3-2018

Human Factors Contributing to Unstabilized Approaches and Landings in Commercial Aviation Incidents: An Analysis of ASRS Reports

Garrin E. Ross
Embry-Riddle Aeronautical University

HUMAN FACTORS CONTRIBUTING TO UNSTABILIZED APPROACHES AND LANDINGS IN COMMERCIAL AVIATION INCIDENTS: AN ANALYSIS OF ASRS REPORTS

by

Garrin Edward Ross

A Thesis Submitted to the College of Aeronautics
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Aeronautics

Embry-Riddle Aeronautical University
Daytona Beach, Florida
March 2018

HUMAN FACTORS CONTRIBUTING TO UNSTABILIZED APPROACHES AND LANDINGS IN COMMERCIAL AVIATION INCIDENTS: AN ANALYSIS OF ASRS REPORTS

by

Garrin Edward Ross

This Master's Thesis was prepared under the direction of the candidate's Thesis Committee Chair, Dr. Ian R. McAndrew, Professor of Aeronautical Science, and Thesis Committee Member, Dr. David C. Ison, Associate Professor of Aeronautical Science.

THESIS COMMITTEE

Digitally signed by Dr. Ian R. McAndrew FRAeS
DN: cn=Dr. Ian R. McAndrew FRAeS, o=College of Aeronautics, ou=Associate Dean Research, email=mcand4f1@erau.edu, c=GB
Date: 2018.03.14 16:24:15 Z

Dr. Ian R. McAndrew
Thesis Committee Chair

David C. Ison

Digitally signed by David C. Ison
DN: cn=David C. Ison, o=ERAU, ou, email=isond46@erau.edu, c=US
Date: 2018.03.15 17:17:26 -07'00'

Dr. David C. Ison
Thesis Committee Member

March 2018

Acknowledgements

And whatever you do, whether in word or deed, do it all in the name of the Lord Jesus Christ, giving thanks to God the Father through Him.

~Colossians 3:17 (NIV)

This thesis is dedicated to Linda.

The glory is solely to my Sovereign God.

Abstract

Researcher: Garrin E. Ross

Title: Human Factors Contributing to Unstabilized Approaches and Landings in Commercial Aviation Incidents: An Analysis of ASRS Reports

Institution: Embry-Riddle Aeronautical University

Degree: Master of Science in Aeronautics

Year: 2018

The purpose of this study was to investigate the human factors reported as contributing to operational incidents of unstabilized approaches and landings in United States-based commercial aviation. While previous aviation safety studies have analyzed aviation incident data when investigating the human factor influences during commercial aviation operations and incidents, unstabilized approaches and landings have not been explicitly examined using similar methods. Informed by the findings and recommendations of the Flight Safety Foundation's Approach and Landing Accident Reduction Task Force, this study examined and analyzed the Aviation Safety Reporting System (ASRS) incident report data from unstabilized approach and landing events. The study used a nonexperimental, single-group, quantitative *ex post facto* design, and binomial logistic regression analysis to test associations between the ASRS-coded human factors and reported unstabilized approach outcomes. Results revealed that there were statistically significant differences in the outcome of unstabilized approaches ($\chi_2(1) = 6.579$, $p = .01$, $w = .26$), with less than 37% of the reported unstabilized approaches being responded to with go-around compliance. However, results from the binomial logistic regression did not reveal significant associations of the ASRS-coded human factors with the likelihood of unstabilized approaches being continued to landing rather than go-around compliance. The continued investigation of human and non-human factors identified as contributing to reported incidents of unstabilized approaches and landings is recommended. Results from such investigations have the potential of informing effective go-around compliance training designs.

Keywords: aviation, Aviation Safety Reporting System, go-around, human factors, unstabilized approaches

Table of Contents

List of Tables

Table Page

List of Figures

Figure Page

Chapter I

Introduction

United States-based commercial air carrier travel has remained the safest mode of transportation based on passenger fatality statistics between 2002 to present (Bureau of Transportation Statistics, n.d.). With the exception of the events on September 11, 2001, when international terrorists intentionally crashed loaded U. S. commercial passenger aircraft, U. S. air carrier travel has statistically been the safest mode of public transportation in the 21st century. As the National Airspace System capacity continues to increase, the commitment to aviation safety has remained a priority for national air transportation (Federal Aviation Administration [FAA], 2016). Moreover, the continued emphasis on aviation safety has shifted from primarily reactive safety assessments based on accident statistics to more proactive assessments of commercial aviation operations and training (see FAA, 2017a; Flight Safety Foundation [FSF], 2017). In March 2017, the Flight Safety Foundation (FSF) identified the frequency of commercial passenger flight crews flying unstabilized approaches and landings as a current threat to aviation safety (FSF, 2017). However, this was not the first time unstabilized approaches and landings had been noted as a persistent concern for National Airspace System commercial aviation in the 21st century.

In 2015, strengthening procedural compliance, particularly compliance with flying stabilized approaches and adhering to go-around policies, was identified as a priority by the National Transportation Safety Board (NTSB). As a result, strengthening procedural compliance as an aviation safety concern was listed on the NTSB's *Most Wanted List*. The NTSB's *Most Wanted List* represents the agency's topmost recommendations of critical changes necessary for saving lives through the reduction of transportation accidents (NTSB, n.d.). Among its recommendations, the NTSB called for improvements by the Federal Aviation Administration (FAA) and air carriers in pilot training for procedures such as those for stabilized approaches. The troika of better procedures, training, and compliance was the agency's mandate for ensuring a culture of safety in commercial aviation.

Statement of the Problem

Approximately 65 percent of commercial aviation accidents occur during the flight phases of approach and landing (FSF, 2017; International Air Transportation Association [IATA], 2016). According to the Flight Safety Foundation study, 83 percent of those approach and landing accidents were avoidable if flight crews had intervened on their unstabilized approaches and initiated a go-around. Thus, following proper operational procedures of initiating a go-around in response to an unstabilized approach could potentially avoid 54 percent of commercial aviation accidents. However, despite commercial aviation industry go-around policies, it is estimated that only approximately 3 percent of unstabilized approaches are met with go-around policy compliance (FSF, 2017).

Questions arose during the FSF study as to why highly trained flight crews frequently ignored a go-around policy designed for safety. It was speculated that this noncompliance might be influenced by the inherent risks of losing control of the aircraft during a go-around (FSF, 2017), such that there was a risk tradeoff. It was further speculated there was a flight crew heuristic that a go-around should only be initiated if its risks were judged as being less than the risks associated with an unstabilized approach and landing (FSF, 2017). Not an intentional component of formal training, this heuristic became the target of the FSF's increased focus on aviation safety.

Following a multi-year study, FSF's Approach and Landing Accident Reduction (ALAR) Task Force provided summary findings of its extensive research in understanding go-around policy noncompliance (FSF, 2017). Among its list of findings, the Task Force identified several systemic issues such as a collective industry norm of accepting noncompliance of go-around policies and low management awareness of the impacts of go-around noncompliance on approach and landing accidents (ALA). In addition, the Task Force identified that flight crews lacked adequate awareness of ALA risks, effective go-around decision making was low, and procedures and training inadequately address the variable challenges of a go-around (FSF, 2017). The Task Force concluded that go-around policies and procedures were not sufficient for ensuring aviation safety during approaches and landings, and among the identified deficiencies was flight crew training for appropriate operational decision making during unstabilized approaches and landings.

In its final report, the ALAR Task Force delivered a series of strategic recommendations that targeted organizational and system deficiencies and necessary improvements. These recommendations included ensuring operationally-meaningful policies, managing those policies effectively, and increasing situational awareness relevant to unstabilized approaches and landings (FSF, 2017). Additional recommendations included ensuring that flight crew training appropriately reflects different risk scenarios in which a go-around should be executed. The ALAR Task Force provided a poignant message that what has been lacking is an "understanding of the psychology of noncompliance" (FSF, 2017, p. 3) for go-arounds. Thus, among the final recommendations was understanding flight crews' situational awareness levels and psychological profiles for managing internal go-around policies.

The ALAR Task Force also provided training-specific recommendations. A strategic priority was ensuring that go-around risk scenarios were incorporated into effective go-around training and awareness (FSF, 2017). In meeting this strategic priority, the ALAR Task Force provided 21 recommendations targeting improvements in training for go-around execution, including an emphasis on go-around training using a range of operational scenarios for realistic simulation of go-around conditions. This realism is expected to incorporate lessons learned through the review and analysis of operational events and incidents. Following the Task Force's (2017) report, there have been no documented efforts reviewing and analyzing operational incidents of unstabilized approaches and landings in commercial aviation toward the outcome of improving effective commercial pilot training for go-around compliance and execution.

Significance of the Study

The purpose of this study was to use Aviation Safety Reporting System (ASRS) data to investigate human factors reported as contributing to operational incidents of unstabilized approaches and landings in commercial aviation. While approach and landing safety has been the subject of multiple efforts and research by various organizations, such as the FAA and IATA, the recommendations offered by the ALAR Task Force provided a new focus on understanding the pervasive noncompliance with go-around policies. Previous studies have analyzed aviation incident data reported in the ASRS database when investigating human factor influences during commercial aviation operations and incidents (e.g., Barnes & Monan, 1990; Jentsch, Barnett, Bowers, & Salas, 1999; Sarter & Alexander; 2000; Sumwalt, Morrison, Watson, & Taube, 1997; Tiller & Bliss, 2017) , but not unstabilized approaches and landings. Likewise, understanding the attitudes and conditions of noncompliance with go-around policies begins with understanding the characteristics of unstabilized approach and landing incidents. By examining and analyzing data reported in ASRS from unstabilized approaches and landings, this study sought to identify human factors associated with and contributing to reported incidents of unstabilized approaches and landings, and provide recommendations informing effective go-around training designs.

Research Questions

There were three research questions that guided the study:

RQ1: What human factors are identified in the ASRS reports as contributing factors to aviation incidents of unstabilized approaches?

RQ2: To what extent, if any, are the ASRS-coded human factors associated with unstabilized approaches reported in the ASRS database?

RQ3: If associations between the ASRS-coded human factors and unstabilized approaches exist, what is the relationship of the human factors in the likelihood that the reported event was an unstabilized approach continued to landing versus go-around?

Limitations and Delimitations

There were several barriers needing to be addressed in the course of this study. One such barrier to the study of human factors during aviation events of unstabilized approach and landing was that direct observation of flight crew operations during commercial aviation incidents of unstabilized approaches and landings was not feasible. Given increased security measures in commercial aviation, it was not possible to gain access to the commercial aircraft flight deck during actual operations in order to gather data through direct observational methods. However, this study was investigating the human factors identified and coded in the ASRS incident reports filed by the flight crew following events of unstabilized approaches. Therefore, direct observation was not necessary for the study.

Another issue relevant to this study was that at the time of the study there existed no consensus on stabilized approach criteria and go-around policies among the commercial aviation operators. Despite this variability, there did exist commonly referenced stabilized approach criteria recommended to the aviation industry and incorporated into standard operating procedures for go-around decision-making (FSF, 2000). These were the stabilized approach criteria used in this study, and the go-around policies themselves were outside the study scope.

There also existed the barrier that the researcher in this study would not have access to all documents used by ASRS analysts in initial coding of the reported incident. ASRS analysts gather information from several other reporting organizations, such as the Aviation Safety Awareness Program, and these documents were not directly available to the researcher. However, this study was investigating the human factors coded by the ASRS analysts and the accompanying flight crew narratives, and this approach did not rely on access to those other information sources.

There are inherent limitations associated with the ASRS database, and data coded from the reported incidents must be carefully interpreted. Incident reports filed with ASRS are voluntary and rely on self-reporting, and therefore vulnerable to voluntary reporting bias. Since reports are filed after the incident has occurred, there is also the risk of hindsight bias and self-protective interpretation (Jentsch et al., 1999). Voluntary reporting data, such as the ASRS data used in this study, is subject to reporting bias not only in what is reported but also what is not reported. Despite this risk of reporting bias, studies have found similarities of voluntarily filed reports with other safety data and a significant correlation (r = .91) of voluntary reporting with mandatory incident reporting has been revealed (Chappell, 1997). Further, it can be assumed that consistently reported aspects identified in large numbers of reports are likely true, since a large number of reporters are not likely to erroneously report in the same way (Chappell, 1997). Another limitation of using ASRS data is that the incident of interest may not be reported in matching terms of interest to analysts and researchers, which poses a challenge in coding the incidents and aggregating relevant data (Wickens & McCloy, 1993). Thus, all incident reports are subject to extensive analysis by the ASRS analyst team, comprised of highly trained pilots, air traffic controllers, mechanics, and members of management teams with substantial aviation and human factors experience (ASRS, 2016). Finally, ASRS reports are only those incidents that were reported, and not reflective of all such incidents and others that share similar operational characteristics. Any conclusions drawn from studying reported events can be generalized only to the reported incidents, and not to the full population of such events. However, if an attribute is reported, then it can be assumed that it is an attribute also existing in the larger population of such events (Chappell, 1997).

Despite these limitations, there are inherent strengths in incident reporting that may benefit human factors research. Data from voluntary reporting has been shown to be similar to data from other safety reporting. The information contained in incident reports is from individuals directly involved in the incident, incident reports provide for larger samples than accident reports, and the reported incident can be considered ecologically valid (Chappell, 1997). Finally, it was assumed that given a large sample of voluntary reports, there exists a high probability that the reports contain information useful in the analysis of possible causes of the reported problems (Billings & Reynard, 1984). This latter point has been among the rationale of substantial research using ASRS data.

There are also limitations inherent in researching archived data. ASRS data is not gathered with the intention of addressing a particular research question, which means that information of other potential variables of interest or important third variables may not have been gathered (Cheng & Phillips, 2014). In addition, as noted earlier, ASRS data is not directly gathered from an individual, but rather it is self-reported. The individuals collecting archived data are not the individuals who are subsequently analyzing the data for research purposes (Cheng & Phillips, 2014). In the context of this study, the researcher analyzing the data entered by the ASRS analysts was not involved in the initial collection of the data being analyzed. In order to mitigate the risks of these limitations, this study followed similar practices as those practices detailed in earlier research using ASRS archived data. Given that the study used de-identified publicly-available archived information, risks of the study were minimal and institutional review board (IRB) approval was not needed.

There were delimitations in this study. Given that this study investigated human factors associated with United States-based commercial aviation incidents, accident reports filed with the NTSB were not included. This study used the incident report data contained in the ASRS database, which has long been identified as the single-most largest publicly available and searchable database of commercial aviation safety incident data (Chappell, 1997). It should not be assumed that the incident reports are any less meaningful than accident reports in investigating aviation safety. In a seven-year study of human factors in aviation incidents, Billings and Reynard (1984) found that the ASRS data suggests that "accidents involving human factors are, in fact, a subset of incidents involving those factors" (p. 963). Accidents originate from the same larger set of attributes as incidents. However, accident reports provide insight only into *what* happened, *when* it happened, and *who* was involved (Harle, 1997). It is aviation incident data that can inform of the *how* and *why* the events occurred (Chappell, 1997; Harle, 1997). Therefore, since the scope of this study was investigating the human factors influencing flight crew noncompliance of go-around policies during unstabilized approaches and landings reported to ASRS, the study data was limited to the aviation safety data contained in the ASRS database.

The time frame for selection of United States-based commercial aviation incidents used in the study spanned five years from 2012 to 2016. It was anticipated that this time frame would provide an adequate sample of unstabilized approach and landing incidents, and there would have been limited changes to go-around policies during that span of time. This study was limited to commercial passenger air carriers operating under Federal Aviation Regulations Part 121, consistent with the operations studied by the FSF's ALAR Task Force (FSF, 2017). Since the study was investigating unstabilized approaches and landings, it used only incidents that occurred during the initial approach, final approach, and landing phases of flight. Furthermore, the study was investigating flight crew human factors during the incidents. This means that the study would be limited to incident reports that were filed by the flight crew involved in the incident. Although there are other individuals who may file a report, such as air traffic control operators, this study was investigating the human factors influencing flight crew noncompliance of go-around policies during unstabilized approaches and landings.

Definition of Terms

Accident. In brief, "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which (a) a person is fatally or seriously injured…; (b) the aircraft sustains damage or structural failure…; or, (c) the aircraft is missing or is completely inaccessible" (ICAO, 2001, p. 1-1).

Approach. Phase of flight beginning when the "crew initiates changes in aircraft configuration and/or speeds enabling the aircraft to maneuver for the purpose of landing on a particular runway; it ends when the aircraft is in the landing configuration and the crew is dedicated to land on a specific runway. It may also end by the crew initiating an 'Initial Climb' or 'Go-around' phase" (IATA, 2016, p. 3).

Approach and landing accident. "Accidents occurring during a visual approach, during an instrument approach after passing the intermediate approach fix, or during the landing maneuver. This term also applies to accidents occurring when circling or when beginning a missed approach procedure" (FAA, 2008b, p. 1).

Communication breakdown. Human factor; human-to-human communication problems and issues, either spoken or visual signals, during human-to-human interactions (ASRS, 2017).

Confusion. Human factor; the loss of orientation of time, location, and personal identity, and may include the loss of memory in correct recall of previous events or new learning (ASRS, 2017).

Distraction. Human factor; being distracted from an operational task (ASRS, 2017).

Fatigue. Human factor; diminished operational performance as a result of prior expenditure of work-related effort and energy (ASRS, 2017).

Go-around. "Begins when the crew aborts the descent to the planned landing runway during the 'Approach' phase; it ends after speed and configuration are established at a defined maneuvering altitude" (IATA, 2016, p. 3).

Human factor. Deficiency or breakdown in flight crew human performance (ASRS, 2017).

Human-machine interface. Human factor; issues attributed to the interface between human and system, either hardware or software. Does not include problems associated with the interface between the human and the entire aircraft, and instead must be human and component (ASRS, 2017).

Incident. "An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation" (ICAO, 2001, p. 1-1).

Instrument meteorological conditions. Meteorological conditions that are less than the minima specified for visual meteorological conditions (ICAO, 2005).

Landing. Phase of flight beginning when the "aircraft is in the landing configuration and the crew is dedicated to touch down on a specific runway; it ends when the speed permits the aircraft to be maneuvered by means of taxiing for the purpose of arriving at a parking area. It may also end by the crew initiating a 'Go-around' phase" (IATA, 2016, p. 3).

Physiological. Human factor; physiological problems other than fatigue, such as illness, health or fitness issue, or stress (ASRS, 2017).

Situational awareness. Human factor; issues associated with decreased awareness of what is happening in order to understand how actions, events, and information impact operational goals and objectives in the present and the near future (ASRS, 2017).

Time pressure. Human factor; internally- or externally-imposed pressure related to time, such as the actual or perceived need to expedite operations (ASRS, 2017).

Training/qualification. Human factor; issues or problems attributed to experience, qualifications, knowledge, and/or recency (ASRS, 2017).

Troubleshooting. Human factor; issues or problems attributed with isolating a fault (ASRS, 2017).

Undesired aircraft state. A safety-compromising aircraft state induced by the flight crew that is still recoverable (IATA, 2016).

