig.
Pilot Training	0.088	5661	0.000
Pilot Understanding	0.046	5661	0.000
Safety Culture	0.039	5661	0.000
Aviation Passion	0.027	5661	0.000
Manual Flight	0.043	5661	0.000

Data transformation. Data Transformation is a mathematical technique to improve normality. Prior to data transformation, each of the factors and their scores were standardized in order to capture which data points were greater than 2 or 3. Standardizing the scores created the ability to plot the points in order to identify outliers. Two types of outliers include potential outliers which are deemed okay and influential outliers that could negatively impact the results. Therefore, four methods were utilized to transform the data: log 10, square root, inversed, and squared, and the option with most enhancement was selected. Manual Flight, Aviation Passion, and Pilot training had standardized scores below 3. Safety Culture had only one score at 3.13 and the rest below 3. Pilot Understanding had 29 standardized scores above 3. Therefore, the decision to transform data for Pilot Understanding was made, and ten cases with the highest value were selected and are depicted in Table 28. The data transformation presented in Table 29 presents the option with Squared transformation to create the most enhancement by lowering the Skewness from -.497 to .074 and changing the Skewness Kurtosis ratio from -15.06 to 2.24 which is under 3 standard deviations.

Table 28

MFI Case Summaries

	Pilot	abs_ZPU
1	6497374040	3.9
2	6525541141	3.9
3	6497522084	3.86
4	6524433649	3.84
5	6521496525	3.77
6	6803805303	3.68
7	6782470502	3.68
8	6778133147	3.62
9	6782188575	3.55
10	6742657693	3.49
Total N	10	10

a Limited to first 10 cases.

Table 29

MFI Data Transformation Comparison

Pilot Understanding	Skewness	Kurtosis	Ratio	Std Error
Original	-.497	0.219	-15.06	0.033
Log 10	0.303	0.114	9.18	
Square root	0.104	0.042	3.15	
Squared	0.074	-0.293	2.24	
Inversed	1.209	2.135	36.64	

The transformation of Pilot Understanding lowered the Kolmogorov-Smirnov statistic from .046 to .013, bringing it close to zero, yet still significant at the 0.05 level. However, based on the Kolmogorov-Smirnov table with the large sample size of 5,661, the statistics presented in Table 30 approximate normality for univariate normality because they are all close to zero.

Table 30

MFI Univariate Normality After Data Transformation

Factor	Kolmogorov-Smirnova		
	Statistic	Df	Sig.
Pilot Training	0.088	5661	0.000
Pilot Understanding (squared)	0.013	5661	0.028
Safety Culture	0.039	5661	0.000
Aviation Passion	0.027	5661	0.000
Manual Flight	0.043	5661	0.000

a Lilliefors Significance Correction

Linearity. To have a meaningful regression analysis, the expectation is that the factors from EFA to CFA should have a meaningful linear relationship. Linearity estimates if there is a linear relationship between variables. As presented in Table 31, the Pearson Correlation was examined to identify the linear relationship. The correlation should be -1 as a negative relationship or +1 as a positive correlation, avoiding 0, which indicates no correlation. Anything between .10 and .29 is considered a small association, .30 and > .49 is considered a medium size relationship, and >.5 is considered a large relationship (Cohen J., Cohen P., West, & Aiken, 2003). All factors have a positive linear relationship with all factors, and all are significant. However, with a large sample, any detected effect will provide a significant relationship. Pilot Training identified a medium relationship with Pilot Understanding, a low relationship to Aviation Passion and Manual Flight, but a very high relationship to Safety Culture. Pilot Understanding further identified a medium relationship to Safety Culture, Aviation Passion, and Manual

Flight. Safety Culture presented a medium relationship with Aviation Passion, but a low relationship to Manual Flight, whereas Aviation Passion had a medium relationship to Manual Flight. All relationships are positive and therefore pass linearity.

Table 31

MFI Five Factor Linearity

		Pilot Training	Pilot Understanding	Safety Culture	Aviation Passion	Manual Flight
Pilot Training	Pearson Correlation	1	.435**	.591**	.156**	.086**
	Sig. (2-tailed)		0	0	0	0
	N	5661	5661	5661	5661	5661
Pilot Understanding	Pearson Correlation	.435**	1	.481**	.372**	.325**
	Sig. (2-tailed)	0		0	0	0
	N	5661	5661	5661	5661	5661
Safety Culture	Pearson Correlation	.591**	.481**	1	.384**	.199**
	Sig. (2-tailed)	0	0		0	0
	N	5661	5661	5661	5661	5661
Aviation Passion	Pearson Correlation	.156**	.372**	.384**	1	.265**
	Sig. (2-tailed)	0	0	0		0
	N	5661	5661	5661	5661	5661
Manual Flight	Pearson Correlation	.086**	.325**	.199**	.265**	1
	Sig. (2-tailed)	0	0	0	0	
	N	5661	5661	5661	5661	5661

**. Correlation is significant at the 0.01 level (2-tailed).

Independence of errors. Independence of errors determines whether residuals are correlated to the previous residuals or not. Mahalanobis distance was utilized to detect outliers. As presented in Table 32, the chi-square probability chart (MedCal, 2018), the threshold of 18.47 was determined utilizing a significance of .001 and four independent variables, meaning nothing on Mahalanobis d-squared table should be greater than 18.47. Table 33 identifies the potential cases that could be influential.

Table 32

MFI Chi-square Distribution Chart

	Probability level (alpha)					
df	**0,5**	**0.10**	**0.05**	**0.02**	**0.01**	**0.001**
1	0.455	2.706	3.841	5.412	6.635	10.827
2	1.386	4.605	5.991	7.824	9.210	13.815
3	2.366	6.251	7.815	9.837	11.345	16.268
4	3.357	7.779	9.488	11.668	13.277	18.465
5	4.351	9.236	11.070	13.388	15.086	20.517

Note: Adapted from MedCal, 2018.

Table 33

MFI Mahalanobis d-squared

Observation number	Mahalanobis d-squared	p1	p2
88	39.013	.000	.001
3250	27.140	.000	.038
265	26.369	.000	.010
2233	26.282.	.000	.001
3993	23.728	.000	.014
1236	23,298	.000	.007
3308	22.881	.000	.005
1561	22.356	.000	.005
2645	22.202	.000	.002
4855	21.360	.001	.007
982	21.309	.001	.003
219	20.622	.001	.010
1647	20.416	.001	.008
1164	20.353	.001	.004
972	20.128	.001	.004
1	19.668	.001	.010
2	19.668	.001	.004
116	19263	.002	.011
779	19.224	.002	.006
4298	18.696	.002	.028
1604	18.543	.002	.029
37	18.454	.002	.024

Table 34 presents multivariate normality of 4.442, whereas this value should be three (Hair et al., 2010). However, Kline (2013) proposed an equation termed the Mardia's Coefficient, utilizing the formula *p* (*p*+2) where *p* equals the number of the indicator variables in the model, and if the original *Mardia's Coefficient* is less than the *adjusted Mardia's Coefficient,* then the data can be deemed multivariate normal (p.11). The initial *Mardia's Coefficient* was 4.441 which is less than the adjusted Mardia's Coefficient [14(14+2)] = 220.0, and thus multivariate normality was assumed.

Table 34

MFI Five Factor Normality Assessment

Variable	Min	Max	Skew	c.r.	Kurtosis	c.r.
SC	0.959	6.137	-0.329	-9.791	-0.318	-4.885
AP	0.848	6.207	-0.179	-5.49	-0.604	-9.275
PT	0.858	6.245	0.285	8.747	-0.569	-8.732
PU	0.893	5.074	-0.497	-15.273	0.278	4.271
MF	0.724	5.428	0.198	5.932	-0.811	-12.451
Multivariate				0.988		4.442

Residuals are the difference from the observed and the predicted values. Subtracting the predicted value from the observed value equals the predicted errors. The standardized residuals should be close to zero. The Kolmogorov-Smirnov value is close to zero at .034, identified in Table 35.

Table 35

MFI Test of Normality

	Kolmogorov-Smirnov[a]		
	Statistic	Df	Sig.
Standardized Residual (MF full path MLR)	.034	5561	.000

a. Lilliefors Significance Correction

Test of Normality utilizing Skewness was evaluated by dividing Skewness of .191 by .033 resulting in 5.79, which is above a threshold of three, as depicted in Table 36.

Table 36

MFI Test of Normality Skewness

			Statistic	Std. Error
Standardized Residual (PT full path MLR)	Mean		.00000000	.01328617
	95% Confidence interval for Mean	Lower Bound	-.0260460	
		Upper Bound	.0260460	
	5% Trimmed Mean		-.0109645	
	Median		-.0662653	
	Variance		.999	
	Std. Deviation		.99964658	
	Minimum		-3.51759	
	Maximum		4.66279	
	Range		8.180.38	
	Interquartile Range		1.44627	
	Skewness		.191	.033
	Kurtosis		-.166	.065

Figure 37 displays four graphics of normality. The Q-Q plot identifies most of the errors are hugging the line, meaning there is independence of residuals. The histogram appears symmetrical with a slight positive skewness, but overall the residuals appear to behave with a normal distribution. The box plot shows two outliers, and the scatterplot identifies no patterns, meaning there are no positive or negative cones left or right, and no hill is depicted.

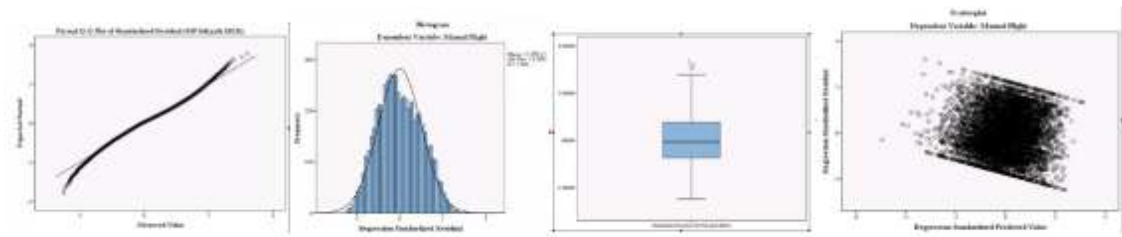


Figure 37. MFI standardized residual diagrams of normality to include Q-Q plot, histogram, box plot, and scatterplot.

There were only 21 cases on the Mahalanobis d-squared over the threshold of 18.46 with a sample size of 5661. The Kolmogorov-Smirnov value was extremely close to zero at .034. Multivariate normality of 4.442 was close to the 3, but adjusted with Marida's coefficient became normal, and the diagrams of normality represent near normality. Therefore, the independence of errors test can be deemed adequate.

Hypothesis Testing Manual Flight

Manual Flight assessment in AMOS. Multivariate analysis of manual flight as the dependent variable is depicted in the path model summary Figure 38.

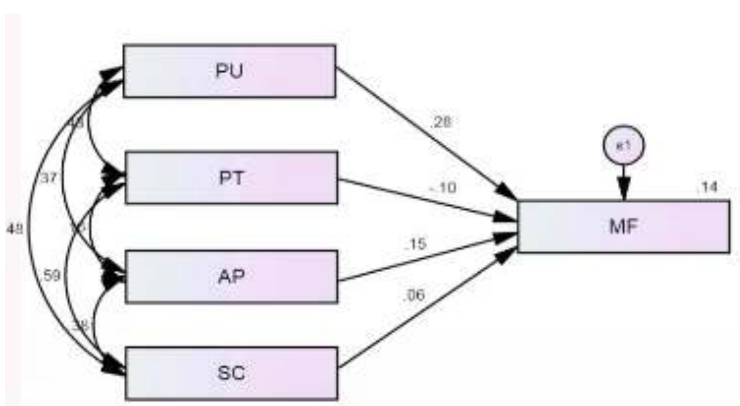


Figure 38. MFI path model for MF as the dependent variable.

The standardized regression weights in Figure 38 are PU= .28, PT = -.10, AP = .15, and SC =.06. Table 37 presents the same Estimates indicating significance at <.001 level. Most influential in this path analysis was Pilot Understanding (PU) with a C.R. of 18.8 and standardized regression weight of .28. Aviation Passion (AP) was the second most influential with a 10.92 C.R. value and a standardized regression weight of .152. Pilot Training (PT) had a negative influence of a -6.1 C.R. value and a standardized regression weight of -.10. Safety Culture (SC) presented a small effect with a 3.7 C.R. value and a standardized regression weight of .06. All results indicated an influence.

Table 37

MFI Manual Flight Regression Weight Estimates

Regression Weights: (Group 1 – Default model)							
			Estimate	S.E	C. R.	P.	Label
MF	<---	PU	.435	.023	18.807	***	par_1
MF	<---	PT	.094	.015	-6.081	***	Par_2
MF	<---	AP	.144	.013	10.924	***	Par_3
MF	<---	SC	.071	.019	3.700	***	Par_4
Standardized Regression Weights: (Group 1 – Default model)							
			Estimate				
MF	<---	PU	.281				
MF	<---	PT	-.096				
MF	<---	AP	.152				
MF	<---	SC	.062				

Manual Flight conclusion. AMOS analysis with Manual Flight as the dependent variable confirm that all relationships with the predictor variables Pilot Understanding, Pilot Training, Aviation Passion, and Safety Culture, as predictors, were significant at the .001 level. The following hypotheses, H_{1A}, $H_{3A,}$ and H_{4A} are supported. While H_{2A} indicates an influence, this influence identified a negative relationship between training and a pilot's willingness to manually fly, therefore was not supported.

H_{1A}: Pilots' aircraft understanding positively influences willingness to manually fly, controlling for pilot training, aviation passion, and safety culture.

H_{2A}: Training positively influences willingness to manually fly, controlling for pilot understanding, aviation passion, and safety culture.

H_{3A}: Aviation passion positively influences pilots' willingness to manually fly, controlling for pilot training, safety culture, and understanding**.**

H_{4A}: Safety culture positively influences pilots' willingness to manually fly, controlling for pilot training, aviation passion, and understanding.

Hypotheses Testing Pilot Training

Pilot Training assessment in AMOS. Multivariate analysis of Pilot Training as the dependent variable is depicted in the path model summary Figure 39.

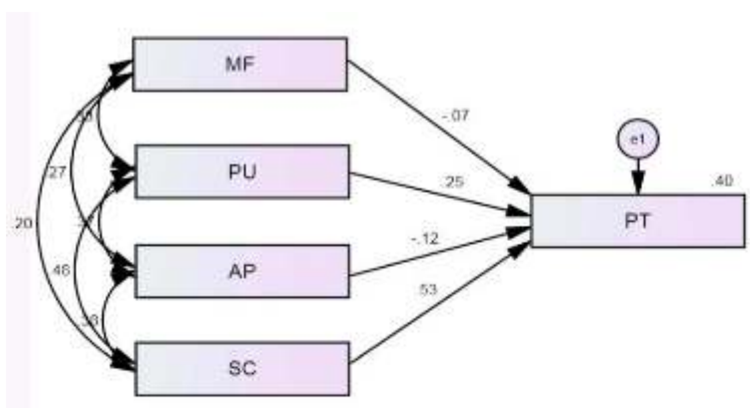


Figure 39. MFI path model for PT as the dependent variable.

Table 38 presents Estimates that mimic the path diagram, indicating significance at <.001 level, which are standardized regression weights for each factor. The standard errors (S.E), are all close to zero and below the .10 level. The critical ratio (C.R.)

identifies the standardized scores which are evaluated with a threshold of anything >3 indicating importance. With Pilot Training (PT) as dependent variable, Safety Culture (SC) has the largest influence on PT with a 44 C.R value and a standardized regression weight of .53. Pilot Understanding (PU) had the second largest influence with a 20 C.R. value and a standardized regression weight of .25. Aviation Passion (AP) and Manual flight (MF) both have a negative relationship with Pilot Training (PT) with C.R. values of -.11 and -.06 respectively. The standardized regression weights of Aviation Passion and Manual Flight are -.122 and -.067, respectively. Between the four factors, Safety Culture presents the greatest predictor of Pilot Training, followed by Manual Flight. All factors have significant relationships.

Table 38

MFI Pilot Training Regression Weight Estimates

Regression Weights: (Group 1 – Default model)							
			Estimate	S.E	C. R.	P.	Label
PT	<---	MF	-.069	.011	-6.081	***	par_1
PT	<---	PU	.391	.020	19.775	***	Par_2
PT	<---	AP	-.119	.011	-10.513	***	Par_3
PT	<---	SC	.627	.014	43.843	***	Par_4
Standardized Regression Weights: (Group 1 – Default model)							
			Estimate				
PT	<---	MF	-.067				
PT	<---	PU	.246				
PT	<---	AP	-.122				
PT	<---	SC	.533				

Pilot Training conclusion. AMOS analysis for Pilot Training confirmed that all relationships were significant at the .001 level. The following hypotheses H_{5A} and H_{7A} were supported. While the following hypotheses H_{6A} and H_{8A} indicate a positive influence, this influence created a negative relationship, meaning that Aviation Passion and Manual Flight negatively influenced Pilot Training. Therefore, H_{6A} and H_{8A} hypotheses were not supported.

$H_{5A:}$ Safety culture positively influences pilot training, controlling for manual flight, aviation passion, and understanding.

$H_{6A:}$ Aviation passion positively influences pilot training, controlling for manual flight, safety culture, and pilot understanding.

H_{7A} Pilot understanding positively influences pilot training, controlling for aviation passion, manual flight, and safety culture.

H_{8A} Manual flight positively influences pilot training, controlling for aviation passion, understanding, and safety culture.

Hypotheses Testing Pilot Understanding

Pilot Understanding assessment in AMOS. Multivariate analysis of Pilot Understanding as the dependent variable is depicted in the path model summary Figure 40.

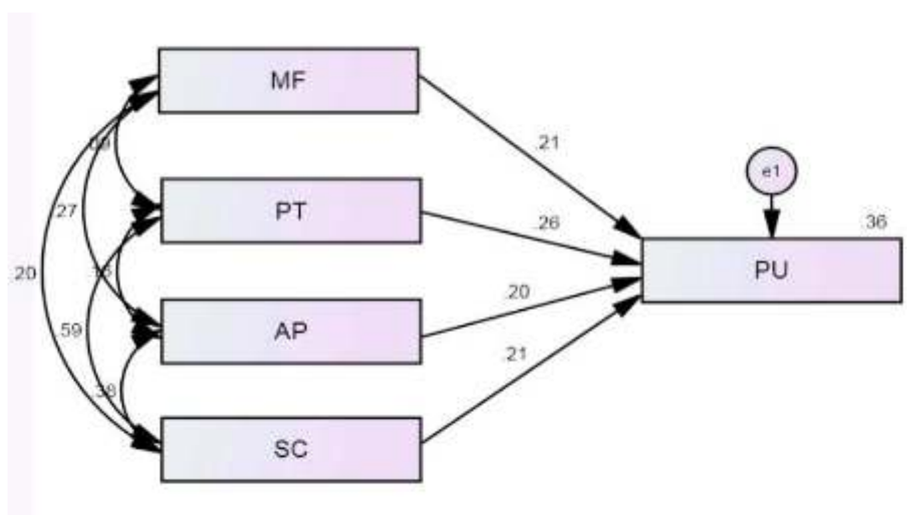


Figure 40. MFI path model for PU as the dependent variable.

Pilot Training displays the greatest effect with a C.R. value of 20, and a standardized regression weight of .27. Manual Flight and Safety Culture both had standardized regression weights of .21, with Manual Flight's C.R. value at 19 and Safety Culture's C.R. value at 15. Aviation Passion had a C.R. value of 17 with a standardized regression weight of .20. All were very similar and significant. Table 39 presents the C.R. for Pilot Training at 19.78, Manual Flight at 18.81, Aviation Passion at 16.48, and Safety Culture at 14.62. All are extremely close and significant.

Table 39

MFI Pilot Understanding Regression Weight Estimates

Regression Weights: (Group 1 – Default model)							
			Estimate	S.E	C. R.	P.	Label
PU	<---	MF	.135	.007	18.807	***	par_1
PU	<---	PT	.165	.008	19.775	***	Par_2
PU	<---	AP	.120	.007	16.478	***	Par_3
PU	<---	SC	.155	.011	14.617	***	Par_4
Standardized Regression Weights: (Group 1 – Default model)							
			Estimate				
PU	<---	MF	.209				
PU	<---	PT	.265				
PU	<---	AP	.195				
PU	<---	SC	.209				

Pilot Understanding conclusion. AMOS analysis for Pilot Understanding confirms that all relationships were significant at the .001 level. The following hypotheses H_{9A} through H_{12A} are all supported. All factors were similar as to the influence of Pilot Understanding, with Pilot Training showing the greatest influence.

$H_{9A:}$ Safety culture positively influences pilot understanding, controlling for manual flight, aviation passion, and pilot training.

$H_{10A:}$ Aviation passion positively influences pilot understanding, controlling for manual flight, safety culture, and pilot training.

H_{11A} Pilot training positively influences pilot understanding, controlling for aviation passion, manual flight, and safety culture.

H_{12A} Manual flight positively influences understanding, controlling for aviation passion, pilot training, and safety culture.

Hypotheses Testing Mediation Hypothesis

Mediation hypothesis. Figure 41 displays the mediation path model where the total effect of Pilot Training (independent variable) on Manual Flight (dependent variable) is mediated by Safety Culture (mediator variable). Testing for a mediation hypothesis is a four-step process that must meet all assumptions of relationships (Baron & Kenny, 1986). Step 1, the independent variable of Pilot Training must be correlated with the dependent variable Manual Flight, identifying the effect could be mediated. Step 2, the independent variable Pilot Training is correlated with the mediator, Safety Culture, where Safety Culture is being treated as a dependent variable. Step 3, Safety Culture must be correlated with Manual flight. Step 4 establishes that Safety Culture mediates the Pilot Training and Manual Flight relationship, where the effect of Pilot Training on Manual Flight controlling for Safety Culture should be zero.

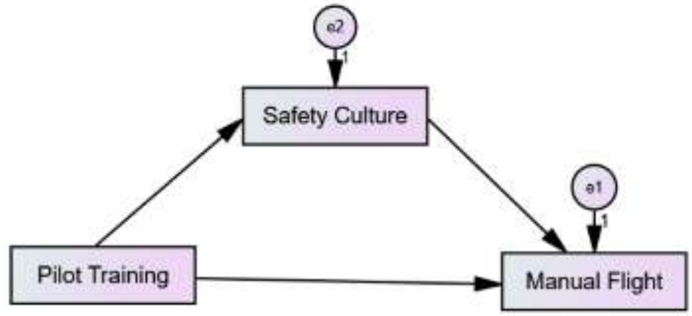


Figure 41. MFI mediation path model with safety culture dependent variable. Pilot training and manual flight.

Step 1. Establish a relationship from Pilot Training to Manual Flight. Figure 40 presents the direct path model and results of a positive relationship of .09. Table 59 presents a C.R. of 6.507, which is significant, meeting the first step assumption.

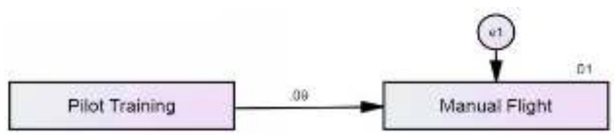


Figure 42. MFI path analysis and regression weights with pilot training and manual flight.

Table 40

MFI Regression Weights PT to MF

			Estimate	S.E.	C.R.	P	Label
MF	<---	PT	.084	.013	6.507	***	

Step 2. Establish a relationship from the independent variable to the mediating variable. Figure 43 and Table 41 present the path model with significant and positive relationship of .59, and a C.R. value of 55.13, meeting the second step assumption.

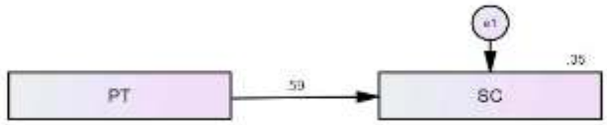


Figure 43. MFI path analysis with pilot training and safety culture.

Table 41

MFI Regression Weights PT to SC

			Estimate	S.E.	C.R.	P	Label
SC	<---	PT	.503	.009	55.135	***	Par 1

Step 3. Establish a relationship from the mediation variable to the dependent variable. Figure 44 and Table 42 present the path model with significant and positive relationship of .20, and a C.R. value of 15.247 respectively, meeting the third step assumption.

Figure 44. MFI path analysis and regression weights with safety culture and manual flight.

Table 42

MFI Regression Weights SC to MF

			Estimate	S.E.	C.R.	P	Label
MF	<---	SC	.228	.015	15.247	***	

Step 4. Figure 45 displays the mediation model results. Pilot Training to Manual Flight is -.05, which indicates a partial mediation because PT to MF was not zero. Table 43 results indicate that Safety Culture is negatively impacting the positive effect that Pilot Training had on Manual Flight with a C.R. -2.975, just less than three, but is considered 3 and therefore significant.

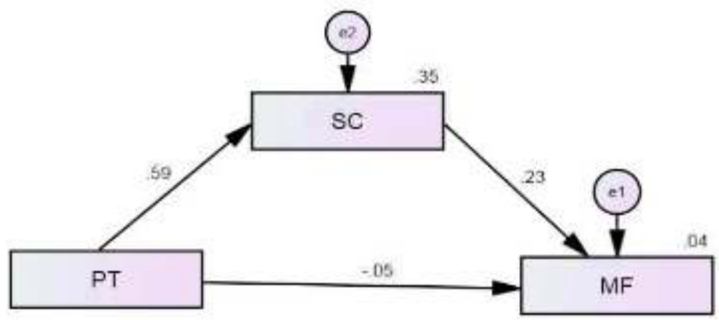


Figure 45. MFI mediation model results with safety culture as the mediating variable between pilot training and manual flight.

Table 43

MFI Regression Weights for Complete Mediation Model

			Estimate	S.E.	C.R.	P	Label
SC	<---	PT	.503	.009	55.135	***	par 3
MF	<---	SC	.260	.018	14.066	***	Par 1
MF	<---	PT	-.047	.016	-2.975	.003	par 2

The indirect effect of PT to SC and MF is .13 and is significant at .001 as identified in Table 44.

Table 44

MFI Indirect Effect of MF Mediation Model

Indirect Effects - Lower Boundes (BC) (Group number 1- Default model)		
	PT	SC
SC	0.000	0.000
MF	0.113	0.000
Indirect Effects - Upper Boundes (BC) (Group number 1- Default model)		
	PT	SC
SC	0.000	0.000
MF	0.113	0.000
Indirect Effects - Upper Boundes (BC) (Group number 1- Default model)		
	PT	SC
SC	…	…
MF	0.001	

Mediating conclusion. Per Baron and Kenny (1986), all four steps and assumptions were complete, and analysis identified there was a mediating effect. Albeit a negative effect, this indicates that Safety Culture is removing a positive relationship that Pilot Training directly had on Manual Flight in a univariate relationship. While significant, hypothesis H_{13A} is non-supported due to the negative influence that safety culture has on a pilot's willingness to manually fly:

$H_{13A:}$ Safety culture positively influences pilot training, which influences a pilot's willingness to manually fly.

