Assessing Flight Safety Differences Between the United States Regional and Major Airlines

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ABSTRACT

During 2008, the U. S. domestic airline departures exceeded 28,000 flights per day. Thirty-nine or less than 0.2 of 1 % of these flights resulted in operational incidents or accidents. However, even a low percentage of airline accidents and incidents continue to cause human suffering and property loss. The charge of this study was the comparison of U. S. major and regional airline safety histories. The study spans safety events from January 1982 through December 2008. In this quantitative analysis, domestic major and regional airlines were statistically tested for their flight safety differences. Four major airlines and thirty-seven regional airlines qualified for the safety study which compared the airline groups' fatal accidents, incidents, non -fatal accidents, pilot errors, and the remaining six safety event probable cause types. The six other probable cause types are mechanical failure, weather, air traffic control, maintenance, other, and unknown causes. The National Transportation Safety Board investigated each airline safety event, and assigned a probable cause to each event. A sample of 500 events was randomly selected from the 1,391 airlines' accident and incident population. The airline groups' safety event probabilities were estimated using the least squares linear regression. A probability significance level of 5 % was chosen to conclude the appropriate research question hypothesis. The airline fatal accidents and incidents probability levels were 1.2% and 0.05% respectively. These two research questions did not reach the 5% significance level threshold. Therefore, the airline groups' fatal accidents and non-destructive incidents probabilities favored the airline groups' safety differences hypothesis.

The linear progression estimates for the remaining three research questions were 71.5% for non-fatal accidents, 21.8% for the pilot errors, and 7.4% significance level for the six probable causes. These research questions' linear regressions are greater than the 5% level. Consequently, these three research questions favored airline groups' safety similarities hypothesis. The study indicates the U.S. domestic major airlines were safer than the regional airlines. Ideas for potential airline safety progress can examine pilot fatigue, the airline groups' hiring policies, the government's airline oversight personnel, or the comparison of individual airline's operational policies.

APPROVAL

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CHAPTER 1: INTRODUCTION

The United States aviation transportation system has a history of operational accidents and incidents (Boeing, 2008). The U.S. National Transportation Safety Board (NTSB, 2009) defined these accidents as property damage, personal injury or human fatality. Business Week reports airline safety has fallen in first half of 2009 (Traufetter, 2009). As late as July, 2009, the U.S. Congress introduced a bill to improve regional airline safety. Additionally, the U.S. Federal Aviation Administration (FAA) asked the airlines to participate in voluntary safety reporting schemes that have been developed and used by a few airlines (Air Transport, 2009). Airline safety is important to the traveling public (Turner, 2001).

Some airline flight safety improvement ideas are before the traveling public. An additional source of flight safety improvement ideas may be the determination of major and regional airlines' safety event similarities and differences. The U.S. scheduled major and regional airlines may have different rates of safety events. These aviation safety events are further separated into many accident and incident data groups, and this safety event information was documented in the U.S. NTSB reports. The NTSB investigation records show the safety event's details and the NTSB accident investigators have assigned a probable cause to each event (NTSB, 2009). This research indicates five potential safety event differences between the U.S. major and regional airlines.

Statement of the Problem and Purpose

The frequency of the U.S. domestic scheduled airline flight operations' accidents and incidents was central to the research purpose. These safety events were the primary problem or difficulty for public air travel (Air Transport, 2009). The major and regional airlines of the United States have experienced 1,391 accidents and incidents between 1982 and 2008 (NTSB, 2009). Many of these airline accidents have caused destruction of property, individual injury, or loss of life. Conversely, airline incidents are non-destructive by definition; however, they can potentially enlarge in classification to become an accident (Turner, 2001). The purpose of this quantitative study was to determine, from historical data, if the major air carriers are more or less inclined to experience accidents and incidents than the regional air carriers. A comparable study of the U.S. major and regional air carriers was not indicated in the review of the available literature.

Background and Significance of the Problem

The popular modes of public transportation in the United States are surface and airborne vehicles (BTS, 2009). The surface transportation vehicles include automobiles, trains, buses, and boats. These vehicles consume considerable amounts of the travelers' time. The public frequently uses airborne transportation as their preferred method of travel when transit time and highway aggregation reduction are a priority (Lavelle, 2007).

Vivid images of a damaged or destroyed passenger aircraft, when shown on the electronic media, reminds the traveling public of their potential personal air travel risks. In addition, documentaries and published articles continue to make the public aware of the potential risk within airline travel. The technological and developmental advancements in aviation between 1982 and 2008 have improved the reliability of aircraft (Boeing, 2008). However, several airline accidents and incidents continue to occur (NTSB, 2009). During 2008, the US scheduled domestic major and regional airlines have been involved in 46 accidents and incidents (NTSB, 2009). The NTSB safety event investigation teams continue to conclude that human errors are the most common cause of aviation accidents and incidents. Pilot errors account for 52% of the fatal commercial accidents in this decade. These human mistakes occur during all phases of flight operations (Kebabjian, 2008).

The airline pilots were susceptible to pilot errors as they simultaneously gather and assess flight environment data. These pilots must also determine the safest course of action for their flight operation. An inadequately or erroneously determined problem diagnosis, the improper corrective action(s), or untimely action will endanger the safety of some or all the individuals aboard the flight (Kern, 2001). Aviation history has numerous occurrences of human injury, death, or property damage (NTSB, 2009).

During the 27 years of the study, the major airline flew some of the older airline aircraft that were designed for flights with a minimum of three flight crewmembers. During the last 10 years, the three-person crewed flights have been replaced with two flight crewmembers aircraft. The newer aircraft are designed with computer-monitored flight circumstances and aircraft system information (Boeing, 2008). Consequently, the remaining two pilot crews have more activities and flight safety responsibility per person (Kern, 2001).

The airline pilots were responsible for their personal health, their continuous search for relevant flight safety information and then their execution of their crew determined safe and timely flight procedures (FAR, 2008). The flight information continually changes and there is an ongoing need for the pilots to maintain personnel situational awareness in a dynamic three-dimensional environment. The pilot's aircraft manipulation and decision-making skills must provide the safe transportation for themselves and their fellow airline passengers (Kern, 2001).

Research Questions

The subsequent five research questions (RQ) facilitated this research by statistically showing the U.S. major and regional airlines accident and incident similarities and differences. The airline flight operations period researched was 1982 through 2008. The airlines' safety histories are documented by NTSB and these airline histories were available to the public from the NTSB records (NTSB, 2009). The strategy behind these research questions was to show the airline flying public the airline accident and incident information for them to evaluate the safety of the U.S. domestic scheduled major and regional airlines.

The first three of the five research questions addressed the severity of both airline groups' safety events. The airline safety events had at least a fatality per accident, substantial property damage per accident without a human fatality, or an incident without substantial damage or a human fatality.

The National Transportation Safety Board defines the aviation accident severities as major, serious, human injury, and damage accidents (About the NTSB, 2008). The study combines the NTSB described major and serious accident and shows these two types of accident combinations as a human fatality. The airline accident fatalities or loss of life comparison question for the major and regional airlines was shown in RQ1. The next category of accident comparison was the accidents without a human fatality. These non-fatality or human injury safety events were addressed in RQ2. All the airline incidents were compiled into one category for the major and regional airlines and were compared in RQ3.

RQ1: To what extent, if any, does the rate of domestic airline accident losses of life per flight departure differ between U.S. major and regional airlines?

RQ2: To what extent, if any, does the rate of domestic airline non-fatal accidents per flight departure differ between U.S. major and regional airlines?

RQ3: To what extent, if any, does the rate of domestic airline incidents per flight departure differ between US major and regional airlines?

Research questions # 4 and #5 compared accident and incident probable causes of the two airline groups. The NTSB probable causes for accidents and incidents were shown as crew error, mechanical failure, weather, Air Traffic Control (ATC), maintenance, other, and unknown. These NTSB determined probable causes were listed in their order of highest to lowest percent of occurrence (NTSB, 2008). Pilot errors in the last eight years have accounted for 52% of the fatal airplane accident probable causes (Kebabjian, 2008). These seven probable causes groups were divided in to two research questions. Crew error or pilot error probable causes were shown in RQ4. The remaining six probable causes were combined and shown in RQ5.

RQ4: To what extent, if any, does the rate of domestic airline safety event pilot errors per flight departure differ between U.S. major and regional airlines?

RQ5: To what extent, if any, does the rate of domestic airline safety events as moderated for those having probable cause determination per flight departure differ between U.S. major and regional airlines?

Brief Review of Related Literature

Several airline safety studies were described in this related literature review. Numerous of these studies have contributed to different segments of air travel safety (Krause, 1996). Within these studies, several of the researchers have addressed the safety of the airline flight operations. However, no U.S. domestic major and regional airline comparison study was located.

This literature review was separated into three categories: the airline operational environment, the airline management, and the airline flight operations. All the airlines described in this review are subject to the U.S. government's regulations (FAR, 2008). Since the mid 1990s, both airline groups operated under 14 Code of Federal Regulations (CFR) Part 121 regulations. The regional airline group operated under the jurisdiction of 14 CFR Part 135 and transitioned to 14 CFR Part 121 by the mid 1990s (NTSB, 2009). The airline operational environment authors below provided information on subjects such as relaxing of federal jurisdiction for some aviation regulations in 1978 (Spitz, 1998), the public perception of airline safety (Hartman, 2000), FAA enforcement of federal regulations (Picket, 2001), and post deregulation airline operations relationship between airline profitability and operational safety (Adawiya, 1993).

The second group of literature reviews had an airline management theme. Airline safety organizational factors were measured and reported by von Thaden (2004). His study of human behavior has been described as the totality of human behavior in relation to the sources of information. In addition, Russo (2004) researched the need for a Director of Safety or an airline maintenance safety officer in smaller flight operations. Squalli (2004) researched the effect of safety priorities as evidenced in the management of some airlines. Other literature addressed the learning and teaching styles of airline pilots (Herrick, 1991).