Unstabilized approach. "Failure to establish and maintain a constant attitude, airspeed, descent rate, on approach, or making aircraft configuration changes at or below 500 feet HAT (AGL) on approach when conducting a precision approach in VMC, or at or below 1,000 feet HAT on approach when conducting a precision approach in IMC. (Air carriers typically require a stabilized approach either by 500 or 1,000 feet HAT, depending on the carrier.) A non-precision approach may also be considered unstabilized if there is a significant variance from appropriate speed, rate of descent, attitude, or configuration profiles" (ASRS, 2017, p. 5).

Visual meteorological conditions. Meteorological conditions of flight visibility, distance from clouds, and cloud ceiling that are not less than the established minima (ICAO, 2005).

Workload. Human factor; issues or problems attributed to the ability to cope with or perform increased task demands (ASRS, 2017).

List of Abbreviations

ALA	Approach and landing accident
ALAR	Approach and landing accident reduction
ASRS	Aviation Safety Reporting System
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FSF	Flight Safety Foundation
IATA	International Air Transportation Association
IMC	Instrument meteorological conditions
NASA	National Aeronautics and Space Administration

NextGen	Next Generation Air Transportation System
NTSB	National Transportation Safety Board
VMC	Visual meteorological conditions

Summary

Although U. S. commercial aviation has long been classified as the safest mode of passenger transportation, safety remains a primary focus in NextGen airspace developments. Unstabilized approaches and landings are persistent and pervasive risks to commercial aviation safety, and they have been identified as a top current safety threat. Echoing the earlier recommendations by the NTSB, the FSF ALAR Task Force called for increased efforts improving flight crew training in order to promote go-around compliance. The ALAR Task Force concluded that go-around policies and procedures have not been sufficient for ensuring aviation safety during approaches and landings (FSF, 2017). Deficiencies in flight crew training for the appropriate operational decision making during unstabilized approaches and landings were identified. According to the ALAR Task Force findings, improvements to flight crew training for go-around compliance need to be informed by the lessons learned from the review and analysis of operational events and incidents of unstabilized approaches and landings (FSF, 2017). To date, there have been no documented efforts reviewing and analyzing operational incidents of unstabilized approaches and landings in commercial aviation toward the end of understanding the psychology of go-around noncompliance and improving effective commercial pilot training for go-around execution.

The purpose of this study was to investigate human factors identified and coded as contributing to reported operational incidents of unstabilized approaches and landings in commercial aviation. Understanding the attitudes and conditions of flight crew noncompliance

with go-around policies and procedures begins with understanding characteristics of unstabilized approach and landing incidents. Thus, the aims of this study were three-fold: (1) identify the human factors that are coded in ASRS reports as contributing to aviation incidents of unstabilized approaches; (2) assess to what extent, if any, the ASRS-coded human factors are associated with unstabilized approaches reported in the ASRS database; and, (3) determine if there was a relationship of the human factors in the likelihood that the reported incident was an unstabilized approach continued to landing versus go-around. This study had the potential of identifying human factors associated with and contributing to reported incidents of flight crew go-around noncompliance during unstabilized approaches and landings, and informing effective go-around compliance training designs.

Chapter II

Review of the Literature

Approach-and-landing accidents (ALAs) have been a persistent aviation safety concern. As early as the Wright brothers' pioneering efforts of manned flight, controlled landing without crashing was a target end state of successful flight (Wright Brothers Aeroplane Company, n.d.). More than a century later, perturbations to the approach and landing phases of flight prevail. In an earlier study by the FSF ALAR Task Force, the average worldwide fatal ALA rate from 1980 through 1996 was 16.8 per year (Joint Safety Analysis Team [JSAT], 1999). Between 2007 and 2016, approximately 56% of all fatal accidents in worldwide commercial operations occurred during the approach and landing phases of flight (Boeing, 2017). Although substantially less than the fatal ALA rate of 23 per year predicted a decade earlier (JSAT, 1999), this was an average fatal ALA rate of 3.5 per year. However, these numbers do not account for the nonfatal ALA accidents and incidents resulting in aircraft damage and other adverse outcomes. While the average fatal ALA rate has been significantly reduced, the overall ALA risk has not. Although only as many as 4 percent of all approaches occur in conditions jeopardizing aviation safety, nearly 97 percent of those at-risk approaches are voluntarily continued to landing (FSF, 2017). According to these numbers, only 3 percent of at-risk approaches in commercial aviation are countered by adherence to the policies and procedures intended to mitigate them. While ALAs occur at a low frequency, the costs of them in terms of fatal outcomes are the highest in commercial aviation.

Understanding the Approach Phase of Flight

Comprising only approximately 14% of total commercial in-flight time (Boeing, 2017), the approach phase of flight is characterized by some of the highest flight crew workload and task saturation (FSF, 2017; Harris, 2011; Schvaneveldt, Beringer, & Lamonica, 2001). Beginning at the top of the descent phase of flight, pilots continuously manage the complex reduction of flight energy in speed, altitude, and distance in order to remain within a narrowing acceptable range for safe landing (IATA, 2016). Pilots are not only working to control the aircraft itself, but doing so among the variable environmental influences of weather and changing airspace around the arrival airport. The aim of the approach is to be in and maintain the proper configuration of the right speed and attitude for a safe landing and completion of the landing roll to taxing speed (IATA, 2016). This is the fundamental intention of a stabilized approach, and the flight crew must *stay ahead of the aircraft* in order to do.

Stabilized approaches. Despite variations across commercial aviation operators in how stabilized approaches are defined in the standard operating procedures (FSF, 2000), there exist certain criteria for stabilized approaches that are essentially the same throughout the industry (IATA, 2016). The most commonly referenced set of criteria for stabilized approaches can be found in the global FSF ALAR Task Force recommendations provided in the ALAR Briefing Notes (FSF, 2000). When on approach, the general requirement is that the flight be stabilized by 1,000 feet above the airport elevation when operating in instrument meteorological conditions (IMC) or stabilized by 500 feet above the airport elevation when operating in visual meteorological conditions (VMC) (FSF, 2000). An approach is stabilized when all of the following criteria are met (FSF, 2000). The aircraft must be on the correct flight path and the path can be maintained with only moderate heading and pitch adjustments being necessary. The aircraft descent sink rate must be no greater than 1,000 feet per minute. The power setting and the speed of the aircraft must be maintained at the manufacturer's recommended setting and speed for landing configuration, with speed deviations being no more than 20 knots above.

Neither power setting nor speed may fall below the recommended setting or speed. Finally, the aircraft is in the correct landing configuration, and all approach briefings and checklists have been conducted. Specific types of approaches, such as instrument landing system approaches, sink rates necessary in excess of 1,000 feet per minute, and approaches in other abnormal conditions, all have additional criteria or require special approach briefings prior to commencing the approach (FSF, 2000).

The criteria for stabilized approaches recommended by the FSF ALAR Task Force are consistent with those criteria identified by the FAA (2014) and IATA (2016). According to the FAA (2014), the aircraft must be in the proper landing configuration early in the approach with landing gear extended, flaps selected and trim set for landing, and fuel properly balanced. The aircraft must be properly configured for landing, on the correct lateral and vertical track, and at the proper speed for landing before descending through the 1,000-foot elevation point in IMC or 500-foot elevation point in VMC (FAA, 2014). The descent rate and indicated airspeed must be maintained within specified limits, and speed should never be less than the manufacturer's recommended speed for landing (FAA, 2014). The IATA (2016) maintains the same elevation stabilization criteria for both IMC and VMC, but also notes that these stabilization altitudes can range from 1,500 feet for IMC to 500 feet for VMC. The IATA criteria includes the approach speed being only slightly faster than the manufacturer recommended touchdown speed, descent rate commensurate with approach angle and speed, aircraft flap and gear configured for landing, aircraft attitude stable in all three axes, and engine thrust above idle and stable (2016). In sum, an aircraft is on a stabilized approach when the pilot establishes and maintains the aircraft in the proper configuration, proper speed, and proper path for landing at a predetermined point on the runway (FAA, n.d.).

Benefits of a stabilized approach. When the approach is stabilized, the flight crew is able to maintain awareness and close monitoring of the horizontal and vertical flight path, rate of descent, aircraft speed, and engine thrust (FSF, 2000). This increased overall situational awareness promotes improved inter- and intra-cockpit communications, crew resource management, decision-making, and judgement of the aircraft landing performance. Pilots are better able to anticipate factors that might risk stabilization, detect deviations in operational limits, take any necessary corrective action to maintain stabilization, and decide when, and if, an approach is no longer stabilized (FSF, 2000). In brief, a stabilized approach is the safest operational profile for the safest handling of the aircraft (FAA, 2014). When such flight conditions are not established and maintained during the approach, it is considered an *unstabilized* approach.

Unstabilized approaches. Given that the challenges and emergent problems faced by a commercial flight crew vary from flight to flight, there is "no such thing as a typical airline flight" (Harris, 2011, p. 148). Challenges or problems emerging during the approach phase of flight may interfere with pilots establishing and maintaining the operational characteristics of a stabilized approach, and the approach may become unstabilized. Fundamentally, an unstabilized approach is an approach that does not meet or maintain the established criteria for a stable approach profile at or below the aforementioned elevation criteria for a stabilized approach (IATA, 2016; FSF, 2000). Transient deviations do not immediately qualify an approach as unstabilized, but instead the approach is unstabilized when deviations in the flight parameters cannot be promptly corrected with effective countermeasures (FSF, 2000).

***Factors influencing unstabilized approaches*.** Unstabilized approaches occur frequently under certain circumstances (Dismukes, 2010), and have been attributed to a number of factors, which themselves are influenced by associated factors (FSF, 2000). The most common tactical error in U. S. commercial aviation accidents between 1978 and 2001 was the failure to appropriately counter an unstabilized approach (Dismukes, Berman, & Loukopoulos, 2007). In a prominent study of 76 approach-and-landing accidents and serious incidents between 1984 and 1997, the FSF ALAR Task Force (2000) identified several hazards increasing the risk of an accident or serious incident related to unstabilized approaches and landings.

Approach hazards. The ALAR Task Force (2000) found that more than half of the reviewed accidents and incidents occurred under one or more of the following conditions:

- Flying a non-precision instrument approach or visual approach;
- In the absence of radar service;
- At airports located in hilly or mountainous terrain;
- During precipitation, either rain or snow; or,
- In darkness or twilight.

A third of the accidents and incidents analyzed by the ALAR Task Force occurred during approaches that experienced unidentified adverse wind conditions, such as low-altitude wind shear (FSF, 2000). Other influencing factors were the absence of safety equipment (e.g., ground-proximity warning system), unexpected automation failure (e.g., autopilot failure to capture glideslope), and inadequate aids for safe approaches and landings (e.g., absence of approach/runway lights). In addition to the aforementioned approach hazards, which may be influenced by the actions or non-actions of the flight crew (FSF, 2000), there are factors influencing unstabilized approaches more directly attributed to actions and attitudes of the flight crew. These contributing factors fall under the category of human factors.

Human factors. In 87 percent of the accidents and incidents analyzed by the ALAR Task Force (2000), flight crew continuation of an unstabilized approach was the causal factor, and attributed to human factors. Nearly 25 percent of the accidents and incidents involved flight crew disorientation, including visual illusions. Fatigue and time pressure are associated with reduced attention and time allocated to planning, preparing, and conducting a safe approach. Reduced situational awareness, often attributed to an increased workload during atypical approaches, interferes with the proper management of flight path, rate of descent, and speed, which subsequently increases workload as pilots take countermeasures to mitigate the disruption to approach stability. Short-notice runway changes or other late communications from ATC may increase workload as the flight crew attempts to reconfigure the aircraft for the new approach, and pilots may be overly confident in being able to accommodate the new approach. Additional factors influencing unstabilized approaches include over-reliance of pilots on each other to assess excessiveness of deviations, over-confidence of flight crews in their ability to recover from unstabilized conditions, and biased belief that the aircraft can be stabilized (FSF, 2000).

In short, an unstabilized approach is one in which the approach is not stabilized at the minimum stabilization altitude prescribed for the IMC or VMC operation of the approach, or the approach becomes unstabilized below that prescribed minimum stabilization altitude (FSF, 2000). Whether the approach is not stabilized or becomes unstabilized due to human or other factors does not influence the appropriate actions that should be taken by the flight crew. In the event of an unstabilized approach, it is an industry standard that either flight crew member should call for a go-around (FSF, 2000; FSF, 2017). When a go-around is called by either flight crew member, it is an industry standard that a go-around be conducted.

Go-Around Policies and Procedures

It is a commercial aviation industry and FAA standard that standard operating procedures (SOPs) for commercial flight deck crew members include go-around policies and procedures (FSF, 2000). These SOPs should include topics addressing the approach philosophy of go-arounds, conditions in which a go-around should be called and conducted, and procedures for calling and conducting a go-around. The FAA recommendations for go-around policies and procedures previously included in the FAA Advisory Circular covering SOPs for flight deck crew members are now found in the Advisory Circular for mitigating the risks of a runway overrun upon landing (FAA, 2104; FAA, 2017b). The FAA recommendation to all commercial aviation operators is that company policies and SOPs emphasize that either flight crew member may call for a go-around (FAA, 2010; FAA, 2014). Furthermore, given the immediacy of the situation during an unstabilized approach, the FAA recommendation is that when a go-around is called by either flight crew member, the pilot flying must immediately respond to the go-around callout by executing a missed approach (FAA, 2010), also referred to as go-around procedure (FAA, 2014). The importance of being prepared for a go-around is increased in the low frequency of occurrence, and this preparation begins with the approach briefing (FSF, 2000).

Approach briefing. The approach briefing is intended to provide both flight crew members an opportunity to correct any erroneous assumptions and develop a shared mental model of the approach (FSF, 2000). Despite this enduring understanding across the industry, the ALAR Task Force found that nearly three-quarters of the accidents and incidents analyzed between 1984 and 1997 were attributed to an inappropriate or omitted approach briefing. A full approach briefing appropriately begins before the flight crew initiates descent, and it will generally include review and discussion of the following items:

- Aircraft and fuel status;
- Automatic Terminal Information Service (ATIS) and Notices to Airmen (NOTAMS);
- Top-of-descent point;
- Approach charts and airport charts;
- Use of automation;
- Landing and stopping configuration and expectations;
- Intended deviations from SOPs; and,
- Go-around and missed approach procedures (FSF, 2000).

As part of the typical approach briefing, the flight crew reviews and discusses the go-around and missed approach procedures. These procedures typically include the necessary flight parameters for a safe approach and landing at the airport, appropriate altitude height for stabilization, specific go-around call to be verbalized if necessary, flight crew task sharing duties, and vertical and lateral navigation necessary for flying the published missed approach (FSF, 2000).

Missed approach. Flying a missed approach following a called go-around requires a compressed highly dynamic sequence of actions on the part of the flight crew (FSF, 2000). On the approach, the aircraft is configured for decreasing altitude, speed, and thrust; however, the configuration for flying a missed approach involves increasing altitude, speed, and thrust. In brief, the flight crew is resetting and maintaining the go-around target pitch-attitude, resetting and verifying the go-around thrust, and monitoring the aircraft performance. Effective and efficient task-sharing and crew resource management during the missed approach are of paramount importance. The pilot flying is selecting the takeoff/go-around mode, rotating the aircraft, following the pitch command, checking go-around power and aircraft performance, and being prepared to either counteract a nose-up pitch effect or trim the aircraft nose-down. The pilot not flying is setting the appropriate flaps, retracting the landing gear, monitoring aircraft attitude, checking the flight-mode annunciator, and monitoring flight parameters ready to call any excessive deviations (FSF, 2000). The flight crew is trying to *stay ahead of the aircraft*. When a go-around is called below the approach minimum altitude, the challenges and risks associated with flying a missed approach increase (FSF, 2017), and this may contribute to flight crews continuing an unstabilized approach to landing. Although go-around policies and procedures for missed approaches are intended to mitigate the unnecessary safety risks of unstabilized approaches, the ALAR Task Force (2017) found in a follow-up study of approach-and-landing accidents and serious incidents that pilot non-compliance with go-around policies continues to be a critical concern for commercial aviation safety. It was this 2017 report by the FSF ALAR Task Force that called for an increased effort on the part of the commercial aviation industry to counter the persistent trend of go-around policy non-compliance.

The Go-Around Decision-Making and Execution Project

In 2008, the FSF ALAR Task Force initiated the Go-Around Decision-Making and Execution Project in response to the persistent serious concerns of go-around noncompliance during unstabilized approaches (FSF, 2017). The FSF earlier study of approach-and-landing accidents and serious incidents from 1984 through 1997 revealed what was later identified as not being an anomalous trend of go-around noncompliance. The failure to conduct a go-around was also subsequently identified as the paramount risk factor in ALAs and the leading causative factor in runway excursions from 1994 through 2010 (FSF, 2017). Given that these and other similar studies (e.g., FSF, 2009; JSAT, 1999; Joint Safety Implementation Team [JSIT], 2001) had thoroughly investigated ALAs and their contributing factors, an understanding of the psychology of go-around noncompliance was lacking (FSF, 2017). It was this understanding of the psychology of go-around noncompliance that was the intention of the Go-Around Decision-Making and Execution Project initiated as part of the FSF Go-Around Safety Initiative of 2011. To meet this goal, the FSF ALAR Task Force commissioned an independent group to investigate go-around decision-making of flight crews and management.

Flight crew decision-making. The psychology of flight crew go-around decision-making during unstabilized approaches was investigated (FSF, 2017). A survey was constructed to gather information from flight crew members related to psychological precursors of unstabilized approach risk assessment and go-around decision-making. A sample of 2,340 pilots were asked to recall unstabilized approach events they had experienced and provide detailed descriptions of the events including subjective aspects (e.g., their situational assessments) and psychological representations of objective characterizations of the aircraft and environment (e.g., flight instabilities). Pilots also reported job-related demographic information and their flight operational characteristics. Based on their responses, pilots were assigned to one of three groups, based on their experiences during unstabilized approach, for response analysis: pilots who only experienced landing during an unstabilized approach, pilots who only experienced a go-around following an unstabilized approach, and pilots who experienced both a landing and go-around during an unstabilized approach. The set of psychological and psychosocial factors that were assessed were suggested as facets of a comprehensive and holistic concept of situational awareness, and included the pilot's:

- Affective awareness (gut feeling for threats);
- Anticipatory awareness (seeing and/or monitoring real and potential threats);
- Critical awareness (drawing on experience to assess emergent events);
- Task-empirical awareness (knowing the operational envelope of equipment);

- Functional awareness (knowing how to read/translate information from instruments);
- Compensatory awareness (knowing how and when to compensate/adjust for present and anticipated operational conditions for safe and compliant operations);
- Hierarchical awareness (knowing operational procedures, order, and sequencing);
- Relational awareness (assessing and engaging crew member relationships for safe and compliant operations); and,
- Environmental awareness (how company support and safety practices influence commitment to safe and compliant behavior) (FSF, 2017).

It was hypothesized that higher scores on these factors would be associated with better assessments of unstabilized approach risks and operationally-compliant go-around decision-making.