Automation Questions

A series of questions, not part of the SEM, were asked to assess the participant's opinions and preference on automation usage, safety, regulatory compliance, complexity, situational awareness, and company policy. Questions were also asked to assess type and elements of the company's training and checking program and how the pilot best learns. Non-SEM questions are presented in Appendix G, and associated comments are presented in Appendix H.

Summary

Given the data analyzed, after pilot testing the survey and the model selection process, the final model positively and significantly identified predictors of manual flight to be pilot understanding, pilot training, aviation passion, and safety culture. The results of the survey analysis, pilot test, EFA and CFA model comparisons, non-SEM questions regarding automation usage, safety, regulatory compliance, complexity, situational awareness, company policy, training, and learning will be discussed in the next chapter.

CHAPTER V

DISCUSSION, CONCLUSTIONS, AND RECOMMENDATIONS

Discussion

The discussion will review the results of hypotheses testing for the manual flight, pilot training, and safety culture hypotheses, in addition to the mediation hypothesis. The battery of supporting questions, referred to as non-SEM questions, will be discussed in relation to how the results relate to the factors and the resultant impact on the manual flight analysis.

Hypotheses testing. Results of the analysis with Manual Flight as the dependent variables confirmed that all relationships with the predictor variables, Pilot Understanding, Pilot Training, Aviation Passion, and Safety Culture were significant. Ten of the 13 hypotheses were accepted due to the significant and positive relationships. Three of the hypotheses were not accepted despite being significant due to a negative relationship. The first twelve hypotheses were direct response hypotheses, and the final hypothesis was a mediation hypothesis accounting for the influence of Safety Culture on Pilot Training. Hypotheses were further identified by the dependent variables of Manual Flight—hypotheses 1-4, Pilot Training—hypotheses 5-8, and Pilot Understanding—hypotheses 9-12.

Manual flight. The Manual Flight hypotheses H_{1A}, H_{3A}, and H_{4A} were supported due to significance. H_{2A} was statistically significant; however, because pilot training identified a negative relationship to the pilot's decision to manually fly, it was not supported.

H_{1A}: Pilots' aircraft understanding positively influences willingness to manually fly, controlling for pilot training, aviation passion, and safety culture.

H_{2A}: Training positively influences willingness to manually fly, controlling for pilot understanding, aviation passion, and safety culture.

H_{3A}: Aviation passion positively influences pilots' willingness to manually fly, controlling for pilot training, safety culture, and understanding.

H_{4A}: Safety culture positively influences pilots' willingness to manually fly, controlling for pilot training, aviation passion, and understanding.

The research question of what impacts a pilot's decision to manually fly was identified to be multiple factors. Pilots' aircraft understanding positively influenced pilots' willingness to manually fly and presented the greatest relationship with manual flight. Aviation passion also positively influenced pilots' willingness to manually fly, identifying that if the pilot was passionate about aviation, they were more likely to engage in manual flight. Training also influenced willingness to manually fly, however, presented a negative relationship. Therefore, the more training the pilot experienced, they were less apt to manually fly their aircraft. Safety culture also showed a significant relationship upon manual flight.

Pilot training. The Pilot Training hypotheses H_{5A} and H_{7A} were supported due to significance. However, while H_{6A} and H_{8A} showed significant relationships, they were not supported due to a negative relationship that Aviation Passion and Manual Flight had with Pilot Training.

H_{5A}: Safety culture positively influences pilot training, controlling for manual flight, aviation passion, and understanding.

H_{6A}: Aviation passion positively influences pilot training, controlling for manual flight, safety culture, and pilot understanding.

$H_{7A:}$ Pilot understanding positively influences pilot training, controlling for aviation passion, manual flight, and safety culture.

$H_{8A:}$ Manual flight positively influences pilot training, controlling for aviation passion, understanding, and safety culture.

Safety culture had a large influence on pilot training, indicating that a positive safety culture would positively influence pilot training, and the reverse would be true—a negative safety culture would negatively influence pilot training. Pilot understanding also positively influences pilot training with the second highest relationship. Pilots' level of understanding influences their training, which could be indicative of self-training programs. Aviation passion positively influenced pilot training, but with a negative relationship. This could identify that the more passionate a pilot is, the more they love to fly, they may resist training processes which appear to be inhibiting manual flight. Manual flight also presents a negative relationship to pilot training. This could be reflecting similar results with aviation passion in that the pilot's desire to manually fly is negatively influencing training, due to manual flight not being made available during pilot training.

Pilot understanding. The Pilot Understanding hypotheses were accepted due to significance.

$H_{9A:}$ Safety culture positively influences pilot understanding, controlling for manual flight, aviation passion, and pilot training.

$H_{10A:}$ Aviation passion positively influences pilot understanding, controlling for manual flight, safety culture, and pilot training.

$H_{11A:}$ Pilot training positively influences pilot understanding, controlling for aviation passion, manual flight, and safety culture.

H_{12A}: Manual flight positively influences understanding, controlling for aviation passion, pilot training, and safety culture.

Results identified that all Pilot Understanding hypotheses were accepted and significant. Pilot training positively influenced pilot understanding and was the most significant. Safety culture and manual flight both positively influenced understanding with a similar relationship with each factor. Aviation passion also positively influenced pilot understanding. These relationships identified that all factors significantly influenced a pilot's level of understanding the aircraft.

Mediating hypothesis. A mediating hypothesis was designed to identify the influence that safety culture had on the relationship between pilot training and manual flight.

H_{13A}: Safety culture positively influences pilot training, which influences a pilot's willingness to manually fly.

The first step in the process was to analyze pilot training with pilots' willingness to manually fly. This relationship identified a small but positive relationship, whereas the multivariate analysis identified a negative relationship. This indicates that in isolation, pilot training had a positive influence upon manual flight; however, when the other variables were accounted for, the relationship turned negative. Safety culture was one of those variables that was analyzed in this process. The relationship between pilot training and safety culture was assessed and found significant, yet slightly higher than the univariate relationship. The mediation path model identified that safety culture influenced pilot training, which influences a pilot's willingness to manually fly, identifying safety culture has a significant influence over manual flight. However, the relationship between pilot training and manual flight was negative, indicating that safety culture is removing the positive effect that pilot training had on manual flight in a univariate relationship. While significant, this hypothesis was not supported due to a negative relationship. This negative relationship with pilot training and manual flight was identified with the multivariate analysis; however, the mediation analysis further indicates that safety culture is a significant and contributing factor to that negative relationship.

Pilot opinion questions. Industry reports supported by academic literature indicate that pilots may not understand aircraft systems, lack flight skills due to automation dependence, and have ineffective monitoring skills that may be attributing to this lack of manual flying. The FAA recommended that pilots should manually fly (FAA, 2013a), yet despite this recommendation, the Office of the Inspector General (OIG) reported pilots continue to lack hand-flying skills and lack monitoring ability (OIG, 2016). However, pilots had yet to be queried as to the reason behind their performance. Performance identified in this research is the level of automation utilized during flight. The FAA and worldwide civil aviation authorities operate under approved training programs and assessment methods. However, results of this research and the literature review indicate among other reasons, that these programs may not be effective for learning and assessing performance. Policy further dictates standard operating procedures; however, results identified that 69% of the participants reported their organization had unwritten policies regarding automation usage. While open-ended comments were not included on the survey, many participants sent comments that helped to further understand the results and are presented in Appendix H. Some of these comments indicate that written policies encourage manual flight, yet the policies oppose the unwritten policies of what is accepted on the flight line, identifying a culture issue.

Manual flight. As identified in Appendix G, question 32, there is a confusion as to what constitutes manual flight, whereas 15% of the participants believe that manual flight is when *only* the autopilot is disconnected, 49% believe both the autopilot and autothrust must be disconnected, and 36% believe that manual flight means that the autopilot, autothrust, and the flight director must be disengaged. This confusion is not unfounded, as there is a taxonomy difference between the OIG and the FAA.

Automation preference. Pilots reported their preference to fly with the autopilot and autothrust connected by 74% and 78%, respectively, as presented in Appendix G, questions 33 and 34, respectively. The presentation of the ensuing responses to the opinion-based questions assist in understanding this preference.

Automation opinion. This series of questions was written as dichotomous questions despite each answer being contingent upon other variables—mental fatigue, physical fatigue, overall flying experience, experience of fellow crewmembers, experience of the active arrival or location, cognitive ability, inter crewmember tension or conflict, life stress, pilot age, weather, location of flight, time of flight, time of crewmember's break, quality of crew rest, passenger issues, recency of training, length of flight, circadian rhythm, or any combination of these variables, or others. Adding the option, "it depends" would have resulted with all participants selecting the option *it depends*, because it does. Safety, overload, confusion, risk, complexity, and situation awareness are not absolutes, and all move along a spectrum of "more" or "less" dependent upon other factors. With this in mind, the following responses provide an overall perception of what pilots think about automation without any conditional factors included. These experiential responses are reflective of the individual's type of flying, and therefore will portray an authentic belief based upon that experience. A domestic short-haul pilot that flies into the same airport multiple times daily will not have the experience to make an accurate response to a more detailed question, such as to the necessity of automation after a long-haul flight, with an augmented crew, flying into a foreign country, after being on duty for 15 hours, but could only answer based upon an assumption. Allowing pilots to answer with the mindset of their daily experience will provide the most authentic responses.

Automation is safer than manual flight. Appendix G, question 35, depicts that 75% of the population believe that automated flight is safer than manual flight. Automation is safer when the automation works, the pilot understands how to use it, and there are no extenuating circumstances. Participant's comments, as presented in Appendix H, indicate automation may be safer due to the lack of manual flight ability, and they do not necessarily agree that fully automated flight is in the best interest of overall safety, despite being safer.

Manual flight overloads the pilot flying. Appendix G, question 36, identifies that 49% of the participants believe that manual flight overloads the pilot monitoring, where 51% believe it does not. The differences in these responses would be contingent upon a number of variables such as operations in a foreign country or airport, complexity of the arrival, ATC involvement, and airport conditions. Therefore, the split difference was varied per the pilot's operating environment. Comments in Appendix H identify the complexity of manual flight, and the decision to manually fly could be based upon overload and complexity of the air traffic system more so that the aircraft.

Manual flight reduces situation awareness. Appendix G question 37, depicts that 51% of the participants believe that manual flight reduces situation awareness, meaning that 49% believe they can remain situationally aware while manually flying the aircraft.

The response to this question is one that is also situational. During high workload, higher levels of automation usage has been identified to improve situation awareness, yet when mental workload is increased due to lack of understanding of complex aircraft systems, operations, or interpreting the automation, higher levels of automation will reduce situation awareness. Concern for situation awareness when something fails on the aircraft is identified in the comments in Appendix H.

Manual flight and the risk of violations. Research has identified that flight skill retention in automated aircraft was determined to remain relatively intact without consistent performance, yet degradation of cognitive ability necessary for manual flight was apparent. Therefore, responses where 61% believe that manual flight exposes the pilot to more risk, as depicted in Appendix G, question 38, can be explained by these results. Without manual flight skill retention, due to lack of practice, there will be an increased potential for error with an ensuing violation.

Fly by wire and automation complexity. The focus of automation research has revolved around flight deck displays of a glass cockpit and integrated system designs with limited discussion on flight control operations and understanding the complexity of the fly-by-wire system. Pilots' lack of understanding, poor attention, limited knowledge, mode awareness issues, and problems managing an automation surprise have been identified to be resultant from automation complexity. It is also believed that automation creates more confusion for the pilot due to complexity. However, of the pilots queried, most of which are operating these complex, highly automated fly-by-wire aircraft, state a different opinion than the aircraft complexity theory. As depicted in Appendix G questions 39, 40, and 41, these participants believe that the fly-by-wire aircraft were meant to be manually flown and were not too complex for manual flight by 71% and

95%, respectively, and 91% did not believe fly-by-wire aircraft were confusing. Naidoo and Vermuelen (2014) best explain this difference of perception of complexity with the contention that it is not necessarily the complexity of the aircraft, but the problem is inadequate training.

Company policy. Corporate culture plays a key role in pilots' performance beyond espoused values, corporate rules, and written procedures, in that the unwritten rules are what often guide behavior and influence performance. Corporate culture therefore extends to performance in *how* the airline culture behaves and transcends to employee performance standards. As reported, worldwide there are a variety of policies regarding automation usage, both written and unwritten, which are depicted in Appendix H. Results identified that unwritten policies are more prevalent than the written policy regarding mandates to utilize automation.

Written policies. Unless corporate policy or civil aviation authority regulations mandate automation usage, the pilot has a choice. Thus, a question as to why pilots are choosing not to disengage the automation, despite FAA recommendations, are answered with these results. Appendix G, question 43, identified that 56% of the participants state that the company has written policies mandating automation usage. However, all carriers operating automated aircraft for hire have policies regarding automation. In that only 7% of the population did not fly an automated aircraft, this response rate could be due to confusion as to the term *automation policies*, similar to the confusion of the term *manual flight*, and is contingent upon understanding the question. English as a second language was identified as a limitation in this research and could be attributed with this response. Comments on automation usage appear to be varied indicating autopilot, autothrust, and flight director policies are company specific, as identified in Appendix H.

Unwritten policies. Whereas 56% of the participants stated their company had written policies mandating automation usage, 69% stated their company has unwritten policies mandating automation usage as identified in Appendix G, question 42. The FAA's recommendation for manual flight, disconnecting both autopilot and autothrust, and the companies' perceived compliance via written policy versus how they actually advise the pilots to operate through unwritten policies are identified in Appendix H. The response to the discernment between unwritten policies and practice could be found in the definition of corporate culture being a pattern of behavior stemming from, in part, espoused values, beliefs, and underlying assumptions, in addition to policies and procedures, which all include elements of a safety culture (Schein, 2010).

Performance. Performance in this research is referenced as to the level of automation the pilot chooses to utilize. In response to how pilots operate related to automation usage and their preference for the other pilot, Appendix G, questions 44 and 45, identify that 71% of the pilots monitoring prefer the pilot flying utilize automation, and 58% state that the pilots they fly with rarely, if ever, fly without the autopilot or autothrust engaged. An example of pilots not wanting their fellow pilot to manually fly and associated concern are presented with comments in Appendix H, indicating the operating environment to be the overloading factor.

Training. A preponderance of research and accident investigations attributed automation-related pilot errors, in part, to inadequate training, with *sub-optimal training* as one of the two most significant flight hazards. Training questions encompassed necessity for supplemental training aids, type of ground school and assessment measures, participant's recency, companies training cycle, debriefing time, self-assessment during the brief and the use of a video, AQP certification, how the pilot studied to pass the oral examination, manual flight during operating experience (OE), and crew compliment during training. Results, as presented in Appendix H, reflect comments regarding training.

Supplemental training. The question as to whether pilots are being provided the tools in their respective companies regarding training is answered in Appendix G, questions 46 and 47, and identified 80% of the pilots queried utilized additional information to learn the aircraft, and 50% of those pilots stated that additional information was necessary in order to pass training. These results indicate that operators are not providing adequate resources to navigate their training program.

Type of ground school. Regulatory agencies have enabled airlines to cancel traditional ground-schools, where pilots are no longer mandated to come together in a classroom environment with an instructor and fellow classmates to learn aircraft operating systems. Under AQP, airline flight operations management have been authorized to allow pilots to teach themselves aircraft systems and computer operations via at-home training programs. This training process relies upon an assumption that pilots will acquire correct systems understanding, and when an inflight emergency arises, the pilot will have accurate knowledge to deal with it. Appendix G, question 48, identifies those with a classroom and instructor represented 24%, whereas completely self-taught were 13%, and a combination of self-taught and classroom represented 63%. Multiple comments, presented in Appendix H, identified that the combination of both could be reflective of self-taught followed by a review.

Type of systems evaluation. Training assessment has been an ongoing challenge, yet, until recently, little research existed on effective simulator training evaluation measures. However, effective evaluation is the only way to determine training program effectiveness. Pilot performance, as identified by accidents, incidents, and ASRS may be better indicators of training effectiveness than current AQP data collection processes during simulator training events and electronic reviews. Accepted training assessment processes do not necessarily substantiate that learning has taken place in the form of understanding and retention, with the capability to transfer that knowledge to the aircraft. Appendix G, question 49, depicts that 39% of participants took a written or electronic systems test, 8% took a systems oral, and 53% stated they took a combination of both. Comments as to learning and knowledge from these assessment methods are presented in Appendix H.

Recency and recurrent training cycle. A recency event is a simulator training event where a pilot performs three takeoffs and landings within 90-days, to maintain currency per Federal Aviation Regulation (FAR) 121.439 (GPO, 2015). Recurrent simulator training is a regulated event where pilots will receive an approved number of simulator days for training and evaluation, conducted on either a sixth month, nine month, or annual cycle (GPO, 2015). There is no requirement for knowledge assessment during pilot recency or recurrent training events beyond rote memorization of limitations or memory items, and no requirements for repetition or practice of manual flight skills (FAA, 2017a; GPO, 2015). Appendix G, questions 50 and 51, identified that the majority of participants were actively flying, and 65% rarely or ever required a recency, 20% needed a recency twice per year, 10% once a year, and 5% visited the simulator three times per year to maintain proficiency. In addition, 57% of the pilots attended a 6-month cycle, 17% every 9 months, and 23% annually.

Average debriefing time. The power of the flight crew debrief has been the focus of much research and is instrumental in how pilots learn from human error (Ellis et al., 2014). Learning depends upon how the debrief was conducted per the outcome of the event. If the checkride was a success, the debrief should only focus upon errors made throughout the event to maximize learning, yet after a failed experience, the focus must also include what the pilot did correctly (Ellis et al., 2014). Ellis et al. (2014) further argued the necessity to accurately assess the experience before learning would occur, and reported that pilots would become more accountable for their behavior if they became responsible for their success and failures during the learning process. Appendix G, question 52, identifies that 13% of the pilots spent less than 15 minutes in a debrief, 49% spent 15 to 30 minutes, and 33 % spent 31 to 60 minutes, whereas 4% spent over 60 minutes. As identified in Appendix H, one participant reported they were forced to select *less than 15 minutes* but did not receive any debrief.

Debrief self-assessment. Automated aircraft provide extensive latitude for safety, meaning there is a great deal of room for error as automation is a safety net that minimizes consequences of pilot performance, thus pilots have the opportunity to perform and respond to mismanaged arrivals, poor decision-making, and lack of SA without resulting in a consequential event, whereas continual success may create erroneous mental models of adequate performance (Dismukes, 2010). While self-assessment is an integral part of effective learning, pilots must possess the resources to accurately measure performance in order to adjust their self-assessments (Sitzmann, Ely, Brown, & Bauer, 2010). Appendix G, question 53, identified that 87% of the pilots were able to self-assess and reflect upon their training experience during their debriefing session.

Oral preparation. How a pilot learns the aircraft between understanding versus memorizing facts will be reflective of operational performance. Automaticity and adaptive expertise improve performance during novel situations, whereas rote memorization results in limited understanding and memorized procedures that may not transfer to the aircraft beyond events practiced and anticipated events in the simulator. Adaptive expertise is where understanding and contextual-based knowledge creates adaptive strategies for unexpected events. Automaticity refers to *when a pilot's knowledge is at the level where he or she does not have to think about what to do, therefore the response is automatic.* Rote memorization does not guarantee the pilot understands the automatic response, whereas knowledge-based automaticity and adaptive expertise implies a deeper level of understanding. When asked how the pilots prepare to pass a systems validation, 43% stated they learned by memorizing facts, where 57% learned the aircraft to understand systems and processes. These results identify that close to half the pilot population may have limited understanding due to memorized procedures that may not transfer to the aircraft beyond events practiced and anticipated in the simulator, as presented in Appendix G, question 54.

Manual flight operating experience. Appendix G, question 55, identified that 68% of the pilots were allowed to disengage the autopilot and autothrottle during operating experience (OE). Therefore 32% were not allowed to disengage the automation, despite a check airman on the aircraft. Appendix H presents a training professional's opinion on the importance of providing the ability to manually fly. Without the ability to disengage the automation with an instructor onboard, the chance the pilots will have confidence to do this on their own is unlikely.

AQP certification. AQP is a train to proficiency program that mandates inclusion of CRM, LOFT, and line operational evaluation (LOE) scenarios. AQP simulator training must be (a) aircraft specific; (b) include indoctrination, qualification, and continuing qualification (CQ) programs; (c) training and evaluation for instructors and examiners; (d) replicate normal flight operation; (e) include a normal crew compliment; (f) collect proficiency data, and; (g) utilize a full flight simulator (FAA, 2017a). Appendix G, question 56, identifies that 48% of the participants were AQP certified, 16% were not, and 36% were unsure. The high response of those who are unsure identifies a culture issue relating to an informed culture, and an associated limited knowledge of training requirements.

Video. When students observe their performance utilizing a video, and self-assessment and reflection are done with an instructor and peers, maximum performance gains will be realized (Mavin & Roth, 2014b). The utilization of a video is not a requirement for AQP but could be an effective tool for collecting proficiency data and assisting with the debrief as this process is a highly efficient and cost-effective tool that could improve training effectiveness. When queried as to the use of this tool, Appendix G, question 57, 85% of the population stated they were not videotaped during training.

Crew complement. A crew compliment is required under AQP. Justification to reduce the number of required simulator sessions was due to pilots being trained and assessed as a crew, where half the training and assessment was being conducted as the pilot monitoring and the other half as the pilot flying. Therefore, training must occur in the pilot's respective seat. A first officer's pilot monitoring training must be conducted in the first officer seat, as there are additional responsibilities that must be learned and practiced. Appendix G, question 58, identifies that 50% of the training is *not* being conducted as a crew, yet only 15% of the pilots reported their training was not AQP certified.

SEM questions. Appendix F displays the SEM questions. For this discussion, these questions were categorized with the factor they belong—Manual Flight (MF), Pilot Understanding (PU), Pilot Training (PT), Safety Culture (SC), and Aviation Passion (AP).

Manual flight questions. The manual flight SEM questions identified the likelihood of automation usage in different phases of flight. Overall, 27-30% of the population are not likely to disengage the autopilot and autothrust at any given time, and more than 50% will not disengage prior to the final approach phase, and more than half would not disengage the flight director. These results identify that pilots are utilizing automation more so than manual flight, and comments in Appendix H reflect that this decision could be primarily due to company policy, written and unwritten, versus personal choice. The FAA has recognized the relationship between manual flight and pilot proficiency because the agency recommended that pilots should manually fly their aircraft (FAA, 2013a). Yet, despite these recommendations, the OIG reported pilots continue to lack hand-flying skills (OIG, 2016). Therefore, company policies could be creating the degraded skills identified by the OIG due to associated lack of practice. Some participants noted their aircraft did not have an autopilot or autothrust, another pilot expressed confusion as to how the autothrust operated, and there appears to be conflicting opinions on aircraft manufacturer mandates as revealed by the comments in Appendix H.

Pilot understanding questions. A seven-point Likert scale was utilized for the SEM opinion and operational based questions, which enabled pilots to answer knowledge-based questions on a level from extremely unlikely to extremely likely versus an absolute. The assumption was, if the pilot absolutely knew the systems question they would select extremely likely (7). However, anything below extremely likely would indicate doubt of absolute knowledge, indicating they might not have the necessary level of understanding. Predicated on the assumption that extremely likely identified knowledge, the participants responses identified that 21% were certain they understood the flight management system, 36% understood the flight mode annunciator, but only 7% were sure they could pass an oral without studying, 9% could handle an emergency without direction, and 12% understood why the procedure was written. These results indicate that pilots may lack understanding of the equipment they fly and operational practices. Knowledge deficiency, in some capacity, has attributed to over 40% of the accidents and 30% of major incidents reviewed, and LOSA narratives identified that flight path errors were due to a knowledge deficit and automation usage (FAA, 2013d). However, due to social desirability theory, the only way to accurately assess the level of understanding would be to administer an actual test. There is also a possibility that the pilots could be unconsciously incompetent, where they don't know what they don't know. Comments regarding pilot understanding are presented in Appendix H.

Pilot training questions. A key factor that could be influencing learning is the high percentage of pilots utilizing rote memorization versus understanding, in that 61% utilized rote memorization in ground school and 57% in simulator training. Of the pilots surveyed, 73% reported they received feedback, and 79% were allowed self-assessment. Only 55% of pilots queried were encouraged by a check airmen to manually fly during OE. Lack of repetition identified that 39% of the pilots questioned did not repeat event sets. Training that lacks repetition and feedback in complex aircraft may directly influence understanding (knowledge), performance (manual flying), and pilot confidence in automated aircraft. Cognitive performance requires practice and repetition for the pilot to remain proficient (Casner et al., 2014). Combining the results of high rote memorization, lack of repetition, and no encouragement to manually fly during training with results from the non-SEM questions identifies that training worldwide may be lacking.

Safety culture questions. The FAA defines safety culture as, "the shared values, actions, and behaviors that demonstrate a commitment to safety over competing goals and demands," and comprises five sub cultures—reporting, just, flexible, informed, and learning (FAA, 2013b, p. 9). *Safety culture is the essence of an organizations culture, and identified by behavior that stems, in part, from* beliefs and underlying assumptions, and is an influential factor in manual flight and pilot training. Overall 54% of the population was unsure or did not believe their suggestions would be taken into consideration, 34% were unsure or unlikely to critique their training program, 41% lacked a belief or were unsure if the leadership in charge of developing training programs had the expertise of learning, 54% were unsure or believed it was best to keep quiet, and 46% were unsure or did not believe their company would exceed regulatory compliance. These results identify that organizations worldwide may lack a positive safety culture. Multiple comments identified a punitive culture, which opposes a safety culture, that will not sustain or support an SMS, as presented in Appendix H.

Aviation passion questions. Aviation passion in this study refers to an individual's involvement in aviation activity beyond work experience, such as recreational flight, aviation club participation, reading aviation magazines and books, flying home simulators, or purchasing aviation themed products. Overall the population appeared to have a strong level of passion, in that 35% were likely to attend an aviation event, 68% were likely to purchase an aviation themed product, 72% were likely to read aviation themed books, 62% were likely to socialize with other aviators outside work, and 81% of them were proud to be pilots.