The third set of reviews was the literature written on the uniqueness of the airline flight operations. The authors contributed to many flight operations subjects. One study researched the flight crew performance on thousands of regularly scheduled U.S. domestic flights (Hines, 1998). He compared airline pilots' manipulation of the newer automated aircraft flight to the less automated airline flights. Commercial airline crews involved in accidents who failed to make use of essential and safety critical information was analyzed by von Thaden (2004). Klinect (2006) investigated the safety of numerous world airlines' flight operations including the U.S. airlines.

Definition of Terms

The following definitions facilitated a better understanding of the airline safety characteristics. The airline industry utilizes some terms that were specific to the airline industry. This domestic airline study incorporated the following key terms to assist in defining the airline accidents and incidents. These definitions of terms are presented in alphabetical order.

Aircraft accidents. The Federal Air Regulations (FAR) within the CFR describe an accident as an event occurring when any person suffers a fatal or serious injury, or in which the aircraft receives substantial damage. A fatal injury was associated with an aircraft's operation and means any injury, which results in a human death within 30 days of the accident date. Medical personnel determine when a person suffers a fatal injury. An aircraft accident takes place between the times any person boards an aircraft with the intention of flight until all such persons have disembarked the aircraft (FAR, 2008).

The Federal Aviation Agency also uses the NTSB (2009) aircraft accident definitions, and NTSB divides accidents into the following four categories:

1. A major airline accident was a safety event, during which a 14 CFR 121 or 135 aircraft was destroyed and included multiple passenger fatalities, or there was one passenger fatality and a 14 CFR 121 or 135 aircraft was substantially damaged.
2. A serious accident was a safety event, during which there was either one fatality without substantial damage to a 14 CFR 121 or 135 aircraft, or there was at least one serious injury and a 14 CFR121 or 135 aircraft was substantially damaged.
3. An injury was a nonfatal accident with at least one serious injury and without any aircraft substantial damage to a 14 CFR 121 or 135 aircraft.

4. Damage was an accident in which no person was killed nor seriously injured, but in which any aircraft was substantially damaged.

Aircraft damage. Aircraft damage refers to an accident resulting in damage or failure that adversely affects the structural strength, performance, or flight characteristics of the aircraft. This damage would normally require major repair or replacement of the affected component or components (NTSB, 2009). Substantial damage also occurs when an engine fails or was damaged, (e.g., bent fairings or cowling). Dented skin, small punctured holes in the skin or fabric, ground damage to rotor or propeller blades are also considered substantial damage. Any damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips was not considered substantial damaged under the definition of an aircraft accident (NTSB, 2009).

Aircraft incident. An aircraft incident was an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of flight operations. An incident was further defined as taking place between the times any person boards an aircraft with the intention of flight until all such persons have disembarked the aircraft (FAR, 2008).

Airline regulation. The United States airlines were authorized by the United States Congress to operate flight operations in compliance with Federal Air Regulations. The U.S. Congress created the FAA to oversight FAR enforcement (Aviation, 2008).

Airline safety event. A safety event takes place when either a flight operations accident or incident occurs (FAA, 2008).

Aviation Safety Reporting System (ASRS). Another potential research source of aviation incident reporting was the ASRS. This self-reporting by aviation professionals is an anonymous reporter program administered by the National Aeronautics and Space Administration (NASA, 2008). The NASA database categorizes the different types of reported aviation incidents or near accidents. The ASRS information is designed to reveal safety weaknesses in aircraft components, flaws in aviation procedures or weak areas human machine interface. The ASRS reports can reveal safety trends and potential changes for flight operations improvements. Some of these operational phases include landing and take-off cycles, day and night operations, their effects on pilot fatigue, and so forth. Other operational considerations studying the inquiries included the results of flight crewmembers not following Standard Operating Procedures (SOP), the quality of navigation information, the runways available for the approaching and landing, the involvement of illegal drugs, and so forth (NASA, 2008).

Domestic flight operations. The scheduled airline operation conducted under FAR 121 or 135 by any person operating turbojet-powered airplanes, or airplanes having a passenger-seat configuration of more than nine passenger seats are a domestic airline. Domestic flight operations refer to airplanes that have a payload capacity of more than 7,500 lb. The domestic operator can fly between any points within the 48 contiguous states of the United States of America (USA), or operations solely within the USA and specifically authorized point located outside the USA (FAA, 2008).

FAR 135 Commuter Operations. Any scheduled operation conducted by any person operating any other than turbojet-powered airplanes. Federal Air Regulation 135, Commuter Operations refers to the aircraft operations with a maximum passenger-seat configuration of 9 seats or less. Also, the aircraft will have a payload capacity of 7,500 lb. or less. The flight frequency of operation of at least five round trips per week on at least one route between two or more points according to the commuter's published flight schedules (FAA, 2008).

Human factors (HF). Ergonomics, or HF, was researched within the airline industry. HF refers to the study of how humans behave physically and psychologically in relation to particular environments, products, or services. HF in airline flight operations was defined as the human manipulation of aircraft. HF concerns emerged during World War II, but HF studies were initiated in airline maintenance facilities in the 1990s. HF was transitioned into the airline flight operations through the FAR 121 required pilot recurrent training courses (Dekker, 2002).

Major airlines. Air carrier groups with annual operating revenues exceeding $1,000,000,000 (BTS, 2007). Major airlines qualifying for this research were composed U.S. Department of Transportation (DOT) air carriers that have flown scheduled air service within the United States before and during the era of the Airline Deregulation Act of 1978. These carriers have continually operated under the FAR Part 121. They operate with larger aircraft and fly longer distances into higher traffic airports (Pachis, 1982).

National airlines. A national airline was an air carrier with annual operating revenues of between $100 million and $1 billion, as defined by the U.S. Bureau of Transportation Statistics (BTS, 2007).

National Transportation Safety Board (NTSB). Forty years ago, the U.S. Congress created an independent accident investigation agency, autonomous of the regulatory enforcement of the FAA. In 1967, U.S. Congress authorized and empowered the NTSB to be responsible for the investigation of transportation accidents. The NTSB is required to investigate the transportation accidents in the United States and determine a probable cause for all travel vehicles manufactured and commercially operated in the United States. The NTSB conducted independent investigations of all civil aviation accidents in the United States. The U.S. Congress did not authorize the NTSB to exercise regulatory or enforcement powers (NTSB, 2008). Therefore, the NTSB aircraft accident and incident database provided standardized and objective airline accident and incident reports.

Passenger injury. A serious passenger injury resulted from an aviation accident when an injury requires hospitalization for more than 48 hours. The injury hospitalization must commence within seven days from the date the injury was received. In addition, the accident injury may result in a fracture of any bone except simple fractures of fingers, toes, or nose. The accident passenger injury may cause severe hemorrhages, nerve, muscle, or tendon damage. In addition, the aviation accident injury may involve any internal organ, second or third-degree burns, or any burns affecting more than 5% of the body surface (NTSB, 2009).

Pilot Records Improvement Act. The Pilot Records Improvement Act of 1996 (PRIA) was enacted by the U.S. Congress to ensure that air carriers adequately investigate a pilot's background before allowing that pilot to conduct commercial air carrier flights. Under PRIA, an air carrier cannot place a pilot into service until after it obtains and reviews the last five years of the pilot's records specified in the Act. The pilot selection process in the United States has been in effect since 1996 (Ryan, 2005). Another facet of the PRIA legislation is the required illegal drug-testing program for new hire pilots and random illegal drug testing of the current commercial pilot population (PRIA, 2008).

Probable cause. Safety event probable causes are the conclusions determined by the NTSB accident or incident investigating group. The NTSB group considers the factors that caused the accident or incident. The probable causes the NTSB considers were crew error, aircraft maintenance, mechanical failure, Air Traffic Control, weather, other, and unknown (NTSB, 2008).

Regional airlines. The regional airlines operators provided air service to smaller communities in the U.S. They frequently flight connected to major cities airports. They generally delivered their passengers to larger airlines at larger airports. Many regional airlines began their flight operations about the time U.S. Congress deregulated the airlines industry in late 1978. Many of regional airlines have merged into other regionals or ceased flight operations. Some of the regionals were owned by major airlines, however the FAA certifies their flight operations separately, and they operated their flight operations separately. The regional airlines may coordinate their flights times and destinations with the major airlines (Moorman, 2004).

Safety events per departure. The comparison of the regional and major airlines' domestic incidents and accident histories included a per flight departure ratio to show a comparative safety level. The comparison of flight departures of the domestic regional and major airlines were presented as an annual safety event ratio.

Study qualified airline operations. The airline populations to be studied for airline safety information were from the major and regional airlines operating flights in the US. The NTSB accident records revealed a more hazardous flight operational situation in Alaska. Therefore, the flight operations in Alaska were excluded from this study because its visibility restrictions, icing conditions, and mountainous obstacles that hamper Alaska's airspace usage. Hawaii airline flight operations were also removed from the accident and incident data because of their low accident and incident rate per departure. The District of Columbia and Puerto Rico; a possession island of the US were included in the studied incident and accident location because their flight operations function as an airline hub airport within the US and flights to a number of Caribbean destinations (NTSB, 2009).

Study qualified major airlines. The major airline's classification has changed over time. Using the 2008 list of major airlines, the researched airlines excluded some of the original air carriers that have fallen out of the continuously operating major airlines criteria. The continuous flight operation histories of the U.S. domestic major airlines between 1982 and 2008 qualified four major airlines for this study. Four of the air carriers listed on the 2008 major airlines were included in the research because they had The rapid growth and other current major airlines were recommended as a third study group for future research. Additional definitive differences may need to be considered as the details of the airlines safety research are discovered (BTS, 2008).

Study qualified regional airlines. The period of this research began after the 1978 U.S. Congress' deregulation of the airlines and continues through the present. The airline deregulation act effectively defined the description of the regional airlines. The regional flight operators or regional airlines management determine the routes they served and the seating capacity of their aircraft (Library of Congress, 2008).

United States certified airlines. The airlines certified in the US by the Federal Aviation Administration (FAA) were classified as majors, nationals, regionals, and fractional air carriers. Within the major and regional air carriers, the airlines were further divided into scheduled and non-scheduled airlines. This study focused on the scheduled regional and scheduled major air carriers and their operations in the U. S. of America (FAR, 2008). Additional aviation terms were defined in Appendix A.