The study also gathered data for assessing the environmental and physical parameters that influence how pilots perceive the risks of unstabilized approaches, and how these perceptions influence the judgments of when to go-around (FSF, 2017). Pilots were presented with hypothetical flight scenario narratives that included five distinct flight parameters, and asked to report the degree of deviation in those scenario-specific parameters that would result in them calling a go-around. The intention of this part of the study was to infer at what point in the approach different risk factors become both salient and important to the pilots.

Management decision-making. The psychology of company management decision-making about how the company responds to go-around noncompliance was investigated and analyzed (FSF, 2017). A second survey was constructed to gather information from company management of their perceptions, beliefs, and experiences regarding unstabilized approaches and how responses to noncompliance are managed by the company. Managers were asked about rates of go-around policy compliance in their company and also the commercial airline industry. In addition, information was gathered as to the managers' level of satisfaction with their company's go-around compliance, appropriateness and effectiveness of their company's go-around policies, level of company-wide support for policing compliance, and their overall assessment of the urgency in addressing the risks of go-around noncompliance. As in the flight crew study, a similar set of psychological and psychosocial factors suggested as facets of a comprehensive and holistic concept of situational awareness were assessed. However, instead of the focus being on the flight approach itself, the focus for the management study was on the level of situational awareness related to the influence of unstabilized approach and go-around policies on company-wide operations. [Note: Given that the aim of this current study was investigating the human factors of flight crew operations during unstabilized approaches, the results of the management study were beyond the scope of the current study. Therefore, it was not included. For more information, see the Final Report to Flight Safety Foundation (FSF, 2017).]

The psychology of non-compliance. Results from the flight crew study revealed that unstabilized approach pilots (i.e., pilots who had landed during unstabilized approaches) evaluated substantially lower ($p < .05$) across all nine situational awareness factors than go-around pilots (i.e., pilots who had conducted a go-around) (FSF, 2017). The conclusion was that a pilot's ability to correctly perceive and assess risk during unstabilized approaches was directly affected by the pilot's situational awareness competencies. There were no differences ($p > .05$) between unstabilized approach pilots and go-around pilots in terms of identifying fatigue, confidence in abilities, willingness to challenge crew or authority, and pressure to land. However, the unstabilized approach pilots reported significantly lower scores ($p < .05$) than go-around pilots in their proper fatigue management, gut feelings of risk to stabilized approaches, ability to anticipate the need for and influence the decision for a go-around, assessment of risk in approach instability, and agreement in and intolerance of deviance from company go-around policies. The conclusion was that unstabilized approach pilots experienced greater perceived pressure to land, lack of crew support for a go-around, discomfort in being challenged or challenging others, and inhibitions about calling for a go-around due to a perceived authority imbalance in the flight deck. Notably, the results indicated that, in hindsight, unstabilized approach pilots report internal regret for their decision to land during an unstabilized approach. In comparison to go-around pilots, unstabilized approach pilots had lower ratings of their flight outcomes and beliefs that they had made the correct decision, and higher ratings of beliefs that they should have made a different decision and they had needlessly endangered the flight. These results appear to convey a conflicting message: unstabilized approach pilots regret their go-around noncompliance, but simultaneously disagree with their company's go-around polices. The ALAR Task Force concluded that there existed a "normalization of deviance" (p. 17) and it poses unnecessary risk to the aviation safety culture (FSF, 2017).

There were also notable findings in the obtained data regarding pilot perceptions of go-around thresholds (FSF, 2017). As a whole, pilots perceived the thresholds for calling for a go-around were lower than the published thresholds, and the perceived threshold varied as a function of the aircraft elevation and instability parameter the pilot was considering as primary reason to call for a go-around. Examples of instability parameters include, but are not limited to, anticipating braking action, sink rate deviation, or aircraft configuration. When considered in conjunction with situational awareness factors, lower situational awareness leads to lowered sensitivity to relevant cues that influence a pilot's correct assessment of the objective risks inherent in the approach. In this context, lower situational awareness is measured as lower sensitivities to the psychological and psychosocial factors conducive to go-around compliance. The result is a mental model of the perceived risks that does not accurately represent the objective levels of the actual risks, and this produces an "over-occurrence of noncompliant [go-around] decision-making" (FSF, 2017, p. 19).

Key ALAR recommendations. There were a number of recommendations provided by the ALAR Task Force in response to the findings of the study. Among these recommendations were corrective actions that should be taken to mitigate go-around policy noncompliance, including ensuring that policies make sense operationally, policies are managed effectively, and awareness of the risks associated with go-around noncompliance increased (FSF, 2017). In order to take these and other corrective actions necessary for improved go-around compliance, the ALAR Task Force provided several recommendations specific to flight crew training. The overarching recommendation was that flight crew training needed to enhance psychosocial awareness and management, and how both psychosocial awareness and management contribute to go-around noncompliance (FSF, 2017). Recommendations specific to flight crew training included, but were not limited to:

- Go-around training should appropriately reflect diverse go-around execution risk scenarios, both typical and atypical;
- Go-around training should include a range of operational scenarios, both typical and atypical, and these scenarios should involve realistic simulation; and,
- Go-around training should incorporate lessons learned from operational events/incidents (FSF, 2017).

In sum, flight crew go-around training must train pilots to exercise tactical judgment and procedural compliance for unhindered appropriate go-around decision-making (FSF, 2017). In order to improve go-around compliance, the recommendation was to vary some initiations of the go-around scenario at different points in the approach when crews appear not ready for them (Rosenkrans, 2015). The speculation is that exposing flight crews to more unexpected circumstances when a go-around is the appropriate response may influence their readiness and willingness to comply with go-around policies. Research has revealed a similar speculation that training improvements will benefit flight crew performance in unexpected unstabilized approach conditions. In a study investigating the effectiveness of airline pilot training for atypical events, Casner, Geven, and Williams (2013) found that when pilots encountered unexpected events, including an unstabilized approach condition of low-level wind shear, there were notable decrements in performance. Based on their findings, Casner et al. (2013) suggested that flight crew training should include additional training for unexpected events. In the context of the ALAR Task Force conclusions, training in a wide range of atypical operational conditions may facilitate increased awareness of the risks inherent in those conditions.

The ALAR Task Force recommendation for improved training for go-around policy compliance is consistent with the FAA recommendations (see FAA, 2008b), which refer to the FSF ALAR’s earlier briefs (see FSF, 2000). The FAA encouraged that flight crews and training managers be familiar with the recommendations for reducing ALAs in order to promote a pro-active orientation to go-around compliance (FAA, 2008a; 2008b). According to the ALAR Task Force, realistic training scenarios are needed for validation of recommended strategies for improved go-around compliance training, and this training should be informed by the lessons learned from actual commercial aviation operations.

Toward Operationally-Informed Go-Around Training Designs

Training is considered one of the controllable variables in commercial aviation safety (Bent & Chan, 2010). In order to inform go-around training designs with lessons learned from operational events and incidents, approach-and-landing incidents must be thoroughly analyzed in the context of this particular goal. The archival resource with the most abundance of aviation incident reports readily available for such analyses is the Aviation Safety Reporting System (ASRS) database.

The ASRS database. ASRS manages a database of voluntarily submitted aviation incident reports toward the end of identifying system deficiencies and operational safety issues threatening aviation safety and providing data for improvements in aviation safety (Aviation Safety Reporting System [ASRS], 2016). Since its inception in April 1976 and through December 2016, ASRS had received nearly 1.5 million incident reports (ASRS, 2016), with each report containing detailed information of the aviation safety incident. Given the breadth of data gathered by the ASRS, the database has been a model for domains other than aviation seeking to develop their own database of safety-related incidents (Killen & Beyea, 2003). In addition, aviation incident data such as that of ASRS has been suggested as beneficial to informing *how* and *why* the adverse aviation incidents occurred (Chappell, 1997; Harle, 1997).

Aviation studies using ASRS data. The ASRS database has been the source of data used in a number of aviation studies. The predictive factors in aviation accidents and incidents have been investigated using ASRS data (e.g., Baker, 2001; Walton & Politano, 2010), but it is the contributing human factors in aviation incidents that are more commonly investigated using ASRS data. Barnes and Monan (1990) used ASRS data in their study of cockpit distractions, and they found that more than one-third of the incidents related to distractions were associated with matters not central to safe flight operations. In an examination of flight crew performance during ASRS incidents involving aircraft malfunctions, Sumwalt and Watson (1995) found significant differences in how flight crews respond to malfunctions as a function of perceived severity. Inadequate flight crew monitoring was investigated by Sumwalt, Morrison, Watson, and Taube (1997) using ASRS reports and the researchers were able to draw conclusions as to the nature of the monitoring inadequacies and the factors that contribute to them. In their investigation of situational awareness-related incidents, Jentsch, Barnett, Bowers, and Salas (1999) used ASRS data to assess if the loss of flight crew situational awareness was related to the role of the pilot, and the results indicated that it was associated with flight crew role. Sarter and Alexander (2000) analyzed ASRS incident reports in their investigation of the types of pilot error (e.g., commission or omission) and the underlying cognitive stage during which the error occurred. The study is an exemplar of using ASRS incident data to understand the *how* and *why* of the incident. Aviation decision-making issues and outcomes were investigated by Mosier et al. (2012) using ASRS data, and the researchers found that there were descriptively distinct interrelationships between specific antecedents and human errors in the events that were insightful as to the issues and challenges in commercial aviation operations. In a study investigating flight crew-ATC communication conflicts reported in the ASRS database, Mosier et al. (2013) identified types of conflicts, operational contexts and operator states during the conflicts, and conditions under which conflicts potentially increase. Ross and Tomko (2016) used ASRS data in their analysis of reported incidents in which flight crew states of confusion were identified as contributing to the adverse event, and they found that the patterns of pilot confusion could be classified in operationally-specific contexts. The aforementioned studies are representative of the broad use of ASRS data for commercial aviation research. However, missing from the growing body of literature are studies of the viability in using ASRS incident report data for a better understanding of unstabilized approaches, and subsequently informing operationally-relevant go-around training scenarios.

Operationally-informed scenarios from ASRS data. ASRS incident reports have been suggested as a logical source of operationally-informed scenarios that can be included in the flight crew training curriculum (Mangold, Morrison, & Frank, 1995). Although this recommendation was provided more than 20 years ago, there have been no documented investigations of the ASRS data as a source of operationally-informed scenarios for go-around compliance training. Thus, it was the purpose of this current study to investigate human factors reported in ASRS incident reports as contributing to operational incidents of unstabilized approaches and landings in commercial aviation. The ALAR Task Force recommended understanding the pervasive noncompliance with go-around policies as pivotal in effective go-around compliance training. Understanding the attitudes and conditions of noncompliance with go-around policies begins with understanding the characteristics of unstabilized approach and landing incidents.

Summary

At the onset of the descent phase of flight, commercial flight crews aim to continuously manage the aircraft configuration of speed and attitude for a stabilized approach to a safe landing. Although occupying less than 14 percent of total commercial flight time, more than half of all fatal accidents in worldwide commercial aviation operations occur during the approach and landing phases of flight (Boeing, 2017). Unstabilized approaches are the primary risk factor in ALAs, and nearly 97 percent of unstabilized approaches are voluntarily continued to landing (FSF, 2017) in conditions that unnecessarily jeopardize commercial aviation safety. In other words, flight crew continuation of an unstabilized approach was the causal factor, and attributable to human factors. Despite go-around policies and procedural training designed to mitigate needless risks to aviation safety, the tendency for highly trained flight crews to continue with an unstabilized approach persists.

In response to the pervasiveness of go-around noncompliance, the FSF ALAR Task Force conducted an extensive study of the psychology of go-around noncompliance as part of the FSF Go-Around Safety Initiative of 2011 (FSF, 2017). The results of the study revealed that there were differences between commercial pilots who had continued an unstabilized approach to landing and commercial pilots who executed a go-around in response to an unstabilized approach. It was found that a pilot's ability to correctly perceive and assess risk during unstabilized approaches was directly affected by the pilot's situational awareness competencies (FSF, 2017). Pilots who executed a go-around scored higher across all nine factors of situational awareness compared to pilots who landed during unstabilized approaches. As for human factors associated with go-around noncompliance, there were also differences (FSF, 2017). Compared to pilots who executed a go-around, it was revealed that pilots who landed during unstabilized approaches experienced greater influence of human factors associated with a perceived pressure to land, lack of crew support for a go-around, discomfort in being challenged or challenging others, and inhibitions about calling for a go-around due to a perceived authority imbalance in the flight deck (FSF, 2017). Further, the ALAR Task Force interpreted from the results a concerning risk to the commercial aviation culture. Commercial pilots who do not comply with go-around policies and procedures appear to have *normalized* an attitude of go-around noncompliance (FSF, 2017).

The ALAR Task Force recommendations included the need to understand the psychology of go-around noncompliance, and the lessons learned need to be applied to commercial pilot training programs. Go-around training needs to incorporate lessons learned from operational incidents in order to appropriately reflect typical and atypical go-around execution risk scenarios, and training scenarios should involve realistic simulation (FSF, 2017). The assumption is that training in a wide range of typical and atypical operational conditions may facilitate increased awareness of the risks inherent in those conditions that pose risk to stabilized approaches and warrant execution of a go-around. According to the ALAR Task Force, realistic training scenarios are needed for validation of recommended strategies for improved go-around compliance training (FSF, 2017). In sum, understanding the attitudes and conditions of noncompliance with go-around policies begins with understanding the characteristics of unstabilized approach and landing incidents.

Chapter III

Methodology

This study critically examined and analyzed ASRS incident report data to investigate the associations of flight crew human factors with reported incidents of unstabilized approaches and landings. The study assumed that the data contained in the ASRS incident reports could be exploited for the benefit of increased operational-fidelity in commercial pilot operations training for go-around decision making and improved national commercial aviation safety.

Research Approach

The study was a continuation, and extension, of earlier analyses of ASRS data to answer questions and test hypotheses informed by previous studies (see Ross & Tomko, 2016; 2017) and relevant research of safety issues in commercial aviation operations using incident report data. This study used a nonexperimental, single-group, quantitative *ex post facto* design. A nonexperimental approach was most appropriate since the independent variables were not manipulated during analysis of the ASRS incident reports. Non-randomized sample data was compiled into a single group for qualitative and quantitative analyses. Since the analyses was of archived, coded data from ASRS reports, an *ex post facto* approach was used for the archival research in the study. Observational and survey methods were not appropriate for this study, as it was outside the scope of the study to observe live commercial pilot operations. Methods similar to those of this study have previously been employed in researching the contributing and predictive factors of aviation accidents (e.g., Baker, 2001; Shappell et al., 2007), aviation incidents (e.g., Barnes & Monan, 1990; Jentsch, Barnett, Bowers, & Salas, 1999; Walton & Politano, 2010), and joint analyses of accidents and incidents (e.g., Mosier et al., 2012), as well as evaluating safety taxonomies (e.g., Tiller & Bliss, 2017).

Study Procedures

Given the categorical and nominal nature of the ASRS data, primarily nonparametric statistical methods were employed. The statistical procedure for this study was binomial logistic regression. Using binomial logistic regression, associations between each nominal independent variable and the nominal dependent variable can be assessed while taking into account all other independent variables (Cohen, Cohen, West, & Aiken, 2003; Tabachnick & Fidell, 2013). Given the intention of this study was to identify the nominally-coded factors (independent variables) that may be associated with nominally-coded adverse aviation events (dependent variable), binomial logistic regression was more appropriate than chi-square contingency tables or log-linear analyses, which are used solely to test associations and relationships between variables (Agresti, 2013).

***A Priori* Power Analysis.** An *a priori* power analysis was computed using G*Power 3 (Faul, Erdfelder, Buchner, & Lang, 2009). Chen, Cohen, and Chen (2010) proposed odds ratio thresholds that could be interpreted consistent with the long-standing Cohen's *d*. Chen et al. (2010) determined that odds ratios < 1.5 and odds ratios > 5.0 were equivalent to Cohen's $d < 0.2$ and Cohen's $d > 0.8$. This interpretation of odds ratios has been used across domains (see Ashford, Lanehart, Kersaint, Lee, & Kromrey, 2016; Cheung et al., 2017; Matejkowski & Ostermann, 2015; Peterson, 2017). Based on early considerations of the literature during the development of this current study, it was determined that the *a priori* power analysis for the binomial logistic regression would use the following input parameters: two-tailed, log-normal distribution, alpha level of .05, power level of .95, and odds ratio of 1.8. Following the recommended thresholds provided by Chen et al. (2010), an odds ratio of 1.8 was used to approximate the lower bounds of a medium effect. While finding a small effect may be desirable in some contexts, small odds ratios may not reflect operationally-meaningful differences that were of interest in this study. The *a priori* power analysis using the noted input parameters and odds ratio of 1.8 indicated a sample size of 95 for the binomial logistic regression.

ASRS incident reports. This study used aviation incident report data from the ASRS database and the following is an overview of the process used by ASRS for coding the data (Figure 1). ASRS receives, processes, and analyzes voluntarily submitted incident reports from pilots, air traffic controllers, and other individuals, which was entered and maintained in a growing database of aviation incident reports. The ASRS analyst team is comprised of highly trained pilots, air traffic controllers, mechanics, and members of management teams with substantial aviation and human factors experience (ASRS, 2016). Given the focus of this study being flight crews, the remaining explanation of the data coding process will be specific to reports filed by the flight crew. ASRS receives reports filed by pilots which are screened by at least two analysts for initial categorization and early triage of processing (ASRS, 2016). During the early stages of screening the reports, ASRS analysts have access to information from other sources, such as the Aviation Safety Awareness Program and air carrier companies, that is relevant to the reported incident. All reports are subject to extensive analysis by ASRS staff, and any reports needing further analysis are identified. Any discrepancies in the individual screening by the analysts are subject to further iteration to ensure inter-coder reliability. Reports are subsequently de-identified and each report is subject to further analysis in a final check to assure coding accuracy. Throughout the coding process, quality assurance checks are performed to ensure coding quality and assuring confidentiality. The finalized coded reports are entered and archived into the publicly-available ASRS database.

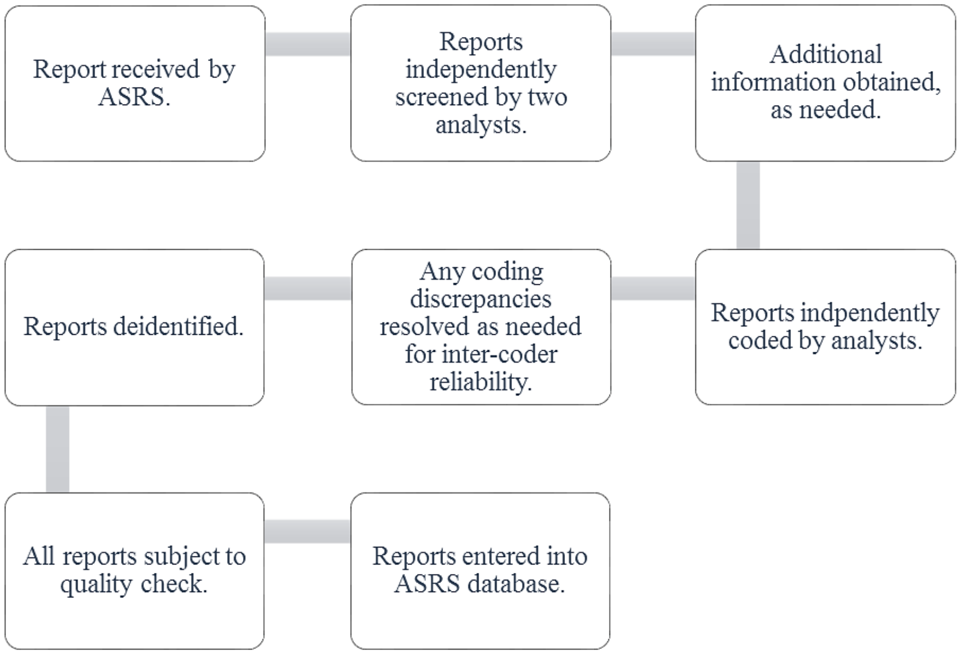

Figure 1. Representation of the ASRS process for coding incident reports. Adapted from ASRS (2016).