Limitations. In addition to the anticipated limitations previously identified in the limitation section, primarily the lack of a sampling frame and the data collection method, there were unanticipated limitations that became apparent reviewing the results. As identified, 17% of the pilots had been trained more than ten years earlier and experienced a different type of initial pilot training than the current process. Those that experienced an oral for an assessment were more than likely in this group and would not reflect the current methodology of an electronic exam. An expatriate category could also have been included, in that a within culture difference exists between a pilot of one culture operating in the environment of another culture, as was identified in comments in Appendix H. English as a second language, while an anticipated limitation, was identified to be an actual limitation to an assumed conceptual understanding some of the questions. In that the data gathered was a broad sample reflecting a worldwide population and was not specific to a geographic area or a particular operator, a further limitation is that any attempt to attribute the results to a specific geographic region without controlling for confounding variables is not recommended.

Conclusions

The overarching research question is—does pilot training, aircraft understanding, aviation passion, and safety culture, impact the decision as to the level of automation usage? Moreover, in what aspects did these factors impact each other, and could demographics such as age, gender, geographic location, flight hours, type of aircraft, general aviation flight, or how a pilot was trained impact pilots' performance associated with the level of automation utilized?

In response to the FAA's (2013) request that pilots manually fly, the resultant OIG's (2016) identification that pilots continued to lack hand flying skills and monitoring ability, and the current industries' concern for flight skill loss due to automation reliance and complacency (Abbott, 2015; Curtis et al., 2010; FAA, 1996; Franks, Hay, & Mavin, 2014; Geiselman, Johnson, & Buck, 2013; Haslbeck et al., 2012; Moll, 2012), questions were posed to active FAA certified check airman and training professionals in order to better understand manual flight and performance concerns. During the preliminary stage of this research, SMEs were queried to help ascertain what was occurring on the flight line in regard to manual flight. An FAA designee on the Airbus A330, at an international airline with the positional power to assess pilot performance and provide his opinion, supported industry concerns when he stated his opinion that pilots were not manually flying because of, "Lack of confidence", "Lack of proficiency", and "Fear" (Personal communication, Captain Miller, February 05, 2015). An example of manual flight performance is further represented by the action of a U.S. international airline captain after he experienced a systems failure during departure which prevented the engagement of the autopilot and autothrust. He flew into RVSM airspace, where reduced vertical separation mandates an operational autopilot, continued to destination, and then declared an emergency in VFR (visual) conditions when ATC would not provide a block altitude for arrival:

> To have my skills degrade to a point where a level 0 VMC landing in Atlanta required declaring an emergency is a personal wake-up call. I hate to think that

someday manual flight operations will be an assumed emergency, but that day may be approaching. (Personal communication, Captain Steve, May 18, 2015)

The results of this research identified that pilot training, aircraft understanding, aviation passion, and safety culture all influenced a pilots' decision to manually fly. However, the most significant influence on the decision to manually fly was the pilots' level of understanding. Pilot training identified as the most significant influential factor on pilot understanding and safety culture presented the greatest influence over pilot training.

When the initial cadre of experienced instructors at a U.S. airline (many had Airbus experience) were learning the Airbus A350 systems (a highly automated aircraft) via a computer-based training program and 100% failed one or more system modules, the efficacy of a CBT training program that required pilots to listen to audio online, support the results of current training programs that may be deficit and are influencing pilots' level of understanding (Personal communication, FAA designee, October 27, 2016). Furthermore, the captain who declared the emergency due to the loss of the auto flight system lacked knowledge that he was prohibited from operating in RVSM airspace (Personal communication, Captain D., June 9, 2015). He was also not provided that information from ground operations, indicative of either a lack of understanding by all or lack of information sharing, both of which are required with an informed culture. Safety culture is the foundation of an SMS, and this research has identified that safety culture worldwide is impacting how pilots operate their aircraft.

Safety culture has the greatest impact on pilot training, therefore, is the underlying factor with the greatest influence as to how pilots learn and operate their aircraft. The captain who declared the emergency in the above example is also the head of human factors and analyzes ASAP reports and further stated, “We as a group are presently not prepared to fly in complex airspace with Level 0 automation. Nor, might I add, are we suitably prepared to fly in complex airspace with Level 4 automation (so says ASAP)” (Personal communication, Captain D., May 08, 2015). Furthermore, this airline’s internal response to the identification of this global flight performance issue was not to improve training but to encourage pilots to declare an emergency if they lost their automation under the construct of workload management (Personal communication, Captain D., July 15, 2016).

Results further identified that pilot training has a negative impact on pilots’ willingness to manually fly when all factors are considered, whereas in isolation, pilot training had a small but positive impact. However, when safety culture was added as a mediator between training and manual flight, this removed any positive impact that pilot training may have had on the pilot’s decision to manually fly and turned that relationship negative. Where safety culture and pilot training present a negative impact on a pilot’s decision to manually fly, aviation passion was the second highest predictor of manual flight and was both significant and positive.

While all factors influence the decision to manually fly, associated policies, written or unwritten, and practices that dictate line operations (safety culture) and how organizations train pilots (pilot training), are events that are at the hands of operators and controlled by the aviation regulatory agencies. Therefore, evaluating practices that could be improved upon was accomplished in this research. A literature review was utilized in conjunction with the researcher’s flight and training experience to develop questions that could assess current training practices to identify whether or not operators were administering best practices for learning, understanding, possessed a safety culture, and were following regulatory mandates and associated flight recommendations. The results of the pilot opinion questions provided a better understanding as to safety culture, current training methodologies, and learning with associated understanding. Pilot understanding is a direct result of learning, and further impacts the decision to manually fly. How organizations train pilots that contradict best practices of learning include:

(1) Learning by rote memorization— Per the results, 43% of the pilots queried utilize rote memorization practices.

(2) Inadequate brief times— Per the results, 62% of the pilots queried received a 30-minutes or less debrief.

(3) Lack of video during debrief— Per the results, 85% of the pilots queried were not recorded on a video.

(4) Inadequate training materials— Per the results, 80% of the pilots queried utilized supplemental material (not provide by the company) with 50% stating this self-gathered material was necessary.

Approved training programs that may be inadequate, non-compliant, or recommendations not followed by operators that could be influencing training and understanding include:

(1) Inadequate assessment measures. Per the results, 39% of the pilots queried received only an electronic or written assessment.

(2) Lack of crew compliment. Per the results, 50% of the pilots queried did not have the correct crew compliment during training.

(3) Lack of a standard taxonomy for manual flight. Per the results, the pilots disagreed as to the meaning of manual flight with 15% of the pilots queried believing it was only the autopilot disconnected, 49% of the pilots queried

believed both the autopilot and autothrust must be disengaged, and 36% of the pilots queried believed that in addition to autopilot and autothrust being disconnected, that the manual flight also meant no use of the fight director.

(4) Lack of flight line teaching without both the autopilot and autothrust. Per the results in the non-SEM questions, 32% of the instructors did not request the pilot to disengage the automation during training, and the SEM results identified 45% of the instructors did not encourage the pilots to disengage the automation.

Safety culture is the essence of the corporation's culture and includes behaviors, values, beliefs, and how the organization does business relative to safety and associated processes, to include communication, reporting, flexibility, information sharing, and improvement strategies. Safety culture has greatest influence over the ultimate impact on pilots' decision to manually fly the aircraft. Results indicate that all areas of safety culture could be improved upon, to include:

(1) Reporting Culture: How likely are you to critique and report any aspect of your employer's training program if you perceive it as substandard? Per the results, 34% of the pilots queried were unsure or would not critique the training program.

(2) Informed Culture: How likely is it that your employer's leadership team in pilot training, involved in program development, has knowledge of how humans learn and is aware of technology to improve learning? Per the results, 41% of the pilots queried were unsure or believed that management involved in training did not have expertise.

(3) Learning Culture: How likely is it that employee suggestions are taken into consideration by your employer? Per the results, 54% of the pilots queried were unsure or believed they would not be taken into consideration.

(4) Just Culture: How likely are you to agree with the following statement—the best way to have a successful career as a pilot is to keep quiet and not make waves? Per the results, 54% of the pilots queried were unsure or believed it was best to keep quiet.

(5) Flexible Culture: How likely is it that your employer will *exceed* minimum regulatory compliance? Per the results, 46% of the pilots queried were unsure or believed their employer would not exceed regulatory compliance.

The greatest issues with pilot training were the lack of repetition, where 39% of the pilots queried did not repeat event sets in direct opposition to learning. Rote memorization was another highlight issue where pilots utilized rote memorization in the systems training and simulator training at a rate of 69% and 57%, respectively, in direct opposition to understanding. Feedback was positive in that 74% of the pilots assessed received feedback.

Aviation passion was assessed, and while the results identified a group that was overall passionate, viewing from a dispassionate perspective, 38% do not socialize with other aviators, 28% do not read aviation books or other aviation reading material, and 32% do not purchase aviation themed products. While 65% do not attend aviation events, 37% of the pilots were flying over 700 hours annually which could indicate a time issue for such events, and expense could be a factor as well. Yet, 19% do not feel proud to be a pilot.

Recommendations

The recommendations fall within three areas: future research, operational practice, and regulatory reform. Operational suggestions are expanded into two categories—pilot training and resultant understanding, and safety culture, the most significant factors impacting how pilots operate their aircraft. Recommendations for future research also include the potential of repeating this study, but with specific operators and countries while controlling for confounding variables.

Future research. The purpose of this research was to examine the relationships among training methodologies, pilots' aircraft understanding, safety culture, aviation passion, and manual flight, to address industry concerns of automation dependence, confusion, lack of mode awareness, and flight skill loss. The strongest predictors of automation usage were identified to be safety culture, pilot training, and understanding and therefore could be utilized for empirical research. Recommendations include:

1. A number of moderation hypotheses could be further evaluated with the data collected from this research to determine how moderators may influence the results. Moderators being supplemental training materials, type of ground school, type of systems assessment, the company's recurrent training schedule, average debriefing time, how the pilot studied to pass an oral, AQP, crew compliment during training with carriers that were AQP, training experience (previous instructor or check airman), and type of primary flight training. Understanding how all factors influence or moderate the results could provide more insight to an industry problem. Organizations interested in utilizing the MFI inventory could also modify the inventory in the following areas: (a) replace the pilot understanding factor questions with a

systems review to accurately assess the level of understanding; (b) replace the safety culture factor with results from safety culture surveys specific to the organization, and (c) FOQA data could identify automation usage.

2. Experiments could be conducted to: (a) assess the efficacy of an electronic exam as compared to an oral exam to assess the pilot's level of understanding (FAA, 2017a); (b) perform an in-house analysis with testing between groups to identify the most efficient and effective means of learning with simulators on motion versus non-motion (Petitt, 2014); (c) assess a three-hour simulator sessions versus four (Mavin & Roth, 2014b); (d) assess the efficacy of video debriefs (Mavin & Roth, 2014b); and (e) determine the benefit of a virtual classroom versus self-taught process to improve the level of understanding (Walcott, & Phillips, 2013).
3. Further research should be conducted with a longitudinal study of aviation passion to determine if passion changes over time. However, results of this study could identify an association with age, type of flying, gender, or hours flown annually or total, or safety culture with negative or positive passion.

Operational practice. Improvement should include addressing pilot training and safety culture, as both are directly impacting operational practices and would be contingent upon results as to the research suggested.

Recommendations to improve training. Pilot training could be improved by employing SMEs who understand how people learn to develop training programs and redesign the training process based upon learning principles, as results identified that 41% of the crews queried believed those designing programs did not have experience to do so. Applying SMS to the training programs to incorporate risk mitigation and proactive safety measures could also ensure pilots are trained to the level of understanding to operate the aircraft in a safe and efficient manner. Dependent upon the results of associated research, the following improvements to training practices could be realized: (a) Restructure current training practices to include principles as to how pilots learn through repetition, feedback, and understanding; (b) Consider a virtual classroom with subject matter experts to ensure understanding versus rote memorization; (c) Follow FAA and ICAO mandates to ensure crew compliment for all AQP operators; (d) Reduce the training scenarios to three hours. The four-hour session was a carryover *prior to* AQP train as a crew and will allow for additional sessions to increase repetition; and (e) ensure instructors are trained how to assess and evaluate to include the elements of how to provide feedback to improve understanding and associated learning.

Recommendations to improve safety culture. Organizations worldwide are participating in SMS and U.S. airlines are mandated to have an SMS program. However, without a safety culture as the foundation, SMS will be ineffective. Safety culture has been identified to significantly influence training and performance, and therefore has a direct relationship to the safe operation. Recommendations to improve safety culture based upon the results identified include: (a) Assess the culture of the organization and based upon results, consider employing an outside organization to assist in a cultural shift, (b) Remove management who oppose a safety culture. As Collins (2001) purports—*who first, then what*. A shift in culture does not have to be a lengthy process if affirmative action prevails by removing the players that participate in a negative culture. Leaving such players in place and attempting to change the culture will fall flat, as the employees will not believe in the change.

Regulatory compliance. Results identify that organizations do not have a safety culture to support SMS mandates, therefore, SMS will not be effective and will continue to influence operational safety. In that this research identified safety culture as an issue impacting training, understanding, and how pilots manually fly, and results identified a lack of a positive safety culture, safety culture issues that should be addressed include: (a) An informed culture should dictate a worldwide taxonomy for manual flight, and operators should inform and educate employees as to the type of required training and required operating practices. The only way employees can accurately assess and critique their training programs is by having knowledge of what is required, and 36% have no knowledge of training requirements, and; (b) In that a negative safety culture with worldwide operators has been identified, modifications to the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR21) should be considered. A punitive approach toward offenders who violate a just and reporting culture required by SMS would send the message to operators worldwide that retaliation is not accepted when an employee reports an unsafe act. Until organizations feel the financial impact and negative publicity of their actions counterproductive to safety, safety culture will continue to be a problem, SMS will fail, and the negative influence on pilot training and operational practices will continue.

The Office of the Inspector General identified that pilots' lacked flight skills and exhibited problems monitoring their instruments, and incidents and safety reports have further identified confusion, lack of understanding, and mode awareness issues contributing to accidents and incidents worldwide. The researcher hypothesized that pilots were not to blame, but a larger system with underlying variables could be attributing factors. The Manual Flight Inventory (MFI) survey was developed to better understand the relationships of safety culture, pilot training, understanding, and aviation passion on automation usage to assist an industry that may be better equipped to both comprehend and solve the problem, in addition to providing a theoretical contribution, adding to the body of knowledge. The questions have been answered by statistical analysis, now it is up to the operators and regulators to utilize this information to improve safety.

Despite training practices, culture, or events beyond the pilot's control, at the end of the day pilots hold the responsibility of professionalism. While this research identified areas of concern at the hand of management who are ultimately influencing aviation safety, a comment made by Captain Nathan Koch in his recollection of a presentation sums up the pilot's responsibility:

> A message I received from listening to Dr. Tony Kern speak, and is emphasized in his books, is one that I live by—Don't worry about what your company might be pushing or the fact that you can get away with less than 100% effort much of the time. You owe it to yourself to always do your best, because today could be the day that you need to fly to the limit of your ability. (Captain Nathan Koch, Qanatas, 2018)

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APPENDIX A

Summary of Literature Review

Summary of Literature Review

Literature Review Summary

Reference	Focus	Summary	Limitations
Abbott (2015); FAA (1996); FAA (2013); FAA (2013d); ;OIG (2016).	Industry Concerns	Automation dependency, confusion, limited knowledge, communication errors, mode awareness, flight skills, and inadequate training.	Concerns are outcomes to outcomes, but no discussion as to how safety culture may impact performance. No discussion as to how aviation passion may impact performance is discussed.
BEA (2012); NTSB (2010); NTSB (2014a); NTSB (2014b); Palmer (2013).	Accident Reports	Accidents resulting from confusion, limited knowledge, communication errors, lack of mode awareness, and inadequate flight skills.	Missing connection related to airline culture or why pilots lack knowledge to avoid resulting accidents.
Airbus, (2003); Harris (2012); Rosay (2015); Ross & Tomko (2016); FAA (2013); FAA (2013d); OIG (2016).	Automation Challenges	Discussion regarding levels of automation usage. Increased complexity adds to confusion, lack of mode awareness, and complacency.	Lack of a consistent taxonomy regarding manual flight. No connection related to safety culture or aviation passion.

Literature Review Summary

Reference	Focus	Summary	Limitations
Bailey & Scerbo, (2007); Casner & Schooler (2014); Compte & Postlewaite (2004); Funk et al., (1999); Kaber & Endsley (2004); Naidoo & Vermuelen (2014); Parasuraman & Riley (1997); Parasuraman & Wickens, (2008); Parasuraman, Molloy, and Singh (1993); Young, Fanjoy, & Suckow (2006)	Beliefs, perceptions, trust, complacency, levels of automation, and equipment failure.	Discussions prevailed as to why pilots were first reluctant to utilize automation and later shifted to over usage identified as complacency. Factors to include reliability, environmental conditions, complexity, lack of understanding, automation function that may not be transparent, pilot overconfidence in the automation, poorly designed equipment, and inadequate training.	Analysis of current pilot training methodologies that may be impacting automation usage are missing. Safety culture identifying unwritten rules with operations and automation usage and how those unwritten policies impact performance, is lacking in relation to operational performance.
Esser (2005); FAA (2013a); FAA (2013d); Gluck (2010); OIG (2016); Sweller, van Merrienboer, & Paas (1998).	Manual Flight	Cognitive errors extend beyond mode awareness to manual flight. Programs are in place to assess performance that include LOSA, FOQA, LCSA, ASAP, and ASRS, but these methodologies may not be effective due to inherent limitations.	There appears to be a limitation to effectively assess manual flight performance in line operations, and no required assessment has extended into the simulator environment with objective standards for manual flight, training, and checking.

Literature Review Summary

Reference	Focus	Summary	Limitations
Casner et al. (2014); Franks, Hay, & Mavin (2014); Geiselman, Johnson, & Buck (2013); Haslbeck et al. (2012); Helmreich (2000); Hendrickson, Goldsmith, & Johnson, (2006); Moll (2012).	Pilot Error	Pilot error and flight skill loss have become an industry concern due to reliance on automation and lack of manual flight practice. Degradation of cognitive ability is addressed, in comparison to flight performance. The distinction between proficiency errors, decision making errors, and communication errors, and training methodologies.	Research is lacking with pilot error and the root cause. In that pilots do not intentionally make errors, the underlying reasons for performance issues should be investigated with training methodologies and associated safety culture within the training environment. Pilot error may not be the cause of an accident but the result of an underlying problem.
Banbury et al. (2007); Casner, Geven, &Williams, (2013); Endsley (1995); Endsley (2001); Endsley, (2010), Gonzalez et al. (2011); Jipp & Ackerman (2016); Lindseth et al. (2013); Maurino (2000); Wickens (2002); Wickens et al. (2004);	Situation Awareness	Situation Awareness (SA) can be reduced by cognition, environmental conditions, and human factors such as fatigue and length of the flight associated with dehydration. Discussions whether automation improves or decreases SA due to cognitive overload versus reduced workload is discussed. Alternative methods with *ESSAI training, beyond FAA approved LOFT scenarios, is discussed as effective.*	An evaluation of current training methodologies is lacking associated with shortened training footprints due to AQP that may be causing overload during the training process, inhibiting learning, and further reducing SA. ESSAI could be further evaluated for effectiveness in replacing the LOFT scenario.

Literature Review Summary

Reference	Focus	Summary	Limitations
Bohle et al. (2014); Casner, Geven, & Williams (2013); Endsley (1995); Jipp & Ackerman (2016); Maurino (2000); Wickens (2002); Wickens et al. (2004)	Automaticity an adaptive expertise	Discussion to the benefits and limitations of automaticity. The discussion between automaticity, adaptive expertise, and rote memorization is further discussed in relation to SA and cognitive overload.	Currently, training methodologies appear to be designed around rote memorization, despite current research identifying limitations to included reduced situation awareness. Application of adaptive expertise could be reviewed.
Besco (1997); FAA (2008); FAA (2015d); FAA (2017a); GPO (2010); GPO (2015); English & Visser (2014); Haslbeck & Hoermann (2016); FAA (2017a); Hattie & Timperley (2007); OIG (2016); Sherman et al. (1997); Strauch, (2016)	Experience	Operational constraints prevent experience with manual flight during line operations. Pilots have been said to fly less than two minutes per cycle. Maintaining currency is a check the box process. While manual flight training during initial training has been required as of 2019, no requirement for manual flight during recency or line operations has been discussed.	Experience has shifted from manual flight experience to automation experience, leaving pilots short on flight skills due to lack of practice. However, no discussion has been ongoing to allow pilots to demonstrate the ability to manually fly the actual aircraft during on line training.

Literature Review Summary

Reference	Focus	Summary	Limitations
Bandura (1982); Bénabou & Tirole (2002); Chapman et al. (1997); Compte & Postlewaite (2004); Cuevas (2003); AA (2013d); Fischer and Budescu (2005); Hattie & Timperley (2007); Johnson & Fowler (2011); Kern (1998); McClumpha et al. (1991); Parasuraman & Wickens (2008); Stewart & John (2006)	**Confidence**	Confidence that corresponds with competence is related to operational success and resultant safety, and is critical to operational safety and efficiency. Confidence is identified with increased performance, whereas overconfidence could result in an operational hazard. Confidence in a pilot's performance with manual flight versus the automation will determine automation usage. Confidence development is discussed. Unconsciously incompetent is addressed.	Performance associated with confidence has been identified; however, due to current training methodologies, pilots may be left short in confidence in their performance, therefore fearful to disconnect the automation. Pilots should be provided the ability to demonstrate to themselves they can perform. Lack of systems and aircraft understanding may also be hidden due to a perception of confidence they understand. However, a person doesn't know what they don't know.

Literature Review Summary

Reference	Focus	Summary	Limitations
Besco (1997); Curtis et al. (2010); Darr et al. (2010); Dismukes, Berman, & Loukopoulos (2007); Endsley & Jones (2012); FAA, (1996); FAA (2013d); Rosenthal, Chamberlin, & Matchette (1993); Parasuraman & Riley (1997); Ross & Tomko (2016); Salas et al. (2010); Wise (2011); OIG, 2016	Understandin g	Lack of aircraft understanding continues to be an industry issue. Distractions of NextGen and the associated learning curve may further increase confusion. Two types of confusion are identified, and errors based on lack of understanding the experience are increasing, as multiple characteristics of confusion addressed. Inadequate training led to 19 accidents. System complexity, interface design, and substandard training lead to lack of understanding. Lack of understanding leads to poor SA.	Despite research that identifies lack of understanding to be directly connected to performance and improved situation awareness, and confusion is directly connected to airline accidents, training methodologies have not addressed improved learning.

Literature Review Summary

Reference	Focus	Summary	Limitations
BEA (2012); Bent & Chan (2010); Casner et al. (2014); FAA (2013d); Kalyuga (2009); NTSB (2010); NTSB (2014a); NTSB (2014b); OIG (2016); Paas, Renkl, & Sweller (2004); Sarter &Woods (1998); Wise (2011); Young et al. (2006)	Training	Research and accident investigations attributed automation-related pilot errors, in part, have been due to inadequate training. Sub-optimal training as one of the two most significant flight hazards. Reducing overload and restructuring information could improve learning and performance. Performance requires repetition.	A preponderance of information to improve training has been presented. However, there is no regulatory requirement for airlines or aircraft operators to heed these lessons. Investigation into safety culture and SMS that could be applied to the training department for proactive risk mitigation to avoid pilot error.
Adamski & Doyle (2005); FAA (2017a); Helmreich et al. (1999); Knowles et al. (2011); Vidulich et al. (2010); Wise (2011).	AQP	AQP, a train to proficiency program that mandates inclusion of CRM, LOFT, and line operational evaluation (LOE) scenarios enables airlines to reduce operating costs and train to proficiency. Under AQP, pilots are allowed to train themselves at home, and associated problems are identified. AQP is required to have assessment measures for both the instructors and pilots to determine success.	AQP success and assessment should be directly associated to industry accidents, incidents, and ASRS reports. Whereas performance is a result of current training, the culture of the operator and SMS with proactive risk mitigation could be reviewed and AQP revisited to redesign current aircraft systems and training methodologies.

Literature Review Summary

Reference	Focus	Summary	Limitations
Allen, Jones, & Sheffield (2010); Banbury et al. (2007); Bent & Chan (2010); Besco (1997); Bohle et al. (2014); Casner et al. (2013); Conti (2009); Dismukes (2010); Ellis et al. (2014); Endsley (1995); English & Visser (2014); Franks et al. (2014); Harris (2012); Hattie & Timperley (2007); Huddleson & Rolfe (1971); Johnson & Fowler (2011); Johnson & Goldsmith (2016); Kalyuga (2009); Matton, Raufaste, & Vautier (2013); Maurino (2000); Mavin & Roth (2014b); Morris & Moore (2000); Nemeth (2015); Paas, Renkl, & Sweller (2003); Vidulich et al. (2010); Walcott, & Phillips (2013); Wickens et al. (2004); Wise (2011)	Elements of learning, to include pilot debrief, cognition, feedback, self-assessment, and training assessment.	Discussion on how learning occurs, to include cognition, aptitude, repetition, feedback, and confidence. Adult learning theories, cognitive load theory, and associated training program methodologies. Effective learning strategies to include the importance of the debrief, self-assessment, and the connection between training and assessment. AQP guidelines to include assessment strategies.	There exists a great deal of research as to how people learn. However, learning concepts have not been utilized to develop pilot training programs, and training management and program developers are not required to have a learning theory background. While assessment measures have been a struggle to assess AQP success, there is no evaluation on pilots' level of understanding versus rote memorization of facts. ASRS reports are indicative of training issues, yet proactive risk mitigation strategies to improve training appears to elude regulations.

Literature Review Summary

Reference	Focus	Summary	Limitations
Adamski & Doyle (2010); Besco (2004); Chen & Chen (2012) FAA (2013b); FAA (2013d); FAA (2015a); FAA (2016); FAA (2017a); Fraher (2015); Gesell & Dempsey (2011); Goh (2003); Helmreich et al. (1999); Helmreich, Klinect, & Wilhelm (2001); Huhtala, Tolvanen, Mauno, & Feldt (2015); Leva et al. (2010); Mager & Pipe (1997); Mathew & Thomas (2004); Merkt (2010); Mearns & Flin (1999); Patankar & Sabin (2010): Reason (1997); Roughton & Crutchfield (2014); Torres (2008); Schein (2010); Skitka et al. (2000); Stolzer & Goglia (2015); Wiegmann et al. (2002)	Safety Culture	Discussion on safety culture and five sub cultures—reporting, just, flexible, informed, and learning. Corporate culture therefore extends to performance in that *how* the airline culture behaves and transcends to employee performance standards. Discussion on the history of CRM, AQP, threat and error management (TEM), and LOSA, in relation to SMS and proactive risk mitigation.	The FAA mandated airlines develop an SMS as of 2018. However, despite the mandate, airline training departments may not be applying proactive risk mitigation strategies associated with SMS.