Highlights and Limitations of Methodology

The data representing the studied airlines' flight safety event records were retrieved from the NTSB database. The logged airline safety event data were sorted to determine the extent of airline groups' safety similarities or differences. Summary tables showed the relevant and important information contrast of the major and regional airline safety event similarities and differences (Trochim, 2001).

The study of major and regional airlines accident and incidents encompassed establishing dependent and independent variables that can be comparatively assessed in response to each of the five research questions. The variables were further developed in chapter three. The U.S. domestic airline safety events or accident and incident data were sorted into the each of the two airline groups or independent variable categories. Within the two airline groups, the safety events and probable causes statistics were sorted as the study's dependent variables. As an example in RQ1, the dependent variables were the NTSB defined airline accidents. The NTSB placed these safety event investigations into one of the five safety event severity categories: major, serious, injury, damage accidents, and incident (NTSB, 2008). Each NTSB investigated accident or incident was defined as one of the five mentioned categories. These five categories facilitated the comparative statistical analysis of major and regional airline accidents for RQ1.

The National Transportation Safety Board investigators scrutinized the airline accidents and incidents for safety event facts (NTSB, 2008). The NTSB investigations were achieved by evaluating the aircraft components and the onboard equipment involved in each accident or incident. The safety event facts were recorded for each accident or incident and then the NTSB determines a probable cause for each safety event (NTSB, 2009).

Research data authenticity can be compromised in the investigation of accidents or incidents. This potential data manipulation could occur when some safety event evidence was altered or removed from the event site. The authenticity reduction could occur prior to the arrival of the NTSB investigators or civil authorities' appearance at the accident or incident site (NTSB, 2008). U.S. airline flight operation statistics were recorded by the BTS (2008). The federal government agencies provided statistics for University research upon request (NTSB, 2008). Many of BTS statistics were available on their Internet site (BTS, 2008).

Summary and Conclusions

The United States scheduled airline accidents, incidents, and fatalities information was available to the traveling public (Aviation Safety Network, 2008). However, there may be a difference in the accident and incident rates for the regional and major airlines. The study is designed to show the statically operational safety similarities and differences of the U.S. domestic scheduled major and regional air carriers. The airline's operational safety histories were contained in the NTSB's airline accident and incident records (NTSB, 2008). Thus, the airline's accident and incident history were extracted from the NTSB archives and were applied to the study's five research questions.

CHAPTER 2: LITERATURE REVIEW

The literature review was begun to give an overview of previous aviation safety studies within the airline industry. The literature was written in the post airline deregulation years (Library of Congress, 1978). The theme of the literature review was the safety techniques of airline flight operations. The review was divided into three major topics and the topics were the airlines' external environment, the airline management, and the airline flight operations. The literature review within each of the themes was in chronological publication order.

The initial review section was study reviews from of the U.S. airlines operational environment. The reviews characterize the airlines operational safety surroundings or environment. Chalk (1983) wrote literature about the public's perception of the airlines as a safe public transportation source. Years later, Hartman (2000) expanded the information on the public's perception of airline safety. Adawiya (1993) studied the relationship between airline profitability and operational safety. An additional author researched the effect of safety regulation enforcement by the FAA (Picket, 2001). A later study addressed the learning and teaching styles of airline pilots (Macleod, 2005).

The second literature review section represented the airline management perspective. The literature begins with airline's relationship to aircraft maintenance issues (Sathisan, 1989). Herrick (1991) researched and wrote on the flight proficiency of regional airline entry-level pilots. Other authors have written on airline safety, such as, Farah (2002), he wrote on Crew Resource Management (CRM) training for pilots and airline accident prevention.

The third segment of the literature review was the flight operations subjects. The segment includes subjects in the following studies: flight crew performance in standard and automated aircraft (Hines, 1998), learning and teaching styles of airline pilots (Hamby, 2001), information behavior in aviation (von Thaden, 2004), and crisis behavior and decision-making involving fatal scheduled airline crashes (Serabian, 2006). Klinect (2006) presented an additional airline flight safety study that was accomplished during the flight operations of numerous world airlines. The flight operations audit was designed to provide a proactive snapshot of safety and flight crew performance before an incident or accident.

External Environment

The literature review section explores the environment within which the airlines were constrained to operate. Some airline operational environment examples were U.S. government regulations, the public perception of airline safety, the relaxing of federal jurisdiction for some regulations in 1978, and FAA enforcement of federal regulations. The airline managers had little or no effect on the airline's external environment (De Jager, 1993).

Airlines in the United States have been deregulated since the fourth quarter of 1978 (Library of Congress, 1978). The deregulation affected the routes the airlines can service and the fares each airline charges for their flight service. The U.S. FARs continue to regulate the manufactures, maintenance of aircraft, pilot training and proficiency, plus other dispatch and flight operations requirements (Spence, 2008)

Regional airline pilot training under the microscope. United States Department of Transportation, Secretary Ray LaHood and FAA administrator Randy Babbitt ordered FAA airline operations inspectors to focus inspection on regional airline training programs to insure that regional airlines were complying with federal regulations. Secretary LaHood and Administrator Babbitt gathered representatives from the major U.S. air carriers, their regional partners, aviation industry groups, and labor in Washington, DC to participate in a "call to action" to improve airline safety and pilot training. The review addressed four key areas: Air carrier management responsibilities for crew education and support, professional flight standards and flight discipline, training standards and performance, and mentoring relationships between mainline carriers and their regional partners ("Regional Airline Pilot Training under the Microscope", 2009).

Building a reliable organization: The evolution of error intolerantance in the FAA. Previous High Reliability Organizational (HRO) research reveals that some organizations demonstrate the ability to use high-risk technologies to routinely conduct operations with little or no error (O'Neil, 2008). A 76-year longitudinal case study examines five major historical aviation legislative periods that elevate seven non-incremental and incremental policy actions to determine the role of policy change and implementation in shaping error intolerance within the FAA's air traffic control services. It was found that ATC services evolved as part of a larger policy agency-industry error intolerant system. A conceptual system model was constructed to explain how legislative oversight, agency regulatory programs, and industry operations combine into an extremely redundant structure that operates with extremely low-error rates.

Risk based decision support for new air traffic operations with reduced aircraft separation. With the steady increase in air traffic, the aviation system is under continuous pressure to increase aircraft handling capacity. Various new Air Traffic Management systems and flight procedures are proposed to increase airport capacity while maintaining the required level of safety. The two most limiting risk events addressed are wake vortex encounters and collision risk between aircraft. The safety assessments show that the current wake vortex separation minimum distances, which depend on aircraft weight, are often overly conservative. Introduction of wind dependent aircraft separation rules will enable an increase of airport capacity, while maintaining safety. The results from Amsterdam Schiphol Airport wake vortex risk analysis are used to support the design and setting of requirements for the ATC-Wake and I-Wake systems and concepts of flight operations (Speijker, 2007).

Risk factors and aeronautical decision making relationship in flight training. The number of flight training accidents with fatalities during 2001 through 2003 was 75. They were resourced from the NTSB aviation accident database. More poor decisions were made during preflight than other phases of flight. Pilot who made multiple poor decisions per flight had significantly higher risk factors per flight. The main threat to validity of this study was the NTSB accident investigation team investigative equality assumption (Wetmore, 2007).

Aircrew coordination and communication: The role of decision styles in individual and group performance under skill-, rule-, and knowledge-based decision making. Dawes (2006) states that human error has been cited as a factor in many aviation accidents. A Skill-, Rule-, and Knowledge-based (SRK) taxonomy has been shown to be an important framework for understanding the decision making (DM) process within large-scale technological systems. The exploratory field study examined the role of decision-making styles in aircrew information processing behavior for a high-performance, multi-role military aircraft. Using an advanced aircraft high-fidelity simulator and realistic flight scenarios, experienced test pilots flew a flight including takeoff, climb, cruise, aerial refueling, approach and landing, under both normal and emergency conditions. The SRK-based decision making taxonomy within an operational environment, coupled with decision style, were shown to influence both the individual and the team behavior. The behaviors in turn have a notable impact on overall mission success of this complex human-machine system.

Human-centered time-pressured decision making in dynamic complex systems. Human operators play an important role in ensuring safety and in achieving operational effectiveness in complex, dynamic, and uncertain systems. The research addresses the issue of joint cognitive problem solving for a class of problems related to supervisory control of vehicle routing. Empirical results from a simulated military mission indicate that the human integrated approach resulted in better performance when compared to purely automated solutions for vehicle routing problems considered in this research study (Ganapathy, 2006).

Automation and human error. Dekker (2005) asked human error questions to identify deep-rooted human constraints in the use of technology. Some of the human factors that Dekker addressed were: (a) what are the potential limitations of human operators? (b) Why do fail-safe systems fail? (c) Why do human operators become complacent? (d) Can human error be automated out of a system? The author presented ideas and models that may help researchers to cope with the complexity of studying human errors (Dekker 2003).

The effects of safety information on flight student's aeronautical decision making. The investigation was to examine whether safety information has a beneficial effect on aeronautical decision-making for students in a collegiate flight environment (Lee, 2005). Research was completed on whether flight students' adherence to a recommended solution during adverse flying conditions, recognition time, and response time to abnormal aircraft conditions were safely determined and executed. The finding of this study suggests that flight students who periodically review the available Aircraft Discrepancy Analysis Metrics (ADAM) safety information demonstrate a beneficial effect on their aeronautical decisions making in critical safety situations.

An integrated decision-making framework for transportation architectures: Application to aviation system design. The National Transportation System (NTS) was an complex system-of-systems. It was a collection of various aviation components that were organized at multiple levels. The levels were designed to achieve a range of possibly conflicting objectives, and they never quite behave as planned. The purpose of this research was to develop virtual transportation architecture for the ultimate goal of formulating an integrated decision-making framework. The foundational endeavor began with creation of a NTS abstraction the with the belief that a holistic frame of reference was required to properly study such a multi-disciplinary, trans-domain system. The culmination of the effort produces the Transportation Architecture Field (TAF) and it was a model of the NTS. A model with the relationships between four basic entity groups were identified and articulated. The entity-centric abstraction framework underpins the construction of a virtual NTS. It was couched in the form of an agent-based model.