Each ASRS report stored in the database contains 63 fields for coded data, although not all fields will contain data depending on the report circumstances and event outcomes. The ASRS report data fields of interest for this study were:

- ACN (accession number)
- Aircraft 1 Aircraft operator
- Aircraft 1 Operating under FAR part
- Aircraft 1 Flight phase
- Person 1 Reporter organization
- Person 1 Function
- Person 1 Human factors
- Person 2 Reporter organization
- Person 2 Function

- Person 2 Human factors
- Events Anomaly
- Events Result
- Assessments Contributing factors/situations
- Assessments Primary problems
- Report 1 Narrative
- Report 2 Narrative
- Report 1 Synopsis

All data necessary for this study could be found in these 17 data fields. The ACN field contains an assigned accession number for the ASRS database coding. Aircraft 1 fields contain data relevant to the commercial aircraft in which the event occurred. Person 1 and Person 2 fields contain data specific to the respective flight crew members. Events fields contain data identifying the incident and outcome. Assessments fields include categories of factors and situations that either contributed to the event or were considered the primary problem. Report 1 and Report 2 fields contain narrative reporting data from Person 1 and Person 2, with exception of the Report 1 Synopsis field which is an overall synopsis provided by the ASRS analyst of the incident.

Sample pool selection. The reports of interest in this study were from commercial passenger air carriers operating under Federal Aviation Regulations Part 121. A study sample pool of incident reports was gathered from the ASRS online reporting system database at https://asrs.arc.nasa.gov/search/database.html using the following criteria:

- Date of incident: 01 January 2012 to 31 December 2016
- Federal aviation regulations: Part 121
- Reporting organization: air carrier

- Reporter function: captain, first officer, pilot flying, pilot not flying
- Phase of flight: initial approach, final approach, landing
- Event type: unstabilized approach
- Contributing factors: human factors

The database query output resulted in a return of 444 reports meeting this initial study sample criteria (Appendix A), and the reports were downloaded in Excel format (Appendix B).

Dual-reporter incidents. Each incident report recorded in the ASRS database may have either one or two reporters. In the case of incidents with only one reporter, there is the potential for each human factor to be coded once for that single reporter. However, incidents with two reporters (i.e., dual-reporter incidents) have the potential of each human factor being coded twice, once for each reporter. There were two approaches that could be taken when determining how to treat dual-reporter incidents. One approach was to analyze the report twice, once for each reporter. However, this approach would create an unnecessary confound of increasing the frequency of incidents, since the single incident would be coded twice in the research study. The alternative approach was to collapse the human factors in dual-reporter reports, such that double indicated human factors (i.e., when the same human factors is attributed to both reporters) would still be coded only once for the specific incident. This study used the second approach of collapsing the data of any dual-reporter incidents, since the investigation was primarily interested in the human factors associated with the incident and not specific to the reporter. The collapsing of the data occurred during the screening for exclusions.

Screening for exclusions. With the initial sample pool of 444 reports downloaded to Excel, reports were screened for exclusions. Exclusions were based on the following criteria: (a) any target field (i.e., cell) of interest was empty (i.e., contained no data); or, (b) the sole human factor coded as contributing to the event was "other/unknown." Reports with missing data in cells of interest were excluded in order to provide for comparisons of all independent variables, assuming an adequate sample size could be maintained. Reports with 'unknown' human factors were not able to be meaningfully analyzed in the context of this study.

Reviewing for exclusions was a multi-phase process, and excluded report ACNs are provided in Appendix C. The first review for exclusions was for all reports that did not have an explicitly coded human factor. When relevant to the incident, an ASRS report will have the human factor(s) coded in the fields titled "Person 1 Human Factors" and/or "Person 2 Human Factors." These fields correspond respectively to columns BS and CC in the Excel data from ASRS database. This resulted in an exclusion of 46 reports. The second review for exclusions was for all reports that had only "Other / Unknown" coded in the "human factors" fields. Reports with 'unknown' human factors are not able to be meaningfully analyzed in the context of this study. This resulted in another three reports being excluded. The third review for exclusions was for any reports that had missing fields of interest, and there were no reports excluded based on this criterion. As part of the process of exclusions, the data of the dual-reporter incidents were collapsed, since this investigation was primarily interested in the human factors associated with the incident and not specific to the reporter. The "Event Anomaly" field of all remaining 395 reports were reviewed and verified as including "Inflight Event / Encounter Unstabilized Approach." All reports included this 'event anomaly,' and there were no additional exclusions. The "Events Result" field was reviewed and two reports were identified with no data in the field, which resulted in the two reports being excluded. A final review for exclusions was for any reports that did not explicitly code "Human Factors" as a "Contributing Factors / Situations" in the incident. This resulted in another 63 reports being excluded. This process of screening for exclusions resulted in a reduced initial sample of 330 ASRS reports, which were subsequently reviewed a second time using the aforementioned process of eliminations to ensure there were no oversights. No additional exclusions were noted, and this became the pool of reports from which the sample set of 95 reports would be randomly selected for this study.

Randomized sample selection. The study sample of 95 reports were randomly selected using a table of random numbers (RAND, 2001) and the following procedural steps:

1. All 330 ASRS report numbers (ACNs) were entered into a single column in Excel, in ascending numerical order, and each report was randomly assigned an independently generated and unique integer from 1 to 330, inclusive.
2. Using a separate sheet in Excel and independent of the ACNs, a starting point on the table of random numbers was determined using the =RANDBETWEEN() function. The starting row was determined using =RANDBETWEEN(0,19999) and the starting column was determined using =RANDBETWEEN(1,10). The randomly generated numbers identified the starting point as Row 8716, Column 8 in the table of random numbers (RAND, 2001), which was the number 94922.
3. The final three digits of the number on the table were used to identify a report for the study sample. If the final three digits were between 001 and 330, inclusive, then the associated ACN listed in Excel as part of step 1 was identified as a member of the study sample. If the final three digits were not between 001 and 330, inclusive, then a different number from the table was identified using the approach in step 4. For example, using the starting number of 94922, this number did not result in an identified report for the study sample because the final three digits were 922. ACNs were assigned unique identifiers of 1 through 330, inclusive.

4. The final digit of the number on the table of random numbers determined the number of rows to advance numerically and the column for the next number. For example, the final digit in the number 94922 is 2. This indicated advancing 2 rows numerically and using the number in column 2 of the table to identify the next potential report for the study sample. If the final digit was a 0, then it represented 10 for advancing to the next number on the table (i.e., advancing 10 rows and to column 10). If a number resulted in a repeated report number, such as 24308 and then 17308 (i.e., both with the final three digits of 308), then the previous digit used for advancing was repeated. If the final row and column of the table of random numbers was reached before the 95 reports for the study sample were identified, then the procedure was to continue at the beginning of the table (i.e., Row 0, Column 1).
5. Following the procedural steps 1 through 4, all 95 reports for the study sample were randomly selected. The ending point on the table of random numbers was Row 10415, Column 10, which was number 7325.

This approach provided for an unbiased random selection of 95 reports from the pool of 330 reports that met the initial selection criteria and subsequently were not eliminated based on the exclusion criteria (Appendix D).

Final review of study sample. The 95 reports identified as the study sample were reviewed for any further exclusions using the Word format of the reports (Appendix E). No additional exclusions were identified. The report narrative(s) and synopsis were reviewed and compared to the coded data. Although no inference was to be made regarding the agreement between narrative data and coded data, this step was intended to check for any possible errors that may have warranted consultation with ASRS analysts. No concerns or errors were noted. All reports were verified as meeting the criteria for inclusion in the study.

Converting text to binary fields. The ASRS database uses text fields for the human factors and event types, which are not appropriately formatted for a binomial logistic regression analysis. Using the Excel format of the 95 report study sample, both the human factors and event type text fields from ASRS were converted to binary fields for the subsequent binomial logistic regression analysis (Appendix F). This process uses a simple 'If-Then' algorithm to locate the target term in the text field (e.g., "confusion") and output a binary value in the newly created numeric field (e.g., "1" if "confusion" was coded in text or "0" if not). A similar process was applied to all text fields of interest.

Independent variables. With a sample size of 95 cases, all 12 ASRS-coded human factors – communication breakdown, confusion, distraction, fatigue, human-machine interface, physiological, situational awareness, time pressure, training/qualifications, troubleshooting, workload, and other/unknown – posed to be too many IVs for a meaningful analysis. Agresti (2013) cites work by Peduzzi et al. (1996) as being a general standard for the number of predictors for which effects can be estimated, which was a 1:10 ratio of IVs to outcomes (i.e., cases). With 95 cases, using all 12 human factors for the binomial logistic regressions would have violated this standard. Therefore, the number of IVs needed to be reduced. A common approach to reducing the number of IVs for binomial logistic regression is *post hoc p* value assessment. However, this common approach is unnecessarily vulnerable to bias and more prone to sampling error (Agresti, 2013).

An alternative approach was taken for this study. The ALAR Task Force report was consulted for the "situational awareness constructs" and "key psychosocial factors" that were assessed as part of the prior FSF 2017 study, since the ALAR Task Force report was informing this current study. The ALAR Task Force situational awareness constructs and key psychosocial factors were carefully mapped to the ASRS-coded human factors (Appendix G). Taking this informed approach, eight ASRS human factors were identified for the current study: communication breakdown, confusion, fatigue, human-machine interface, situational awareness, time pressure, training/qualifications, and workload. Since these ASRS-coded human factors map to the constructs and factors identified by the ALAR Task Force, these eight human factors were identified as IVs for this current study.

Given that the overall goal of this study was to inform aviation training designs, the remaining four human factors were reviewed for reconsideration as an IV in the current study. Of those remaining human factors, distraction was identified for inclusion. It was assumed that training designs can impose distractions, and distractions have been found to influence overall flight crew performance (Barnes & Monan, 1990; Foyle et al., 2005; Stayer & Cooper, 2015). This resulted in a total of nine human factors used for this current study: communication breakdown, confusion, distraction, fatigue, human-machine interface, situational awareness, time pressure, training/qualifications, and workload.

Statistical procedures. Data was exported from Excel and imported into IBM SPSS Statistics 24 for generating descriptive statistics, chi-square tests, and binomial logistic regressions. Effect size for chi-square goodness-of-fits tests used the statistic *w*, which is interpreted using the same scale as *phi*. From the binomial logistic regressions, odds ratios were evaluated, and confidence intervals and significance levels also evaluated using maximum likelihood estimations. The quality of the model was evaluated using a Hosmer and Lemeshow goodness of fit test, which identifies how poorly a model predicts categorical outcomes. A significant Hosmer and Lemeshow test would indicate a poorly fitted model. Evaluating the variance in the dependent variable that can be accounted for by the model was accomplished using the Nagelkerke R^2 value. Sensitivity, specificity, positive predictive value, and negative predictive value were also be evaluated. An alpha level of .05 was used as the cutoff for statistical significance.

Reliability and Validity

It was a fundamental assumption of this study that ASRS coding procedures and standards provide for adequate assurance of reliability and validity. As previously noted, each ASRS incident report is independently reviewed, analyzed, and coded by at least two highly trained analysts. Reports are cross-checked and discrepancies are subject to further iteration to ensure inter-coder reliability. Although there are no published reports including data on ASRS analyst inter-coder reliability (Beaubien & Baker, 2002), numerous investigations and studies of aviation safety have utilized the ASRS data.

The potential concerns of validity in this study were specific to the ASRS classification and coding system. Beaubien and Baker (2002) summarize several considerations regarding the internal validity of taxonomies and reporting systems, following the work of Fleishman and Quaintance (1984). According to Beaubien and Baker (2002), internally valid taxonomies “reliably categorize events despite random fluctuations in the wording of the narrative text,…use mutually exclusive and exhaustive descriptors, and…reveal meaningful patterns” (p. 5). In terms of external validity, Beaubien and Baker (2002) summarize Fleishman and Quaintance’s (1984) suggestions that externally valid taxonomies “cross-validate with new data sets,…identify gaps in the available research,…that predict meaningful outcomes” (p. 6). ASRS takes specific measures to mitigate the risks to validity. All ASRS reports are independently analyzed and coded by at least two highly trained analysts. Given the voluntary self-reporting by the flight crew, ASRS analysts use additional information from other sources and aviation experience when coding reports. It was assumed that risks to internal and external validity were mitigated by the aforementioned measures taken by ASRS.

As for other potential issues of reliability and validity specific to this current study, the researcher did not make additional inferences from the coded or narrative text data in the ASRS incident reports. Nor did the researcher make further interpretation of narrative text provided by flight crew or analyst synopses. Rather, the researcher used the ASRS coding and data explicitly as it appears in the report outputs generated from the ASRS online database.

Chapter IV

Findings and Results

The purpose of this quantitative *ex post facto* study was to critically examine and analyze ASRS incident report data to investigate the associations of coded flight crew human factors with reported incidents of unstabilized approaches and landings. The current study used binomial logistic regression to test associations and relationships between the independent and dependent variables in the study sample of ASRS reports. The independent variable in this study was the ASRS-coded human factors previously identified by ASRS analysts as contributing to the reported aviation event. The dependent variable in this study was the reported event outcome of the unstabilized approach, either *continued to landing* or *go-around*. Results of the binomial logistic regression were used to answer three research questions that guided the study. These questions were of the human factors contributing to unstabilized approaches, associations of the contributing human factors with unstabilized approaches, and relationships of the contributing human factors in the likelihood of the aviation event outcome.

Outcomes of Unstabilized Approaches

Preliminary analysis of the study sample was conducted using a chi-square goodness-of-fit test (Table 1). The assumptions of the chi-square test (Agresti, 2007; 2013) were satisfied. A single dichotomous variable was to be tested (reported unstabilized approach outcome), observations were independent (i.e., the outcome of one reported event was independent of all other reported events), and expected frequencies of each group of the tested variable was at least five. Results of the chi-square test revealed statistically significant differences in the outcome of the reported unstabilized approaches ($\chi^2(1) = 6.579$, $p = .01$, $w = .26$), with less than 37% of unstabilized approaches responded to with go-around compliance. These results suggest that the differences in event outcomes during unstabilized approaches could not be attributed to chance, which supported the efforts of this study in understanding these differences.

Table 1

Chi-square Goodness-of-Fit Test of Unstabilized Approach Event Outcome

Event outcome	Observed	Expected	χ^2	*p*
Continued to landing	60	47.5	6.579	.01
Go-around/missed approach	35	47.5		

Note. *N* = 95. α = .05.

Human Factors Contributing to Unstabilized Approaches

During routine processing of ASRS incident reports, twelve human factors are assessed by ASRS analysts for their contribution as factors to the reported aviation incidents: communication breakdown, confusion, distraction, fatigue, human-machine interface, physiological-other, situational awareness, time pressure, training/qualification, troubleshooting, workload, and other/unknown. Using the study sample, frequencies were calculated and crosstabs constructed to assess the extent to which the twelve human factors are identified by the ASRS analysts as contributing factors to aviation incidents of unstabilized approaches. Review of the report sample revealed that all twelve human factors were coded as contributing to reported unstabilized approaches. However, the proportion of reports in which each human factor contributed varied. A table illustrating the human factors and event outcome coded by ASRS report number is provided in Appendix H.

The frequencies of human factors coded as contributing to unstabilized approaches are provided in Table 2. Given that a criteria of this study was that human factors were identified as a contributing factor in the reported incident, each report contained at least one human factor coded as contributing. There were 21 reports (22.1%) that had 1 contributing human factor, 30 reports (31.6%) with 2 contributing human factors, 17 reports (17.9%) with 3 contributing human factors, 10 reports (10.5%) with 4 contributing human factors, 9 reports (9.5%) with 5 contributing factors, 7 reports (7.4%) with 6 contributing factors, and 1 report (1.1%) with 7 contributing factors.

Table 2

Frequencies of Human Factors Contributing to Unstabilized Approaches

ASRS-coded human factor	Contributed to unstabilized approach	
	% of reports[a]	# of reports[b]
Communication breakdown	31.6%	30
Confusion	30.5%	29
Distraction	31.6%	30
Fatigue	12.6%	12
Human-machine interface	25.3%	24
Physiological-other[†]	1.1%	1
Situational awareness	77.9%	74
Time pressure	14.7%	14
Training/qualifications	22.1%	21
Troubleshooting[†]	1.1%	1
Workload	27.4%	26
Other/unknown[†]	4.2%	4

Note. *N* = 95. [a]Total percentage of reports will exceed 100% because each contributing may be coded in more than one report of the sample. [b]Total number of reports will exceed 95 because each contributing may be coded in more than one report of the sample. [†]Excluded from subsequent analyses.

Cross-tabulations of the human factors with the outcome of unstabilized approaches were constructed. Each human factor is noted as either being coded ("Yes") or not coded ("No") by ASRS analysts in reports of unstabilized approaches that had an outcome of either *continued to landing* ("Non-compliance") or *go-around* ("Compliance"). The cross-tabulation data provides a more detailed depiction of human factors contributing to the dichotomous outcome of reported unstabilized approaches.

Communication breakdown. Communication breakdown was coded as a contributing factor in 31.6% of the sample incident reports. Of those reports noting communication breakdown as a contributing factor, 63.3% of the reported incidents were unstabilized approaches continued to landing and 36.7% of the reports noted flight crews completing a go-around (Table 3). When communication breakdown was not coded as a contributing factor, data indicated a near identical proportion, with 63.1% of reports noting flight crews continued an unstabilized approach to landing rather than executing a go-around (36.9%).

Table 3

Cross-tabulation of Communication Breakdown in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Communication breakdown	Yes	Count	19 *(18.9)*	11 *(11.1)*
		% within factor	63.3%	36.7%
	No	Count	41 *(41.1)*	24 *(23.9)*
		% within factor	63.1%	36.9%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Confusion. Confusion was coded as a contributing factor in 30.5% of the sample incident reports. Of those reports noting confusion as a contributing factor, 72.4% of the reported incidents were unstabilized approaches continued to landing and 27.6% of the reports noted flight crews instead completing a go-around (Table 4). When confusion was not coded as a contributing factor, data reflected a similar trend but of a lesser magnitude: 59.1% of reports noting flight crews continued an unstabilized approach to landing rather than executing a go-around (40.9%).