Literature Review Summary

Reference	Focus	Summary	Limitations
Astakhova (2014); Brown & Moore (2013); Ho, Wong, & Lee (2011); Kocjan (2015); Schaufeli, et al. (2008) Vallerand, et al. (2008); Ericsson (2008)	Aviation Passion	Discussion includes types of passion to include harmonious and obsessive passion and association with work engagement and job performance.	Research is missing to assess the impact of aviation passion on pilot performance, or whether passion is connected to manual flight tendencies.

APPENDIX B

Informational Website

Informational Website

APPENDIX C

IRB Exemption

IRB Exemption

Embry-Riddle Aeronautical University
Application for IRB Approval
Exempt Determination

Principle Investigator: Karlene Petitt **Other Investigators:** Dr. David Esser
Role: Student **Campus:** World Wide **College:** COA

Project Title: Aviation Passion, Pilot Training, Aircraft Understanding, Manual Flight, and Safety Culture: Underlying Factors of Pilot Error

Submission Date: 7/31/2017 **Determination Date:** 8/23/2017

Review Board Use Only

Initial Reviewer: Teri Gabriel Date: August 3, 2017

Exempt: Yes

Approval:

Cheri Marcham, PhD	August 8, 2017		
Dr. Cheri Marcham Pre-Reviewer Signature	Date		
Michael E. Wiggins, Ed.D. [illegible]	August 23, 2017	18-011	August 22, 2018
Dr. Michael Wiggins IRB Chair Signature	Date of Approval	Approval #	Expiration Date

Brief Description: The purpose of this survey study is to identify the relationships between safety culture, pilot training, aircraft understanding, aviation passion, and the impact on automation usage, in order to identify the root cause of performance issues, beyond pilot error.

APPENDIX D

Data Collection Device

Data Collection Device

LETTER OF INTENT

Whenever an accident occurs the industry blames the pilot. However, if we continue to blame the pilot then no one needs to be accountable for necessary improvements. In 2016, the Office of the Inspector General (OIG) identified that pilots' lacked flight skills and exhibited problems monitoring their instruments. Incidents and safety reports have further identified confusion, lack of understanding, and mode awareness issues. However, this researcher hypothesizes that pilots are not to blame, but a larger system with underlying variables may be accountable.

The purpose of this research is to identify the relationships between safety culture, pilot training, understanding, aviation passion, and the impact of automation usage, in order to identify the root cause of performance issues, beyond pilot error.

You will remain anonymous—no names will be collected on the survey, ensuring your identity will never be linked to the results. Participation is voluntary and will take approximately 10-15 minutes. You may also quit at any time without issue. There will be no risk involved in your participation, and your reward will be the positive impact that this research could have on your career and the safety of our aviation industry.

It is essential your responses are authentic and genuine. Data does nothing if it does not represent reality, and the reality is—change is taking place with increased pilot hiring, NextGen and associated automation requirements, and SMS mandates. Data is necessary to assist this change in a positive direction.

Qualifications to Participate:

You must be a commercial pilot (airline, charter, corporate), with a required crew compliment of at least two pilots, and 18 years of age, or older. You may also be retired or between jobs if you were actively employed within the previous calendar year.

If you meet the qualifications and want to participate, please select the link below that will take you to the consent form, followed by the survey.

Thank you!

Sincerely,

Karlene Petitt
ERAU doctoral candidate
PetittK@my.erau.edu

Tell us about yourself (questions 1-4)

1. Seat Position:

☐ Captain ☐ Retired
☐ First Officer ☐ Between Jobs
☐ Cruise Pilot

2. Age:

☐ < 21	☐ 41-45	☐ 56-60	☐ 71-75	☐ 86-90
☐ 21-35	☐ 46-50	☐ 61-65	☐ 76-80	☐ > 90
☐ 36-40	☐ 51-55	☐ 66 -70	☐ 81-85	

3. Gender:

☐ Female ☐ Male

4. Are you currently, or have you ever been an instructor or check airman for commercial operations, general aviation or military?

☐ Yes
☐ No

"How Likely" are you… (Questions 5-30)

NOTE: Answer questions based upon your current aircraft. If you are between jobs or retired, please answer the questions based upon your most recent aircraft flown, most recent employer, and your flying behavior, training, and knowledge at the time of employment.

5. In VFR weather conditions, how likely are you to disengage ***both*** the autopilot and autothrust ***prior to*** beginning the arrival phase?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

6. How likely is it that you understand ***all*** functionality of the flight management system on your aircraft?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

7. During your employer's pilot training (ground school), how likely is it that a pilot will receive feedback to ensure clarity of aircraft systems operations?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

8. If an emergency were to occur, beyond knowing ***what*** to do by following a directed procedure, how likely are you to know ***why*** most emergency procedures are written?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

9. How likely are you to read aviation books or magazines for enjoyment?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

10. In VFR weather conditions, how likely are you to disengage ***both*** the autopilot and the autothrust on final approach ***prior to*** 1000 feet?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

11. If your aircraft lost one or more of its hydraulic systems, and the Engine Indicating and Crew Alerting System (EICAS) of something similar (if installed) and in-flight reference manuals or written procedures were ***not available***, how likely are you to know what to do?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

12. How likely is it that during your initial checkout, on your current aircraft, the systems training (ground school) was based on rote memorization versus in-depth understanding?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

13. During your initial checkout, or your current aircraft, how likely were you to repeat event sets multiple times, during simulator training, until you felt comfortable?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

14. How likely is it that you will attend an aviation conference or an aviation event within the next 12 months?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

15. How likely are you to go to the airport, or join a social media site to connect with other aviators?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

16. How likely is it that you could pass a systems oral on your current aircraft without any studying or preparation first?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

17. How likely are you to buy yourself aviation themed products? Examples include (but not limited to) an aircraft model, t-shirt, artwork, or coffee mug.

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

18. How likely is it that during your initial checkout, on your current aircraft, the procedures training in the simulator was based on rote memorization versus in-depth understanding?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

19. How likely is it that your employer will *exceed* minimum regulatory compliance?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

20. How likely are you to agree with the statement—I feel great pride being a pilot, and it defines who I am?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

21. During your initial operating experience (in-flight pilot training) on your current aircraft, how likely was it that your instructor encouraged you to disengage both the autopilot and autothrust?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

22. How likely are you to agree with the following statement—the best way to have a successful career as a pilot, is to keep quiet and not make waves?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

23. How likely is it that employee suggestions are taken into consideration by your employer?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

24. If your aircraft is on final approach (fully configured) without the autopilot ***and*** autothrust engaged, and you execute a missed approach at 200 feet, how likely are you to know ***all*** the items displayed in the flight mode annunciator (FMA) during the missed approach?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

25. In VFR weather conditions, how likely are you to fly ***without any*** automation engaged (no autopilot, no autothrust ***and*** no flight director) during the course of the flight?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

26. How likely are you to keep the autothrust engaged until ***after*** touchdown?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

27. How likely are you to critique and report any aspect of your employer's training program if you perceive it as substandard?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

28. In VFR weather conditions, how likely are you to disengage ***both*** the autopilot and the autothrust on final ***below*** 1000 feet and ***prior to*** 200 feet before touchdown?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

29. How likely was it that your pilot training (simulator) debriefing sessions included self-assessment and reflection, in conjunction with your instructor's comments?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

30. How likely is it that your employer's leadership team in pilot training, involved in program development, has knowledge of how humans learn and is aware of technology to improve learning?

Extremely Unlikely	Highly Unlikely	Unlikely	Unsure	Likely	Highly Likely	Extremely Likely
☐	☐	☐	☐	☐	☐	☐

Help us understand how you feel about automation usage. Even if you don't fly a fly-by-wire aircraft, your opinion counts. (questions 31-43)

31. What best defines your perception of manual flight?

- ☐ *Only* the Autopilot must be disengaged.
- ☐ Both the Autopilot and Autothrust *must* be disengaged.
- ☐ Autopilot, Autothrust and the Flight Director *must* be disengaged.

32. Under most circumstances I prefer to fly with the autopilot engaged.

- ☐ True
- ☐ False

33. Under most circumstances I prefer to fly with the autothrust engaged.

- ☐ True
- ☐ False

34. I believe that flying with automation is safer than manual flight

- ☐ True
- ☐ False

35. Manual flight overloads the pilot monitoring.

- ☐ True
- ☐ False

36. Manual flight reduces situation awareness.

- ☐ True
- ☐ False

37. Manual flight exposes me to the added risk of violations.

- ☐ True
- ☐ False

38. A fly-by-wire aircraft was not designed to be manually flown.

- ☐ True
- ☐ False

39. Automated aircraft are too complex to manually fly.

- ☐ True
- ☐ False

40. Manual flight with a fly-by-wire aircraft is confusing.

- ☐ True
- ☐ False

41. Company *unwritten* policy prefers pilots fly with automation.

- ☐ True
- ☐ False

42. Company *written* policy mandates automation usage.

- ☐ True
- ☐ False

43. The pilot monitoring (Captain or First Officer) generally does not want the other pilot to manually fly the aircraft.

- ☐ True
- ☐ False

Share Your Experience (Questions 44-55)

44. Current, or last flown, aircraft type:

- ☐ Airbus
- ☐ Boeing
- ☐ Bombardier
- ☐ Embraer
- ☐ Tupoloev
- ☐ Corporate Jet
- ☐ McDonnell Douglas
- ☐ Other

45. Current, or last flown, flight deck type:

- ☐ Glass Cockpit with EICAS (or similar)
- ☐ Round-dial
- ☐ Round-Dial, No EICAS, but some electronic instruments

46. Type of aircraft trim *with automation disengaged* on current, or last flown, aircraft:

- ☐ Pilot controlled trimming
- ☐ Aircraft controlled trimming

47. *Primary* type of flying with current, or most recent employer**:**

- ☐ Long-haul (defined by 3 or more required pilots)
- ☐ Short-haul (defined by 2 required pilots)

48. Typical number of flight legs per day with current, or most recent, employer:

- ☐ 1
- ☐ 2-3
- ☐ 4 or more

49. Most recent, or current, employer:

- ☐ Major Airline
- ☐ Regional Airline
- ☐ Corporate
- ☐ Charter

50. Corporate Headquarters Location: Select where your employer's corporate headquarters is located (or closest to).

- ☐ Europe
- ☐ Asia, Australia/Oceanic
- ☐ United States
- ☐ Canada
- ☐ Mexico
- ☐ South America
- ☐ Africa
- ☐ Central America/ Caribbean
- ☐ Alaska

51. Estimated *total* flight hours:

- ☐ < 500
- ☐ 501 to 2,000
- ☐ 2,001 to 5,000
- ☐ 5,001 to 10,000
- ☐ >10,001

52. Estimated flight hours for your ***primary*** job in the previous 12 months:

None	1 to 400	401 to 700	701 to 1,000	> 1,000
☐	☐	☐	☐	☐

53. Estimated *recreational* flight hours in the previous 12 months:

None	1 to 400	401 to 700	701 to 1,000	> 1,000
☐	☐	☐	☐	☐

54. Primary flight training: where you earned your pilot certificate.

- ☐ Air Force
- ☐ Navy/Marine/Coast Guard
- ☐ Army
- ☐ Other Military
- ☐ Flight College
- ☐ General Aviation
- ☐ Other

55. Initial training: How long has it been since you attended the initial training program on your current, or last flown, aircraft?

- ☐ <1 year
- ☐ 1 year to 3 years
- ☐ >3 to 5 years
- ☐ >5 to 10 years
- ☐ >10 years

Tell us about Your Pilot Training (Questions 56-68 The End!)

56. Did you utilize supplemental training information while studying for your current, or last flown, aircraft beyond company provided materials? Examples: study guides, notes from friends, online training materials, etc.

- ☐ Yes
- ☐ No

57. Do you feel the supplemental material was necessary to learn the aircraft?

- ☐ Yes
- ☐ No
- ☐ Not applicable

58. Type of ground school for your current, or last flown, aircraft:

- ☐ Classroom with instructor
- ☐ Self taught
- ☐ Combination of both

59. Type of systems assessment for your current, or last flown, aircraft:

- ☐ Electronic or written systems test
- ☐ Systems oral, beyond limitations, conducted by a check airman or equivalent
- ☐ Combination of both
- ☐ None

60. On average, how often do you (did you) perform 3 takeoffs and landings in a simulator to maintain takeoff and landing currency?

- ☐ One time per year
- ☐ Twice per year
- ☐ Three times per year
- ☐ Rarely or never needed simulator training for currency

61. Company's recurrent training schedule:

- ☐ 6 months
- ☐ 9 months
- ☐ 12 months
- ☐ Other

62. Average debriefing time after each initial training simulator event:

- ☐ < 15 minutes
- ☐ 15 minutes to 30 minutes
- ☐ 31 minutes to 60 minutes
- ☐ > 60 minutes

63. During your debriefing session, did your instructor allow you to verbally self-assess and reflect upon your training experience?

- ☐ Yes
- ☐ No

64. Which statement best describes how you prepared to pass your aircraft system validation test or oral:

- ☐ Memorized facts and procedures
- ☐ Learned to understand systems and processes

65. During our operating experience on the aircraft did your instructor request you to disengage both the autopilot and autothrust and fly manually?

- ☐ Yes
- ☐ No

66. Is your employer, or most recent employer, AQP Certified?

- ☐ Yes
- ☐ No
- ☐ Not sure

67. Was a video of your performance during training utilized to debrief your training sessions?

- ☐ Yes
- ☐ No

68. During your initial training, was your simulator session comprised of a normal crew compliment? (Example: first officer paired with a captain)

- ☐ Yes
- ☐ No
- ☐ Sometimes

THANK YOU
For Your Participation!

"The world is a dangerous place, not because of those who do evil,
but those who sit back and do nothing."
Albert Einstein

Thank you for making a difference!

APPENDIX E

Permission to Conduct Research

Permission to Conduct Research

EMBRY-RIDDLE
Aeronautical University

Dissertation Proposal Approval Form

Student Name: Karlene K Petitt ID# 194,020

Department of: Doctoral Studies

Proposed Title: Training, Understanding, and Safety Culture: Underlying Factors Of Pilot Error

***Committee Approval** (Please print names. **List University organization if other than ERAU.)

Chairperson:	Dr. David Esser	**University:	Embry-Riddle University
Dept:	Aeronautical Science	Signature:	David A. Esser
Member:	Dr. Alan Stolzer	**University:	Embry-Riddle University
Dept:	College of Aviation	Signature:	Alan J. Stolzer
Member:	Dr. Haydee Cuevas	**University:	Embry-Riddle University
Dept:	School of Graduate Studies	Signature:	Haydee M. Cuevas
Member:		**University:	
Dept:		Signature:	

External Member:	Dr. Tony Kern	**Affiliation:	Safety Standdown
Dept:		Signature:	Tony Kern

Administrative Approval:

Department Chair	Signature:

APPENDIX F

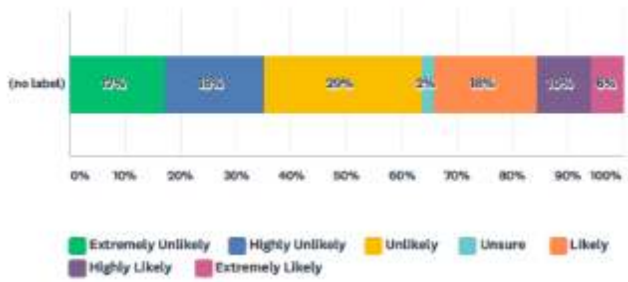
SEM Question Results

SEM Question Results

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q7 6. In day VFR weather conditions, how likely are you to disengage both the autopilot and autothrust prior to beginning the arrival phase?

Answered: 6,679 Skipped: 812



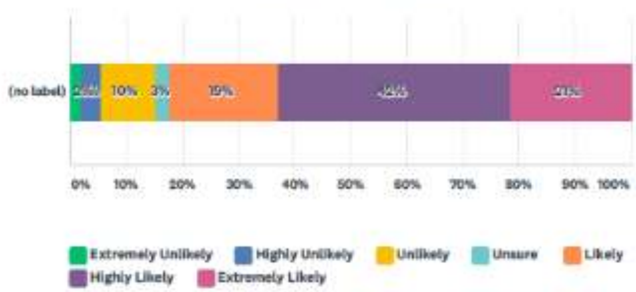
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	17% 1,145	18% 1,192	29% 1,909	2% 147	18% 1,235	10% 658	6% 393	6,679	3.40

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 3.00	Mean 3.40	Standard Deviation 1.81

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q8 7. How likely is it that you understand all functionality of the flight management system (FMS) on your aircraft? If no FMS leave blank.

Answered: 6,550 Skipped: 941

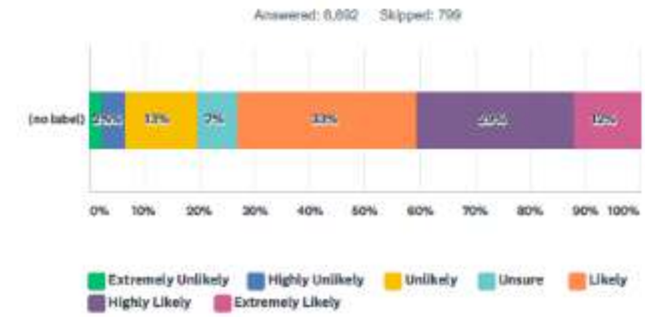


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	2% 111	4% 235	10% 645	3% 172	19% 1,254	42% 2,727	21% 1,406	6,550	5.45

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 6.00	Mean 5.45	Standard Deviation 1.45

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q9 8. During your employer's pilot training (ground school), how likely is it that a pilot will receive feedback to ensure clarity of aircraft systems operations?

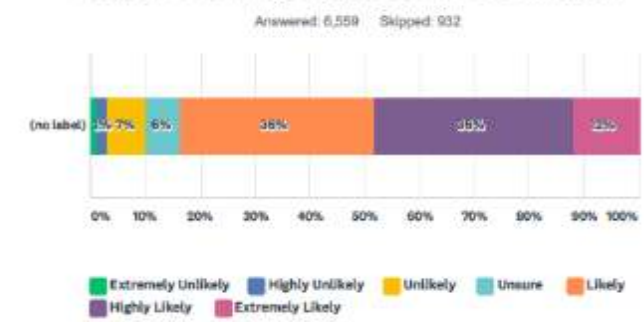


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	2% 139	4% 288	13% 872	7% 485	33% 2,185	29% 1,921	12% 803	6,692	4.98

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.98	Standard Deviation 1.44

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q10 9. If an emergency were to occur, beyond knowing what to do by following a directed procedure, how likely are you to know why most steps in an emergency procedure are written?



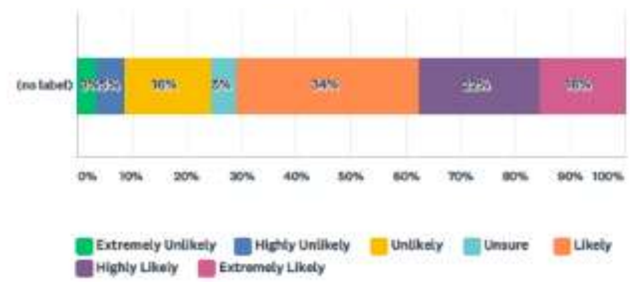
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	1% 48	2% 139	7% 470	6% 391	36% 2,340	36% 2,385	12% 786	6,559	5.31

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 5.31	Standard Deviation 1.18

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q11 10. How likely are you to read aviation books or magazines for enjoyment?

Answered: 6,560 Skipped: 931



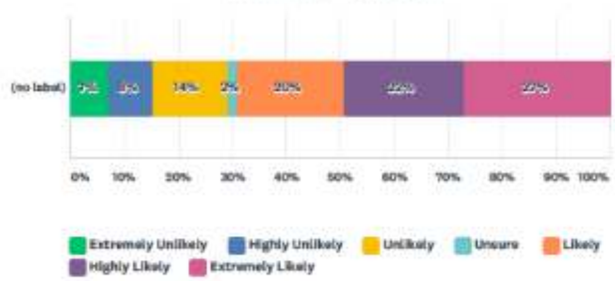
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	3% 224	5% 338	16% 1,027	5% 311	34% 2,199	22% 1,427	16% 1,034	6,560	4.88

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.88	Standard Deviation 1.59

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q12 11. In day VFR weather conditions, how likely are you to disengage both the autopilot and the autothrust on final approach prior to 1000 feet?

Answered: 6,557 Skipped: 934



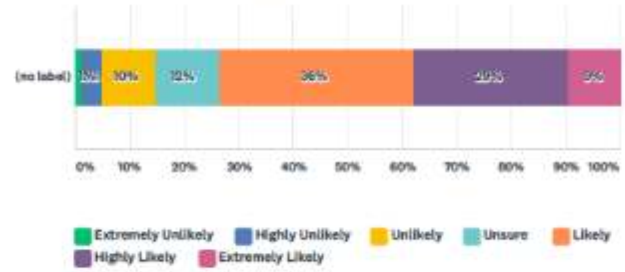
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	7% 451	8% 543	14% 901	2% 119	20% 1,306	22% 1,454	27% 1,783	6,557	4.95

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.95	Standard Deviation 1.93

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q13 12. If your aircraft lost one or more of its hydraulic systems, and the Engine Indicating and Crew Alerting System (EICAS) or something similar (if installed) and in-flight reference manuals or written procedures were not available, how likely are you to know what to do?

Answered: 6,360 Skipped: 1,131



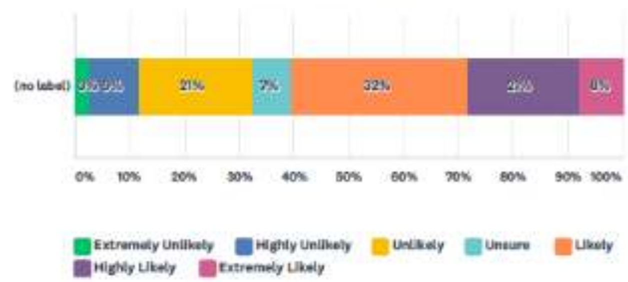
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	1% 66	4% 238	10% 617	12% 755	36% 2,289	29% 1,821	9% 594	6,360	5.01

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 5.01	Standard Deviation 1.29

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q14 13. How likely is it that during your initial checkout, on your current aircraft, the systems training (ground school) was based on rote memorization versus in-depth understanding?

Answered: 6,369 Skipped: 1,122



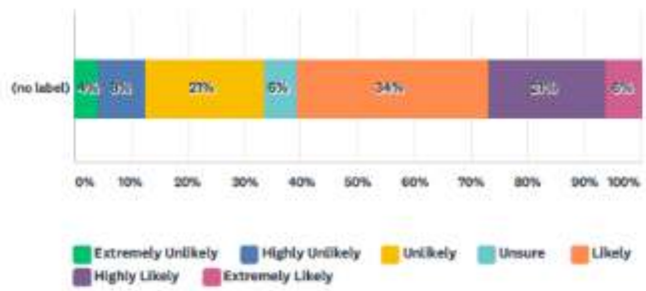
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	3% 168	9% 577	21% 1,320	7% 445	32% 2,051	21% 1,314	8% 496	6,369	4.50

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.50	Standard Deviation 1.56

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q15 14. During your initial checkout, on your current aircraft, how likely were you to repeat event sets multiple times, during simulator training, until you felt comfortable?

Answered: 6,365 Skipped: 1,126



	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	4% 259	8% 535	21% 1,325	6% 376	34% 2,147	21% 1,323	6% 400	6,365	4.44

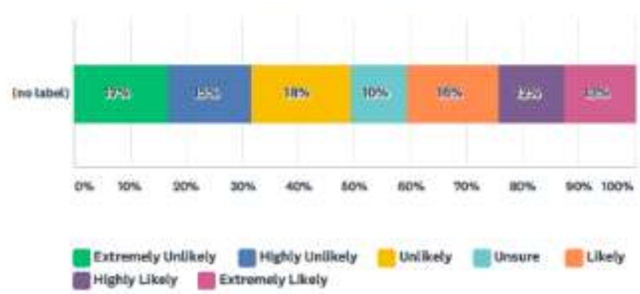
BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	7.00	5.00	4.44	1.56

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q16 15. How likely is it that you will attend an aviation conference or an aviation social event within the next 12 months?

Answered: 6,334 Skipped: 1,157



	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHT AVERAG
(no label)	17% 1,052	15% 946	18% 1,119	10% 640	16% 1,039	12% 744	13% 794	6,334	3

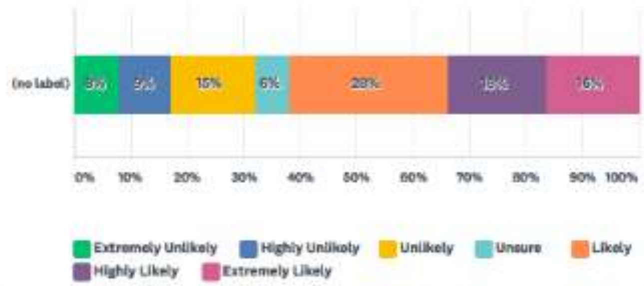
BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	7.00	4.00	3.80	2.00

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q17 16. How likely are you to go to the airport, or join a social media site to connect in order to socialize with other aviators?

Answered: 6,334 Skipped: 1,157



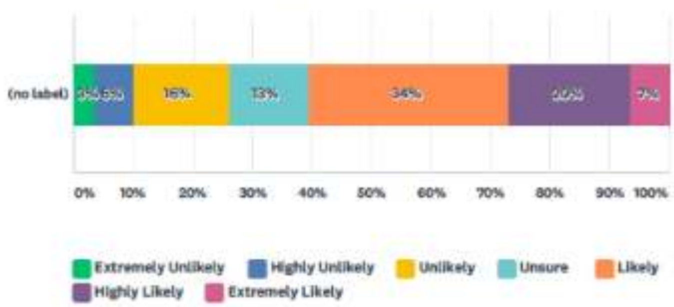
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	8% 499	9% 577	15% 948	6% 375	28% 1,781	18% 1,122	16% 1,032	6,334	4.56

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.56	Standard Deviation 1.84

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q18 17. How likely is it that you could pass a systems oral on your current aircraft without any studying or preparation first?

Answered: 6,332 Skipped: 1,159



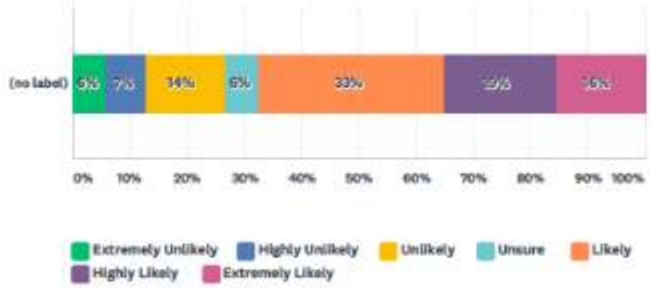
	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	3% 214	6% 411	16% 1,029	13% 843	34% 2,131	20% 1,280	7% 424	6,332	4.55

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.55	Standard Deviation 1.47

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q19 18. How likely are you to acquire aviation themed products? Examples include (but not limited to) an aircraft model, t-shirt, artwork, or coffee mug.