The transportation consumers and the service providers are identified as adaptive agents that apply a set of preprogrammed behavioral rules. The transportation infrastructure and multitude of exogenous entities (disruptors and drivers) in the whole system can also be represented without resorting to an extremely complicated structure. The outcome is a flexible, scalable, computational model that allows for examination of numerous scenarios that involve the cascade of interrelated effects of aviation technology, infrastructure, and socio-economic changes throughout the entire aviation industry (Lewe, 2005).

Pilot training barriers. Macleod (2005) analyzed human barriers to aviation safety. He evaluated the strengths and weaknesses of the airline's pilot training. The airline development and implementation of Crew Resource Management (CRM) was the primary recommendation of Macleod's (2005) writing. His development of CRM dealt directly with the avoidance of human errors and the management of the consequences of the errors that do occur (Macleod, 2005).

Human error. The current production and future design of airliner aircraft are very technologically inclined for the pilots and maintenance personnel usage. The effective and safe uses of these new technologies are eroded by potential human error. Cognitive engineers and risk managers are designing technologies to reduce human errors in future aircraft design (Reason, 2003).

Human-centered systems analysis of aircraft separation from adverse weather. Weather information plays a key role in mitigating the impact of adverse weather on flight operations by supporting air transportation decision-makers' awareness of operational and mission risks. The emergence of new technologies for the surveillance, modeling, dissemination and presentation of information provides opportunities for improving both weather information and user decision-making. In order to support the development of new weather information systems, it is important to understand this complex problem thoroughly (Vigeant-Langlois, 2004).

The thesis applies a human-centered systems engineering approach to study the problem of separating aircraft from adverse weather. The approach explicitly considers the role of the human operator as part of the larger operational system. A series of models describing the interaction of the key elements of the adverse aircraft-weather encounter problem and a framework that characterizes users' temporal decision-making were developed. Another framework that better matches pilots' perspectives compared to traditional forecast verification methods articulated the value of forecast valid time according to a space-time reference frame. The models and frameworks were validated using focused interviews with ten national subject matter experts in aviation meteorology or flight operations. The experts unanimously supported the general structure of the models and made suggestions on clarifications and refinements, which were integrated, in the final models.

In addition, a cognitive walk-through of three adverse aircraft-weather encounters was conducted to provide an experiential perspective on the aviation weather problem. The scenarios were chosen to represent three of the most significant aviation weather hazards: icing, convective weather and low ceilings and visibility. They were built on actual meteorological information and the missions and pilot decisions were synthesized to investigate important weather encounter events. The cognitive walk-through and the models were then used to identify opportunities for improving weather information and training. Of these, the most significant include opportunities to address users' four-dimensional trajectory-centric perspectives and opportunities to improve the ability of pilots to make contingency plans when dealing with stochastic information.

Human and non-human factors in aircraft accidents. Sullivan's (2003) study showed that airline operation problems affect organizational attention and thus the rate of solutions generated. Solutions spawn in different ways at different stages of a learning process. The study indicated the HF solutions lie within the context of the organization's purpose. In addition, the problems compete for the organization's attention; consequently, the solutions depend on the types of problems (Sullivan, 2003).

However, in the context where problems are disconnected with solutions in a substantial way, organizational attention is guided by the interaction between the urgency created by problems and priority given to other different activities. Sullivan's study presented potential solutions through examining the formation of airline safety rules by the FAA. The test indicated safety problems in the airline industry are more effectively resolved when the problems are prioritized with rules created to deal with the problems. Problems and rules were categorized into two types: those associated with human factors and those associated with nonhuman factors (Sullivan, 2003).

The two types of problems compete for scarce management attention (Sullivan, 2003). However, at the stage of rule finalization, attention is guided by the interaction between priority given to different types of rules and urgency induced by new problems. The study showed this effect is due to the following facts. First, problems are linked directly to the search for solutions at the stage of proposing rules but not at the stage of finalizing rules. Second, human and nonhuman factor problems have a distinctive boundary. Third, individual problem can generate a general sense of urgency (Sullivan, 2003).

The findings from Sullivan's (2003) study supported the concept that problems lead to solutions, but with two important qualifications. First, organizational capacity for generating solutions is constrained. Second, problems cannot only stimulate the search for solutions to specific problems, but can also generate a general sense of urgency. Sullivan's study indicated that interaction of problem, task load, and organizational capacity are problem-solution constraints. Human factors and nonhuman factors in aircraft accidents were separated in this dissertation (Sullivan, 2003).

Regulation enforcement. The process of Picket's (2001) transportation safety project was to examine how the FAA determined a tolerable safety target. The study's results were applied to the U.S. railroad industry. The Federal Railroad Administration (FRA) collected the railroad accident reports over a recent 10-year period. Next, the rail accidents were apportioned into groupings based on a fault- or event-tree of the root causes of the accidents. Next, a current level of performed safety was calculated. A comparison of the airline safety target against the observed railroad safety level indicated that the railroads are safer than the airlines. Pickett's project showed a 10-year history of U.S. aviation safety and U.S. railroad safety. The fault or root causes of both groups accidents were analyzed (Pickett, 2001).

Public perception of airline safety. When consumers cannot verify a product's quality even after they have consumed the product, they must find other means of assessing product quality. Hartmann's (2000) study indicates that consumers are able to verify airline safety. A structural model was used to analyze consumer and carrier behavior in a full oligopoly market setting with differentiated airline products. Aggregate preferences were constructed for air travel consistent with data on individual consumer carrier choices from the Department of Transportation's Origin and Destination Survey. The survey structure allowed for separate decomposing effect of safety on the demand and cost conditions (Hartmann, 2000).

In addition to the oligopoly model, a structural equation was developed for the process that generates accidents (Hartmann, 2000). Bayesian model was applied for updating data, such as consumers observing additional flight outcomes. The consumer can update their beliefs about a carrier's accident probability. Consumers were tested to confirm their level of airline safety information despite having not observed the accident. Then, the consumer was asked if they were informed about unobservable safety occurrence. The conclusion was that consumers learning about the provisions of airline safety from flight outcomes, and that any accidents adversely affect the demand for other carriers' service. The estimates of Hartmann's structural model were small. The estimates simulated the short-run market effects of altering FAA safety standards with regard to maintenance expenditures (Hartmann, 2000).

The carriers' profits were higher when the airline was able to choose their optimal maintenance provision without any constraints. The profits were higher even if the constraint did not bind their own maintenance decision (Hartmann, 2000). The consumer's welfare was found to fall with the elimination of the government minimum standard. Simulations also indicated that carriers, as well as consumers, would prefer an independent entity to certify its chosen safety provision rather than have the FAA mandate. FAA certification of the airlines eliminates the uncertainty about safety provision and makes it more profitable to provide additional maintenance (Hartmann, 2000).

Federal Aviation Administration in a catastrophic airline accident. Lutte (1999) investigated the FAA activity before and after six catastrophic airline accidents. The investigation examined the relationship between crises and the FAA's behavior. The FAA regulatory, inspection, and enforcement activities were reviewed. The study showed that change in agency activity occurred following a crisis event. The location of the event appears to influence the direction of change. When crises occurred within the U.S. of America, FAA activity increased following the accident. The opposite was found to occur for airline accidents outside the US (Lutte, 1999).

The increase in FAA activity following U. S. based events supports the reactionary reputation that the FAA has acquired. In addition, the research revealed nine FAA activities judged by industry experts as having the ability to improve safety in the airline industry. The agency activities included aviation inspections and certificate actions. The proceedings were considered activities that would improve safety. Regulatory actions such as fines, warning notices, and letters of correction were judged as non-safety enhancing activities. The author stated that this research contributed to an increased understanding of agency response to crises, and the consequences of the response (Lutte, 1999).

Federal Aviation Administration decision-making. The focus of this literature was to describe the decision-making process at the Office of Accident Investigation (OAI) within the FAA (Manos, 1999). The OAI was mandated by the U.S. Congress to construct safety recommendations submitted to the FAA by the NTSB. The NTSB submits safety recommendations to the FAA after an aviation accident or incident. This safety submission is completed to promote public safety in aviation (Manos, 1999).

During Manos's research, data was collected from members of the OAI by a semi structured personal interview technique. Documents were gathered, researched, and analyzed after on-site visits to the FAA and the NTSB in Washington, D.C. Cross-validation techniques were used to verify findings in the U.S. Congressional Record (Manos, 1999).

The research questionnaire process revealed a consistent pattern of decision making within the OAI. All mandates were found to have been met with regard to the normative decision-making process. Implementation of recommendations was found to have been carried out by general orders, notifications, and progress toward changes in policies. However, corrective action programs developed to ensure greater public safety have been limited (Manos, 1999).

Manos (1999) concluded that FAA's implementation of NTSB airline safety recommendations were relatively weak. The FAA decision-making policies and the standards set forth by the U.S. Congress were source of enforcement authority. The implementation weakness was determined to be a result of the organizational restraints on the FAA from Department of Transportation (DOT). The FAA operates under the authority of DOT (FAA, 2008). The FAA lacked the power or authority to take corrective action through helpful programs or to meet the rapidly changing demands of the airline industry (Manos, 1999).

The study's recommendations were based on the research objectives (Manos, 1999). The study recommended that the NTSB determined changes be sent to the OAI with the full implementation authority for the OAI members. A separate FAA division should be established to deal with corrective action programs only. Third, a separate division should be formed under the Director of FAA to investigate accidents and to handle FAA recommendations. Fourth, U.S. Congress passed the Federal Aviation Independent Establishment Act of 1988 to comply with the NTSB recommendations. Fifth, further study should be completed to investigate total organizational constraints that affect decision-making ability at the OAI. Last, the NTSB/FAA recommendation process should be studied to ensure the same uniformity found in the NTSB procedural recommendations from 1988 to the present (Manos, 1999).