Table 4

Cross-tabulation of Confusion in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Confusion	Yes	Count	21 *(18.3)*	8 *(10.7)*
		% within factor	72.4%	27.6%
	No	Count	39 *(41.7)*	27 *(24.3)*
		% within factor	59.1%	40.9%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Distraction. Distraction was coded as a contributing factor in 31.6% of the sample incident reports. Of those reports noting distraction as a contributing factor, 60.0% of the reported incidents were unstabilized approaches continued to landing and 40.0% of the reports noted flight crews completing a go-around (Table 5). When distraction was not coded as a contributing factor, data revealed similar, with 64.6% of reports noting flight crews continued an unstabilized approach to landing rather than executing a go-around (35.4%).

Table 5

Cross-tabulation of Distraction in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Distraction	Yes	Count	18 *(18.9)*	12 *(11.1)*
		% within factor	60.0%	40.0%
	No	Count	42 *(41.1)*	23 *(23.9)*
		% within factor	64.6%	35.4%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Fatigue. Fatigue was coded as a contributing factor in 12.6% of the sample incident reports. Of those reports noting fatigue as a contributing factor, 66.7% of the reported incidents were unstabilized approaches continued to landing and 33.3% of the reports noted flight crews completing a go-around (Table 6). When fatigue was not coded as a contributing factor, 62.7% of the reports noted that flight crews continued an unstabilized approach to landing rather than executing a go-around (37.3%).

Table 6

Cross-tabulation of Fatigue in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Fatigue	Yes	Count	8 *(7.6)*	4 *(4.4)*†
		% within factor	66.7%	33.3%
	No	Count	52 *(52.4)*	31 *(30.6)*
		% within factor	62.7%	37.3%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.
†Expected count less than 5.

Human-machine interface. Human-machine interface was coded as a contributing factor in 25.3% of the sample incident reports. Of those reports noting human-machine interface as a contributing factor, 58.3% of the reported incidents were unstabilized approaches continued to landing and 41.7% of the reports instead indicated that flight crews completed a go-around (Table 7). When human-machine interface was not coded as a contributing factor, report data revealed that 64.8% of flight crews continued an unstabilized approach to landing rather than executing a go-around (35.2%).

Table 7

Cross-tabulation of Human-Machine Interface in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Human-machine interface	Yes	Count	14 *(15.2)*	10 *(8.8)*
		% within factor	58.3%	41.7%
	No	Count	46 *(44.8)*	25 *(26.2)*
		% within factor	64.8%	35.2%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Physiological-other. Physiological-other was coded as a contributing factor in only 1 of the 95 sample incident reports (1.1%), and it was a report of an unstabilized approach continued to landing (Table 8). Of the remaining reports in which physiological-other was not coded as a contributing factor, 59.4% of the reports noted that flight crews continued an unstabilized approach to landing rather than executing a go-around (34.6%). Physiological-other was not included as an IV in the subsequent binomial logistic regressions.

Table 8

Cross-tabulation of Physiological-Other in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Physiological-other	Yes	Count	1 *(0.6)*†	0 *(0.4)*†
		% within factor	100.0%	0.0%
	No	Count	59 *(59.4)*	35 *(34.6)*
		% within factor	62.8%	37.2%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.
†Expected count less than 5.

Situational awareness. Situational awareness was coded as a contributing factor in 77.9% of the incident reports. For reports noting situational awareness as a contributing factor, 68.9% of the reported incidents were unstabilized approaches continued to landing and 31.1% of the reports noted flight crews instead completing a go-around (Table 9). When situational awareness was not coded as a contributing factor, data showed a different trend: fewer flight crews continued unstabilized approaches to landing (42.9%) than executed a go-around (57.1%).

Table 9

Cross-tabulation of Situational Awareness in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Situational awareness	Yes	Count	51 *(46.7)*	23 *(27.3)*
		% within factor	68.9%	31.1%
	No	Count	9 *(13.3)*	12 *(7.7)*
		% within factor	42.9%	57.1%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Time pressure. Time pressure was coded as a contributing factor in 14.7% of the sample incident reports. Of those reports noting time pressure as a contributing factor, 64.3% of the reported incidents were unstabilized approaches continued to landing and 35.7% of the reports noted flight crews had completed a go-around (Table 10). When time pressure was not coded as a contributing factor, 63.0% of the reports noted flight crews had continued an unstabilized approach to landing rather than executing a go-around (37.0%).

Table 10

Cross-tabulation of Time Pressure in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Time pressure	Yes	Count	9 *(8.8)*	5 *(5.2)*
		% within factor	64.3%	35.7%
	No	Count	51 *(51.2)*	30 *(29.8)*
		% within factor	63.0%	37.0%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Training/qualifications. Training/qualifications was coded as a contributing factor in 22.1% of the sample incident reports. Of those reports noting training/qualifications as a contributing factor, 53.8% of the reported incidents were unstabilized approaches continued to landing and 46.2% of the reports instead indicated that flight crews completed a go-around (Table 11). When training/qualifications was not coded as a contributing factor, report data revealed that 66.7% of flight crews continued an unstabilized approach to landing rather than executing a go-around (33.3%).

Table 11

Cross-tabulation of Training/Qualifications in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Training/qualifications	Yes	Count	13 *(13.3)*	8 *(7.7)*
		% within factor	61.9%	38.1%
	No	Count	47 *(46.7)*	27 *(27.3)*
		% within factor	63.5%	36.5%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Troubleshooting. Troubleshooting was coded as a contributing factor in only 1 of the 95 sample incident reports (1.1%), and it was a report of an unstabilized approach continued to landing (Table 12). Of the remaining reports in which troubleshooting was not coded as a contributing factor, 62.8% of the reports noted that flight crews continued an unstabilized approach to landing rather than executing a go-around (37.2%). Troubleshooting was not included as an IV in the subsequent binomial logistic regressions.

Table 12

Cross-tabulation of Troubleshooting in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Troubleshooting	Yes	Count	1 *(0.6)*†	0 *(0.4)*†
		% within factor	100.0%	0.0%
	No	Count	59 *(59.4)*	35 *(34.6)*
		% within factor	62.8%	37.2%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.
†Expected count less than 5.

Workload. Workload was coded as a contributing factor in 27.4% of the sample incident reports. Of those reports noting workload as a contributing factor, 53.8% of the reported incidents were unstabilized approaches continued to landing and 46.2% of the reports noted flight crews completing a go-around (Table 13). When workload was not coded as a contributing factor, data indicated that in 66.7% of reports flight crews continued an unstabilized approach to landing rather than executing a go-around (33.3%).

Table 13

Cross-tabulation of Workload in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Workload	Yes	Count	14 *(16.4)*	12 *(9.6)*
		% within factor	53.8%	46.2%
	No	Count	46 *(43.6)*	23 *(25.4)*
		% within factor	66.7%	33.3%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.

Other/unknown. Other/unknown was coded as a contributing factor in 4 of the 95 sample incident reports (4.2%), and 3 of those 4 reports were of an unstabilized approach continued to landing (Table 14). Of the remaining reports in which other/unknown was not coded as a contributing factor, 62.6% of the reports noted that flight crews continued an unstabilized approach to landing rather than executing a go-around (37.4%). Other/unknown was not included as an IV in subsequent binomial logistic regressions.

Table 14

Cross-tabulation of Other/Unknown in Relation to Unstabilized Approach Outcomes

			Unstabilized approach outcome	
			Non-compliance	Compliance
Other/unknown	Yes	Count	3 *(2.5)*†	1 *(1.5)*†
		% within factor	75.0%	25.0%
	No	Count	57 *(57.5)*	34 *(33.5)*
		% within factor	62.6%	37.4%

Note. *N* = 95. Non-italicized counts are observed counts and italicized counts are expected counts.
†Expected count less than 5.

The remaining analyses were conducted using the nine human factors identified for the binomial logistic regression: communication breakdown, confusion, distraction, fatigue, human-machine interface, situational awareness, time pressure, training/qualifications, and workload. The goals of the analyses were to test for associations and relationships of the human factors with reported unstabilized approach outcomes.

Associations and Relationships of Human Factors and Unstabilized Approaches

A binomial logistic regression was used in testing associations of human factors with unstabilized approaches reported in the ASRS database. The assumptions and requirements for binomial logistic regression (Agresti, 2007; 2013; Tabachnick & Fidell, 2013) were examined and all were satisfied. The dependent variable –reported unstabilized approach event outcome – was dichotomous: *continued to landing* or *go-around*. The independent variables – nine human factors – were nominal: coded as either *contributing* or *not contributing* to the reported unstabilized approach. The observations were independent, such that a human factor was coded by an ASRS analyst as either contributing or not contributing and an observation could not belong to both categories of event outcome (i.e., not both *continued to landing* and *go-around*). Finally, there were at least 10 cases per independent variable, no indication of multicollinearity (Appendix I), and no significant outliers.

Initial review of the unweighted case processing indicated that the analysis was constructed properly, as the total number of cases processed was the expected sample of 95 reports. There were no missing cases and no cases were unselected (Table 15).

Table 15

Case Processing Summary

Unweighted cases		*N*	Percent
Selected cases	Included in analysis	95	100.0
	Missing cases	0	0.0
	Total	95	100.0
Unselected cases		0	0.0
Total		95	100.0

Review of the categorical variable coding revealed no low frequency counts (Table 16). Frequencies of human factors being coded as contributing factor (“Yes”) in the reported unstabilized approach ranged from being coded in 12 to 74 reports, with a median of 26 and mode of 30 reports. Frequencies of human factors being coded as not contributing (“No”) in the reported unstabilized approach ranged from being not coded in 21 to 83 reports, with a median of 69 and mode of 65 reports.

Table 16

Frequency of Categorical Variables Codings

Categorical variable	Frequency	
	Yes	No
Communication breakdown	30	65
Confusion	29	66
Distraction	30	65
Fatigue	12	83
Human-machine interface	24	71
Situational awareness	74	21
Time Pressure	14	81
Training/qualifications	21	74
Workload	26	69

Baseline analysis. As a baseline analysis at Step 0, no independent variables were added to the model, which left only the constant. Without any independent variables added and using a cutoff value of .500, the model correctly predicted that a report would be one of an unstabilized approach continued to landing 63.2% of the time (Table 17).

Table 17

Classification Table with Constant Only at Step 0

			Predicted		
			Unstabilized approach outcome		
	Observed		Non-compliance	Compliance	Percent correct
Step 0	Unstabilized approach outcome	Non-compliance	60	0	100.0
		Compliance	35	0	0.0
	Overall percentage				63.2

Table 18 displays the iteration history when only the constant is included in the model, with the iteration terminated when the parameter estimates changed by less than 0.001. The variable included in the equation of the baseline analysis is the dependent variable of the reported unstabilized approach outcome (Table 19). The results at Step 0 indicated that for every one unit increase in the dependent variable there was a 1.714 increase in the likelihood of a report being one in which the unstabilized approach was continued to landing versus go-around.

Table 18

Iteration History with Constant Only at Step 0

Iteration		-2 Log likelihood	Coefficients constant
Step 0	1	125.044	.526
	2	125.041	.539
	3	125.041	.539

Table 19

Variables in the Equation at Step 0

		B	SE	Wald χ^2	*df*	*p*	Odds Ratio
Step 0	Constant	.539	.213	6.422	1	.011	1.714

Note. $\alpha = .05$.

The independent variables not included in the model at Step 0 are provided in Table 20. Based on the results at Step 0, only one human factor was expected to improve the fit of the model. Situational awareness had a Lagrange multiplier test score of 4.775 ($p = .029$). All other human factors had *p*-values greater than .215, indicating that the fit of the model was not expected to improve when the other human factors were entered.

Table 20

Variables not in the Equation at Step 0

			Score	*df*	*p*
Step 0	Variables	Communication breakdown	.001	1	.981
		Confusion	1.537	1	.215
		Distraction	.188	1	.665
		Fatigue	.073	1	.787
		Human-machine interface	.321	1	.571
		Situational awareness	4.775	1	.029
		Time pressure	.009	1	.925
		Training/qualifications	.018	1	.893
		Workload	1.334	1	.248
	Overall Statistics		7.680	9	.567

Note. $\alpha = .05$.

Binomial logistic regression results. At Step 1, binomial logistic regression tested the overall statistical significance if the independent variables – i.e., human factors – were added to the model. The overall statistical significance of the model is an indication of how well the model that includes the independent variables can predict the dependent variable compared to when no independent variables are added to the model. For the purposes of this study, the dependent (outcome) variable is whether or not the report to which the coded human factors are attributed is either an unstabilized approach that continued to landing versus go-around. Table 21 displays the iteration history when the independent variables were included with the constant in the model, with the iteration terminated when the parameter estimates changed by less than 0.001. The initial -2 Log Likelihood was 125.041 and the estimation was terminated after four iterations as an ending -2 Log Likelihood value of 117.265.

Table 21

Iteration History with Variables Added at Step 1

		-2 Log likelihood	Constant	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Situational awareness	Time pressure	Training/ qualifications	Workload
Step 1	1	117.400	-.262	-.180	-.531	.082	.042	.170	.992	-.240	.195	.470
	2	117.265	-.264	-.209	-.645	.091	.074	.190	1.065	-.274	.226	.539
	3	117.265	-.264	-.210	-.650	.092	.076	.191	1.067	-.275	.227	.542
	4	117.265	-.264	-.210	-.650	.092	.076	.191	1.067	-.275	.227	.542

The significance of the contribution of human factors to the model is reported in Table 22. The omnibus test revealed that adding the independent variables of the human factors to the model did not provide a significant contribution ($\chi^2(9) = 7.776$, $p = .557$). Although the human factors did not significantly contribute to the model, the results of the Hosmer and Lemeshow Test (Table 23) indicate that the model is not a poor fit ($\chi^2(8) = 6.882$, $p = .549$).

Table 22

Omnibus Test of Model Coefficients for Human Factors

		χ^2	*df*	*p*
Step 1	Step	7.776	9	.557
	Block	7.776	9	.557
	Model	7.776	9	.557

Note. $\alpha = .05$.

Table 23

Hosmer and Lemeshow Test

	χ^2	*df*	*p*
Step 1	6.882	8	.549

Note. α = .05.

The model summary provides an indication of the amount of variation in the dependent variable that can be explained by the model containing the independent variables. The Cox & Snell R^2 and Naglekerke R^2 values are equivalent to the R^2 of multiple regression. The results of the logistic regression model summary indicate that the explained variation in the dependent variable – i.e., outcome of the reported unstabilized approach – based on the model including the human factors ranges from 7.9% to 10.7%, depending on the method used in calculating the explained variance (Table 24).

Table 24

Model Summary

	-2 Log Likelihood	The Cox & Snell R^2	Naglekerke R^2
Step 1	117.265	.079	.107

Adding the independent variables and using a cutoff value of .500, the model at Step 1 correctly predicted that a report would be one of an unstabilized approach continued to landing 67.4% of the time (Table 25). This represents a 4.6% increase in classification accuracy. The model sensitivity was 88.3%, indicating the correct prediction of a report being one of an unstabilized approach continued to landing. Model specificity indicated that 31.4% of the reports of an unstabilized approach resulting in a go-around were correctly predicted by the model.

Positive predictive value of the model was 68.8%, which is calculated as the ratio of correctly predicted reports of unstabilized approach continued to landing (*n* = 53) to the total of number of reports predicted with the outcome (*n* = 77). Negative predictive value of the model was 61.1%, which is calculated as the ratio of correctly predicted reports of unstabilized approach met by go-around (*n* = 11) to the total of number of reports predicted with the outcome (*n* = 18).

Table 25

Step 1 Classification Table with Human Factors Added

			Predicted		
			Unstabilized approach outcome		
	Observed		Non-compliance	Compliance	Percent correct
Step 1	Unstabilized approach outcome	Non-compliance	53	7	88.3
		Compliance	24	11	31.4
	Overall percentage				67.4

The results of the logistic regression with the human factors entered into the model with the constant are reported in Table 26. Three human factors – communication breakdown, confusion, and time pressure – were associated with decreased odds of the report being one of an unstabilized approach continued to landing when the human factor was coded as contributing to the event outcome. The remaining six human factors – distraction, fatigue, human-machine interface, situational awareness, training/qualifications, and workload – were associated with increased odds of the report being one of an unstabilized approach continued to landing when the human factor was coded as contributing to the event outcome.

Table 26

Variables in the Equation at Step 1

Variable entered at Step 1	*B*	SE	Wald χ^2	*df*	*p*	Odds Ratio	95% CI for OR	
							Lower	Upper
Communication breakdown	-.210	.561	.140	1	.709	.811	.270	2.435
Confusion	-.650	.562	1.337	1	.248	.522	.173	1.571
Distraction	.092	.520	.031	1	.860	1.096	.396	3.036
Fatigue	.076	.700	.012	1	.913	1.079	.274	4.257
Human-machine interface	.191	.573	.111	1	.739	1.210	.394	3.722
Situational awareness	1.067	.571	3.487	1	.062	2.906	.949	8.906
Time pressure	-.275	.721	.145	1	.703	.760	.185	3.124
Training/qualifications	.227	.559	.165	1	.684	1.255	.420	3.754
Workload	.541	.520	1.084	1	.298	1.718	.620	4.757
Constant	-.264	1.033	.065	1	.798	.768		

Note. $\alpha = .05$.

Using the Wald χ^2 test to determine the statistical significance of the contribution for each human factor to the model, the results indicate that none of the human factors added significantly to the model (all *p*s > .06). Although situational awareness was expected to improve the fit of the model as indicated during the baseline analysis, it did not result in a statistically significant contribution to the model when added (Wald $\chi^2(1) = 3.487$, $p = .062$, OR = 2.906, 95% CI [.949, 8.906]). This result suggests that when situational awareness is coded as a contributing factor, the reported event is 2.91 times more likely to be an unstabilized approach continued to landing than when the factor is not coded as contributing. However, this contribution did not show an improvement above the null model when no independent variables were added.

Post Hoc Power Analysis

A *post hoc* power analysis was computed using G*Power 3 (Faul et al., 2009). The following same input parameters from the *a priori* power analysis were used for *post hoc* power analysis input: two-tailed, log-normal distribution, alpha level of .05, and power level of .95. However, for the *post hoc* power analysis, odds ratio of 1.7 and Naglekerke R^2 value of .107 were used based on the results from the study. The power analysis output indicated that the study had an actual power of .88 with the given *post hoc* input parameters.

Summary

A binomial logistic regression was used to test the associations and relationships of ASRS-coded human factors on the likelihood that the reported event was an unstabilized approach continued to landing versus go-around. Preliminary chi-square test analysis of the study sample revealed statistically significant differences in the outcome of reported unstabilized approaches ($\chi2(1) = 6.579$, $p = .01$), with more than 63% of the reported unstabilized approaches continued to landing and less than 37% responded to with go-around compliance. Nine of the twelve ASRS-coded human factors were used as the independent variables in the logistic regression: communication breakdown, confusion, distraction, fatigue, human-machine interface, situational awareness, time pressure, training/qualifications, and workload. The dependent variable was the reported unstabilized approach event outcome, either *continued to landing* or *go-around*. The model explained between 7.9% and 10.7% of the variance in event outcome, depending on the method used in calculating the explained variance (Cox & Snell R^2 or Naglekerke R^2, respectively). The model sensitivity was 88.3%, specificity was 31.4%, positive predictive value was 68.8%, and negative predictive value was 61.1%. However, the logistic regression model was not statistically significant ($\chi2(9) = 7.776$, $p = .557$). Although there were associations of the ASRS-coded human factors with reported unstabilized approaches, the relationships of these associations were not statistically significant.