Answered: 6,262 Skipped: 1,229

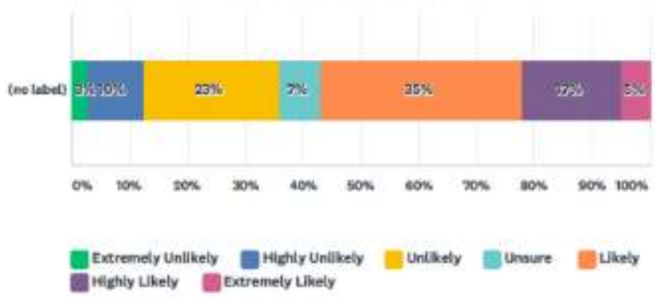


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	6% 351	7% 437	14% 888	6% 368	33% 2,040	19% 1,214	16% 984	6,262	4.74

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.74	Standard Deviation 1.70

Q20 19. How likely is it that during your initial checkout, on your current aircraft, the procedures training in the simulator was based on rote memorization versus in-depth understanding?

Answered: 6,249 Skipped: 1,242

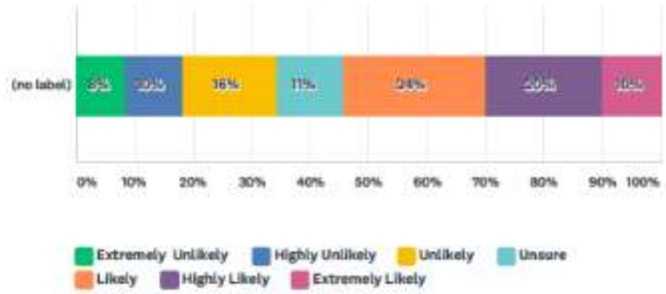


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	3% 159	10% 617	23% 1,465	7% 444	35% 2,189	17% 1,073	5% 302	6,249	4.33

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.33	Standard Deviation 1.49

Q21 20. How likely is it that your employer will exceed minimum regulatory compliance?

Answered: 6,260 Skipped: 1,231

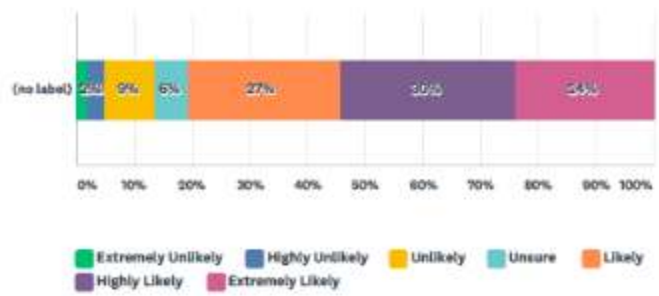


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	8% 518	10% 611	16% 1,010	11% 713	24% 1,518	20% 1,247	10% 643	6,260	4.34

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.34	Standard Deviation 1.77

Q22 21. How likely are you to agree with the statement—I feel great pride being a pilot, and it defines who I am?

Answered: 6,205 Skipped: 1,286

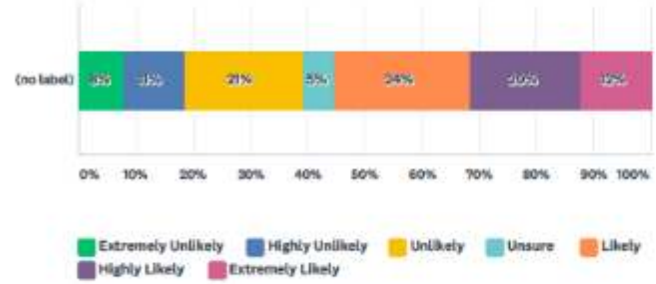


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	2% 109	3% 191	9% 539	6% 350	27% 1,652	30% 1,878	24% 1,486	6,205	5.39

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 6.00	Mean 5.39	Standard Deviation 1.44

Q23 22. During your initial operating experience (in-flight pilot training) on your current aircraft, how likely was it that your instructor encouraged you to disengage both the autopilot and autothrust?

Answered: 6,192 Skipped: 1,299

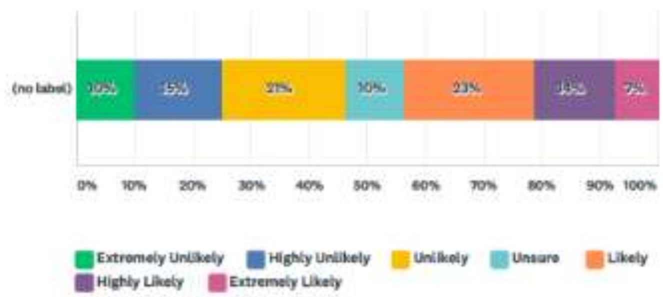


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	8% 489	11% 651	21% 1,283	5% 338	24% 1,463	20% 1,210	12% 758	6,192	4.34

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.34	Standard Deviation 1.83

Q24 23. How likely are you to agree with the following statement—the best way to have a successful career as a pilot, is to keep quiet and not make waves?

Answered: 6,201 Skipped: 1,290

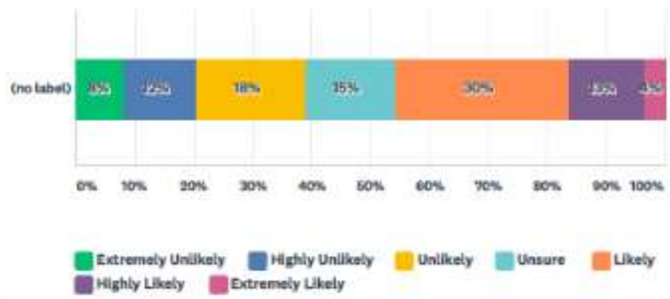


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	10% 614	15% 933	21% 1,315	10% 621	23% 1,402	14% 856	7% 460	6,201	3.91

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 4.00	Mean 3.91	Standard Deviation 1.77

Q25 24. How likely is it that employee suggestions are taken into consideration by your employer?

Answered: 6,143 Skipped: 1,348

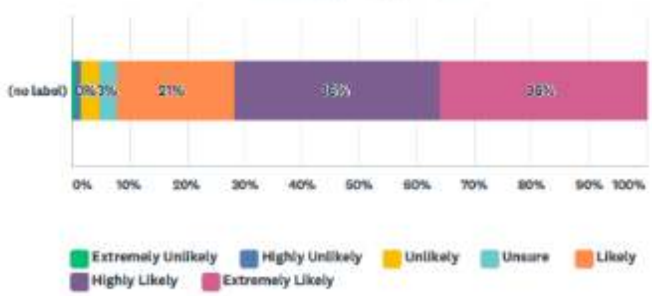


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	8% 494	12% 752	18% 1,136	15% 932	30% 1,820	13% 793	4% 216	6,143	3.99

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 4.00	Mean 3.99	Standard Deviation 1.59

Q26 25. If your aircraft is on final approach (fully configured) without the autopilot and autothrust engaged, and you execute a missed approach at 200 feet, how likely are you to know all the items displayed in the flight mode annunciator (FMA) during the missed approach? If no FMA leave blank.

Answered: 5,930 Skipped: 1,561

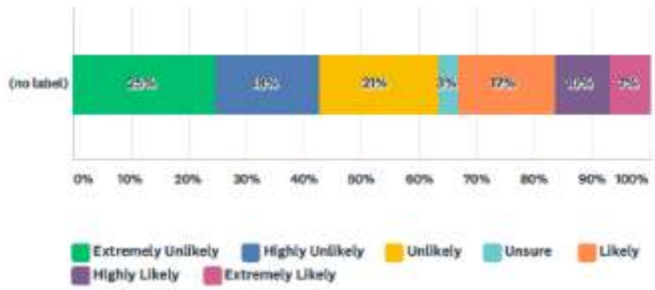


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	0% 25	1% 59	3% 207	3% 158	21% 1,222	36% 2,119	36% 2,140	5,930	5.94

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 6.00	Mean 5.94	Standard Deviation 1.12

Q27 26. In day VFR weather conditions, how likely are you to fly without any automation engaged (no autopilot, no autothrust and no flight director) during the course of the flight?

Answered: 6,135 Skipped: 1,356

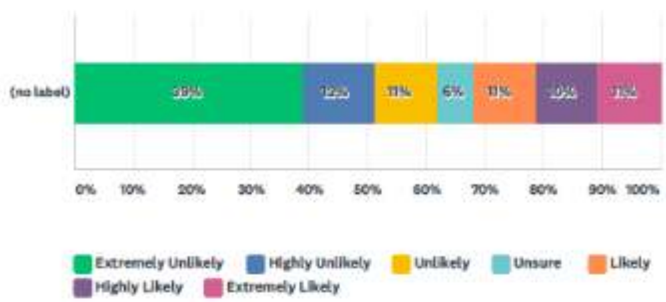


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	25% 1,510	18% 1,117	21% 1,272	3% 194	17% 1,034	10% 592	7% 416	6,135	3.26

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 3.00	Mean 3.26	Standard Deviation 1.94

Q28 27. How likely are you to keep the autothrust engaged until after touchdown?

Answered: 5,836 Skipped: 1,655

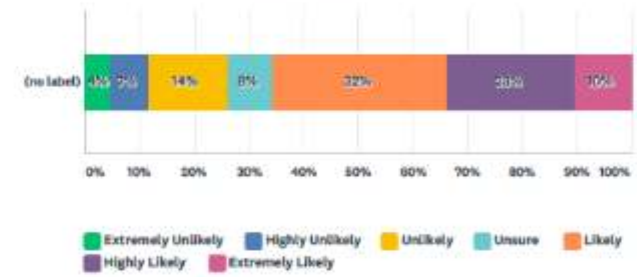


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	39% 2,279	12% 693	11% 625	6% 379	11% 623	10% 588	11% 649	5,836	3.13

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 2.00	Mean 3.13	Standard Deviation 2.20

Q29 28. How likely are you to critique and report any aspect of your employer's training program if you perceive it as substandard?

Answered: 6,079 Skipped: 1,412

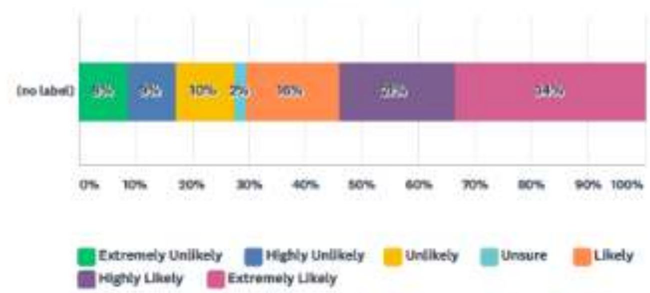


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	4% 273	7% 424	14% 881	8% 494	32% 1,952	23% 1,422	10% 633	6,079	4.68

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.68	Standard Deviation 1.60

Q30 29. In day VFR weather conditions, how likely are you to disengage both the autopilot and the autothrust on final below 1000 feet and prior to 200 feet before touchdown?

Answered: 6,059 Skipped: 1,432

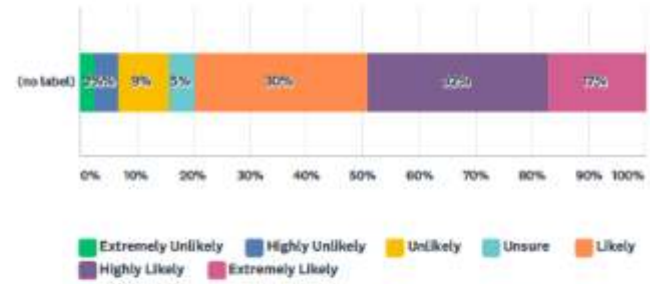


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	8% 515	9% 518	10% 628	2% 127	16% 996	21% 1,245	34% 2,030	6,059	5.05

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 6.00	Mean 5.05	Standard Deviation 2.03

Q31 30. How likely was it that your pilot training (simulator) debriefing sessions included self-assessment and reflection, in conjunction with your instructor's comments?

Answered: 6,011 Skipped: 1,480

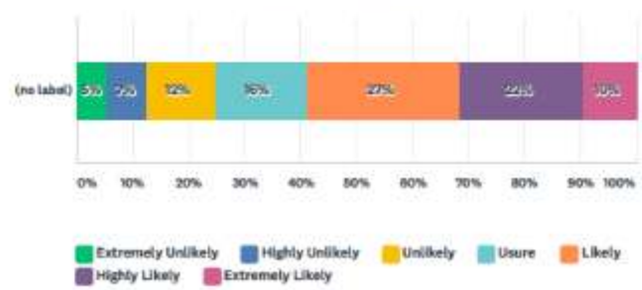


	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	UNSURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	2% 142	4% 253	9% 548	5% 282	30% 1,833	32% 1,933	17% 1,020	6,011	5.21

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 5.21	Standard Deviation 1.46

Q32 31. How likely is it that your employer's leadership team in pilot training, involved in program development, has knowledge of how humans learn and is aware of technology to improve learning?

Answered: 6,015 Skipped: 1,476



	EXTREMELY UNLIKELY (1)	HIGHLY UNLIKELY (2)	UNLIKELY (3)	USURE (4)	LIKELY (5)	HIGHLY LIKELY (6)	EXTREMELY LIKELY (7)	TOTAL	WEIGHTED AVERAGE
(no label)	5% 319	7% 427	12% 736	16% 982	27% 1,639	22% 1,338	10% 574	6,015	4.58

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.58	Standard Deviation 1.60

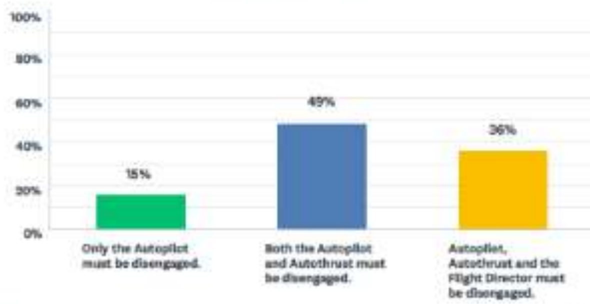
APPENDIX G

Automation, Training, and Processes Results

Automation, Training, and Processes Results

Q33 32. What best defines your perception of manual flight?

Answered: 5,948 Skipped: 1,543



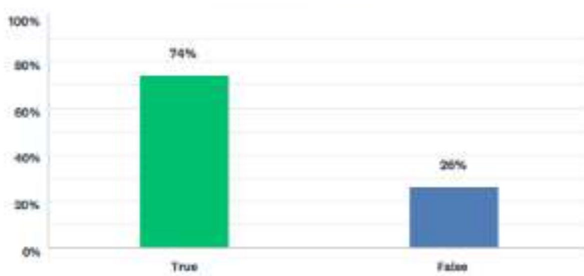
ANSWER CHOICES	RESPONSES	
Only the Autopilot must be disengaged. (1)	15%	909
Both the Autopilot and Autothrust must be disengaged. (2)	49%	2,899
Autopilot, Autothrust and the Flight Director must be disengaged. (3)	36%	2,140
TOTAL		5,948

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	3.00	2.00	2.21	0.69

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q34 33. Under most circumstances I prefer (or preferred) to fly with the autopilot engaged.

Answered: 5,947 Skipped: 1,544



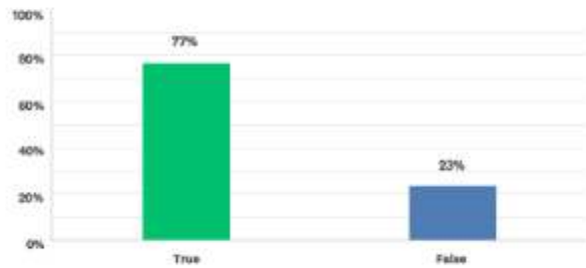
ANSWER CHOICES	RESPONSES	
True (1)	74%	4,386
False (2)	26%	1,561
TOTAL		5,947

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.26	0.44

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q35 34. Under most circumstances I prefer (or preferred) to fly with the autothrust engaged.

Answered: 5,791 Skipped: 1,700



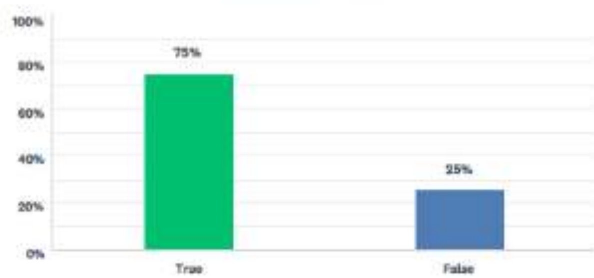
ANSWER CHOICES	RESPONSES	
True (1)	77%	4,447
False (2)	23%	1,344
TOTAL		5,791

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.23	Standard Deviation 0.42

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q36 35. I believe that flying with automation is safer than manual flight.

Answered: 5,928 Skipped: 1,563



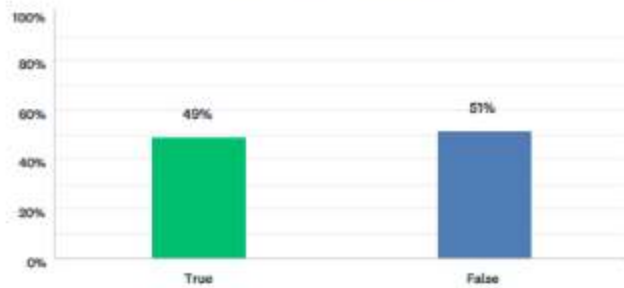
ANSWER CHOICES	RESPONSES	
True (1)	75%	4,447
False (2)	25%	1,481
TOTAL		5,928

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.25	Standard Deviation 0.43

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q37 36. Manual flight overloads the pilot monitoring.

Answered: 5,945 Skipped: 1,546



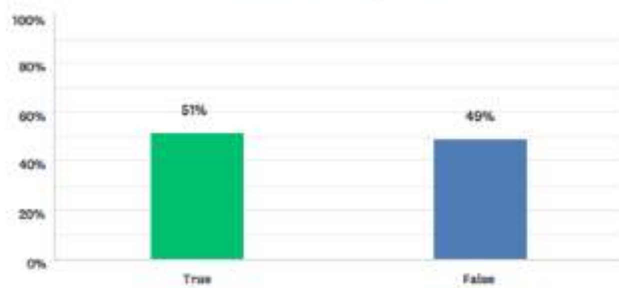
ANSWER CHOICES	RESPONSES	
True (1)	49%	2,911
False (2)	51%	3,034
TOTAL		5,945

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.51	Standard Deviation 0.50

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q38 37. Manual flight reduces situation awareness.

Answered: 5,923 Skipped: 1,568



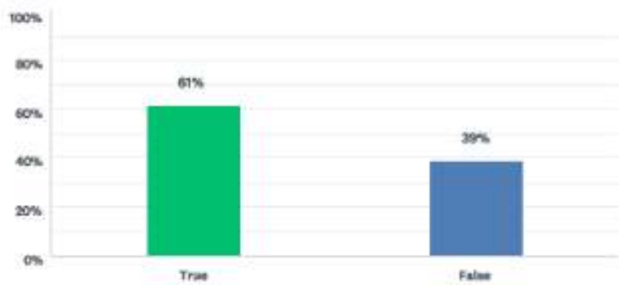
ANSWER CHOICES	RESPONSES	
True (1)	51%	3,041
False (2)	49%	2,882
TOTAL		5,923

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.49	Standard Deviation 0.50

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q39 38. Manual flight exposes me to the added risk of violations.

Answered: 5,916 Skipped: 1,575



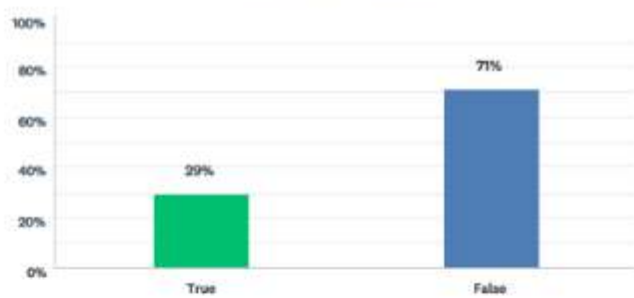
ANSWER CHOICES	RESPONSES	
True (1)	61%	3,631
False (2)	39%	2,285
TOTAL		5,916

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.39	0.49

ERAU Worldwide Commercial Pilot Survey Embry-Riddle Aeronautical University Doctoral Research

Q40 39. A fly-by-wire aircraft was not designed to be manually flown.

Answered: 5,863 Skipped: 1,628

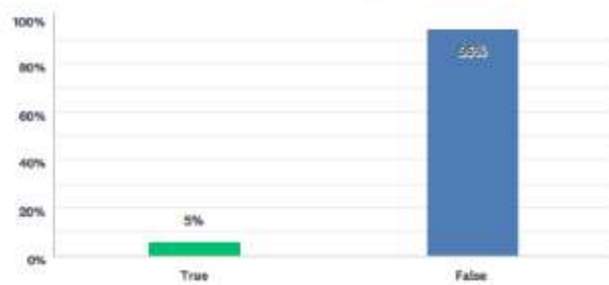


ANSWER CHOICES	RESPONSES	
True (1)	29%	1,683
False (2)	71%	4,180
TOTAL		5,863

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	2.00	1.71	0.45

Q41 40. Automated aircraft are too complex to manually fly.

Answered: 5,897 Skipped: 1,594

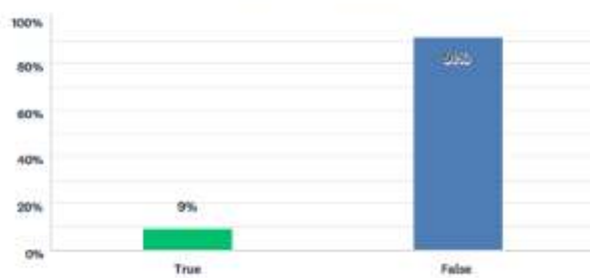


ANSWER CHOICES	RESPONSES	
True (1)	5%	317
False (2)	95%	5,580
TOTAL		5,897

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	2.00	1.95	0.23

Q42 41. Manual flight with a fly-by-wire aircraft is confusing.

Answered: 5,785 Skipped: 1,706

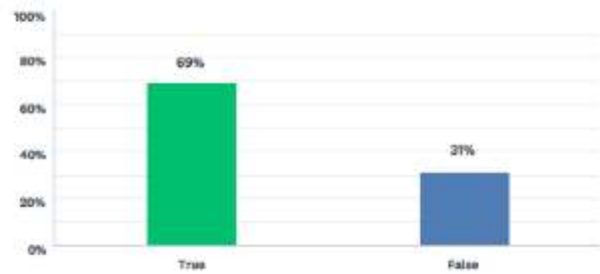


ANSWER CHOICES	RESPONSES	
True (1)	9%	518
False (2)	91%	5,267
TOTAL		5,785

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	2.00	1.91	0.29

Q43 42. Company unwritten policy prefers pilots fly with automation.

Answered: 5,883 Skipped: 1,608

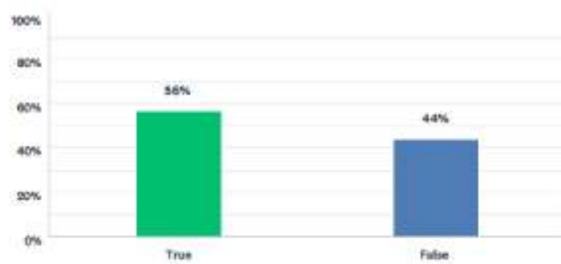


ANSWER CHOICES	RESPONSES	
True (1)	69%	4,054
False (2)	31%	1,829
TOTAL		5,883

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.31	0.46

Q44 43. Company written policy mandates automation usage.

Answered: 5,868 Skipped: 1,623

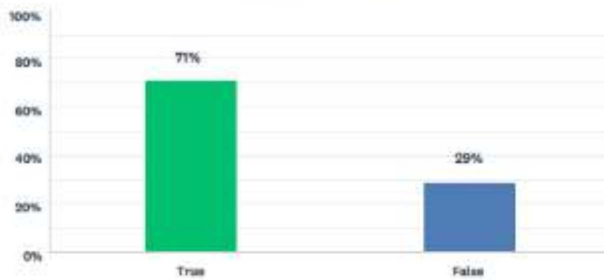


ANSWER CHOICES	RESPONSES	
True (1)	56%	3,309
False (2)	44%	2,559
TOTAL		5,868

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.44	0.50

Q45 44. The pilot monitoring (Captain of First Officer) generally prefers the pilot flying to utilize automation.

Answered: 5,868 Skipped: 1,823

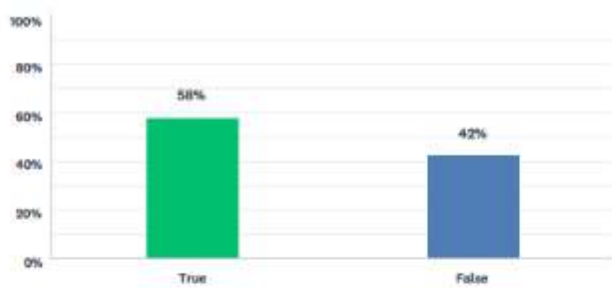


ANSWER CHOICES	RESPONSES	
True (1)	71%	4,168
False (2)	29%	1,700
TOTAL		5,868

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.29	Standard Deviation 0.45

Q46 45. The pilots I fly with rarely, if ever, fly without the autopilot or autothrust engaged.

Answered: 5,871 Skipped: 1,820

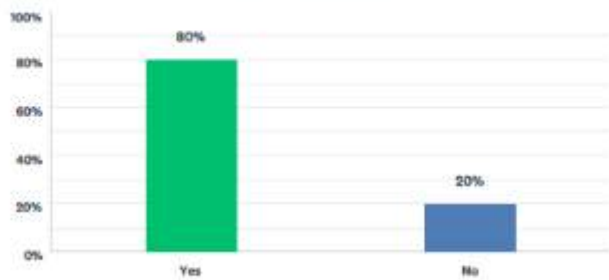


ANSWER CHOICES	RESPONSES	
True (1)	58%	3,382
False (2)	42%	2,489
TOTAL		5,871

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.42	Standard Deviation 0.49

Q47 46. Did you utilize supplemental training information while studying for your current, or last flown, aircraft beyond company provided materials, in the form of (but not limited to) study guides, notes from friends, and or online training materials?