Flight deck miscommunications. The research attempts the identification of interpersonal and communication relationship and their process dynamics. The research information was obtained from the *black boxes* of the three studied flights. The black box is designed to record the critical last minutes of the flight. Four patterns of communication were found to be compelling distractions during the error events. Acts of mitigation, aggression and silence, shifts in consciences, and disruption in personal authority were derived from the recorded flight information. Symer (1999) recommended the development of training models. Further research and use of Crew Resource Management (CRM) was recommended.

Relationship of airline profitability and safety. Adawiya (1993) studied the relationship between airline profitability and their level of operational safety. Six U.S. scheduled passenger air carriers were studied for flight operations between 1975 and 1990. The period of flight operation was 75% deregulated, but deregulation consequences took years to be felt in the airlines' flight operations. The results of Adawiya's study indicated that no statistically significant relationship exists between the financial soundness of an airline and the number of accidents experienced by the airline (Adawiya, 1993).

Airline deregulation affect on safety. After an unfortunate series of accidents in the mid 1930s, the Air Transport Association (ATA) lobbied U.S. Congress for regulation of the industry. The ATA claimed that unfair competition was endangering the public safety. The Civil Aeronautics Act of 1938 created the Civil Aeronautics Board (CAB) and gave the CAB the authority to regulate the industry. During the regulation era, airline ridership increased and safety improved (De Jager, 1993).

Within the regulation period, opportunities for comparing the airline safety record of the regulated industry against the record of the unregulated segment of the industry were limited. A few safety comparison attempts rendered inconclusive results (De Jager, 1993). During a period of high inflation and high interest rates in the 1970s, an interest in deregulating the airlines arose. With passage of the Airline Deregulation Act of 1978, interest in the effects of regulation on airline safety was renewed. When De Jager (1993) began his research, more than a decade has passed since the 1978 airline deregulation

(NTSB, 2008). The scheduled airline industry has continued to improve its safety record during the deregulation period. However, the question remains: *How has deregulation affected airline safety* (De Jager, 1993)?

Passenger perceptions of airline safety. Becker (1990) studies which components of airline safety that the airline passengers indicated was of special interest. A descriptive-correlation study was conducted with 354 respondents from four passenger groups. The surveys were self-administered.

Fourteen hypotheses were tested. The four groups confirmed three of these hypotheses. The passengers confirmed that there was not enough airline safety related information available to the public. Second, the safety factors used by the studied group were especially important when choosing an airline. The third hypothesis sated that participants did not avoid any particular type of aircraft when requesting a flight. The other eleven hypothesizes were rejected on numerous passenger choice basis (Becker, 1990).

Development of an air carrier safety system. Remlin (1990) studied a specific group of aircraft accident during an eight-year period in the 1980s. The studied aircraft groups included U. S. registered aircraft conducting flight operations under 14 CFR 135 and 14 CFR 121. The accidents were investigated with the purpose of determining a common accident cause or common trend identification within the accident groups. It was determined that controlled flight into terrain was statistically prevalent in 14 CFR135 operations. Aircraft systems that provide ground proximity warning and terrain avoidance radar were recommended for installation in the 14 CFR 135 operations (Remlin, 1990).

Service quality and social welfare of the airlines after deregulation. There are two prevalent views of how safety is provided in air travel industry. The first of these views contends that the technical complexity of aviation prevents consumers from monitoring the safety of air carriers and aircraft manufacturers. Therefore, markets will not inherently provide incentives for firms to invest in safety precautions, thus compelling the need for regulation to assure consumers that they have the level of safety they expect. The counter view contended that, because of consumer demand for safety expenditures that the markets should generate endogenous mechanisms to provide them. In general, these endogenous mechanisms can be warranties with the use of agents, or individual airlines' reputations (Spitz, 1989).

Public perception of airline safety. The author presents two categories of consumers' views to characterize airline air safety (Chalk, 1983). The first consumer view is the aviation technical complexity prevents the consumer from monitoring airline safety. The other customer perspective represents the airline market safety as self-evident by the public through public available information sources (Chalk, 1983).

The effectiveness of airline regulation was examined by Chalk's study of the FAA to see how it regulates safety. He found that many of the FAA's regulations are non-binding on air carriers, and according to this research, the level of FAA enforcement was too meager to exert much impact. Airline reputation effects had not been demonstrated previously. Chalk presented an empirical technique to achieve this; reasoning that aircraft crashes publicly perceived, as design flaws will depreciate the aircraft manufacturer's reputation and not the airline's reputation. The researcher developed a technique to test for these perceptions. Two types of tests were conducted, one on a large sample of accidents and the other on a specific crash in which the aircraft's design was a major issue (the 1979 Chicago DC-10 crash). The results were consistent with the hypothesis that a reputation effect exists in the air travel market. In this market, the average asset value of reputation was found to be at least $50 million. The regulatory implications of these findings are explored. Emphasis is placed on regulatory agencies pursuing policies to improve consumer information (Chalk, 1983).

Airline Management

The second section of the literature review is relevant to the airline office manager's activities. Airline management requires planning, organizing, resourcing, leading, and controlling. The following literature review section reflects management responsibilities.

Examining personnel error reduction and accountability training affects on related pilot error. In the late 1970s, Cockpit Resource Management (CRM) training began to address the issue of human factors in aircraft mishaps (Cioffi, 2009). CRM focuses on the development of interpersonal communication among crewmembers in the flight deck, as well as communication with available agencies and individuals outside the cockpit. By contrast, Personal Error Reduction and Accountability (PERA) training emphasizes intrapersonal development and individual responsibility for improving performance and safety in the flying environment. The Cioffi research is the first attempt to measure the effectiveness of the PERVA training using data collected in cooperation with U.S. Marine Corp aviation. A mixed research method of quantitative and qualitative analyses was used to evaluate the U.S. Marine Corp PERA training program. The 4th Marine Air Wing who had completed three phases of PERA training and the pilots from the 2nd Marine Air Wing who had completed phase one of the PERA training, were the participants in the Cioffi research. The initial findings indicated that PERA training had an increasing positive influence on attitude for those personnel who had completed the three phases of PERA, as compared to those who had completed only the initial PERA training (Cioffi, 2009).

A human error classification system for small air cargo operators. Accident records show there is a disparity between the flight crews that operate under Title 14, Part 121 of the Code of Federal Regulations (CFR) and those that operate under Part 135 of that same code. In their daily operations, the performances of both groups are shaped by the complexity of this environment, their interactions with the system and their own personal, as well as team skill sets. However, the flight crews of Part 135 operators consistently make more errors, ranging to procedural, tactical and regulatory. The factors have been studied from a broad theoretical framework using many different perspectives, but a conclusive explanation for the disparity in the accident rates between the Part 121 and 135 operators remains elusive. One common methodology of error classification is analyzing a database of accident and incident information to identify the errors that pilots make in specific operational areas within the aviation system. In the last decade, researchers have developed a number of error classification schemes, and the reports of their findings are abundant in the literature describing the taxonomy of human errors in the aviation system. However, there is little research that correlates the flight training methodology that is designed to mitigate these errors, to the error classification schemes commercial air carriers currently use. Furthermore, there is no research that focuses on the classification errors made by pilots or flight crews that operate under the Part 135 regulations. The thesis examines some of the most influential literature that has shaped the development of systems designed to analyze and encode aviation accidents and incidents, as well as systems to classify human error in the aviation system. The thesis examines the structure and elements necessary to develop an effective human error classification system, the methodology used to design classification systems in general, as well as the taxonomy used to develop human error classification systems. The thesis reviews the methodology used in the current aviation human error classification systems. Additionally, it proposes a preliminary model for a system designed to classify pilot and flight crew error that occurs during the operation of commercial aircraft under Part 135 regulations, as well as suggests corrective actions to mitigate these errors. The system is based on the development of a theoretical concept for identifying, analyzing, encoding, and classifying flight crew error. It lists corrective actions in a terminology that can be used to develop flight-training activities and scenarios that will reduce the number of errors pilots and flight crews make during Part 135 regulated flight operations. The thesis reports the analysis of trials, in which Part 135 flight instructors and/or check airman, as well as flight instructors that are licensed and regulated under Part 91 of the Federal Aviation Regulations classified five randomly, selected reports from the Aviation Safety Reporting System. A comparison of the results of the classifications made by Part 91 instructors, verses the part 135 instructors and or check airman will be discussed. Finally, based on the finding of the analysis of these trials, recommendations for improvements in the design and implementation of future error classification systems designed to mitigate the pilot errors made during commercial flight operations are discussed (Paluszak, 2008).

Examining the relationship between Part 121 air transport pilots and burnout. The current air transport industry environment and evidence of fatigue in Part 121 air transport pilots (ATP) indicated the need to examine the relationship between Part 121 ATP and burnout. The Maslach Burnout Inventory-General Survey (MBI-GS) measured burnout for this quantitative, correlation research study. Identified were organizational, situational, and individual factors as potential correlates of the three dimensions of the burn-out syndrome: (a) exhaustion, (b) cynicism, and (c) professional efficacy. 1,100 randomly sampled Part 121 ATP received the survey packet. The effective response rate was 12.6%, yielding 138 usable survey packets. The study findings indicated that situational factor, quantitative work overload and organizational factor, and fair rewards were the only Part 121 ATP environment dimensions examined that had statistically significant correlations with the three dimensions of the burnout syndrome (Keamey, 2008).

Experimental and neutral network-based model for human-machine systems reliability. The development and integration of advanced controllers and automated systems have led to a transition from physical work to supervisory and decision-making tasks for the human operator. Hence, research endeavors within the aegis of human reliability analysis (HRA) focuses on the development of methodologies for assessing human performance in a system by quantifying human error.

Performing HRA normally involves a sequence of procedures, including conducting task analysis and experiments, which have been found generally difficult, time consuming and expensive. Therefore, the objective of this thesis is threefold: (1) to conduct a literature review to determine the current state-of-the-art in the area of human-machine systems reliability and identify major research issues; (2) to perform an experimental design analysis on one of the recently developed, dynamic HRA techniques, where the effect of various factors on human reliability is studied in a troubleshooting application as a test bed; and (3) to develop a neural network-based model for predicting human reliability in a dynamic HRA method, with an application in the chemical industry.