Chapter V

Discussion, Conclusions, and Recommendations

Informed by the findings and recommendations of the Flight Safety Foundation's Approach and Landing Accident Reduction Task Force, this study critically examined and analyzed commercial aviation incident report data from unstabilized approach and landing events. Toward this end, this study used ASRS incident report data to investigate the associations of analyst-coded flight crew human factors with reported incidents of unstabilized approaches and landings. The independent variables in this study were the ASRS-coded human factors previously identified by ASRS analysts as contributing to the reported aviation event. The dependent variable in this study was the reported event outcome of the unstabilized approach, either *continued to landing* or *go-around*. Results of the binomial logistic regression were used to answer three research questions that guided the study. These questions were of the human factors contributing to unstabilized approaches, associations of the contributing human factors with unstabilized approaches, and relationships of the contributing human factors in the likelihood of the adverse aviation event outcomes.

Discussion of Results

The results of the preliminary chi-square goodness of fit test revealed that there were statistically significant differences in the outcome of reported unstabilized approaches ($\chi^2(1) = 6.579$, $p = .01$, $w = .26$), with less than 37% of the reported unstabilized approaches being responded to with go-around compliance. Given this low-medium effect size, the significant differences in event outcomes – unstabilized approaches continued to landing versus an executed go-around – were meaningful and could not be attributed to chance. These findings provided support for subsequent analyses of the human factors and their associations to the event outcomes, and investigating answers to the research questions of this study.

Contributing human factors. The study results provided answers to all three research questions. The first question of this study was not used for hypothesis testing, but rather for descriptive understanding of the human factors coded during events of unstabilized approaches.

RQ1. What human factors are identified in the ASRS reports as contributing factors to aviation incidents of unstabilized approaches?

Using descriptive statistics, it was found that all 12 human factors were represented in the contributing factors of the study sample. Situational awareness was the most often coded human factor, indicated as contributing to 77.9% of the reported unstabilized approaches. No other human factor was nearly as frequently coded. Five human factors were coded as contributing factors in 25.3% to 31.6% of the reports: communication breakdown, distraction, confusion, human-machine interface, and workload. The remaining human factors were coded in less than 23% of the reports. These results suggest that the reported events of unstabilized approaches are most frequently accompanied by the flight crew's loss of situational awareness. This is a finding consistent with the results reported by the ALAR Task Force (2017).

A particular pattern was revealed for all human factors other than situational awareness. Each human factor (excluding situational awareness) was coded as a contributing factor in fewer reports than coded as not contributing to the reported unstabilized approach. When the human factor was coded as contributing, the outcome of the reported unstabilized approach was that the flight crew continued to landing rather than executed a go-around. However, when the human factor was coded as not contributing to the reported unstabilized approach, it was still more likely that the report was of an unstabilized approach continued to landing. This was not true of the reports in which situational awareness was coded as a contributing factor. When coded as a contributing factor, the reports showed a pattern similar to all other human factors in that the outcome was an unstabilized approach continued to landing. However, when situational awareness was not coded as contributing to the event, the reports were more likely to be of an unstabilized approach met with go-around compliance.

It was also revealed during the review of the descriptive statistics that the majority of reports (53.7%) had only one or two human factors coded as contributing to the reported unstabilized approach. There were decreasing number of reports as the human factors coded as contributing to the event increased. These findings taken together suggest that the likelihood of an unstabilized approach may not be influenced by the number of contributing human factors, but rather the degree to which any human factor present in the event perturbed flight crew performance. Another potential explanation is that any human factor present during the adverse event interacted with other factors that were not part of this study, such as contributing factors of airspace structure or weather conditions.

Associations of human factors with unstabilized approaches. The remaining two research questions are accompanied here with the associated null and alternate hypotheses for discussion. Since the two research questions are related, discussion of results relevant to the final two research questions will be presented together.

RQ2. To what extent, if any, are the ASRS-coded human factors associated with unstabilized approaches reported in the ASRS database?

H_0. There are no statistically significant associations of ASRS-coded human factors with unstabilized approaches reported in the ASRS database.

H_1. There are statistically significant associations of ASRS-coded human factors with unstabilized approaches reported in the ASRS database.

Based on the binomial logistic regression analysis ($\chi^2(9) = 7.776$, $p = .557$), the null hypothesis cannot be rejected. There were no statistically significant associations revealed of ASRS-coded human factors with unstabilized approaches reported in the ASRS database. The only human factor that approached a significant association with reports of unstabilized approaches was situational awareness (Wald $\chi^2(1) = 3.487$, $p = .062$, OR = 2.906, 95% CI [.949, 8.906]). These findings suggest that reports of unstabilized approaches continued to landing rather than met with go-around compliance cannot be solely attributed to the influence of the human factors assessed by ASRS analysts as contributing to the event.

RQ3. If associations between the ASRS-coded human factors and unstabilized approaches exist, what is the relationship of the human factors in the likelihood that the reported event was an unstabilized approach continued to landing versus go-around?

H_0. There are no statistically significant relationships of human factors in the likelihood that the reported event was an unstabilized approach continued to landing versus go-around.

H_1. There are statistically significant relationships of human factors in the likelihood that the reported event was an unstabilized approach continued to landing versus go-around.

Based on the binomial logistic regression analysis ($\chi^2(9) = 7.776$, $p = .557$), the null hypothesis cannot be rejected. There are no statistically significant relationships of ASRS-coded human factors in the likelihood that the reported event was an unstabilized approach continued to landing versus go-around. Although when situational awareness is coded as a contributing factor the reported event is 2.91 times more likely to be an unstabilized approach continued to landing, this relationship was not significant (Wald $\chi^2(1) = 3.487$, $p = .062$, OR = 2.906, 95% CI [.949, 8.906]). As previously noted, this finding is consistent with the results reported by the ALAR Task Force (2017), which found that unstabilized approaches are most frequently accompanied by the flight crew's loss of situational awareness. Elevated odds ratios were revealed in five other human factors, although not found to be significant relationships with reported unstabilized approach outcomes: distraction, fatigue, human-machine interface, training/qualifications, and workload. In sum, the likelihood that a reported unstabilized approach was continued to landing versus go-around compliance is not solely influenced by the human factors assessed by ASRS analysts as contributing to the event.

Conclusions

This study was an analysis of human factors identified as contributing factors in unsafe acts and attitudes, operational errors, and flight crew behaviors during unstabilized approaches in commercial aviation incidents reported to ASRS. The primary aim of the study was to assess if there was an association of the human factors with reported unstabilized approaches, such that the relationship of the human factors influenced the likelihood that the reported event was an unstabilized approach continued to landing versus go-around compliance. The results of this study revealed that there is a statistically significant difference in the outcome of reported unstabilized approaches, in which it is more likely the unstabilized approach will be continued to landing. The influence of decrements in flight crew situational awareness approached the threshold of being a significant contribution to the likelihood that the reported unstabilized approach was continued to landing. However, results from the binomial logistic regression of this study do not support a claim of the outcome likelihood being influenced by the contribution of any sole or combination of human factors.

Limitations. Limitations were identified at the onset of this study and these remain limitations. The inherent limitations associated with the ASRS database and self-report safety incident data could not be avoided. ASRS reporting is voluntary and relies on self-reporting, and therefore vulnerable to voluntary reporting bias. As previously noted, there is inherent risk of hindsight bias and self-protective interpretation (Jentsch et al., 1999), and thus subject to reporting bias not only in what is reported but also what is not reported. Another limitation is that the narratives of the flight crew involved in the reported unstabilized approach may not include terms readily identified by ASRS analysts as matching the definitions and descriptions used for coding the human factors, and the narratives may not include adequate reporting for ASRS analysts to make more meaningful interpretations of the events. ASRS does not publish inter-coder reliability data. Since ASRS reports are only those incidents that were reported, and not reflective of all such incidents and others that share similar operational characteristics, the analyses of this study are limited to a subpopulation of all commercial aircraft approaches.

An additional limitation of this study that was not addressed at the onset is that it tested for odds ratios equivalent to a low-medium effect. It may be that the sample size of 95, although providing adequate power for detecting a low-medium effect if one existed, was not adequate for detecting odds ratios within the range of a small effect. When running an *a priori* power analysis using the parameters of this study with an adjusted odds ratio of 1.3 and R^2 value of .107, the required sample size was determined to be 247 reports. When reducing the anticipated power from .95 to .80, and maintaining all other parameters, the required sample size was determined to be 148 reports. It may be that a low-medium effect does not exist. Further, detecting an existing small effect would require a larger sample than was obtained and used for this study. If binomial logistic regression models from the analyses are not significant, it may suggest that binomial logistic regression is not be the appropriate statistical test for the human factors data as it is currently coded in the ASRS database. Despite human factors being coded as contributing to adverse aviation events reported to ASRS, it remains possible that the ASRS database may not be the appropriate source for data investigating the psychology of go-around noncompliance.

Recommendations

Although advances in the National Airspace System have resulted in increased commercial aviation system performance, these advances have created gaps in understanding flight crew performance, particularly in the context of operations during both typical and atypical conditions (Krois, Piccione, & McCloy, 2010). Changes in the flight deck that are part of evolving capabilities and technologies provide for new flight crew errors and a change in the nature of the errors (Krois et al., 2010). In addition, changes in flight crew member roles, responsibilities, and tasks necessitate flight crews needing to develop and maintain the appropriate knowledge and skills for safe operations (Krois et al., 2010). Therefore, the effectiveness of established flight crew training techniques for mitigating errors and ensuring safe operations is increasingly important to NextGen commercial aviation safety.

To this end, a recommendation is to use the results of the current study to inform investigation of smaller effects (i.e., smaller odds ratios) with the required larger sample size. There remains the potential of identifying patterns of human factors associated with and contributing to flight crew performance during reported incidents of unstabilized approaches and landings. In addition to using the ASRS-coded data, latent semantic analysis may provide additional guidance for interpreting the flight crew narratives of the events and using this data to cross-check the coding by ASRS analysts.

Another recommendation is to analyze associations of the different combinations of human factors coded by ASRS as contributing to reported unstabilized approaches. It may be that certain combinations of human factors are associated with an increased likelihood in the outcome of unstabilized approaches. For example, while fatigue and workload alone are not significant contributors to the likelihood of unstabilized approaches continuing to landing, when both are present during an unstabilized approach, there may be an increased influence due to the interaction of these two human factors. Additional investigation in this direction may be beneficial.

Human factors may indeed have an influence on the likelihood of unstabilized approaches continued to landing rather than go-around compliance, and these human factors may be interacting with other non-human contributing factors. A more extensive analysis of ASRS data may provide additional lessons learned from reported unstabilized approaches and landings, and inform go-around training designs for improved flight crew compliance with go-around policies and procedures. Although the results of this current study did not reveal significant associations and relationships of human factors in the likelihood that the reported unstabilized approach was continued to landing versus go-around, the ASRS database includes other contributing factors and flight characteristics. Analyses of these other contributing factors, human factors, and other flight characteristics is warranted.

References

American Psychological Association. (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.

Agresti, A. (2007). *An introduction to categorical data analysis* (2nd ed.). Hoboken, NJ: Wiley-Interscience.

Agresti, A. (2013). *Categorical data analysis* (3rd ed.). Hoboken, NJ: Wiley-Interscience.

Ashford, S. N., Lanehart, R. E., Kersaint, G. K., Lee, R. S., & Kromrey, J. D. (2016). STEM pathways: Examining persistence in rigorous math and science course taking. *Journal of Science Education and Technology, 25*, 961-975.

Aviation Safety Reporting System. (2016). *ASRS program briefing* [PowerPoint slides]. Retrieved from https://asrs.arc.nasa.gov/docs/ASRS_ProgramBriefing2016.pdf

Aviation Safety Reporting System. (2017, October 25). *Contributing factors/situations and human factors.* Unpublished definitions. Retrieved by email communication with Jorge Moya on October 25, 2017.

Aviation Safety Reporting System. (2017, November 2). *Event anomaly definitions.* Unpublished definitions. Retrieved by email communication with Jorge Moya on November 2, 2017.

Baker, B. J. (2001). Identifying the probability of an accident occurring with suspected unapproved parts as a contributing factor. *Journal of Aviation/Aerospace Education & Research, 10*, 15-29.

Barnes, V. E., & Monan, W. P. (1990). Cockpit distractions: Precursors to emergencies. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 34*, 1142-1144.

Beaubien, J. M., & Baker, D.P. (2002). A review of selected aviation Human Factors taxonomies, accident/incident reporting systems, and data reporting tools. *International Journal of Applied Aviation Studies, 2,* 11-36.

Bent, J., & Chan, K. (2010). Flight training and simulation as safety generators. In E. Salas and D. Maurino (Eds.), *Human factors in aviation* (2nd ed.) (pp. 293-334). Burlington, MA: Academic Press.

Billings, C. E., & Reynard, W. D. (1984). Human factors in aircraft incidents: Results of a 7-year study. *Aviation, Space, and Environmental Medicine,* 960-965.

Boeing Commercial Airplanes, Aviation Safety. (2017). *Statistical summary of commercial jet airplane accidents. Worldwide operations 1959–2016.* Retrieved from www.boeing.com/news/techissues/pdf/statsum.pdf

Bureau of Transportation Statistics. (n.d.). *Transportation accidents by mode*. Retrieved on 28 October 2017 from https://www.bts.gov/content/transportation-accidents-mode

Casner, S. M., Geven, R. W., & Williams, K. T. (2013). The effectiveness of airline pilot training for abnormal events. *Human Factors, 55,* 477-485.

Chappell, S. L. (1997). Using voluntary incident reports for human factors evaluation. In N. Johnson, N. McDonald, and R. Fuller (Eds.), *Aviation Psychology in Practice* (pp. 149-169). Burlington, VT: Ashgate.

Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics-Simulation and Computation, 39,* 860-864.

Cheng, H. G., & Phillips, M. R. (2014). Secondary analysis of existing data: Opportunities and implementation. *Shanghai Archives of Psychiatry, 26,* 371-375.

Cheung, R. T. H., Wong, R. Y. L., Chung, T. K. W., Choi, R. T., Leung, W. W. Y., & Shek, D. H. Y. (2017). Relationship between foot strike pattern, running speed, and footwear condition in recreational distance runners. *Sports Biomechanics, 16*, 238-247.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences*. New York, NY: Routledge.

Dismukes, R. K. (2010). Understanding and analyzing human error in real-world operations. In E. Salas and D. Maurino (Eds.), *Human factors in aviation* (2nd ed.) (pp. 335-374). Burlington, MA: Academic Press.

Dismukes, R. K., Berman, B. A., & Loukopoulos, L. D. (2007). *The limits of expertise: Rethinking pilot error and the causes of airline accidents.* Burlington, VT: Ashgate.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41,* 1149-1160.

Federal Aviation Administration. (n.d.). *What is an unstable approach?.* Retrieved from https://runwayexcursions.faa.gov/content.html?id=d

Federal Aviation Administration. (2008a). *Approach and landing accident reduction (ALAR): Recommended flightcrew training* [InFO 08029]. Retrieved from https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2008/info08029.pdf

Federal Aviation Administration. (2008b). *InFO 08029 supportive information.* Retrieved from http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/info/all_infos/media/2008/InFO08029Support.pdf

Federal Aviation Administration. (2010). *Go-around callout and immediate response* [SAFO 10005]. Retrieved from https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2010/SAFO10005.pdf

Federal Aviation Administration. (2014). *Mitigating the risks of a runway overrun upon landing* [AC No. 91-79A]. Retrieved from www.faa.gov/documentlibrary/media/advisory_circular/ac_91-79a.pdf

Federal Aviation Administration. (2015). *Flightcrew member line operational simulations: Line-oriented flight training, special purpose operational training, line operational evaluation* (Advisory Circular 120-35D). Retreived from http://ipv6.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-35D.pdf

Federal Aviation Administration. (2016). *NextGen implementation plan 2016*. Washington, DC: Author.

Federal Aviation Administration. (2017a). *NextGen priorities joint implementation plan rolling plan 2017-2019* (Executive Report). Retrieved from https://www.faa.gov/nextgen/library/

Federal Aviation Administration. (2017b). *Standard operating procedures and pilot monitoring duties for flight deck crew members* [AC No. 120-71B]. Retrieved from https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-71B.pdf

Fleishman, E. A., & Quaintance, M. K. (1984). *Taxonomies of human performance: The description of human tasks.* Orlando, FL: Academic Press.

Flight Safety Foundation. (2000). FSF ALAR (approach-and-landing accident reduction) briefing notes. *Flight Safety Digest, 19*, 1-196.

Flight Safety Foundation. (2009). *Reducing the risk of runway excursions* (Report of the Runway Safety Initiative). Retrieved from https://flightsafety.org/files/RERR/fsf-runway-excursions-report.pdf

Flight Safety Foundation. (2017). *Go-around decision-making and execution project* (Final Report to Flight Safety Foundation). Retrieved from https://flightsafety.org/toolkits-resources/go-around-project-final-report/

Foyle, D. C., Hooey, B. L., Byrne, M. D., Corker, K. M., Deutsch, S., Lebiere, C., . . . Wickens, C. D. (2005). Human performance models of pilot behavior. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *49*, 1109-1113.

Harle, P. G. (1997). Investigation of human factors: The link to accident prevention. In N. Johnson, N. McDonald, and R. Fuller (Eds.), *Aviation Psychology in Practice* (pp. 127-148). Burlington, VT: Ashgate.

Harris, D. (2011). *Human performance on the flight deck.* Burlington, VT: Ashgate.

International Air Transportation Association. (2015a). *Guidance material and best practices for the implementation of upset prevention and recovery training* (1st ed.). Montreal, Quebec: Author.

International Air Transportation Association. (2015b). *Loss of control in-flight accident analysis report* (1st ed.). Montreal, Quebec: Author.

International Air Transportation Association. (2016). *Unstable approaches: Risk mitigation policies, procedures and best practices* (2nd ed.). Montreal, Quebec: Author.

International Civil Aviation Organization. (2001). Aircraft accident and incident investigation. *Annex 13 of the Convention on International Civil Aviation.* Retrieved from http://www.airsafety.com.au/trinvbil/C619icao.pdf

International Civil Aviation Organization. (2005). Rules of the air. *Annex 2 of the Convention on International Civil Aviation.* Retrieved from www.icao.int/Meetings/anconf12/Document Archive/an02_cons[1].pdf

Jentsch, F., Barnett, J., Bowers, C. A., & Salas, E. (1999). Who is flying this plane anyway? What mishaps tell us about crew member role assignment and air crew situational awareness. *Human Factors, 41,* 1-14.

Joint Safety Analysis Team. (1999). *Results and analysis*. Retrieved from http://cast-safety.org/pdf/jsat_approach-landing.pdf

Joint Safety Implementation Team. (2001). *Results and analysis*. Retrieved from http://cast-safety.org/pdf/jsit_approach-landing.pdf

Killen, A. R., & Beyea, S. C. (2003). Learning from near misses in an effort to promote patient safety. *AORN Journal, 77*, 423-425.