Answered: 5,862 Skipped: 1,629

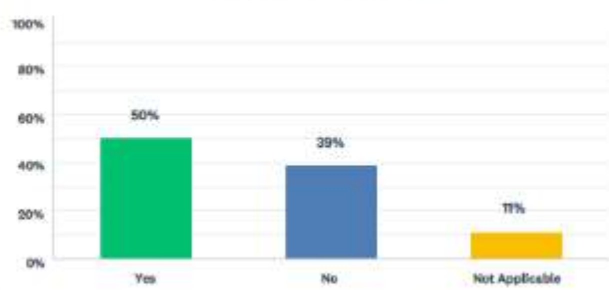


ANSWER CHOICES	RESPONSES	
Yes (1)	80%	4,688
No (2)	20%	1,174
TOTAL		5,862

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.20	0.40

Q48 47. Do you feel the supplemental material was necessary to learn the aircraft?

Answered: 5,865 Skipped: 1,626

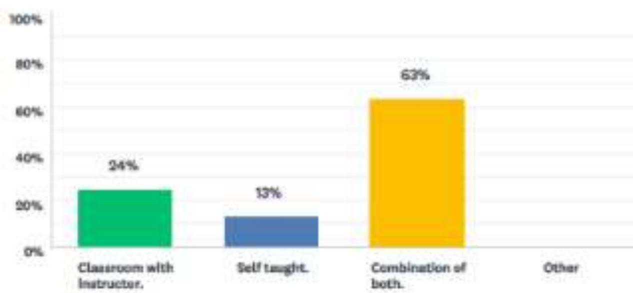


ANSWER CHOICES	RESPONSES	
Yes (1)	50%	2,955
No (2)	39%	2,261
Not Applicable (3)	11%	649
TOTAL		5,865

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	3.00	1.00	1.61	0.68

Q49 48. Type of initial ground school for your current, or last flown, aircraft:

Answered: 5,865 Skipped: 1,626

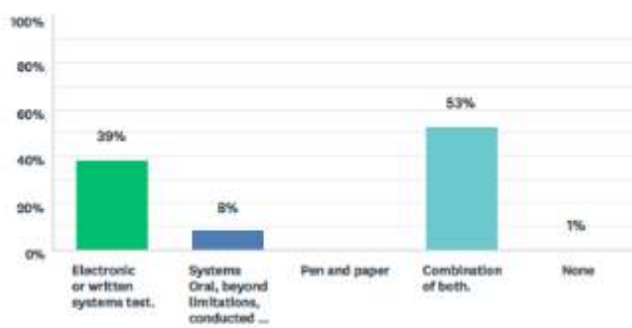


ANSWER CHOICES	RESPONSES	
Classroom with instructor. (1)	24%	1,427
Self taught. (2)	13%	748
Combination of both. (3)	63%	3,690
Other (4)	0%	0
TOTAL		5,865

BASIC STATISTICS				
Minimum 1.00	Maximum 3.00	Median 3.00	Mean 2.39	Standard Deviation 0.85

Q50 49. Type of systems assessment for your current, or last flown, aircraft.

Answered: 5,844 Skipped: 1,647

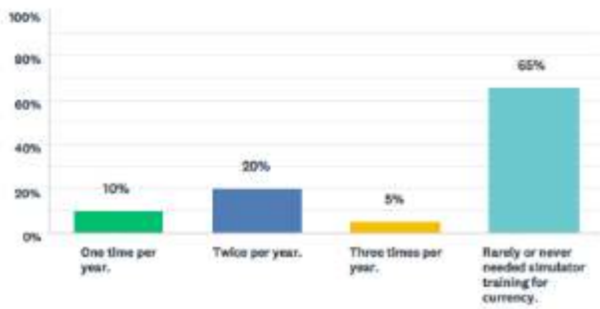


ANSWER CHOICES	RESPONSES	
Electronic or written systems test. (1)	39%	2,263
Systems Oral, beyond limitations, conducted by a check airman or equivalent. (2)	8%	456
Pen and paper (3)	0%	0
Combination of both. (4)	53%	3,082
None (5)	1%	43
TOTAL		5,844

BASIC STATISTICS				
Minimum 1.00	Maximum 5.00	Median 4.00	Mean 2.69	Standard Deviation 1.44

Q51 50. On average, how often do you (did you) perform 3 takeoffs and landings in a simulator to maintain takeoff and landing currency?

Answered: 5,839 Skipped: 1,652

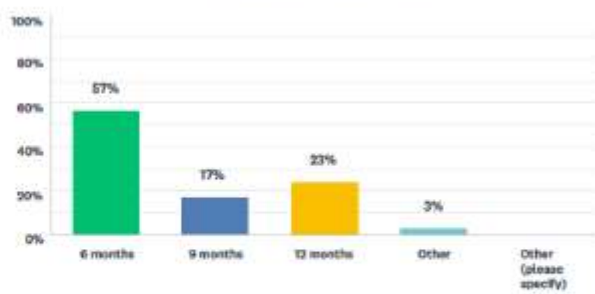


ANSWER CHOICES	RESPONSES	
One time per year. (1)	10%	555
Twice per year. (2)	20%	1,172
Three times per year. (3)	5%	292
Rarely or never needed simulator training for currency. (4)	65%	3,820
TOTAL		5,839

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	4.00	3.26	1.08

Q52 51. Company's recurrent training schedule:

Answered: 5,842 Skipped: 1,649

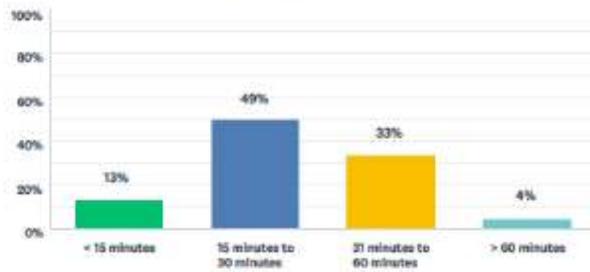


ANSWER CHOICES	RESPONSES	
6 months (1)	57%	3,304
9 months (2)	17%	1,004
12 months (3)	23%	1,365
Other (4)	3%	169
Other (please specify) (5)	0%	0
TOTAL		5,842

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	1.00	1.73	0.92

Q53 52. Average debriefing time after each initial training simulator event:

Answered: 5,831 Skipped: 1,660

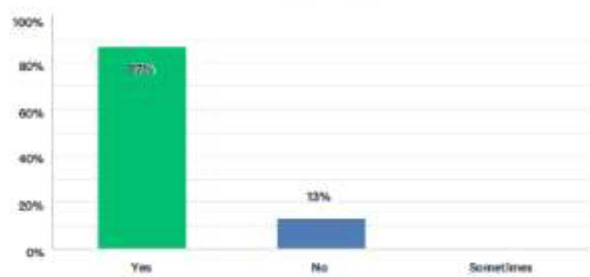


ANSWER CHOICES	RESPONSES	
< 15 minutes (1)	13%	762
15 minutes to 30 minutes (2)	49%	2,873
31 minutes to 60 minutes (3)	33%	1,941
> 60 minutes (4)	4%	255
TOTAL		5,831

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	2.00	2.29	0.74

Q54 53. During your debriefing session, did your instructor allow you to verbally self-assess and reflect upon your training experience?

Answered: 5,829 Skipped: 1,662

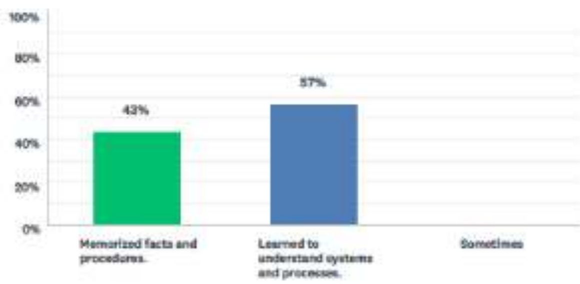


ANSWER CHOICES	RESPONSES	
Yes (1)	87%	5,060
No (2)	13%	769
Sometimes (3)	0%	0
TOTAL		5,829

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.13	0.34

Q55 54. Which statement best describes how you prepared to pass your aircraft system validation test or oral:

Answered: 5,823 Skipped: 1,668

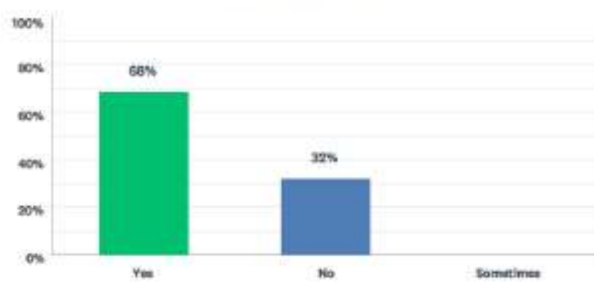


ANSWER CHOICES	RESPONSES	
Memorized facts and procedures. (1)	43%	2,528
Learned to understand systems and processes. (2)	57%	3,295
Sometimes (3)	0%	0
TOTAL		5,823

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.57	Standard Deviation 0.50

Q56 55. During your operating experience on the aircraft, did your instructor request you to disengage both the autopilot and autothrust, and fly manually?

Answered: 5,819 Skipped: 1,672

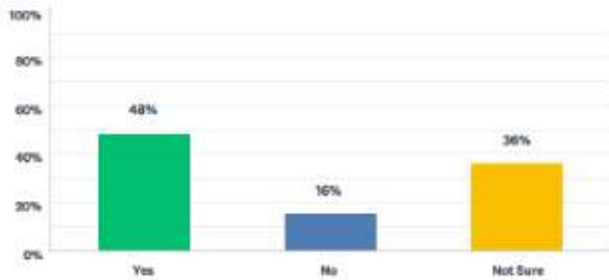


ANSWER CHOICES	RESPONSES	
Yes (1)	68%	3,984
No (2)	32%	1,835
Sometimes (3)	0%	0
TOTAL		5,819

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.32	Standard Deviation 0.46

Q57 56. Is your employer, or most recent employer, AQP Certified?

Answered: 5,811 Skipped: 1,680

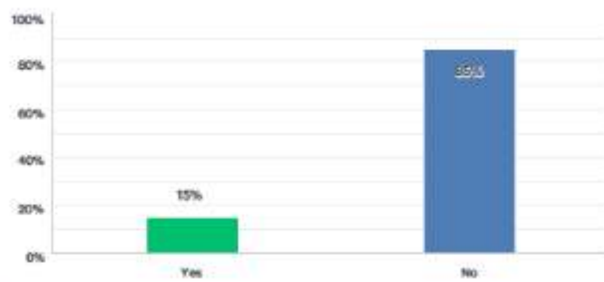


ANSWER CHOICES	RESPONSES	
Yes (1)	48%	2,802
No (2)	16%	901
Not Sure (3)	36%	2,108
TOTAL		5,811

BASIC STATISTICS				
Minimum 1.00	Maximum 3.00	Median 2.00	Mean 1.88	Standard Deviation 0.91

Q58 57. Was a video of your performance during training utilized to debrief your training sessions?

Answered: 5,820 Skipped: 1,671

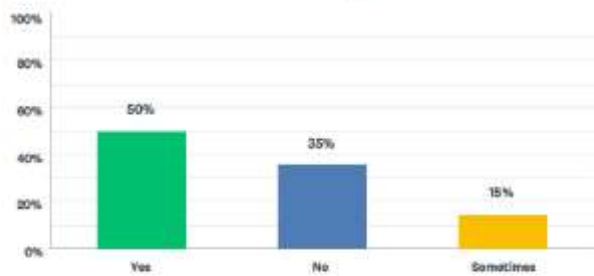


ANSWER CHOICES	RESPONSES	
Yes (1)	15%	864
No (2)	85%	4,956
TOTAL		5,820

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.85	Standard Deviation 0.36

Q59 58. During your initial training, was your simulator session comprised of a normal crew compliment? (Example: first officer paired with a captain.)

Answered: 5,812 Skipped: 1,679

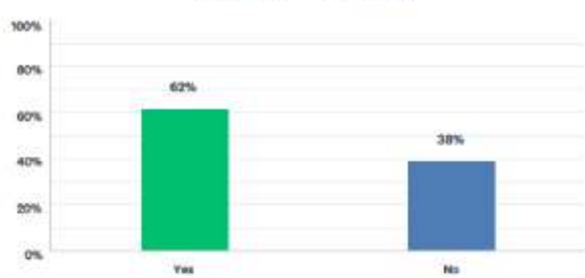


ANSWER CHOICES	RESPONSES	
Yes (1)	50%	2,899
No (2)	35%	2,062
Sometimes (3)	15%	851
TOTAL		5,812

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	3.00	2.00	1.65	0.72

Q60 59. Are you currently, or have you ever been an instructor or check airman for commercial operations, general aviation, or military?

Answered: 5,799 Skipped: 1,692

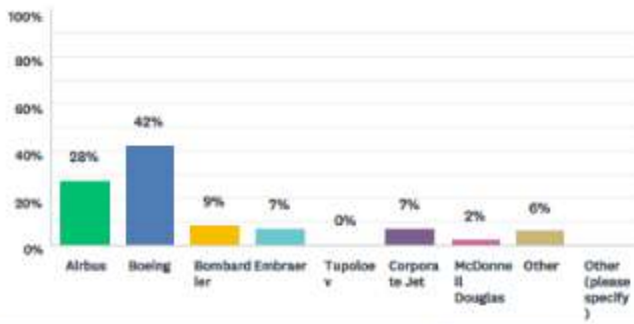


ANSWER CHOICES	RESPONSES	
Yes (1)	62%	3,568
No (2)	38%	2,231
TOTAL		5,799

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.38	0.49

Q61 60. Current, or last flown, aircraft type:

Answered: 5,805 Skipped: 1,686

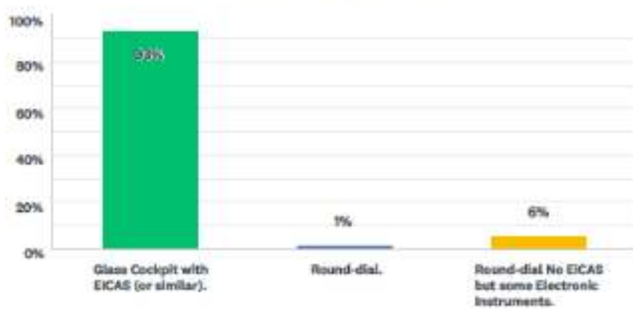


ANSWER CHOICES	RESPONSES	
Airbus (1)	28%	1,608
Boeing (2)	42%	2,450
Bombardier (3)	9%	500
Embraer (4)	7%	396
Tupoloev (5)	0%	5
Corporate Jet (6)	7%	399
McDonnell Douglas (7)	2%	109
Other (8)	6%	338
Other (please specify) (9)	0%	0
TOTAL		5,805

BASIC STATISTICS				
Minimum 1.00	Maximum 8.00	Median 2.00	Mean 2.67	Standard Deviation 1.97

Q62 61. Current, or last flown, Flight Deck Type:

Answered: 5,799 Skipped: 1,692

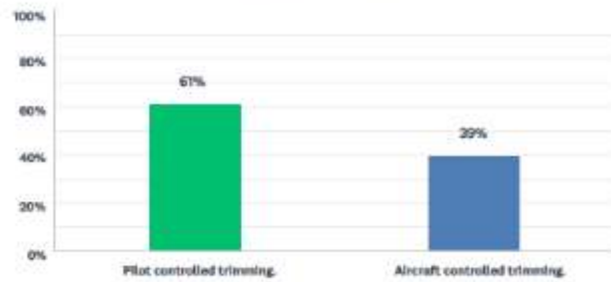


ANSWER CHOICES	RESPONSES	
Glass Cockpit with EICAS (or similar). (1)	93%	5,387
Round-dial. (2)	1%	84
Round-dial No EICAS but some Electronic Instruments. (3)	6%	328
TOTAL		5,799

BASIC STATISTICS				
Minimum 1.00	Maximum 3.00	Median 1.00	Mean 1.13	Standard Deviation 0.47

Q63 62. Type of Aircraft Trim with automation disengaged on current, or last flown, aircraft:

Answered: 5,776 Skipped: 1,715

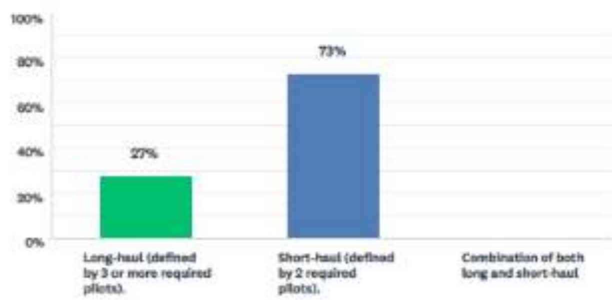


ANSWER CHOICES	RESPONSES	
Pilot controlled trimming. (1)	61%	3,520
Aircraft controlled trimming. (2)	39%	2,256
TOTAL		5,776

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 1.00	Mean 1.39	Standard Deviation 0.49

Q64 63. Primary type of flying with current, or most recent, employer:

Answered: 5,783 Skipped: 1,708

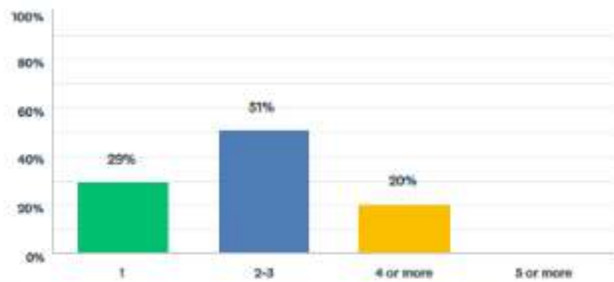


ANSWER CHOICES	RESPONSES	
Long-haul (defined by 3 or more required pilots). (1)	27%	1,585
Short-haul (defined by 2 required pilots). (2)	73%	4,198
Combination of both long and short-haul (3)	0%	0
TOTAL		5,783

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.73	Standard Deviation 0.45

Q65 64. Typical number of flight legs per day with current, or most recent, employer:

Answered: 5,786 Skipped: 1,705

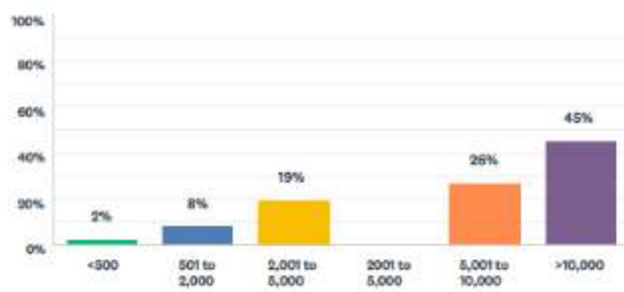


ANSWER CHOICES	RESPONSES	
1 (1)	29%	1,696
2-3 (2)	51%	2,927
4 or more (3)	20%	1,163
5 or more (4)	0%	0
TOTAL		5,786

BASIC STATISTICS				
Minimum 1.00	Maximum 3.00	Median 2.00	Mean 1.91	Standard Deviation 0.70

Q66 65. Estimated total flight hours:

Answered: 5,789 Skipped: 1,702

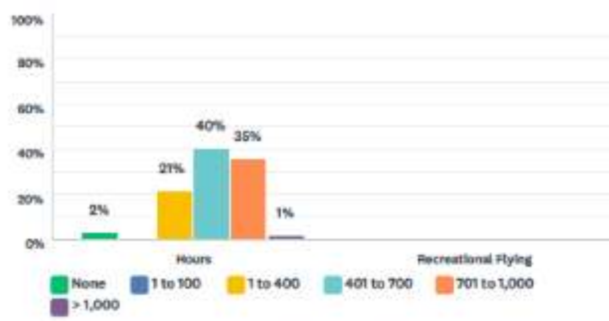


ANSWER CHOICES	RESPONSES	
<500 (1)	2%	105
501 to 2,000 (2)	8%	462
2,001 to 5,000 (3)	19%	1,086
2001 to 5,000 (4)	0%	0
5,001 to 10,000 (5)	26%	1,520
>10,000 (6)	45%	2,616
TOTAL		5,789

BASIC STATISTICS				
Minimum 1.00	Maximum 6.00	Median 5.00	Mean 4.76	Standard Deviation 1.47

Q67 66. Estimated Flight hours for your primary job in the previous 12 months:

Answered: 5,760 Skipped: 1,731

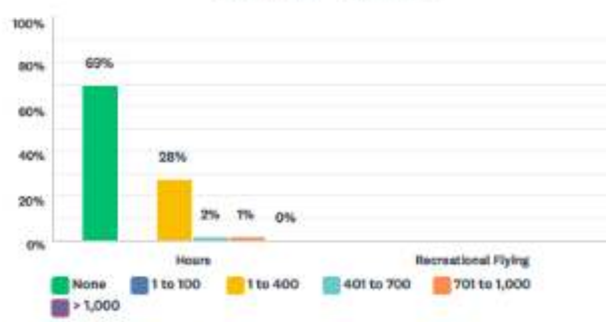


	NONE (1)	1 TO 100 (2)	1 TO 400 (3)	401 TO 700 (4)	701 TO 1,000 (5)	> 1,000 (6)	TOTAL
Hours	2% 130	0% 0	21% 1,214	40% 2,297	35% 2,044	1% 75	5,760
Recreational Flying	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Hours	1.00	6.00	4.00	4.10	0.90
Recreational Flying	0.00	0.00	0.00	0.00	0.00

Q68 67. Estimated recreational flight hours in the previous 12 months:

Answered: 5,749 Skipped: 1,742

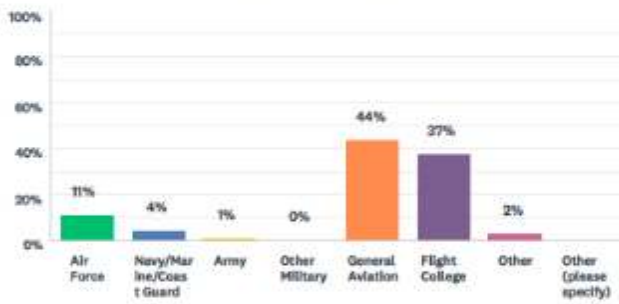


	NONE (1)	1 TO 100 (2)	1 TO 400 (3)	401 TO 700 (4)	701 TO 1,000 (5)	> 1,000 (6)	TOTAL
Hours	69% 3,982	0% 0	28% 1,590	2% 94	1% 75	0% 8	5,749
Recreational Flying	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	0

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Hours	1.00	6.00	1.00	1.66	1.03
Recreational Flying	0.00	0.00	0.00	0.00	0.00

Q69 68. Primary flight training:

Answered: 5,772 Skipped: 1,719

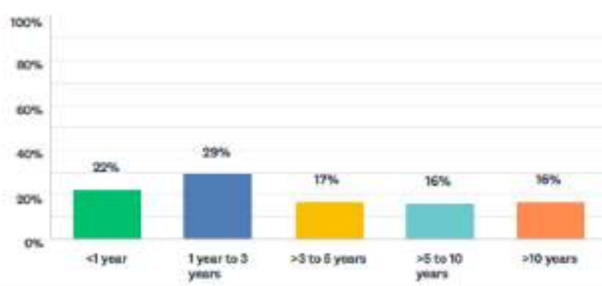


ANSWER CHOICES	RESPONSES	
Air Force (1)	11%	645
Navy/Marine/Coast Guard (2)	4%	233
Army (3)	1%	69
Other Military (4)	0%	11
General Aviation (5)	44%	2,515
Flight College (6)	37%	2,161
Other (7)	2%	138
Other (please specify) (8)	0%	0
TOTAL		5,772

BASIC STATISTICS				
Minimum 1.00	Maximum 7.00	Median 5.00	Mean 4.83	Standard Deviation 1.63

Q70 69. Initial training: How long has it been since you attended the initial training program on your current, or last flown, aircraft?

Answered: 5,771 Skipped: 1,720

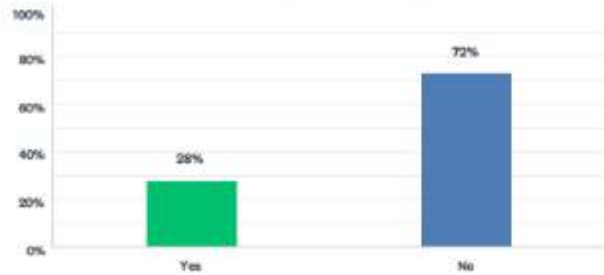


ANSWER CHOICES	RESPONSES	
<1 year (1)	22%	1,271
1 year to 3 years (2)	29%	1,682
>3 to 5 years (3)	17%	953
>5 to 10 years (4)	16%	915
>10 years (5)	16%	950
TOTAL		5,771

BASIC STATISTICS				
Minimum 1.00	Maximum 5.00	Median 2.00	Mean 2.76	Standard Deviation 1.39

Q71 70. Does your company have standard operating procedures that require autothrust to touchdown?

Answered: 5,366 Skipped: 2,125

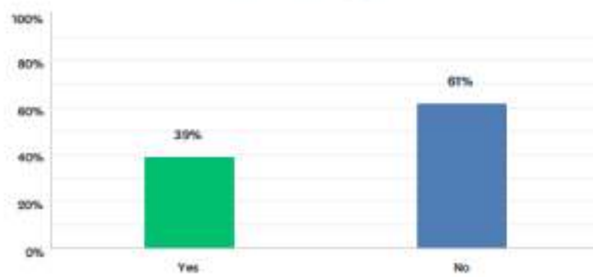


ANSWER CHOICES	RESPONSES	
Yes (1)	28%	1,484
No (2)	72%	3,882
TOTAL		5,366

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.72	Standard Deviation 0.45

Q72 71. Does your company have standard operating procedures that require autopilot on approach?