The literature survey conducted covers the applicability of different methodologies in diverse domains (i.e., nuclear, aviation, healthcare) and stresses the needs for advanced HRA techniques. To address some of the issues uncovered during the literature review, an interactive troubleshooting application was developed for use as test bed in this research, with usability consideration taken into account in its design. A split-plot experimental design was used to study the influence of a selected set of performance factors on human performance in a simulated fault-diagnosis task. Analysis of the experimental data suggests that training has a major effect on human performance, with other factors (and a combination of factors) having significant effects on the overall human reliability as well (Thiruvengadachari, 2007).

Reducing pilot error mishaps. The text examines the role of life stressors as primary or contributing causal factors in pilot error mishaps (PEM) that caused fatalities within US commercial passenger and military aviation. Evidence and professional consensus are presented demonstrating pilot error is implicated in a constant 80% proportion of mishaps, and that many PEMs are due to life stressor adverse impacts on pilot decision-making. Gaps in our knowledge and under-standing of how to identify and mitigate life stressor roles in PEMs are elucidated. The spectrums of logical steps are from the concept that life stressors are implicated in mishaps to interventions, which may reduce pilot error mishaps, and fatalities are encapsulated. Analyses of existing and potential PEM "at risk" pilot identification methods and interventions are provided. An exemplar research design to test the efficacy and effectiveness of PEM "at risk" pilot interventions is offered (Walker, 2007).

The essential elements of aeronautical decision making. The research explores Aeronautical Decision Making (ADM) in General Aviation (GA). ADM is an important skill when piloting any aircraft. The primary cause of aviation accidents and fatalities is pilot error, specifically, improper decision making. The General Aviation accident rate has leveled off at a high rate over the past decade. The study surveys private pilot ground schools and post-secondary institutions to determine the essential elements of ADM, which essential elements are included in the Federal Aviation Administration's (FAA's) ADM model, and which essential elements of the FAA's ADM model may need to be updated to improve the model's effectiveness. Findings to the research questions may lead to the development of an improved ADM model that could lower aircraft accidents and aviation fatalities (Abner, 2006).

Analyses of air carrier line check safety audits. Airline treat and error mitigation analysis was studied using three data collection methods. Esser's (2006) research determined the Flight Operational Quality Assurance (FOQA), Aviation Safety Action Program (ASAP), and the Line Check Safety Audits (LCSA) programs were useful and a valid source of information concerning evaluation of the approved Advanced Qualification Program (AQP) training used by some airlines to train their pilots. Recommendations from the study include mitigating the data collection instruments to an electronic format and addressing data collection on short stage flights (Esser, 2006).

Use of alcohol among air carrier pilots. Hardy (2005) researched two published incidents of air carrier pilots reporting for duty while under the influence of alcohol. Hardy determined the majority of pilots do not fly while under the influence of alcohol. The research investigated the frequency, quantity, and consequences of alcohol by airline pilots (Hardy, 2005).

Development and transfer of higher order thinking skill in pilots. The aviation community recognizes a need for at least one order of magnitude improvement in general aviation safety. The improvement will virtually eliminate the primary cause of today's accidents with human factor errors. The study examined a method of teaching higher order thinking skills and compared it to the traditional method of instruction used in flight education. It used a pretest-posttest control-group experimental research design to compare an example of a blended problem-based learning (PBL) and non-PBL methods of instruction. The results of the experiment showed improvements in all measures and significant improvements in several measures of (a) pilot performance, (b) situational awareness, and (c) aeronautical decision-making for pilots transitioning to technically advanced aircraft (TAA). Additional research is needed to determine the value of this method for other aviation training (Robertson, 2005).

Safer approaches and landings: A multivariate analysis of critical factors. The approach-and-landing phases of flight represent 27% of mission time while resulting in 61 of the accidents and 39% of the fatalities. The landing phase itself represents only 1% of flight time but claims 45% of the accidents. Inadequate crew situation awareness (SA), crew resource management (CRM), and crew decision-making (DM) have been implicated in 51%, 63%, and 73% respectively of these accidents. The human factors constructs of SA, CRM, and DM were explored; a comprehensive definition of SA was proposed; and a "proactive defense" safety strategy was recommended. Data from a 1997 analysis of worldwide fatal accidents by the Flight Safety Foundation (FSF) Approach-and-Landing Accident Reduction (ALAR) Task Force was used to isolate crew and weather-related causal factors that lead to approach-and-landing accidents

(ALAs). Logistic regression and decision tree analysis were used on samplings of NASA's Aviation Safety Reporting System (ASRS) incident records and the National Transportation Safety Board's (NTSB) accident reports to examine hypotheses regarding HF and these HF combinations. The HF can dramatically increase the opportunity for accidents. An effective scale of risk factors was introduced for use by crews to proactively counter safety related error chain situations (Heinrich, 2004).

Analysis of flight management attitudes. The widely used measures of pilot safety attitudes, the Flight Management Attitude and Safety Survey (FMASS) were administered to the Canadian airline pilots. Gatein (2004) research indicated the survey data were not able to confirm the management attitude proposed structure. The results showed poor internal consistency. Additionally, the study indicated more research is needed on the psychometric properties (Gatein, 2004).

Director of safety. The United States aviation industry is composed of thousands of aircraft operators (Russo, 2004). While few air carriers are large companies, with well-developed management resources, the majority of carriers and corporate flight operating departments exist with the minimum management staffs allowable under the rules of the FAA. Since 1994, the FAA has required the operators of large aircraft and operators of medium-size aircraft in scheduled service to have a position of Director of Safety. Smaller aircraft operators are not required to have a safety department. Therefore, with small management staffs and the lack of a regulatory requirement, most of these operators exist without the benefit of a formal safety program (Russo, 2004).

Russo (2004) sought to supplement the safety attributes of commonly observed airline safety programs with research in the fields of safety, education, psychology, and law. Safety sub-programs were encouraged by small operators with minimal staffing. Next, an internet-based system was established for the population of small carriers. The Internet system provided the small flight operator with a continuous flow of safety management information, similar to that provided by the safety staff of carriers with safety offices. After an introductory period of program operation, the users were sampled regarding the perceived usefulness of the various program elements. The program was modified to improve usefulness, and the users were polled again. Data from on-site audits of various carriers with and without safety programs was analyzed to match the overall operations and maintenance management strength with the degree of maturity of the carrier's safety program (Russo, 2004).

The objective of Russo's (2004) study was to show that safety program management could be extended economically to the smaller air carriers. The small air carriers would ordinarily not participate in such a safety program, because of the program costs. Additional study objectives were to determine the usability of such a system, and to estimate whether the effectiveness of a safety program would be beneficial. If the program was successful, this model could provide the template for a nationwide or even worldwide system of safety program management, elevating the level of safety awareness, training, and performance for the largest segment of the aviation industry. The model could also apply to other industries with a large number of small, fragmented, and safety-sensitive operators (Russo, 2004).

An analysis of airline safety. Squalli's (2004) airline safety study shows substantial differences across large and small air carriers. Squalli ranked airline accidents by their level of severity to distinguish accidents with material losses from those with human losses. The author tested customer behavior across air carriers and found that large carrier accidents have no impact on enplanement for large rival carriers. However, Squalli found that air carrier accidents lead to generalized fear of flying small rival carriers (Squalli, 2004).

Decision-making styles associated with accidents: Defining the high-risk pilot. The dissertation describes a cognitive psychology based program designed to improve aviation safety. The study was founded upon over 24 years of research, development, and experimental validation in the area of pilot decision-making. It was determined in the early 1970s that 51.6% of the fatal general aviation accidents were due to faulty decision-making. The effort guided the way to determine if decision-making could be taught, if so, how it could be taught, and then, how its impact could be assessed.

The purpose of this research was to characterize the decision-making styles of accident free and accident-prone pilots. The psychological basis of the Decision-Making Styles (DMS) instrument is discussed in detail, including extensive evidence for a variety of host factors that influence decision-making. The first step in this study was to validate the DMS instrument with an extensive, experimental survey of approximately 4000 pilots. The hypotheses were designed to determine whether the ten categories of 122 decision-making variables tested are associated with having an aviation accident, incident, or near accident (cases) in comparison with those who have been accident free (controls). The information data set provides a rich core of knowledge that has not been analyzed before as a whole.

The method of data collection is discussed in detail. This includes a review of the methods proposed for analyzing the DMS instrument data, selection of participants for the mailing, their classification as cases or controls, and the mailing procedures. Mailing procedures to ensure a high response rate are outlined, and data collection procedures are summarized. The proposed measures and methods for data analysis are described. Due to the predominance of Lickert scale type of data, the primary analyses focuses on the nonparametric Mann-Whitney Test.

The results are organized into confirmed, unconfirmed, and anecdotal hypotheses. The confirmed hypotheses resulted in a description of accident-prone pilots as more likely to: expose themselves to high risk flying experiences, feel time pressure when making decisions, have a false sense of their ability to handle the situation, and not review alternative options or solutions.

In addition, the analyses included the development of a discriminate function to determine if cases and controls could be correctly classified using the DMS instrument. It was found that 80.1% could be correctly classified using the entire 122 question set. If a simplified seven variable (26 question) set was used, 68.2% of the cases and controls could be correctly classified (Adams, 2002).

Crew Resource Management and airline accident prevention. Crew Resource Management (CRM) is the elite training method that deals with human error reduction within the aviation industry (Farah, 2002). Farah evaluated archival NTSB aircraft mishap data to support these human error conclusions. The author emphasized human resources as the training that can reduce pilot errors in flight operations (Farah, 2002).

Conceptual framework for a software black box. The flight crash protected Flight Data Recorder (FDR) is supplemented in accident investigations with the Software Black Box (SBB). Elbaum's (1999) research indicates insufficient or inappropriate flight information has been retained to permit the reconstruction of the circumstances that led to the flight failure. The SBB architecture, operation, advantages, limitations, and potential are revealed (Elbaum, 1999).