Krois, P., Piccione, D., & McCloy, T. (2010). Commentary on NextGen and aviation human factors. In E. Salas and D. Maurino (Eds.), *Human factors in aviation* (2nd ed.) (pp. 701-710). Burlington, MA: Academic Press.

Mangold, S. J., Morrison, F. R., & Frank, S. M. (1995). The use of ASRS incident reports in AQP training. *ASRS Research Reports.* Retrieved from https://asrs.arc.nasa.gov/publications/research.html

Matejkowski, J., & Ostermann, M. (2015). Serious mental illness, criminal risk, parole supervision, and recidivism: Testing of conditional effects. *Law and Human Behavior, 39*, 75-86.

Mosier, K. L., Fisher, U., Cunningham, K., Munc, A., Reich, K., Tomko, L., & Orasanu, J. (2012). Aviation decision making issues and outcomes: Evidence from ASRS and NTSB reports. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 56*, 1794-1798.

Mosier, K. L., Rettenmaier, P., McDearmind, M., Wilson, J., Mak, S., Lakshmi, R., & Orasanu, J. (2013). Pilot-ATC communication conflicts: Implications for NextGen. *The International Journal of Aviation Psychology, 23*, 213-226.

National Transportation Safety Board. (n.d.). *Most wanted list*. Retrieved from https://www.ntsb.gov/safety/mwl/Pages/default.aspx

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology, 49*, 1373-1379.

Peterson, S. A. (2017). Certification of financial aid administrators: Is it time to move forward?. *Journal of Student Financial Aid, 47*, 47-82.

RAND. (2001). *A million random digits with 100,000 normal deviates.* Santa Monica, CA: Author.

Rosenkrans, W. (2015, March 31). *Go-around risks*. AeroSafety World. Retrieved from https://flightsafety.org/asw-article/go-around-risks/

Ross, G., & Tomko, L. (2017, May). *Perturbing permutations: An analysis of co-occurring factors during events of pilot confusion.* Poster presented at the 19th International Symposium on Aviation Psychology, Dayton, OH.

Ross, G., & Tomko, L. (2016). Confusion in the cockpit: Typology, antecedents, and sources. *Proceedings of the Human Factors and Ergonomics Society 2016 Annual Meeting, 60*, 1299-1303. doi: 10.1177/1541931213601301

Sarter, N. B., & Alexander, H. M. (2000). Error types and related error detection mechanisms in the aviation domain: An analysis of Aviation Safety Reporting System incident reports. *The International Journal of Aviation Psychology, 10*, 189-206.

Schvaneveldt, R. W., Beringer, D. B., & Lamonica, J. A. (2001). Priority and organization of information accessed by pilots in various phases of flight. *The International Journal of Aviation Psychology, 11*, 253-280.

Shappell, S., Detwiler, C., Holcomb, K., Hackworth, C., Boquet, A., & Wiegmann, D. A. (2007). Human error and commercial aviation accidents: An analysis using the human factors analysis and classification system. *Human Factors*, *49*, 227-242.

Strayer, D. L., & Cooper, J. M. (2015). Driven to distraction. *Human Factors, 57*, 1343-1347.

Sumwalt, R. L., Morrison, R., Watson, A., & Taube, E. (1997). What ASRS data tell about inadequate flight crew monitoring. *ASRS Research Papers.* Retrieved from https://asrs.arc.nasa.gov/publications/research.html

Sumwalt, R. L., & Watson, A. W. (1995). What ASRS incident data tell about flight crew performance during aircraft malfunctions. *ASRS Research Papers.* Retrieved from https://asrs.arc.nasa.gov/publications/research.html

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). New York, NY: Pearson.

Tiller, L. N., & Bliss, J. P. (2017). Categorization of near-collisions close calls reported to the Aviation Safety Reporting System. *Proceedings of the Human Factors and Ergonomics Society 2017 Meeting*, 1866-1870.

Walton, R. O., & Politano, P. M. (2010). Analysis of hazardous material incidents reported to aviation safety reporting system. *Journal of Aviation/Aerospace Education & Research, 20*, 13-20.

Wickens, C. D., & McCloy, T. M. (1993). ASRS and aviation psychology. *Proceedings of the Seventh International Symposium on Aviation Psychology,* 1028-1030.

Wright Brothers Aeroplane Company. (n.d.). *The decade after: Dec 1903 to Oct 1905. Landing without crashing.* Retrieved from http://www.wright-brothers.org/History_Wing/History_of_the_Airplane/Decade_After/Landing_Without_Crashing/Landing_Without_Crashing.htm

Appendices

Appendix A

Table A1

Initial Reports Returned from ASRS Database Query

1414688, 1414603, 1413626, 1413586, 1413132, 1412801, 1412795, 1412762, 1412760, 1412521, 1412007, 1412005, 1412004, 1410473, 1409778, 1409426, 1409167, 1409093, 1408599, 1407790, 1407596, 1406972, 1406675, 1406354, 1406311, 1405273, 1405100, 1404471, 1404053, 1403881, 1403827, 1403525, 1401551, 1401405, 1399587, 1399074, 1397905, 1397395, 1397131, 1396613, 1394959, 1393492, 1392765, 1391653, 1388636, 1387450, 1386643, 1385080, 1384058, 1383795, 1383653, 1383381, 1382407, 1380480, 1379894, 1378648, 1377405, 1376157, 1375898, 1375004, 1374700, 1374634, 1374232, 1373143, 1373083, 1373082, 1367469, 1366763, 1366660, 1366006, 1365666, 1365584, 1365490, 1364701, 1363844, 1362844, 1360886, 1359059, 1356944, 1356752, 1354104, 1353015, 1351836, 1351148, 1350732, 1349591, 1349312, 1348328, 1348273, 1348090, 1348079, 1347580, 1346137, 1345503, 1345428, 1345374, 1345218, 1345216, 1344743, 1343684, 1343657, 1343435, 1342377, 1341860, 1341069, 1340892, 1340338, 1339182, 1338132, 1337976, 1337968, 1337572, 1336808, 1336722, 1336150, 1335199, 1334891, 1334677, 1334273, 1333888, 1333863, 1333577, 1333548, 1333430, 1332152, 1332051, 1332015, 1330266, 1329346, 1328189, 1327695, 1327519, 1326553, 1326350, 1325447, 1325395, 1324915, 1324913, 1323301, 1323068, 1322997, 1322851, 1322849, 1322540, 1321489, 1321321, 1320960, 1320754, 1320218, 1320030, 1319979, 1317459, 1317109, 1316669, 1316634, 1316061, 1315557, 1314989, 1314699, 1314470, 1313626, 1313544, 1313483, 1313460, 1313228, 1312881, 1311640, 1310569, 1310542, 1310136, 1309389, 1308918, 1307960, 1307521, 1306527, 1306375, 1306371, 1306364, 1305966, 1305846, 1305208, 1303151, 1302997, 1302829, 1302589, 1301619, 1301258, 1301224, 1300686, 1300263, 1299247, 1298831, 1297996, 1297464, 1296985, 1296951, 1296660, 1295731, 1295428, 1295055, 1294869, 1294824, 1293789, 1292658, 1291948, 1291764, 1291760, 1291630, 1291417, 1291333, 1291328, 1289944, 1288371, 1287500, 1287195, 1287126, 1287084, 1286770, 1285548, 1285378, 1285256, 1284142, 1283708, 1283176, 1283142, 1282495, 1282125, 1281248, 1281122, 1279707, 1278675, 1278561, 1277889, 1277566, 1275842, 1275759, 1275733, 1275613, 1275067, 1274993, 1274797, 1274670, 1274453, 1274356, 1272592, 1272529, 1271960, 1270141, 1269994, 1269699, 1269280, 1268372, 1268324, 1268264, 1268057, 1267226, 1265652, 1265502, 1265050, 1264315, 1263798, 1262825, 1259842, 1259778, 1259369, 1256598, 1256422, 1256410, 1256160, 1255810, 1255795, 1255485, 1255136, 1254885, 1253009, 1249901, 1249653, 1248662, 1248626, 1247208, 1246382, 1245601, 1244567, 1243430, 1241728, 1240824, 1240423, 1239445, 1238861, 1238596, 1237849, 1237573, 1237272, 1236187, 1235287, 1235223, 1234287, 1233088, 1233013, 1232882, 1230172, 1229487, 1225041, 1222952, 1221462, 1220314, 1219207, 1216835, 1213939, 1212836, 1211144, 1207037, 1206147, 1204771, 1204276, 1202663, 1202512, 1201009, 1200969, 1200906, 1200264, 1200017, 1199392, 1199034, 1197233, 1196972, 1196657, 1196189, 1196188, 1196012, 1195963, 1193113, 1193080, 1192672, 1189311, 1189301, 1188272, 1188011, 1188009, 1187114, 1186810, 1181206, 1180924, 1180426, 1180418, 1179168, 1176170, 1175877, 1174061, 1172797, 1171884, 1171791, 1171169, 1166896, 1164988, 1164044, 1159773, 1156858, 1155343, 1153527, 1149809, 1147406, 1145608, 1145555, 1145259, 1143311, 1143167, 1140139, 1138517, 1129035, 1125691, 1125286, 1124183, 1123288, 1122904, 1122376, 1121745, 1121313, 1120843, 1120826, 1120607, 1120225, 1119793, 1118670, 1118442, 1116949, 1116428, 1115098, 1111985, 1111797, 1099831, 1098189, 1093678, 1093059, 1092426, 1092101, 1089901, 1086832, 1083103, 1082532, 1081126, 1079372, 1078505, 1077026, 1076937, 1073107, 1072832, 1069544, 1067908, 1066801, 1065701, 1059618, 1056719, 1053350, 1050062, 1046405, 1044988, 1043438, 1042497, 1035852, 1033302, 1033301, 1032599, 1031520, 1030437, 1030428, 1022898, 1013802, 1010803, 1009258, 1007892, 1007386, 1005647, 1002221, 1001577, 995801, 995011, 994901, 993418, 993408, 990416, 990391, 990077, 988672

Note. ACNs listed in descending order.

Appendix B

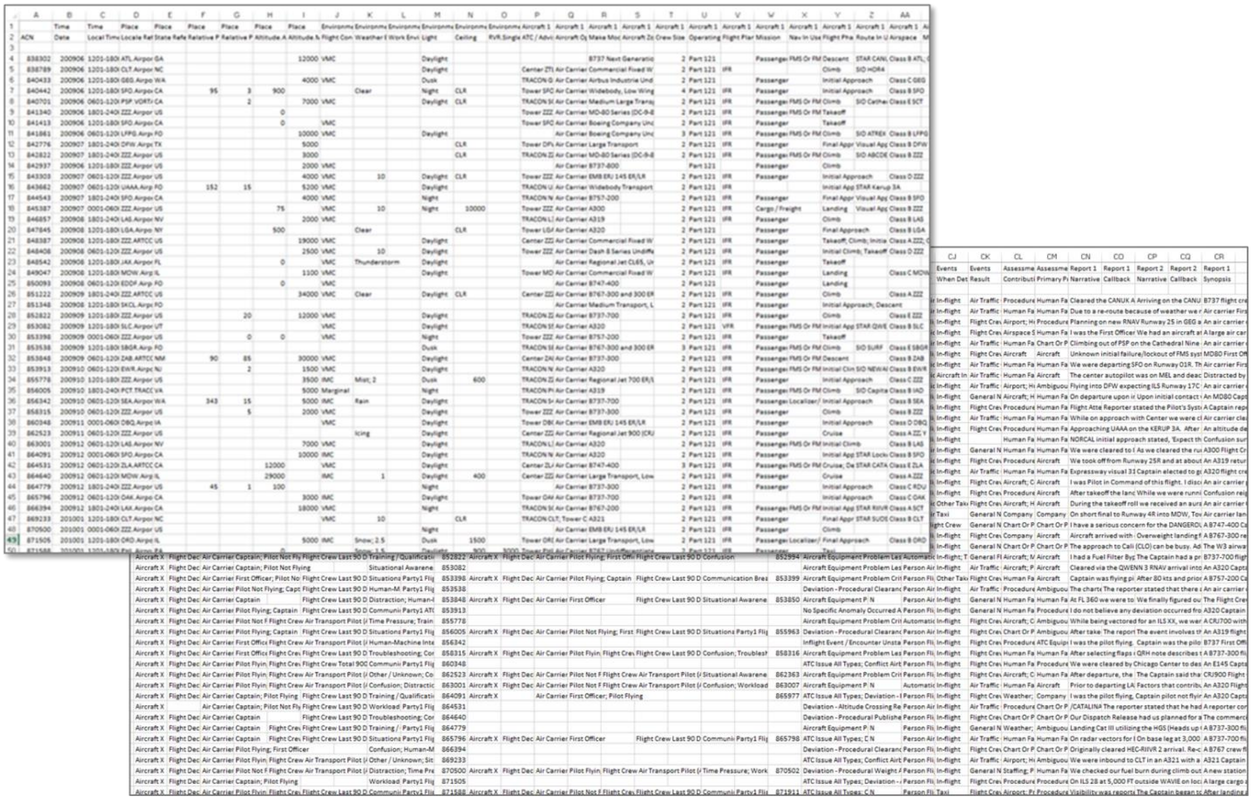

Figure A1. Representative ASRS database output in Excel format.

Appendix C

Table A2

Reports Excluded from the Initial Return from ASRS Database Query

Excluded due to no "human factors" coded: 1042497, 1043438, 1044988, 1065701, 1089901, 1175877, 1199034, 1211144, 1233013, 1236187, 1241728, 1264315, 1267226, 1268372, 1274356, 1296985, 1297464, 1306364, 1315557, 1317459, 1320960, 1322540, 1334891, 1336150, 1345374, 1345503, 1346137, 1348273, 1349591, 1351148, 1356944, 1364701, 1373143, 1374232, 1374634, 1382407, 1383381, 1383795, 1384058, 1396613, 1397131, 1409778, 1412005, 1412795, 1413586, 1414603
Excluded due to "Other / Unknown" being the only coded data of "human factors": 1115098, 1129035, 1332051
Excluded due to "Human Factors" not being explicitly coded as a "Contributing Factors/ Situations" for the incident: 988672, 994901, 1031520, 1033301, 1046405, 1066801, 1083103, 1093678, 1116428, 1120607, 1125286, 1164988, 1166896, 1196657, 1199392, 1200906, 1229487, 1234287, 1237573, 1239445, 1240423, 1243430, 1248662, 1255136, 1255795, 1256410, 1259369, 1262825, 1265050, 1265502, 1275733, 1275759, 1285378, 1286770, 1287500, 1288371, 1291333, 1291760, 1292658, 1294824, 1301224, 1301619, 1306375, 1313483, 1316634, 1320218, 1332152, 1333430, 1337572, 1347580, 1348079, 1354104, 1365584, 1366660, 1377405, 1387450, 1397905, 1399074, 1406972, 1407790, 1409167, 1412004, 1413626
Excluded due to "Events Result" field being empty: 1053350, 1072832

Note. 114 total exclusions.

Appendix D

Table A3

ASRS Reports Included in the Study Sample

993418, 995801, 1002221, 1007892, 1030428, 1035852, 1050062, 1067908, 1077026, 1081126, 1092426, 1099831, 1111985, 1118442, 1118670, 1121313, 1124183, 1138517, 1143167, 1143311, 1149809, 1155343, 1176170, 1181206, 1193113, 1200017, 1200264, 1216835, 1220314, 1222952, 1225041, 1230172, 1233088, 1235223, 1237272, 1238861, 1248626, 1253009, 1256422, 1263798, 1269699, 1270141, 1274993, 1277889, 1282495, 1283142, 1283708, 1284142, 1287126, 1287195, 1289944, 1291417, 1295731, 1302589, 1302829, 1305208, 1305846, 1310136, 1310542, 1311640, 1313460, 1314470, 1314699, 1316669, 1326350, 1327695, 1328189, 1330266, 1333577, 1336722, 1337968, 1337976, 1338132, 1339182, 1341860, 1343435, 1345216, 1348090, 1349312, 1353015, 1366763, 1367469, 1373082, 1376157, 1385080, 1399587, 1401405, 1401551, 1406354, 1409093, 1409426, 1410473, 1412521, 1412760, 1413132

Note. N = 95.

Appendix E

ACN: 838302

Time / Day

Date : 200906
Local Time Of Day : 1201-1800

Aircraft

Flight Phase : Descent

Person : 1

Function.Flight Crew : Pilot Not Flying
Function.Flight Crew : Captain
ASRS Report Number.Accession Number : 838302
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck
Human Factors : Communication Breakdown
Human Factors : Time Pressure
Human Factors : Distraction
Human Factors : Confusion

Person : 2

Function.Flight Crew : Pilot Flying
Function.Flight Crew : First Officer
ASRS Report Number.Accession Number : 838303
Location Of Person.Aircraft : X
Location In Aircraft : Flight Deck

Events

Anomaly.ATC Issue : All Types
Anomaly.Deviation - Altitude : Excursion From Assigned Altitude
Anomaly.Deviation - Procedural : Clearance
Detector.Person : Air Traffic Control
Result.Air Traffic Control : Issued New Clearance
When Detected : In-flight

Assessments

Contributing Factors / Situations : Procedure
Contributing Factors / Situations : Human Factors
Primary Problem : Human Factors

Narrative: 1

Cleared the CANUK Arrival into ATL. As we descended from altitude to cross CANUK at 14000 FT, we were told to 'expect landing 8 left, fly the 8 left transition.' Since we were arriving from the south, we had set up the FMS for a south landing. The First Officer changed the runway to 8L, and selected the proper transition. As we crossed CANUK, the First Officer asked me what the bottom altitude on the chart was for the arrival, and I said 4000 FT and set 4000 FT in the altitude window. As we left 14000 FT for 12000 FT at the net point, we were given a frequency change. The Controller was surprised that we were descending and had us stay at 12000 FT. Later on the arrival we were instructed to call center upon arrival at our gate. The rest of the approach and landing were uneventful. I called the Operations Manager at the number given, and we discussed the problem. No traffic separation problems were noted, and he just wanted to clarify the situation. The manager did explain the continuing problems they are experiencing with this arrival. I do know the difference between 'fly the transition' and 'descend on the transition.' As the Captain, I am responsible, and I accept full responsibility, for the actions of my aircraft and crew. This will not happen again in my aircraft. I have two suggestions to help us with this arrival. 1) If there is any way to assign the transition earlier in the descent, it would cut down considerably in the cockpit workload. We were given this change as we leveled off at Canuk, dealing with the resulting discontinuity in the FMS, and checking the points and altitudes against the paper chart. Managing all three issues at exactly the same time contributed to our confusion regarding the clearance. 2) If the Controllers would state 'fly the 8L transition, maintain 14000 FT,' there would be no confusion. As we became task saturated when our workload increases, we remember the last number we hear. I am now convinced we would not have descended out of 14000 FT had these two words been added to the clearance. For my part, I will strive to never let cockpit workload get in the way of aircraft safety. In the future, I will clarify any questions I may have regarding a clearance.