Answered: 5,438 Skipped: 2,053



ANSWER CHOICES	RESPONSES	
Yes (1)	39%	2,106
No (2)	61%	3,332
TOTAL		5,438

BASIC STATISTICS				
Minimum 1.00	Maximum 2.00	Median 2.00	Mean 1.61	Standard Deviation 0.49

APPENDIX H

Pilot Comments

Pilot Comments

Automation Comments
Flying fully automated with no previous years of lots of manual flying can be a big threat.
Automation is safer that manual flight
I take it to heart being part of the generation of flying with no autopilot, here in Asia its an exponential on-growing trend of over relying on automation, as if flying manual is dangerous, but of course to the industry is easy and cost beneficial to teach how to press buttons than to develop aviating skills. A real shame.
I can relate to every question. Automation dependency poses a major problem nowadays. How many of us can fly a straight and level unaccelerated flight without AP, AT , and FDs?? In my company very few fly without FDs, since it's a trigger on OFDM when you turn them off. However some procedures require them to be turned off/ recycled, such as no precision or circling. Also very few pilots (there are over 4000 pilots in my company) do visual approaches, only because they are not sure how to execute them properly. Company's mantra has scared them and thus they lost their confidence. If you have any questions I'll be glad to help you anyway I can. Looking forward to seeing the final paper!
I just completed the survey and find it very interesting. I would say automation dependency is becoming prevalent, and there will be a generation of pilots who do not know the pitch thrust relationship for their aircraft. One specific example comes to mind, while flying as a captain on the E175 at [Blank], I first placed my hand in front of the N1 guages at cruise, then asked the FO what he thought it should be roughly. He answered honestly saying he had no idea, but then I told him to take a guess, he said maybe 65%. We were closer to 87%, and I was hoping he'd say 85-90%, so I told him it was higher, then uncovered the gauges. It really drove the point home, and he acknowledged that he should have a better idea. I should add at [Blank] now there is very much a culture of leave everything on- even though the book allows for disconnecting everything to stay proficient. When I have hand flown, or offered to let the FO hand fly, on a VFR day in a low workload environment, they seem timid at first. Which brings me to another story, I flew with a different FO from my first story, and he was surprised that I wanted to let him turn everything off (AT, AP, FD). At first I gave him guidance on what to

do, but as he flew, he got more proficient and realized how his skills needed to be used so that he would not regress. During upgrade training, I made the suggestion that there should be more emphasis on the pitch + power/thrust relationship, as a few months prior a crew disengaged the AT in a descent, but did not bring thrust back up. They got the shaker over Santa Monica coming into LAX. I am glad they recovered, but I feel if they were prepared to set a N1 for the desired airspeed, it would have been a much better outcome. Given recent accidents like Asiana in SFO, or Emirates in DXB emphasizes the importance of not only monitoring, but making adjustments if the automation is not doing what it should, or what the pilots want. Interestingly the children of the magenta uses the phrase click, click (AP)...click, click (AT) to describe this. If the automation does not give the desired reaction, pilots can still manipulate the controls to do so which is our job at the end of the day.
I hear and read that many Companies in the World require and mandate full automation during the whole flight...what I think of it is that it is counterproductive to safety! I agree that the autopilot flies better than a human, but it flies only what the human tells it to fly!
Automation can be an improvement to safety. But at the end of the day, we still need pilots with a high level of flying skills and the ability to recognize when automation is being helpful, and when it becomes a distraction and a threat.
After a 30 yr. career I have observed hand flying skills deteriorate quite a bit with my first officers. However, They do an excellent job with the automation.
In [Blank] they were pro automated flights, which I think it´s great when you have your manual flying background experience: that experience that takes you to disconnect and fly manually, with confidence, when the airplane is not doing what you want. And works great in airports with high density traffic. But, on the other hand, you feel you gradually lose your manual flight skills.
As well.... the Boeing 777 autothrottle remains connected all the time. We are encouraged and do fly "manually" below 10000 feet, with the autopilot off. Some questions may give the impression that we do not do any "manual" flying because we always have the autothrottle connected.
We are not allowed to disengage the autothrust at any time, no matter the circumstances. A few years ago we lost the autothrust inflight on the A330 and even though it was a non-event, we had to file a safety report with the company. Yup, that's how bad it gets here. The flight directors have to stay on at all times as well. It's unfortunate but they do not trust us at all at this carrier. If there's anything more

you would like to know please let me know. It might be a few days but I will get back to you.
Manual Flight
Done! Very good survey, i was glad to participate... i would fly more manually without the auto thrust if my company allowed it... shame!
I had great confidence in my first officer's performance and he opted to manually fly the full arrival into Seattle. With vectors, altitude and speed constraints, and requirement to slow to 180 knots where L/D [Lift over drag] requires speed brakes to descend on profile [B777]. I have never been so busy keeping up with him. If the plane had crashed I would have been two miles behind the accident.
The aircraft I fly has AP and AT and it's definitely a mood or fatigue feeling regarding the disengagement of them individually or all off, and since we get worked like ragged dogs the automation is used a lot....not ALL the time but a lot. I've found nearly everyone with the automation disengaged keeps the flight director on at all times as it still provides a relevant source of direction, turn source, etc. Another factor in disengagement of the automation depends on the environment flown into - not just weather specific but airspace/type of flying specific. I'm more likely going to hand fly into Jackson Hole in VMC than I would into LAX unless I'm behind a heavy for example.
Important topic. We put a lot of emphasis on manual flight. Autopilot off means athrust off in my company. Manual flying is generally allowed, and in high regard, depending on the situation. However we also have a policy when to go fully automated, it goes like this: "Non-ILS approaches are flown at the highest available level of automation until Rwy is in sight and identified." Result: in VMC conditions, with the runway in sight, independant of the type of approach, you can fly how you want (if allowed by airspace design, STAR design etc.): automatics on, automatics off, with or without FD if you choose automatics off (however AP off always means also ATHR off, these two are linked together). At the end, we are pilots, and we can steer an aircraft manually into the touchdown

zone within speed, bank, pitch and VS limits. The same applies to ILS approaches: you choose what you use (except in LowVis Ops, there clear rules apply). However, in all other approaches, without the runway in sight, we use highest avail level of automation: that means AP, ATHR and FD, but also highest FMA-modes of the autoflight system. The reason is: IMC non-precision-approaches are far more demanding than ILS-approaches or approaches in VMC, so we want full mental capacity, therefore highest available level of automation.
I just took survey. I am recently retired B767 Captain.After 30 yr career I have observed hand flying skills deteriorate quite a bit with my first officers. However, They do an excellent job with the automation. Management doesn't have the time and money to cram in anything but the bare requirements for training session. [Blank] is good example, plus all the YouTube videos of pilots trying to land airplanes during windy conditions. Good luck with your thesis.
Situational Awareness
If someone doesn't have manual flight routine that drags with it that there is no situational awareness...with serious system failure onboard the a/c there will be no automation and with a pilot with no manual flying routine there will be no situational awareness and a huge amount of stress!
auto safer than manual: I believe, that using automation correctly does help with situational awareness (see later answers), especially in high density areas (think JFK or ORD). But there are times when manual flight is safer, e.g. quickness of response, technical issues.
Automation Policy
I worked at (blank) before, which has one of the strictest policies regarding manual flight. Raw data (flight directors off) was banned as of last year, and manual flight is banned in most busy airports, as the "airport briefings" the company publishes state "Mandatory use of AP". Manual flight is also banned from most smaller airports, again the "airport briefings" state "Mandatory use of AP due to possible VFR traffic". Which leaves very little room for hand-flying the aircraft legally. I would say less than 5% of (blank) pilots would regularly or even occasionally hand-fly the aircraft above 1000 ft.
Our company policy is AP can be disconnected bellow 10000 ft, but FD and AT shall be ON except in case of non-normal or MELs. So it is "Highly unlikely" I will disconnect AP and AT for the arrival or the approach as it is a company policy, *but I would like to do it!* [Emphasis added]

I am passionate on the subject, I was a Mariner sailing on Cargo ships for 20 years the switched careers to a flying job, I will forward to other pilots i know and have completed the survey myself. W.r.t to the automation questions I did my initial training on the A320 with a smaller airline with a number of older trainers from purely civil as as defence back grounds who encouraged manual flight - however i am now a check pilot myself and company policies with my current employer do not permit manual flying above 1000 feet on routine line flights and permit on Auto pilot or Auto thrust disconnection not both at the same time. Most new pilots therefore and not habitual to include air speed in their scan
I've completed your survey. It is an interesting topic to me because I have been flying at 2 different airlines where the former required as much automation as possible and the latter required te PROPER automation for the situation, where manual flight without AP/AT and FD is highly encouraged and flown like this I would say on every 5th leg. Wish you all the best!
Our policy about flying with AP/AT is written in our OMA. It is recommended to use AP/AT as it lowers the workload, however we are allowed to fly manual for practice. It is not recommended in the TMA, but in the final stage I encourage it as much as practicable.
My company prefers to use automation to the extreme, and they do the training to the extreme usage of SOP! NO manual FLIGHT! I was lucky to fly manually years ago when there was no EICAS/EFIS
I have been flying at 2 different airlines where the former required as much automation as possible and the latter required the PROPER automation for the situation, where manual flight without AP/AT and FD is highly encouraged and flown like this I would say on every 5th leg.
Our ops manual requires the highest level of automation at all times so we are not allowed to turn off the autothrust and/or flight directors at any time. We are however, allowed to hand fly the airplane below 10,000 ft. I personally try to do that as much as possible, but *I have flown with numerous pilots who turn on the autopilot as soon as the gear is up and disconnect only around 400-500 ft on final*. [Emphasis added].
I fly the 737 in a company where manual flying is accepted but I can see the tendency of forcing pilots to be less and less "pilots" of the airframe more than vectors of accomplishing the daily duty quite obvious. I hear some companies in Europe now force pilot to use LNAV/VNAV for visual approach as mandatory, or Asiatic companies even force the use of AP and AT down to minimum or the aircraft manual minimum, which I find compelling.

My current airline inherits a much more pragmatic Schandinavian culture, has more relaxed SOP’s and strongly encourages manual flight, including raw data hand-flying Around 90% of my colleagues hand-fly the departure to around 10,000 feet and disconnect on base leg during the approach. About 20 to 30% of hand-flown departures and approaches are flown with Flight Directors off.
The aircraft I fly (Airbus A320 Family) or the Company's automation policy prevents me from disconnecting everything on routine flights. AutoThrust remains the engaged in all phases of flight from thrust reduction altitude till the flare, when the thrust levers are retarded for all normal flights. The only exception being in case of a failure.
My present company mandates the use of ALL automation from 10000ft-10000ft. Below that ONLY the Autopilot may be disengaged, but FDs & A/THR need to be engaged. My previous company which got me my initial experience on the A320, did however have flexibility in these areas & I was lucky enough to benefit from flying without AP/FD & A/THR on regular line flights occasionally to practice & keep my skills sharp. The present day scenario however has scores of pilots from varying backgrounds & experience and it is therefore no wonder the company mandates the use of automation. [Emphasis Added].
When asked about written company policies "requiring" automation, I answered "yes". To be more specific, our company has a written policy requiring the use of automation during RNAV departures, but encourages "hand-flying" when conditions permit, so there was no absolutely correct answer. My personal thought about the use of "partial" automation is as follows; during a hand flown approach, autothrottles should be disconnected when the autopilot is disconnected. The reason I feel this way is that any pitch change made by the pilot during the approach causes a change in airspeed. Autothrottles will respond in order to maintain the selected speed. As the throttles move, the pilot will then need to re-adjust his pitch, which will cause a corresponding change with the thrust setting, which will then require... You can see the cycle that begins to happen. If you have any questions, or if there is any way I may offer any help, please let me know.
"highest available level" was consciously worded like this, meaning not to exclude any approach or airport option due to a technical issue. You can still fly non-precision-approaches in IMC with ATHR defect, because you are still "highest available". From experience, this policy gives plenty of opportunity to practice manual skills, while making a clear statement under which circumstances highest support of automation must be used.

Just two sentences define all you need: 1. manual flight (with or without FD) equals manual thrust 2. Non-ILS approaches are flown at the highest available level of automation until Rwy is in sight and identified. I feel this policy [combined with the principle that manual flight (with or without FD) also means manual thrust] is the clearest, most sensible and most practical way of a sensible usage of automation while keeping crews skilled AND comfortable in manual flight. It should be adopted by more airlines in my opinion.
I did your survey for you. Just to add some extra it might be worth noting that like you I fly the B777 and our company and I believe BOEING mandate the use of the autothrottle at all times. We can hand fly the jet at sensible times but not with out the auto throttle. I hope that helps in the way I may have have answered some of your questions.
I did the Survey and I would like to add some things to it...I hear and read that many Companies in the World require and mandate full automation during the whole flight...what I think of it is that it is contraproductive to safety! I agree that the autopilot flies better than a human but it flies only what the human tells it to fly! I am very lucky that I still fly and work in the Company that doesn't forbid manual flying...should any problem occur to a pilot who flies only with automation, she/he in that crucial moment doesn't have necessary confidence to do and to finish the things routinely with her/his own hands! That's tha fact!!! I know since I have seen the things! Manual flying should be encouraged in certain percentage in 30 days or so!
Automation Unwritten Policy
Where discussing auto flight v. Manual flight your survey touches on corporate requirements/policy. My airline for example has conflicting policies on this. It states in on part of our FCOM that we are to use automation as much as possible, later on in the same manual and in the SOP it states that pilots will maintain hand flying skills. It does not give guidelines as to when or how this is to be accomplished.
I recently finished a captain checkout on the B777 with 25-yrs previous flying Captain on the 74. During training the instructors said to *never* disengage the autothrust. But the then (blank) put out a training video recommending that the pilots should disengage the autothrust and the importance of doing so, telling pilots to memorize power settings in order to fly etc. (In my opinion wrong… a pilot needs to know how to manage the aircraft.) During line ops I was told that we never disengage the autothrust on this aircraft. The company manuals and training state one thing for FAA approval, but the company doesn't follow their own rules. That's how they roll. I think the FAA knows and doesn't care. The fox is guarding the henhouse sort of thing.

Pilot Flying Overloads the PF
I recently started flying long haul with pilots that are about to retire and they just don't want any sort of trouble. In 9 months flying the 787 only last Monday I got to fly with a Captain that allowed me to disconnect both the AP and AT above 10.000. Many times I've been told "this aircraft is not designed to be hand flown". I would hand fly every approach in VMC with the AP and AT off, however I usually fly with this sort of Captains.
I found some questions I couldn't really answer the way I should. For example, about automation my actual company discourages to disengage but for me is not a problem because on the contrary in the previous company when proper conditions the company could encourage to disconnect. But honestly the local pilots of my actual company are mostly really bad pilots so I understand. In my last simulator the captain was not even able to land twice flying a circling approach [Emphasis Added]... Cheers
Training
"Unfortunately, today's training environment is too centered (in my opinion) on automation and discourages us from thinking like aviators,"
Automation really is changing how we do things and how we are taught to do things in new airplanes. Unfortunately, I feel that the school houses aren't doing a very good job. Been getting a lot of, "The manufacturer wanted us to tell you this, but we can't explain why or how." Last two initials I went through, I barely felt like I understood anything about how the aircraft functions systems wise.
A few of my responses may have been skewed by the fact that questions regarding initial training on my current aircraft (B747-400/-8) did not occur at my current company (my 3rd airline on the same aircraft type), but I came up with the best answers I could for your research. Good luck with your doctoral program.
Type of Ground School
I answered combination because I was self-taught using a flash drive and then went to classroom where they gave the foot stomper questions that would be on the test so we could pass. The second part wasn't teaching more giving the answers.
I had to learn on my own and nobody to ask questions. We don't have real manuals anymore, but all are on a computer. Not sure if I really know what I know, but then it doesn't seem anyone cares anyway.
I had to google the cockpit of my plane because the company flash drive manual was in black n white and aircraft symbols mean different things depending on their color. Never have I seen training so bad in all my years of airline flying. Scary

where the kids will be who don’t have experience to fall back on to help understand systems and operations.
Oral Examination
Systems was a “memorize the book take a computer test and regurgitate information” and then the oral was on limitations, also memorized for that event. Nobody really asked me anything to see if I understood the aircraft or how it operated.
In (Blank) there is no “oral” as part of a proficiency check. Depending on the operator, there may be a few questions prior to the ride, but usually it’s just discuss the profile and then get in the sim and go do it. The US system of oral examination and on understanding systems seems appealing, but perhaps Airbus don’t design their aircraft to be understood in quite such that manner. I don’t perhaps Airbus don’t design their aircraft to be understood in quite such that manner. I don’t know, I’m a Boeing driver. I do feel very strongly that robust initial training which sets high standards, combined with robust but people based checking and training is the way to build a professional pilot. I remember my most challenging and educational training moment was in the States during initial training. An oral exam that lasted between 4-6 hours on the PA28. Not anyone. Company culture and welfare toward pilots are more important. Manual flight is a basic concept but automation is kind of trend! Especially long distance flight and automation is kind of trend! Especially long distance flight and auto flight are well connected all the time. After all the that’s why we need simulator training twice a year.
Debrief
I had to select the option “less than 15 minutes”, but the truth is we never had a debrief during my entire initial training. Granted it was late at night and the instructor wanted to get home, but training was a firehose event and by the next day I forgot what we did the night before. I really depend on debriefs so I can take notes and review for the next day and when I get to the line.
Automaticity
In regard to systems knowledge, I think the pendulum has swung to rote and saying what the switch does but that’s not to say I need to know how many holes are drilled around the edge of the static port. The studying was pretty easy since we had a study guide and the instructors could only ask questions out of the systems bank. But the toughest part of all this is finding experienced people who can help because a third of (blank) pilots are new hire FO’s. We’ll figure it out one way or another!

Importance of Manual flight.
I'm a Flight Instructor on the A320 and believe manual flight is a lost art. I get crews to practice as often as the weather allows. Either manual thrust or Auto pilot off F/D off and when comfortable all three. Ground courses are too short, SIM's are tick the box regulatory exercises and don't give the crew time to practice, practice practice. I believe over learning is the key, I'd like to say that's my idea, but I can't. Another sad thing is I sometime feel like I am the "alien" and no one else see the pattern. Maybe it show my age lol. Anyhow I will share it for sure. Keep up the good work I have been reading the survey, and at this moment I have just finished training in a local low cost airline in [Blank], to fly B738s. I am starting my flight training this coming Friday. So far, I´ve only been doing observation flights. So, I think I could best answer the survey next week when I have already started flying. What do you think? This is a big difference: flying for [Blank] on Airbus a320s, where they like the flights to be flown almost fully automated, to flying in Argentina B738s with a mentality of favoring manual flying. What a difference! I guess it has to do with a latin macho mentality of "I can perfectly fly this airplane manually", which I´ve seen from the flight inspector in my simulator check ride and I could sense in the atmosphere from my colleges.
Manual Flight
Most pilots at my company will elect to turn the autopilot off once within 1000-500' of the runway in visual conditions. I almost always have it off by the 1000' callout. Auto throttles are usually left on until 30' with most pilots. I've only ever seen 1 or 2 pilots do a visual approach with no AP, no AT and no FD at my airline. It's extremely frowned upon at our company especially since the level of experience is starting to get lower and lower with the pilot shortage.
Unfortunately, it's also a double edged sword isn't it? It keeps pilots within a safety margin in day to day dealings however whenever a failure occurs it's twice as dangerous as it could potentially be because many pilots have no experience flying an approach in a jet without any automation...!
As per the company, any & all "Raw-Data" flying is supposed to be done during the simulator sessions. Airbus as a manufacturer in a way also prefers that it be flown using all the automation available...but that is not to detract from the fact that if something ain't right, you take over! One of the "Airbus Golden Rules"!

(Blank and blank), two airlines that have a clear policy against the regular practice of manual flight, have both come very close to crashes due to loss of control in flight (failing to understand what the automation was doing, or failing to manually recover the aircraft from an undesired state).
We are restricted from disconnecting AT during all phases of Flight unless dictated by the QRH during non-normal situations. We are also required to engage auto Flight during RNAV sids that require accurate lateral navigation, especially in Europe. There was no restrictions on the 737 and 767 and for that matter the 777 (autothrottles were recommended) The 787 sop's require AT always and Auto pilot recommendations.
Manual Flight and Aircraft Differences
Manual Flight: for me, the least I have to do is disengage the autopilot. From there on I fly the aircraft manually (at least as far as this is possible on the Airbusses ;-) I might disengage the autothrust, as well, but the boundary between auto flight and manual flight lies with the use of the autopilot.
Airbus aircraft can't land with auto-thrust on. At 20 feet (manual landing), the aircraft will order "Retard! Retard!" so the pilot will close the thrust levers, thereby disengaging the auto-thrust.
Flying Airbus, rarely did we disconnect A/T during an approach, whereas Boeing encourages manual flight. So, I would have answered very differently had I still been flying Airbus.
A couple things that are unique to the Eclipse 550 (Airplane I am currently flying) that are unusual and possibly unique to the airplane. The autothrottles automatically kick off when the landing gear is lowered. The software was designed that way because they wanted the pilot "in the loop" closer to the ground.
Pilot Understanding
A working knowledge of airplane systems is an important part of training, however, you will agree with me that "trouble shooting outside the scope of the problem at hand" is NOT recommended when an issue arises on board. Pilots are trained and expected to FOLLOW published procedures as contained in the QRH or on the ECL (Electronic Checklists) as displayed on EICAS. To know what to do if there was no EICAS or CHECKLIST would be a BIG problem in today's airplanes
This reliance [or overreliance] on automation seems to have made pilots complacent in their monitoring duties, in some cases, not understanding or comprehending what IS actually happening and the expected results.

Automation really is changing how we do things and how we are taught to do things in new airplanes. Unfortunately, I feel that the school houses aren't doing a very good job. Been getting a lot of, "The manufacturer wanted us to tell you this but we can't explain why or how." Last two initials I went through, I barely felt like I understood anything about how the aircraft functions systems wise. I believe there will be a generation of pilots that will understand nothing about how their aircraft truly work and I believe this will lead to a loss of life. The final report, as you've said, will blame the pilot.
Safety is a great subject and a not negotiable element in aviation. I have a very interesting incident that happened to me in London on …. and the lack of understanding of safety by certain airlines is just mind boggling to say the least ! Should you want to know more you welcome to make contact with me.
I frequently observe the absolutely worst scenario: use of automation by pilots who don't possess full understanding of the FMS/FMA/AT relationship. To exacerbate the problem, verbal FMA annunciations are not required by our manuals, so errors are plentiful. It saddens to see how young men and women who were flight instructors in their recent past become willing slaves to the flight director and forget all about primary instrumentation scan! It scares me when I think of those pilots being forced to execute a manual go-around in IMC and/or at night, immediately envisioning recent horrific accidents in my native Russia and other parts of the world that were caused by the somatogravic illusion, illusions in particular and by degradation of instrument scanning skills in general.
The problem arises when folks don't understand the automation & what level of automation to use at which stage of flight. Boeings have been far more conventional in their approach to ergonomics & the "Man-Machine" interface...where the bond is a lot stronger! I feel that I'm still a rookie in this aircraft, having flying the Baby 'Bus for a little over 10 years, as it still foxes me into saying, "Oh shit! What now???”
The US and EU methods of training, the US system of oral examination and on understanding systems seems appealing, but perhaps Airbus don't design their aircraft to be understood in quite such that manner. I don't know, I'm a Boeing driver. I do feel very strongly that robust initial training which sets high standards, combined with robust but people based checking and training is the way to build a professional pilot. I'm always sceptical of what I term 'missionary pilots' who have a mentality that is just that bit too keen. I remember my most challenging and educational training moment was in the States during initial training. An oral exam that lasted between 4-6 hours on the pa28. 4 hour sim slots and a technical exam are not of the same robustness but there has to be an atmosphere and support which aids that system

The main problem in commercial Aviation is the lack of skill and training in manual flight and when to decide reversing to manual in case of not understanding automation or in case of emergency. with ATQP it is now possible to ask for manual training during Sim session .
Pilot Training
We seem to do type ratings in the minimum time to save costs and it’s effectively a box ticking exercise. We are the same re autothrottle or autothrust. Not to be ever taken out but we can dispatch with it u/s. We never practice it but we have to demonstrate our ability to fly a single engine ILS and go around every three years.
I have noticed a trend with new pilots. Their training is extremely basic and although they know the procedures well they can’t manually fly and do not understand the systems. I spend a lot of time teaching them how to land. They cannot even do it properly. Thanks to the reliability of the modern planes their lack of knowledge and skills is not obvious but will certainly come into consideration in degraded situations. Some of these young pilots are becoming captains and unfortunately will become the last fence in case of problem or unusual situation. I am not sure they have the resources to cope with that. I expect an increase in aviation accidents and incidents in the future due to this lack of skills.
Required training for pilots seems to have been reduced in terms of flight time and with the introduction of the Multi Pilot License, (MPL), actual real world experience has also been cut down to simulator training time.
Honestly, from what I've seen, the basics are often over looked. Once I was told that a plane is just a plane. I've carried that through training with several of my type ratings. Maintaining the basics of flying has made each type easier to handle. Understanding certain principals, pitch and power, descent planning, over all hand flying on good days, has made me exponentially better on bad days. I appreciate the levels of automation far more now that I use them in what I feel is a proper way. Some fundamentals are lost in training events, because it's assumed that you should have them at this level. It's not always the case and they are perishable. In extreme events, it could even have devastating results when pilots are assumed to be proficient at flying. After all, we do it day in and day out.
Safety Culture
Look into the corporate culture, run by non aviation personnel with better perks, which has bull dozed the airlines in the few couple of decades. Pilots r treated like bus drivers now.

Cabin crew from far eastern countries (South Korea, China, Japan) will never contradict you or let you know if you are wrong, NEVER! (quite a big threat!) They tend to speak English not fluently and will never ask you to explain again what you just said and they did not understand. Their authority gradient is HUGE in their countries.
I'm an old pilot from GA and the B727, DC9-80, MD80 ,B767 A320/330/340 with approximately. 25K hours on everything. What really worries me, is that you are encouraged NOT to fly manually, not to fly visual and that we are getting punished in China if doing so… I got punished with 1500 USD, for continuing under VMC conditions, (CAVOK), down to 500 feet AGL. Stabilized at 550 feet as required by Boing and Airbus, but punished as they do not allow us to fly VMC approaches as stated by FAA and EASA. And I took over and flew it manually. Big mistake. These guys will never, never be able to cope with an unusual situation, that requires manual flying. And most of these guys , do NOT, understand English beyond the very basics as required in an emergency situation. Maybe FAA and EASA should introduce English requirements to foreign pilots(Chinese) as the Chinese are doing towards US. Until very recently our airline used the training department (with very specific instructors) as a punitive medium, or cost control medium (I have been affected by both), so more detail into how the ACTUAL company culture affects the safe operation and or learning environment could be explored.
I myself had been that "operator-pilot" when I used to fly in Russia where hand flying is strongly discouraged and the punitive culture of low uncertainty tolerance prevails. Joining (blank) was a transformative experience when I realized that manual flying is still a thing.
Many pilots like to fly manually and manual flight is requested in all simulator training in China. The problem is the punishment culture for any deviation based in QAR data. So it's better to keep all automation engaged in order to reduce the risk of flight deviations.
Regarding the company requirements of automation usage...my current company talks about using and not using it. Whereas when I worked for a company in China they wanted the automation on ASAP and off when landing. Different mindsets....also explains why some of the Asiatic countries can't fly a visual approach to save their lives...literally. The other issue is that they are exposed to only a couple hundred hours of hand flying and then that's it.
A few of my colleagues at that time told me while they were CFIs in China some of the students would taxi out, set the parking brake, hop out and have a smoke and let the HOBBS meter spin never doing ANY of their solo flying. The management encouraged this as it kept the tach times low (!!!!!!!!). This was from multiple sources at different schools. Imagine seeing 2-3 planes in a run-up with props spinning and NOBODY in them.