Pilot training at United Airlines. Futrell (1998) studied United Airlines' conceptual and philosophic changes in their pilot training. The study ranged from 1931 through 1996. Three major training periods were studied. First, the period was the initial formation of United Airlines during the 1930's. Second, the technological advances in aviation from the 1940's and 1950's. The last studied period is the jet age of the 1960's through the 1990's.

After World War II the Link trainer was utilized to train pilots how to fly airplanes during restricted visibility. The conceptual changes of the jet age had a major impact on pilot training curriculum. Ground Proximity Warning System

(GPWS), Windshear and Microburst (WM), Situational Awareness (SA), aircraft automation, and Line Oriented Flight Training (LOFT) were encompassed in pilot simulator and computer ground training (Futrell, 1998).

The philosophical changes were from a technical knowledge of the aircraft systems and their functions, to an operational knowledge base. The changes included Command, Leadership, Resource Management (CLRM) training and the Advanced Training Program (AQP). The study analyzed the cockpit concept of crew coordination, inherent problems of automation, and the glass cockpit technology. The historical analysis revealed that pilots are capable in terms of perceptual motor skills, but that cognitive processing skills of individuals are significantly improved when working as a team. Pilot training has changed to realize that effective cockpit teams function together and make effective decisions as a group with the captain as the team leader. As a result, airline training has been restructured to develop and foster team-building skills through advances in the training curriculum (Futrell, 1998).

Training for junior cockpit team members. Novice team members need to know how to provide backup, but also when to do it. In the past, the copilot training focused on *what to do* rather than *when to do*. The latter action was referred to as asserting oneself. The asserting the recognition of a perceived problem has been an enhancement to the safety of flight and shows the training of flight crewmembers as the concept of met cognition (Jentsch, 1997).

The study results indicate that only the met cognitive training led to significantly more effective prioritizing by the trainees. Conversely, only behavioral training led to significantly better assertion. Further, effects of training on the performance were mediated by trainee knowledge of the training contents. Together, the results indicate that met cognitive training can be a viable addition to existing team training, especially when cognitive skills are to be trained (Jentsch, 1997).

Assessment and statistical analysis of Canadian airline accidents. The Mielcarek (1995) study of the Canadian commercial aviation industry is presented for the period of 1967 to 1993. The study presented the technological and economic aspects influencing the successful developments in the field of flight, as well as the specific elements affecting its safety record. An assessment of the risk of flying is made using accident, fatality, and injury rates per year.

Flight crew wind shear and microburst training. The metrological reality of microburst and wind shears were acknowledged in the 1970s and the airlines began training programs for the pilots in the flight simulators (Nadhrah, 1995). Nadhrah surveyed four major airlines and five regional airlines to determine their microburst and wind-shear training methods. The questionnaire showed training deficiencies in both airline types. The quality of the wind shear training conducted by the major airlines was determined fit in terms of its design. The training was taught as an emergency procedure and it was integrated with CRM. The training used a combination of methods and covered all wind shear training techniques (Nadhrah, 1995).

Safety of air carrier multinational flight crew operations. Multinational flight crews (MNFC) are becoming common in cockpits of many international air carriers. Saudi Arabian Airlines flight crews are staffed from 37 nationalities. Berenji (1994) developed research to measure performance of individuals in MNFC. A Flight Deck Activity Observation Log (FDAOL) was developed and used during eighty-six flights involving 153 flight crews that generated 8,560 behavioral observations over all phases of flight. The research shows that the MNFC have comparable safety to single national flight crews (Berenji, 1994)

Regional airline pilot qualifications. Herrick's (1991) study indicated a relationship between the availability of proficient entry-level airline pilots and the level of flight training of new-hire pilots at regional airlines. Pilot hiring criteria was used in this study to represent the level of flight training of entry-level pilots. The study also identified areas of need for additional flight training and methods for acquiring the flight experience needed to pursue an airline career. The pilot entry-level qualifications data was surveyed from chief pilots employed by large and medium size regional airlines. The study used the mail-survey questionnaire method to collect data from 126 regional airlines' chief pilots (Herrick, 1991).

Herrick's major findings had five components. In four of six hiring criteria tested, availability of proficient entry-level pilots proved to be a factor. Second, the size of the regional airline was not a major factor in relaxing hiring criteria for entry-level pilots. It was true in times of pilot shortage and no-shortage conditions. The surveyed chief pilots of large and medium regional airlines perceived that additional training was needed for the entry-level pilots. The greatest pilot proficiency need was in basic instrument flight or simulator training. Fourth, the chief pilots of large and medium regional airlines perceived methods as to how a new-commercial/instrument pilot should acquire the aircraft type rating and quality of flight experience needed to pursue an airline career. Last, as perceived by chief pilots, the first choice method for acquiring the flight experience needed to pursue an airline career was as an air-taxi/charter pilot (Herrick, 1991).

Herrick's study showed that some hiring criteria might be relaxed during periods of proficient entry-level pilot shortage. Proven instrument-flight skills and simulator training were crucial and such training should not be left to chance. Time-based rather than proficiency-based flight-training programs provided new-commercial/instrument pilots pursuing airline careers with the best training. Although the literature provides ample support for proficiency-based flight training, such as the Ab-Initio program run by Lufthansa, chief pilots did not seem to trust any training not based on accrued flight time (Herrick, 1991).

United States airline's maintenance safety. Sathisan (1989) studied how aircraft maintenance related indicators show the safety posture of airlines. This author indicated airline safety posture is the incidence of service difficulties. Airlines document these service difficulties in the Service Difficulty Reports (SDRs). The SDRs are reports on equipment-related problems encountered with aircraft while in service and by the incidence of engine shutdowns and removals. An aircraft that experiences a high incidence of equipment-related problems is considered to have a high risk of accidents (Sathisan, 1989).

A theoretical framework was proposed in Sathisan's research and it was a model of the escalation of relatively minor equipment problems into more severe incidents and, eventually, into accidents. Airline maintenance safety is analyzed using statistical techniques. Key variables, such as fleet mix, average aircraft age, engine type, scale of operations, rate of aircraft utilization, equipment exposure measures, and maintenance expenditures are used to define the safety perspective for airline management (Sathisan, 1989).

Sathisan's suggested that there are significant differences among aircraft types and among airlines. Narrow-body aircraft and their engines have better safety postures than their wide-bodied counterparts. The engine shutdown and removal rates are higher for wide-bodied aircraft. Furthermore, the rate of serious SDRs increases faster with age for wide-bodied aircraft than for narrow-bodied aircraft (Sathisan, 1989).

Aircraft age alone does not explain the incidence of serious SDRs. The effects of age appear to be partially masked by the other factors. However, there appears to be a rapid discovery process for the reliability and maintenance of new engine models, as indicated by the substantial decline in the rates of engine failure after their first three years in service. The effects of operations time exposure, measured by the hours of operations, are more significant for engine shutdowns and removals than for SDRs. In addition, the rate of engine shutdowns appears to decrease with increased daily utilization. Last, the safety posture of the established airlines does not appear to be any better than that of the new entrants. If airline deregulation has encouraged the introduction of new entrants, then by doing so, it has not adversely affected safety. Airline safety has never been better, and there is no indication that it is worsening. However, further research is needed to ascertain the implications of aging and maintenance on the safety posture of specific types of aircraft (Sathisan, 1989).

Airline Flight Operations

Flight operations are defined by many airline activities. The activities include the aircraft moving from the gate, taxi for takeoff, takeoff, climb, cruise, descent, landing, and taxi into a gate position. The pilots are the individuals responsible for this portion of the airline's operations. Some of the flight operations attributes of the airlines have been shown in the following literature.

Line operations safety audit. Klinect's (2006) research presented a field observation method called the Line Operations Safety Audit (LOSA). This observation was designed to provide a proactive snapshot of system safety and flight crew performance before an incident or accident. The data indicators underlying this effort are based on a conceptual framework known as Threat and Error Management (TEM). The framework proposes that threats (such as adverse weather or aircraft malfunctions), pilot errors (such as selecting a wrong automation mode or missing a checklist item), and undesired aircraft states (such as altitude deviations or speed limit breaches) are everyday events that flight crews must successfully manage to maintain safety (Klinect, 2006).

By having cockpit observers collect TEM data, LOSA provides an opportunity, never before realized, to understand the complex interactions among operational context, flight crew processes, and outcomes during routine flights. The type of insight benefited airlines and researchers (Klinect, 2006). For airlines, LOSA provides a diagnosis of operational performance strengths and weaknesses without relying on adverse safety events for such information. For researchers, LOSA addresses the shortage of field findings in aviation by providing TEM performance data gathered in its natural context (Klinect, 2006).

Line Operation Safety Audit has been developed and refined since 1996 with projects conducted at over 20 major international and regional airlines from 10 different countries. Using this experience as a foundation, Klinect (2006) described the rationale underlying LOSA as well as its methodology, data analysis strategies, and safety implications for the aviation industry. Some highlights include a discussion of the 10 operating characteristics designed to gain pilot trust and lessen the tendency to feign good actions during an observation (Klinect, 2006).

The Line Operation Safety Audit's instrumentation, observer selection procedures, training objectives, and quality control checks were used to enhance data reliability and validity (Klinect, 2008). The audit was a multistage approach to data analysis and interpretation that demonstrates the transformation of LOSA data into knowledge that can drive airline safety management practices. Initial findings were from an archive of over 2,600 collected observations. The dissertation concluded with a discussion of current regulatory, pilot association, airplane manufacturer support for LOSA, and the efforts under way to expand its methodology to other domains within aviation (Klinect, 2006).

Behavior and decision making in fatal airline crashes. The purpose of this research was to determine organizational patterns before; during, and after commercial passenger airplane crashes. The qualitative study classified the accident finding into strategy, operations, and technology. Pattern determination of these organization dimensions was based on the chronological finding in the NTSB factual report. The author stated that significant insight into how airline decisions are made, or not made, in specific accidents, and when airline decisions are taken as a group. Serabian also studied how commercial airline systems and organizations decide, learn, and adapt to accidents. All these characteristics were a result of accidents and incidents (Serabian, 2006).