Narrative: 2

Arriving on the CANUK to ATL landing to the east. I briefed the visual backed up by the ILS to Runway 10 with a back up of the same approach to 9R. I did not brief or discuss landing on the north side. Well into the arrival, nearing CANUK at 14000 FT we are instructed by approach to fly the transition to 8L. I look at the approach plate and see we don't have a lot of time to make the split and head NW. There are also several different altitudes on the arrival to 8L. I decide I have time to put the 8L transition in the FMS with autopilot on at 14000 FT and begin to do so. We have passed CANUK and the next altitude is 12000 FT and then 7000 FT. The Captain rolls in the lower altitude. I am still working on clearing some excess points out of the FMS, we have made the turn to the northwest. I ask the Captain if we are cleared to descend after he puts in the lower altitude. I have a feeling something isn't quite right. He says yes, we are cleared for the transition. I react poorly and do not ask for verification from the Controller. The Captain was changing the radios and MCP while I verified the FMS and began briefing the new arrival runway. We are busy. As we approach 12000 FT, Approach Control queries us on our altitude. We were not cleared to descend from 14000 FT. The clearance I heard was 'cleared for the 8L transition'. I had not heard what I needed to hear to descend, cleared to descend via the 8L transition. This is my error and I should have not left 14000 FT without proper clearance. I would add that the lateness of clearance to the 8L transition allowed little time to properly process and interpret the clearance we were given. We had been up approach for several minutes and had no indication of landing runway or a requirement to land on the north side. All that said, I definitely now better than to get caught like this.

Synopsis

B737 flight crew arriving ATL is cleared to fly the CANUK7 RNAV with the north transition, after having set up for the south transition. This last minute change and the required FMC work lead the crew to descend without clearance.

Figure A2. Representative ASRS report in Word format.

Appendix F

	Person 1
ACN	Human Factors
838302	Communication Breakdown; Confusion; Distraction; Time Pressure
838789	Communication Breakdown; Confusion
840433	Communication Breakdown; Confusion; Distraction; Situational Awareness; Workload
840442	Human-Machine Interface; Confusion; Communication Breakdown; Situational Awareness
840701	Situational Awareness; Confusion; Human-Machine Interface
841340	Troubleshooting; Human-Machine Interface; Confusion
841413	Training / Qualification; Confusion
841861	Distraction; Confusion; Human-Machine Interface; Troubleshooting
842776	Time Pressure; Situational Awareness; Distraction; Confusion; Communication Breakdown
842822	Other / Unknown
842937	Confusion; Troubleshooting; Training / Qualification; Situational Awareness; Distraction; Communication Breakdown
843303	Communication Breakdown; Confusion; Situational Awareness; Training / Qualification
843662	Human-Machine Interface; Distraction; Confusion; Communication Breakdown
844543	Communication Breakdown; Confusion
845387	Communication Breakdown; Confusion; Situational Awareness
846857	Human-Machine Interface; Confusion; Distraction; Fatigue; Troubleshooting; Workload
847845	Human-Machine Interface; Workload; Communication Breakdown; Distraction; Fatigue

ACN	P1-HF Comm	P1-HF Confuse	P1-HF Distract	P1-HF Fatigue	P1-HF H-M Int	P1-HF Physio	P1-HF Sit Awar	P1-HF Time	P1-HF Tr/Qual	P1-HF Trouble	P1-HF Work	P1-HF Other
838302	1	1	1	0	0	0	0	1	0	0	0	0
840433	1	1	1	0	0	0	1	0	0	0	1	0
840442	1	1	0	0	1	0	1	0	0	0	0	0
840701	0	1	0	0	1	0	1	0	0	0	0	0
841861	0	1	1	0	1	0	0	0	0	1	0	0
842822	0	0	0	0	0	0	0	0	0	0	0	1
843303	1	1	0	0	0	0	1	0	1	0	0	0
843662	1	1	1	0	1	0	0	0	0	0	0	0
848408	1	1	0	0	0	1	0	0	0	1	0	0
851348	0	1	0	0	0	0	1	0	0	0	1	0
853538	1	1	0	0	1	0	1	0	0	0	0	0
853848	0	1	1	0	1	0	1	0	0	0	0	0
853913	1	1	0	0	0	0	0	0	0	0	0	0
855778	0	1	1	0	1	0	1	1	1	1	1	0

Figure A3. Representative ASRS database output showing text field (upper panel) converted to binary fields (lower panel).

Appendix G

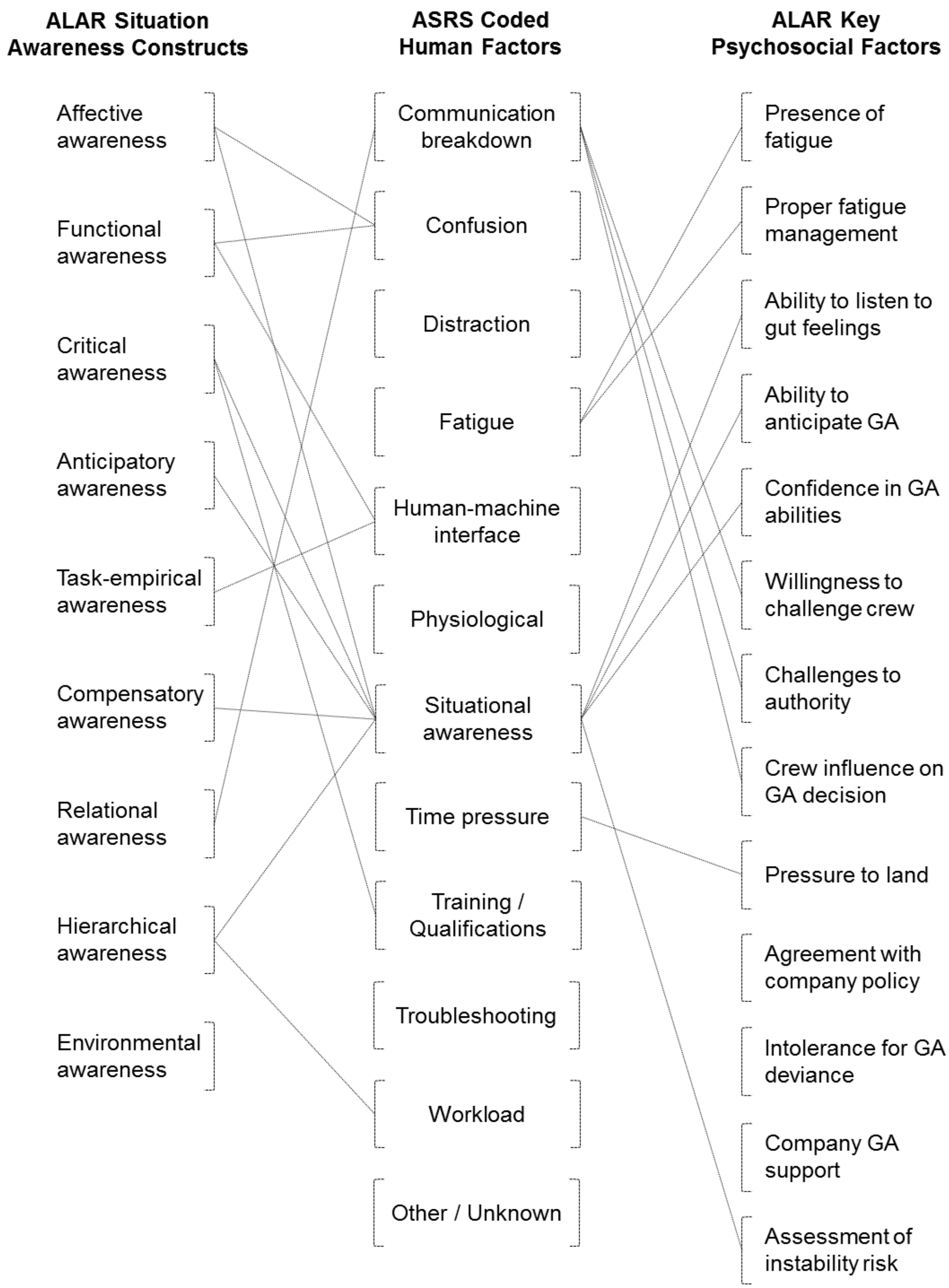

Figure A4. Diagram mapping the ALAR Task Force "situational awareness constructs" and "psychosocial factors" to the ASRS-coded human factors. Each line indicates a mapping from the situational construct or psychosocial factor to the human factor.

Appendix H

Table A4

Human Factors and Event Outcome Coded by ASRS Report Number

	Communication Breakdown	Confusion	Distraction	Fatigue	Human-Machine Interface	Physiological	Situational Awareness	Time Pressure	Training/ Qualification	Troubleshooting	Workload	Other/Unknown	Go-around Non-compliance
993418			●				●				●		✖
995801							●		●			●	
1002221		●	●		●			●	●		●		
1007892	●	●		●	●		●						✖
1030428		●	●						●		●		
1035852	●	●			●		●						✖
1050062	●		●				●		●				✖
1067908							●		●				✖
1077026				●			●						✖
1081126					●						●		✖
1092426	●				●		●						✖
1099831							●					●	✖
1111985		●	●	●			●				●		
1118442	●				●		●		●				✖
1118670	●	●			●		●	●	●	●			✖
1121313							●						✖
1124183			●				●		●				
1138517	●	●			●		●						✖
1143167	●			●	●				●				
1143311							●						✖
1149809		●			●		●					●	✖
1155343	●		●		●								
1176170							●				●		✖
1181206					●		●		●				✖
1193113	●											●	✖

	Communication Breakdown	Confusion	Distraction	Fatigue	Human-Machine Interface	Physiological	Situational Awareness	Time Pressure	Training/ Qualification	Troubleshooting	Workload	Other/Unknown	Go-around Non-compliance
1200017	●		●	●			●	●					
1200264	●				●								✖
1216835	●	●	●		●			●					✖
1220314							●	●					✖
1222952		●					●						✖
1225041							●	●			●		✖
1230172	●	●		●									✖
1233088					●		●		●				✖
1235223	●	●			●			●			●		
1237272							●						
1238861		●					●						✖
1248626		●					●		●				✖
1253009							●						✖
1256422					●		●						
1263798							●				●		✖
1269699				●			●						✖
1270141	●	●		●	●		●				●		✖
1274993			●				●						✖
1277889			●			●		●					✖
1282495			●				●				●		✖
1283142							●						✖
1283708			●				●						✖
1284142			●		●		●				●		
1287126		●					●						
1287195							●				●		
1289944			●				●						
1291417		●					●						✖
1295731	●	●	●				●	●	●				✖
1302589							●						

	Communication Breakdown	Confusion	Distraction	Fatigue	Human-Machine Interface	Physiological	Situational Awareness	Time Pressure	Training/ Qualification	Troubleshooting	Workload	Other/Unknown	Go-around Non-compliance
1302829	●		●				●		●		●		
1305208		●					●				●		✖
1305846	●		●	●			●				●		✖
1310136		●	●				●	●	●		●		✖
1310542								●			●		
1311640	●						●		●				✖
1313460							●						
1314470			●				●						✖
1314699					●		●						
1316669		●	●	●			●	●			●		✖
1326350	●				●								
1327695											●		
1328189							●				●		✖
1330266				●			●						✖
1333577							●						✖
1336722			●										✖
1337968							●						
1337976		●					●						✖
1338132							●						✖
1339182		●					●						✖
1341860		●					●						
1343435							●						
1345216	●	●	●				●	●					✖
1348090	●	●	●				●		●		●		✖
1349312		●		●			●		●				
1353015											●		
1366763	●		●		●		●						
1367469	●		●		●								✖
1373082					●								

	Communication Breakdown	Confusion	Distraction	Fatigue	Human-Machine Interface	Physiological	Situational Awareness	Time Pressure	Training/ Qualification	Troubleshooting	Workload	Other/Unknown	Go-around Non-compliance
1376157							●						
1385080							●						
1399587	●	●	●					●	●		●		
1401405									●				✖
1401551	●	●	●				●		●				✖
1406354							●						✖
1409093							●						✖
1409426	●						●						
1410473							●						✖
1412521			●				●				●		✖
1412760	●						●				●		
1413132	●		●										

Appendix I

Table A5

Correlation Matrix

		Constant	Communication breakdown	Confusion	Distraction	Fatigue	Human-machine interface	Situational awareness	Time pressure	Training/ qualifications	Workload
Step 1	Constant	-	.065	.009	-.102	-.582	-.304	-.185	-.309	-.347	-.191
	Communication breakdown	.065	-	-.096	-.210	-.180	-.332	-.181	-.003	-.117	.118
	Confusion	.009	-.096	-	.028	-.177	-.065	.086	-.291	-.177	-.110
	Distraction	-.120	-.210	.028	-	.029	.156	-.053	-.171	-.125	-.205
	Fatigue	-.582	-.180	-.177	.029	-	.072	.075	.039	.110	-.038
	Human-machine interface	-.304	-.332	-.065	.156	.072	-	-.220	.020	.004	.069
	Situational awareness	-.185	-.181	.086	-.053	.075	-.220	-	-.210	.041	-.078
	Time pressure	-.309	-.003	-.291	-.171	.039	.020	-.210	-	-.024	-.137
	Training/ qualifications	-.347	-.117	-.177	-.125	.110	.004	.041	-.024	-	.038
	Workload	-.191	.118	-.110	-.205	-.038	.069	-.078	-.137	.038	-

Appendix J

Alignment with Program Core and Specialty Outcomes

Core Outcome 1

Students will be able to apply the fundamentals of air transportation as part of a global, multimodal transportation system, including the technological, social, environmental, and political aspects of the system to examine, compare, analyze and recommend conclusion.

This study targeted safety concerns and issues of an ever-growing U.S. air transportation system. According to the International Air Transport Association (IATA) (2016), safety is top priority for the aviation industry and the primary goal of 'continuous improvement' efforts has been improving crew responses to undesired events. Among the concerning events are loss of control in-flight (LOC-I) events, which occur when flight crew are unable to maintain adequate and proper control of the aircraft and deviate from the intended flight parameters (IATA, 2015b). Analyses of LOC-I events indicate that multiple factors can influence the ability of flight crew to maintain controlled flight, and deteriorated conditions can result in airplane upset. Of additional concern are undesired aircraft states and unstabilized approaches, the latter of which is one of the most significant safety issues in commercial aviation (IATA, 2016). It is an IATA recommendation that commercial pilot training programs emphasize early recognition of flight parameter deviations threatening stable aircraft states in order to mitigate safety risks through appropriate corrections in flight operations (IATA, 2015a). By examining and analyzing ASRS data, the primary aim of this study was identifying incident-related influences and evaluating findings in support of recommendations informing effective interventions and aviation training for safer NextGen commercial operations.

Core Outcome 2

The student will be able to identify and apply appropriate statistical analysis, to include techniques in data collection, review, critique, interpretation and inference in the aviation and aerospace industry.

Given the categorical and nominal nature of the ASRS data, primarily nonparametric statistical methods were used. The appropriate statistical procedure for this study was binomial logistic regression. Binomial logistic regression allows for prediction of a discrete dependent outcome or criterion variable from a set of nominal independent or predictor variables (Tabachnick & Fidell, 2013). Given the aim of this study was to identify the factors that can predict adverse aviation events, binomial logistic regression is more appropriate than chi-square contingency tables or log-linear analyses, which are used to test associations and relationships between variables (Agresti, 2013). An *a priori* power analysis was computed using G*Power 3 (Faul et al., 2009) and the binomial logistic regressions were conducted using IBM SPSS Statistics 24. From the binomial logistic regressions, odds ratios were evaluated, and confidence intervals and significance levels were evaluated using maximum likelihood estimations. A *post hoc* power analysis was also computed using G*Power 3.

Core Outcome 3

The student will be able across all subjects to use the fundamentals of human factors in all aspects of the aviation and aerospace industry, including unsafe acts, attitudes, errors, human behavior, and human limitations as they relate to the aviators adaption to the aviation environment to reach conclusions.

This study included explicit analysis of human factors identified as contributing factors in unsafe acts and attitudes, operational errors, and human behaviors and limitations during commercial aviation incidents reported to ASRS. The ASRS database contains record of human factors contributing to the reported aviation events, including communication breakdown, confusion, distraction, fatigue, human-machine interface, physiological, situational awareness, time pressure, training/qualification, troubleshooting, and workload. These are the factors, among others identified by ASRS analysis as contributing to aviation incidents, and these factors were analyzed in this study for their associations to the likelihood of unstabilized approach incident outcomes. If the ASRS-coded contributing and human factors were associated to the likelihood that the reported event was an unstabilized approach continued to landing, then it was assumed that a model could be constructed and used to mine the ASRS database. Using algorithms based on identified factor relationships, common aviation events might be identified and gathered from the database, and the accompanying narratives used in designing training scenarios aimed at mitigating the *human factor* in aviation events.

Core Outcome 4

The student will be able to develop and/or apply current aviation and industry related research methods, including problem identification, hypothesis formulation, and interpretation of findings to present as solutions in the investigation of an aviation/aerospace related topic.

The study was a continuation, and extension, of earlier analyses of ASRS data to answer questions and test hypotheses informed by previous studies (see Ross & Tomko, 2016, 2017) and relevant research literature investigating commercial aviation operations using incident report data. This study used a nonexperimental, single-group, quantitative *ex post facto* design. A nonexperimental approach was most appropriate since the independent variables were not manipulated during analysis of the ASRS incident reports. Further, non-randomized sample data were compiled into a single group for quantitative analyses. Since the analyses were of archived, coded data from ASRS reports, an *ex post facto* approach was used. Methods similar to those of this study have previously been employed in researching contributing and predictive factors of aviation accidents (e.g., Baker, 2001; Shappell et al., 2007), aviation incidents (e.g., Barnes & Monan, 1990; Jentsch, Barnett, Bowers, & Salas, 1999; Walton & Politano, 2010), and joint analyses of accidents and incidents (e.g., Mosier et al., 2012), as well as evaluating safety taxonomies (e.g., Tiller & Bliss, 2017).

Aviation Aerospace Education Technology Outcome

The student will investigate, compare, contrast, analyze and form conclusions to current aviation, aerospace, and industry related topics in education technology, including computer based instruction, simulation systems, education foundations, curriculum development, continuing education, adult teaching and learning techniques, and memory and cognition.

The fundamental aim of this study was to determine and assess the extent to which the identified contributing factors and narratives of ASRS incident reports might be exploited for scenario-based commercial aviation training designs. According to the FAA (2015), the aim of line operational simulation (LOS) is to provide flight crew opportunity for training line operations in realistic operational environments, including line operational flight training (LOFT) and special purpose operational training (SPOT). Both LOFT and SPOT are intended to include realistic scenarios including "normal, non-normal, abnormal, or emergency procedures" (FAA, 2015), and the fidelity of the scenarios depends on explicit similarity to operational conditions. Where commercial aviation accidents may be few, the growing ASRS database contains detailed data and narratives of aviation incidents. It was an assumption of this study that these narratives might provide meaningful and realistic descriptions of normal, non-normal, abnormal, and emergency events. If the factors coded in the ASRS database are associated with the likelihood of such aviation events as unstabilized approaches continued to landing, the next step would be to use the model to build the algorithms to mine the database for event-specific narratives, and use the reports to build training scenarios for safer commercial pilot operations in NextGen commercial aviation.