Aviation Passion
It amazed me how incredibly uninhibited most of my captains of previous generation had been when it would come to downgrading automation levels to basic raw data flying when either a situation dictated that or purely for enjoyment of flying. Eventually*, I am proud to say, I have become that pilot, too*. [Emphasis Added]. Granted those were less automated airplanes (E145 and CRJ-700) than A320 that I had operated overseas, with no A/T and integrated vertical navigation.
I do take great pride in being a pilot, but it does not define me.
I still enjoy hand flying when I can regardless of having 26,000 + hours.
I've found those that flew in Alaska in smaller airplanes, those that continue to fly small GA planes are more in tuned with the jet - the hand/eye coordination but this should come as no shocker. I've only met one jet pilot who owned a GA plane, a tail wheel nonetheless, and he was just a crappy pilot regarding landings. Go figure
Automation is great: it makes us safer, and more aware, but I have so many thousands of hours on antiques, classic Lears, DC-9s, that I still appreciate old-school flying. The industry, as a whole, is losing important skills.
Overall assessment
Fatigue and company pressure is also an extremely important part of the risk factor. I have also noticed a trend with new pilots. Their training is extremely basic and although they know the procedures well they cant manually fly and do not understand the systems. I spend a lot of time teaching them how to land. They can not even do it properly. Thanks to the reliability of the modern planes their lack of knowledge and skills is not obvious but will certainly come into consideration in degraded situations. Some of these young pilots are becoming captains and unfortunately will become the last fence in case of problem or unusual situation. I am not sure they have the resources to cope with that. I expect an increase in aviation accidents and incidents in the future due to this lack of skills. Thanks for your interest in that question. Looking forward to read about your survey and your thesis! Kind regards.
Survey done. A very interesting topic - I could talk for hours about automation, the modern flight deck, training and engagement with the aircraft being flown. Having raced around with my hair on fire in Royal Air Force fast jets, flown pretty much all the Airbus types and now the B787-9 I hope I would not be bragging to say I've experienced a wide variety of flying. The biggest problem I see these days is a real reluctance to disengage the automatics (autopilot, autothrust and FD) due to company policy but primarily lack of confidence due, in my opinion, to lack of practice. When flying with the automatics most pilots are not fully 'engaged' with

what the a/c is doing but when you are hand flying it you are 'engaged' because you are physically 'putting the a/c where you want it'. I hear all to often these days my F/O say can he hand fly the aproach because he has his sim check coming up and wants to practice - isn't that the wrong way around??? LOL but a serious point.
I like the questions that you asked. Hopefully it will lead to some changes in the training's, the procedure and the mentality. Sadly most pilots don't know how to fly anymore. When the WX or the traffic allowed, I often encourage my FO to disconnect the automation and fly the approach, almost no one do it, in the last 5 years I think only 2 guys. People aren't comfortable. Is it because the Airbus doesn't feel right? Because the training we received, or the company policy, maybe a bit of all. One thing for sure, we got our wings clipped from the industry long time back and only those that do the extra mile to keep their skills at the risk sometime to be call in the office stay really proficient.
I just finished the survey. There were some questions which didn’t give me the choice of saying that I am doing certain things because the company SOP requires it. For example we are not allowed to fly manually by many airlines. Also the fear culture in some Airlines. That means managements behavior towards pilots. Mostly pilots in major airlines do things or don’t do things because they don’t want to get in trouble with the management n called into the office. I have worked for six airlines n the reason of leaving was to go to an airline who respects their pilots. Most of them harass pilots through the flight data monitoring system. Some airlines have negative training through instructors who over load u with multiple failures n shouting n degrading in the PCs. Some make u feel absolutely inadequate through the company’s culture n SOPs. I can go on forever. But u r doing a good job. I will forward this survey to my very professional colleagues.
Thanks for the answer. I have been an instructor at both airlines I have worked at: [Blank] and [Blank]. [Blank] I was a line check pilot and usually the last chance guy. [Blank] I was an instructor on the 744 in the sim and now on the 767 as a linecheck pilot. Both were appendix F training places. Being that both aren't places that pilots dreamed working at, I have seen a wide swath in initial qualifications as well as high turn over and a dilution of culturally ingrained techniques. Obviously one had schedules of high flight cycles and the other is extremely low cycles. I have found extremely surprising similar weaknesses in both types of flying. The three main weakness being: mode confusion, knowing when to use what level of automation, and recognizing red flags of task saturation in early stages. I see you flew the Classic as well. When we parked them, I was surprised how well people that had flown steam for 40 years tend to adapt. There were outliers, but the vast majority picked it up well. The odd thing I found was that on the 744, with our

FAR minimum training at 6 and 12 month sim visits was that the vast majority could fly the plane quite well when it was the silly OEI hand-flown ILS. You would still see pilots who flew the plane for a decade struggle with using the automation in normal, or slightly abnormal (leveling under 10k if a door pops) situation. It was odd. The pilot stuff one does every six months was actually way better than expected. Probably a ramble, but I find this subject fascinating. I could go on for days.
I filled out your survey...very interesting and I can't wait to see your results and conclusions. I must say, being a former Air Force (TacHel, Ab Initio Jet Instructor, Fighters) for 20 years and showing up in the Commercial world now for 8 yrs, I couldn't believe how little energies are spent for hands on flying...My 3 previous aircraft all had sticks, the first 2 had no automation at all, and you would only live for about 5 secs if you let go of the cyclic on the B212...the Hornet was pretty whiz bang with level3 automation. It was pretty funny and sometimes "not cool" when I would ask the Capt as a newbie FO if I could hand fly the APP or DEP all the way...it seems we have become systems managers, relying mostly on 2-3 AP to make us look good most of the time. When asked in the sim if there is something (sequences) I would like to see/do when our official script is complete, I always ask to fly a VFR circuit to a T&G, and time permitting a SE ILS APP manually to 200 & 1/2...sometimes it's nice, sometimes not soo much...ha!
Hi. I just took your survey. I want to point out one thing that stood out to me in the survey. There were several questions that asked about my initial training on my aircraft. The answers I provided would be different if I were doing that training today. I initially trained on my aircraft 20 years ago and upgraded to Captain on it 11 years ago. The training today is very different than it was back then. Anyway, I hope that helps. Thank you for tackling this issue. I think it is important and I'm glad you are doing it. Automation can be an improvement to safety. But at the end of the day, we still need pilots with a high level of flying skills and the ability to recognize when automation is being helpful, and when it becomes a distraction and a threat. Unfortunately, today's training environment is too centered (in my opinion) on automation and discourages us from thinking like aviators.
that’s a very nice initiative as something has definitely to be done. Companies are more focussed on their short term statistics and strongly discourage to disconnect the automation. This has a negative impact on our handling and safety as we get less and less practice. Hopefully the future results of your survey will be significant and you’ll be able to show them to the autorithies. I’ve already completed my part, all the best.

In Canada, there is no "oral" as part of a proficiency check. Depending on the operator, there may be a few questions prior to the ride, but usually it's just discuss the profile and then get in the sim and go do it. My operator's policy is that the autopilot may be disengaged as the pilot wishes, however the auto thrust should remain engaged until 50'AGL at the latest. It was difficult for me to answer your Qs accurately given that. In Canada, 2 pilots can operate long legs (7-10hrs) without a third pilot. Usually it is a pilot agreement mandated requirement for augmented crews unless the flight is ultra long haul. There is an amendment of the regs in the works, but it is taking excruciatingly long to implement. Given the above it may be a challenge for non-US pilots to answer your Qs. Overall though, well done! Have you had a chance to review CPPC material?
there are on our industry pilots and people who achieve to have a Licence... big issue is that we stop to achieve our minimum required performance. And most people hide behing automation and forget what is their obligations as pilots. Normally i ask pilots about max crosswind limitations with or without autopilot... curious stuff human max. Still above auto pilot... why ?! That s question. ... reply is very easy... i barely use auto pilot on any approach ... is moment to be in control and to make my training. ... that s why i found curious ... ILS are authorised to 200 ft without automation as you know ... if so is because we must be able to do ... this subject apart i understand the objective of your questions... but don t be afraid to chock.. you wanna know the reality .... i think !! All Lucky At last someone willing to take on the Human Factor beast lurking in the shadows, hiding behind a quick blame-the-pilot escape. I will gladly participate in this research. Good luck with the Phd and thank you for making a stand for us pilots.
Future Research
One day, you should investigate the reporting culture in China. Their punishment culture.
I do not believe I saw one single question on your survey related to fatigue. Fatigue is a very serious issue for any commercial airline crew. A pilot's decision to hand-fly an aircraft will be affected by the pilot's determination of his/her physical state and the state of his/her fellow Flight Deck crew member. If the Flying Pilot (FP) is too tired, he'll more than likely allow the Autopilot (AP) to fly the aircraft. If my departure time is before 7:00 AM, I normally do not hand-fly the aircraft because my day more than likely started at 5:00 AM or 4:00 AM in the morning. We normally get on the hotel van an hour before departure time and I normally wakeup an hour before the hotel van time; therefore, a 7:00 AM departure is a 5:00 AM wakeup call, a 6:00 AMdeparture is a 4:00 AM wakeup call, and a 5:00 AM departure is a 3:00 AM wakeup call. I've had a few 5:00 AM departures. They

are dangerous to say the least. Even if you go to bed at 8:00 PM, you more than likely will just lay in bed until 10:00 PM, which only allows you to get 5 hours or less of sleep. This is the best time to allow the AP system to fly the aircraft. Also, if you are on the last hour of your 12, 13 or 14 hour duty day, allowing the AP to fly the aircraft is more than likely the safest thing to do; especially if your landing after 11:00 PM.

One more thing: the regional airline industry is an entry level industry for new pilots that graduate from schools like ERAU. Mainline carriers take the best regional Captains and military pilots so they don't have the same new hire safety issues that regional airlines have. Safety is at its most risky point during a new hire's first year or first 500 hours. During this time, it's good to have the new hire pilot use the AP as much as possible because it will teach him/her how to fly the aircraft through AP demonstration and recognize the different automation modes.

I fly the Bombardier CRJ700 (70 Seats) for a regional airline. The aircraft has a glass instrumented Flight Deck but no Auto-Thrust system. We hand-fly the aircraft as much as possible below 10,000 feet and normally engage the AP before FL180 but definitely before FL290 due to RVSM automation requirements. We do this primarily because it's FUN! We know that some day we'll move on to a "mainline" carrier and fly an aircraft that wasn't even designed to have the pilot fly it except for 5 minutes during the takeoff and landing. Mr. Henry is more than likely experiencing this now at his mainline carrier (he's a former regional pilot).

APPENDIX I

Tables

Tables

Table I-1

Pilot Test 5-model Validity Measures

	CR	AVE	MSV	MaxR (H)	MF	PU	PT	SC
MF	0.691	0.322	0.233	0.732	**0.567**			
PU	0.757	0.388	0.354	0.775	0.483**	**0.623**		
PT	0.590	0.220	0.657	0.679	-0.266†	-0.595***	**0.469**	
SC	0.725	0.358	0.657	0.769	0.096	0.396**	-0.810***	**0.598**
AP	0.776	0.421	0.071	0.811	0.023	0.064	-0.124	0.267*

Table I-2

Pilot test 5-model Model Fit Measures E 2 Model Fit Measures PreTest 5 Factor

Measures	Acceptable Thresholds	Observed Model Fit
CMIN/df	<3.0*	1.643
CFI	>.95 Excellent ; >.90 Traditional; > .80 Permissible*	0.738
SRMR	<.05 Good Fit; .05-.08 Adequate Fit, >.10 Poor fit*	0.099
RMSEA	<.05 Good Fit; .05-.10 Moderate, >.10 Poor fit*	0.078
PCLOSE	1=Perfect	0.000

*Hu and Bentler (1999)

Table I-3

Inter-item Correlation Matrix Table

Inter-item Correlations Matrix table

		SC1	SC3	SC5	PT1	PT6	PU1	PU2	PU3	PU4	PU5	AP1	AP2	AP3	AP4	MF3	RevMF4	MF2
SC1	Pearson Correlation	1	.585**	.407**	.417**	.329**	0.138	0.071	0.131	0.044	.201*	0.163	.207*	-0.062	0.169	0.001	-0.082	0.157
	Sig. (2-tailed)		0	0	0	0	0.14	0.453	0.163	0.642	0.031	0.082	0.026	0.512	0.071	0.992	0.383	0.093
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
SC3	Pearson Correlation	.585**	1	.418**	.444**	.433**	.244**	0.133	0.105	0.104	.256**	.233*	0.172	0.072	.233*	-0.042	0.037	0.006
	Sig. (2-tailed)	0		0	0	0	0.009	0.156	0.264	0.269	0.006	0.012	0.067	0.442	0.012	0.653	0.692	0.947
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
SC5	Pearson Correlation	.407**	.418**	1	.301**	.325**	0.071	-0.033	0.087	0.079	0.158	0.049	0.173	-0.093	0.162	-0.158	-0.095	0.035
	Sig. (2-tailed)	0	0		0.001	0	0.449	0.726	0.355	0.401	0.092	0.607	0.065	0.321	0.084	0.092	0.31	0.711
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PT1	Pearson Correlation	.417**	.444**	.301**	1	.288**	.402**	.187*	.201*	0.177	.406**	0.101	0.161	0.002	0.106	0.079	0.02	0.103
	Sig. (2-tailed)	0	0	0.001		0.002	0	0.045	0.032	0.058	0	0.283	0.085	0.983	0.261	0.401	0.832	0.275
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PT6	Pearson Correlation	.329**	.433**	.325**	.288**	1	0.104	-0.05	0.061	0.128	.247**	0.141	0.159	0.095	.242**	0.072	0.07	0.082
	Sig. (2-tailed)	0	0	0	0.002		0.267	0.593	0.515	0.173	0.008	0.132	0.089	0.311	0.009	0.447	0.46	0.381
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PU1	Pearson Correlation	0.138	.244**	0.071	.402**	0.104	1	.306**	.513**	.371**	.366**	-0.079	0.008	-0.074	-0.037	0.131	0.027	.246**
	Sig. (2-tailed)	0.14	0.009	0.449	0	0.267		0.001	0	0	0	0.401	0.932	0.434	0.693	0.162	0.771	0.008
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PU2	Pearson Correlation	0.071	0.133	-0.033	.187*	-0.05	.306**	1	.293**	.457**	.409**	0.012	-0.043	0.115	0.023	0.031	0.027	0.128
	Sig. (2-tailed)	0.453	0.156	0.726	0.045	0.593	0.001		0.001	0	0	0.899	0.652	0.22	0.806	0.74	0.776	0.174
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PU3	Pearson Correlation	0.131	0.105	0.087	.201*	0.061	.513**	.293**	1	.369**	.320**	-0.119	0.065	0.02	-0.001	0.166	0.058	0.031
	Sig. (2-tailed)	0.163	0.264	0.355	0.032	0.515	0	0.001		0	0	0.204	0.49	0.831	0.991	0.076	0.537	0.741
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PU4	Pearson Correlation	0.044	0.104	0.079	0.177	0.128	.371**	.457**	.369**	1	.547**	0.081	-0.085	0.178	0.065	0.041	-0.064	.191*
	Sig. (2-tailed)	0.642	0.269	0.401	0.058	0.173	0	0	0		0	0.392	0.367	0.057	0.49	0.666	0.499	0.041
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
PU5	Pearson Correlation	.201*	.256**	0.158	.406**	.247**	.366**	.409**	.320**	.547**	1	0.15	-0.025	0.071	0.098	0.095	0.014	.272**
	Sig. (2-tailed)	0.031	0.006	0.092	0	0.008	0	0	0	0		0.11	0.789	0.449	0.298	0.315	0.885	0.003
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
AP1	Pearson Correlation	0.163	.233*	0.049	0.101	0.141	-0.079	0.012	-0.119	0.081	0.15	1	.351**	.541**	.600**	-0.092	-0.096	0.045
	Sig. (2-tailed)	0.082	0.012	0.607	0.283	0.132	0.401	0.899	0.204	0.392	0.11		0	0	0	0.329	0.306	0.631
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
AP2	Pearson Correlation	.207*	0.172	0.173	0.161	0.159	0.008	-0.043	0.065	-0.085	-0.025	.351**	1	.420**	.432**	-0.081	0.005	-0.048
	Sig. (2-tailed)	0.026	0.067	0.065	0.085	0.089	0.932	0.652	0.49	0.367	0.789	0		0	0	0.387	0.958	0.608
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
AP3	Pearson Correlation	-0.062	0.072	-0.093	0.002	0.095	-0.074	0.115	0.02	0.178	0.071	.541**	.420**	1	.499**	-0.017	-0.007	0.04
	Sig. (2-tailed)	0.512	0.442	0.321	0.983	0.311	0.434	0.22	0.831	0.057	0.449	0	0		0	0.853	0.938	0.673
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
AP4	Pearson Correlation	0.169	.233*	0.162	0.106	.242**	-0.037	0.023	-0.001	0.065	0.098	.600**	.432**	.499**	1	-.217*	-0.105	-0.036
	Sig. (2-tailed)	0.071	0.012	0.084	0.261	0.009	0.693	0.806	0.991	0.49	0.298	0	0	0		0.02	0.266	0.702
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
MF3	Pearson Correlation	0.001	-0.042	-0.158	0.079	0.072	0.131	0.031	0.166	0.041	0.095	-0.092	-0.081	-0.017	-.217*	1	.564**	.401**
	Sig. (2-tailed)	0.992	0.653	0.092	0.401	0.447	0.162	0.74	0.076	0.666	0.315	0.329	0.387	0.853	0.02		0	0
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
RevMF 4	Pearson Correlation	-0.082	0.037	-0.095	0.02	0.07	0.027	0.027	0.058	-0.064	0.014	-0.096	0.005	-0.007	-0.105	.564**	1	.282**
	Sig. (2-tailed)	0.383	0.692	0.31	0.832	0.46	0.771	0.776	0.537	0.499	0.885	0.306	0.958	0.938	0.266	0		0.002
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
MF2	Pearson Correlation	0.157	0.006	0.035	0.103	0.082	.246**	0.128	0.031	.191*	.272**	0.045	-0.048	0.04	-0.036	.401**	.282**	1
	Sig. (2-tailed)	0.093	0.947	0.711	0.275	0.381	0.008	0.174	0.741	0.041	0.003	0.631	0.608	0.673	0.702	0	0.002	
	N	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115

Table I-4

Inter-item Correlation Matrix Table

Inter-Item Correlation Matrix

	Q9_PU_5	Q7_PU_1	Q17_PU_2	Q31_SC_3	Q30_PT_6
Q11_MF_2	0.079	0.052	0.135	0.075	0.077
Q29_MF_3	0.054	0.012	0.077	0.042	0.048
Q6_MF_1	0.1	0.122	0.146	0.076	0.059
Q26_MF_5	0.094	0.075	0.167	0.055	0.04
RecQ27_MF4	0.011	-0.035	0.053	0.02	0.036
Q16_AP_4	0.093	-0.005	0.143	0.112	0.089
Q15_AP_1	0.126	0.047	0.201	0.122	0.092
Q18_AP_2	0.082	0.029	0.11	0.047	0.053
Q10_AP_3	0.15	0.094	0.181	0.083	0.06
Q12_PU_4	0.431	0.308	0.406	0.121	0.109
Q9_PU_5	1	0.342	0.335	0.22	0.19
Q7_PU_1	0.342	1	0.285	0.102	0.111
Q17_PU_2	0.335	0.285	1	0.157	0.135
Q31_SC_3	0.22	0.102	0.157	1	0.483
Q30_PT_6	0.19	0.111	0.135	0.483	1
Q24_SC_1	0.197	0.073	0.163	0.481	0.3
RecQ19_PT3	0.243	0.125	0.168	0.271	0.239
RecQ13_PT2	0.227	0.13	0.191	0.25	0.201

Inter-Item Correlation Matrix

	Q11_MF_2	Q29_MF_3	Q6_MF_1	Q26_MF_5	RecQ27_MF4
Q11_MF_2	1	0.592	0.534	0.463	0.395
Q29_MF_3	0.592	1	0.314	0.311	0.451
Q6_MF_1	0.534	0.314	1	0.515	0.207
Q26_MF_5	0.463	0.311	0.515	1	0.189
RecQ27_MF4	0.395	0.451	0.207	0.189	1
Q16_AP_4	0.092	0.066	0.068	0.087	0.04
Q15_AP_1	0.089	0.073	0.095	0.117	0.039
Q18_AP_2	0.051	0.041	0.033	0.046	0.014
Q10_AP_3	0.1	0.055	0.118	0.127	-0.006
Q12_PU_4	0.14	0.101	0.161	0.152	0.065
Q9_PU_5	0.079	0.054	0.1	0.094	0.011
Q7_PU_1	0.052	0.012	0.122	0.075	-0.035
Q17_PU_2	0.135	0.077	0.146	0.167	0.053
Q31_SC_3	0.075	0.042	0.076	0.055	0.02
Q30_PT_6	0.077	0.048	0.059	0.04	0.036
Q24_SC_1	0.061	0.048	0.086	0.07	0.033
RecQ19_PT3	0.033	0.013	0.029	0.034	0.02
RecQ13_PT2	0.026	0.011	0.042	0.044	0.035

Inter-Item Correlation Matrix

	Q16_AP_4	Q15_AP_1	Q18_AP_2	Q10_AP_3	Q12_PU_4
Q11_MF_2	0.092	0.089	0.051	0.1	0.14
Q29_MF_3	0.066	0.073	0.041	0.055	0.101
Q6_MF_1	0.068	0.095	0.033	0.118	0.161
Q26_MF_5	0.087	0.117	0.046	0.127	0.152
RecQ27_MF4	0.04	0.039	0.014	-0.006	0.065
Q16_AP_4	1	0.513	0.413	0.407	0.074
Q15_AP_1	0.513	1	0.321	0.39	0.127
Q18_AP_2	0.413	0.321	1	0.427	0.058
Q10_AP_3	0.407	0.39	0.427	1	0.164
Q12_PU_4	0.074	0.127	0.058	0.164	1
Q9_PU_5	0.093	0.126	0.082	0.15	0.431
Q7_PU_1	-0.005	0.047	0.029	0.094	0.308
Q17_PU_2	0.143	0.201	0.11	0.181	0.406
Q31_SC_3	0.112	0.122	0.047	0.083	0.121
Q30_PT_6	0.089	0.092	0.053	0.06	0.109
Q24_SC_1	0.152	0.203	0.098	0.134	0.124
RecQ19_PT3	0.042	0.066	-0.015	0.049	0.157
RecQ13_PT2	0.067	0.092	0.021	0.068	0.166

Inter-Item Correlation Matrix

	Q24_SC_1	RecQ19_PT3	RecQ13_PT2
Q11_MF_2	0.061	0.033	0.026
Q29_MF_3	0.048	0.013	0.011
Q6_MF_1	0.086	0.029	0.042
Q26_MF_5	0.07	0.034	0.044
RecQ27_MF4	0.033	0.02	0.035
Q16_AP_4	0.152	0.042	0.067
Q15_AP_1	0.203	0.066	0.092
Q18_AP_2	0.098	-0.015	0.021
Q10_AP_3	0.134	0.049	0.068
Q12_PU_4	0.124	0.157	0.166
Q9_PU_5	0.197	0.243	0.227
Q7_PU_1	0.073	0.125	0.13
Q17_PU_2	0.163	0.168	0.191
Q31_SC_3	0.481	0.271	0.25
Q30_PT_6	0.3	0.239	0.201
Q24_SC_1	1	0.253	0.247
RecQ19_PT3	0.253	1	0.638
RecQ13_PT2	0.247	0.638	1

APPENDIX J

Figures

Figures

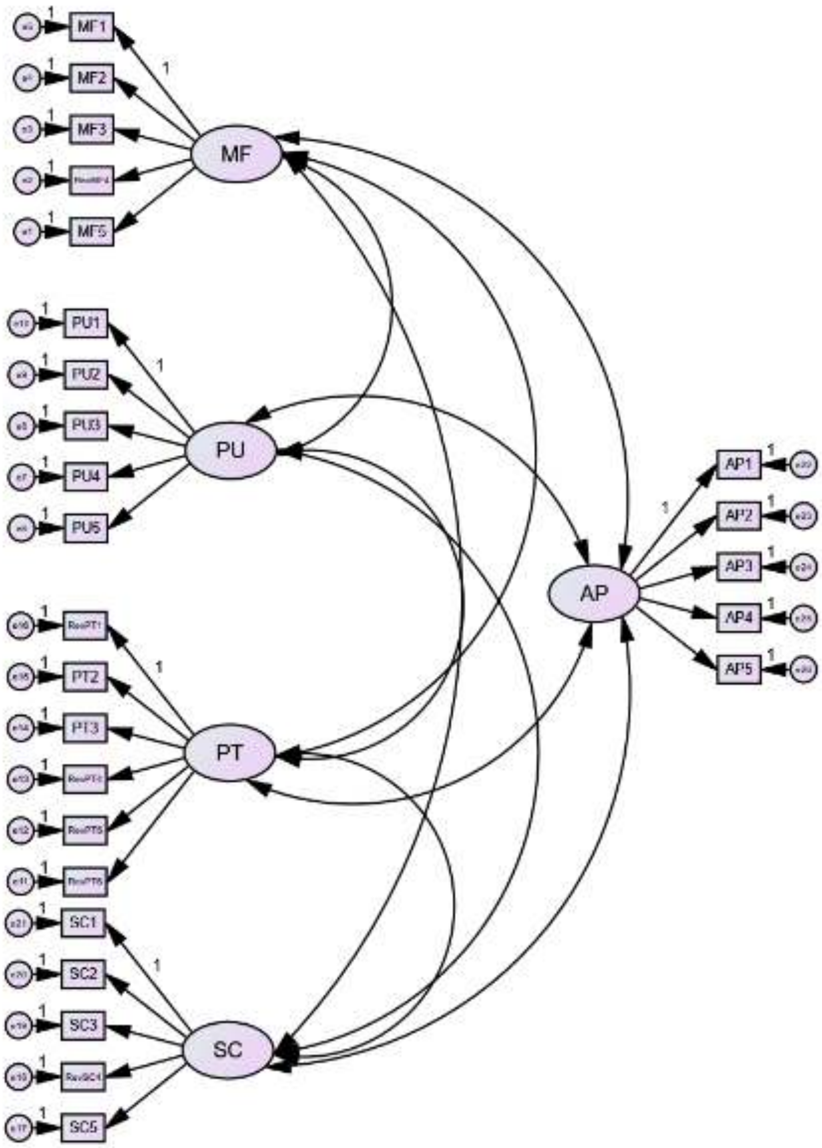


Figure J-1. Pretest 5 factor model.