Naturalistic decision making in aviation: Understanding the decision making process of experienced naval aviators during novel or unexpected situations in flight. The study focuses on problems that these aviators encountered and examines what information and these individuals in dealing with their issues used strategies. Eleven experienced F/A-18 naval aviators were interviewed using the Critical Decision Method and then analyzed in two steps: (a) first, separately for each participant (within-participant analysis); and then (b) across participants (between-participant analysis) in order to identify themes and patterns that emerged.

Findings of the study address the following six areas: (a) the types of problems that arose; (b) how the aviators identified problems as novel or unexpected; (c) how the aviators first identified the existence of a problem; (d) cues and factors that were noticed and considered by the aviators throughout their decision making process; (e) strategies the aviators utilized ; and (f) difficulties that the aviators encountered in selecting and implementing these strategies. Implications of the findings for practice are discussed, including the importance of educating aviators on cues and factors that they should be considering in various types of situations, such as when flying off of aircraft carriers or engaging in combat. Limitations of the study and suggestions for future research are also provided (Denihan, 2005).

Disturbance management on modern flight decks. Nikolic's (2004) research presented the concept that the commercial aircraft automation technology leads to new cognitive demands on the pilots. The research program was observed in a flight simulator from the cockpit jump seat position. The research also included a flight instructor survey, an incident database analysis, and first mission simulation of flight disturbances. The study was conducted with 12 airline pilots in order to examine the effectiveness of current pilot strategies for diagnosing and recovering from flight disturbances.

The study results show that aspects of feedback designed delayed the interdiction and thus escalated the severity of a disturbance. Generic rather than inefficient recovery strategies were observed. The pilots tended to rely on high levels of automation when trying to manage the consequences of erroneous actions or assessments (Nikolic's, 2004).

Measuring organizational factors in airline safety. Human information behavior has been described as the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking and information use (von Thaden, 2004). It includes face-to-face communication as well as passive information reception, with no intention of acting on the given information. Distributed use of information within groups remains a weak link between actual information, the meaning given to information, and the sense made of the information (Von Thaden, 2004).

In the world of aviation, accident investigations frequently point to a breakdown in communication with no indication of how this breakdown occurs. Von Thaden's (2004) study distinguished how this breakdown may occur through understanding human information behavior on the flight deck. The study indicates that high-performing flight crews practice employs different information behaviors than low performing or accident involved flight crews. Principles from information science, psychology, and communication studies were used to analyze how commercial flight crews involved in accidents fail to make use of essential safety information (Von Thaden, 2004).

The Crew Information Behavior Grid was used to assess this communication information flow. Von Thaden's (2004) work indicates a way to implement Crew Resource Management through understanding the social practice of information structuring and communication patterns within the practice of the flight crew. From it, researchers may be able to identify the role that information (needs, seeking, and use) plays in critical communication patterns related to supportive or ineffectual infrastructure used in the negotiation of meaning on the flight deck (Von Thaden, 2004).

Cockpit conversation analysis of three aviation accidents. Driscoll (2002) studied Cockpit Voice Recorders (CVR) of three historical Controlled Flight Into Terrain (CFIT) accidents. The discourse analysis methods of research were used to probe the data of the accidents. A loss of Situational Awareness (SA) is often implicated in CFIT accidents and was a major concern.

The study revealed that in the three accidents, there was a reciprocal relationship between communication and the loss of SA. The ineffective application of communication skills appeared to increase the chances of loosing awareness and its loss effected the communication that took place. The study implied that communication plays an important role, not only in relation to the loss of SA but also in its restoration and maintenance (Driscoll, 2002).

Learning and teaching styles of airline pilots. Hamby (2001) measured the personal satisfaction of pilot-trainees with each of four surveyed airline-training experiences for the perceived effect of individual learning style, demographic data, and instructional delivery in a study. Hamby used the 2000 Aviation Training Survey (ATS). An empirical review of the correlation between an instructor's trainer type and learning style showed no significant correlation. Some instructor trainer types and pilot learner differences were notable and corroborated by personal interviews. The overall conclusion of the research was that deference to instructional delivery has a significant effect on the satisfaction of a training experience, and that this satisfaction could be a factor in a pilot's desire to remain with the company. Hamby believed the pilot's respect for their training quality might affect their diligence to be vigilant during flight and thus assure a safer flight operation (Hamby, 2001).

Flight crew performance in standard and automated aircraft. Hines (1998) observed 3,266 regularly scheduled domestic and international flight of five U.S.

airlines. Flights crews were observed for performance understanding on both standard and automated airline aircraft. The automated flights are on aircraft with auto land systems and glass cockpit information displays. The introduction aircraft for the glass cockpit was the B-767 in 1982 (NASA, 2008).

Hines tracked seven core measures of crew performance and four core measures of automation when present. Crew performance was found to vary as a function of the quality of the pilot in command briefing. Three scales of crew performance were observed and recorded: command, crew interaction, and automation management. Automation posed new and additional issues; in addition, automation increased modes of possible errors (Hines, 1998).

Aircrews' evaluation of flight deck automation training and use. Sherman (1997) surveyed 1,718 airline pilots for their perspective of automated aircraft they were trained to fly. The pilot's attitude toward their management of the aircraft automated systems was also surveyed. Roughly, one quarter of the pilots felt that training did not adequately prepare them for operating their aircraft.

The study analysis demonstrated differences across aircraft type and manufacturers. Three scales were derived measuring pilot automation preference, respondent's discretion in use of automation, and recognition of the increased communication needs on an automated flight deck. Generally, more experienced pilots showed slightly higher recognition of the increased for communication on the automated flight deck and preferred automation slightly less than the younger pilots (Sherman, 1997).

Vertical navigation of long-haul aircraft. The Patrick (1996) study shows that most decisions made in the cockpit are related to safety, and have therefore, been implemented in order to reduce risk. It leaves passenger comfort and cost of flight operation to be studied. The airline pilots were surveyed to determine their preference in flight planning.

A genetic algorithm of analysis was used to represent the pilot and dispatchers decisions of the trajectory space. The representation is a sequence of command attitudes, and they were chosen to be compatible with the constraints imposed by Air Traffic Control, and the training given the pilots (Patrick, 1996).

An agent-based cockpit task management system: A tank-oriented pilot-vehicle interface. In today's highly automated aircraft, the role of the pilot has changed from an airplane controller to a system manager. As a system manager in a cockpit, today's pilot is in charge of a management-level activity called cockpit task management (CTM). In earlier studies of 470 ASRS (Aviation Safety Reporting System) reports, CTM errors were found in almost 50 percent of the incidents. The primary objective of this research was to reduce CTM-related pilot errors. A prototype pilot-vehicle interface (PVI) called the cockpit task management system (CTMS) was developed and its effectiveness in improving CTM performance was evaluated (Kim, 1995).

The concepts and methods of object-oriented design (OOD) and distributed artificial intelligence (DAI) were employed in developing the CTMS. The components of the CTMS were implemented as software units called agents: system agents represented aircraft subsystems and pilot tasks by task agents. After the CTMS was implemented, it was integrated into a PC-based flight simulator to perform an experiment to evaluate its effectiveness.

Eight volunteer subjects were used to collect performance data in the flight simulator. In order to compare subject performance between flying with the CTMS and without the CTMS, each subject flew two data-collection scenarios in the simulator: one with the CTMS, the other without it. The results of the experiment indicated that a statistically significant improvement was observed when the subjects flew with the assistance of the CTMS (Kim, 1995).

Issues in cockpit and cabin communication and coordination. The thesis shows misunderstandings, attitudes, and interactions between crewmembers and the possible impact on aviation safety. Chute (1994) conducted a survey of pilots and flight attendants at two U.S. airlines. The survey revealed flight attendant confusion regarding appropriate conditions for violating the sterile cockpit regulation, as well as concern about the frequency of flight-deck briefings of the cabin crew and the frequency of crew introductions.

Descriptive statistics were compiled for preferences regarding organizational unification, work-related differences with extended crew pairings, and other duty-related topics. The results of this study indicate that there are substantial differences in the attitudes of pilots and flight attendants; however, there is also agreement between them regarding potential organizational changes to reduce the isolation between them and maximize crew cohesion (Chute, 1994).

Summary

The literature review summary divides the review subjects into three distinctive categories: airline operational environment, airline management, and airline flight operations. The airline operational environment reviews include a study by Hartman (2000). He studied the public's perception of airline safety. Picket (2001) researched the FAA enforcement of federal regulations. Spitz (1998) studied the relaxing of federal jurisdiction for some regulations in 1978 Another author studied post deregulation airline operations to determine the relationship between airline profitability and operational safety (Adawiya, 1993).

The group two of this literature review has an airline management theme. Von Thaden (2004) management focused on measuring organizational factors in airline safety management. His study of human behavior has been described as the totality of human behavior in relation to sources and channels of information. In addition, Russo (2004) researched the need for a Director of Safety and airline maintenance safety specialist in smaller flight operations. Squalli (2004) researched the effect of safety priorities as evidenced in the management of some airlines. Other literature addresses the learning and teaching styles of airline pilots (Herrick, 1991). Still another author researched the hiring qualifications of regional airline's new hires.

Some literature has been written on the characteristics of the airline flight operations and it makes up the literature review's third section. The authors contribute to many flight operations subjects. One study is on flight crew performance on thousands of regularly scheduled U. S. domestic flights that were observed by Hines (1998). He compared many airline pilots manipulation of the newer automated aircraft flight to the less automated airline flight. Von Thaden (2004) analyses how commercial airline crews involved in accidents fail to make use essential, safety critical information. An additional researcher presented an airline safety study that investigated the flight operations of numerous airlines of the world (Klinect, 2006).

CHAPTER 3: RESEARCH METHOD

Overview

The complexity of flying transport aircraft in a limited airspace with weather constraints can be a formidable challenge. Consequently, an occasional aircraft mechanical problem or pilot situational disorientation can add to these flight challenges; increasing the potential for a major flight safety event (Kern, 1996). Most of the flight challenges have been safely met; consequently, many incident and accidents have been avoided (Boeing, 2008). However, on 1,391 occasions in the last 27 years flight safety challenges have developed into aviation accident and incident statistics (NTSB, 2009).

The objective of this airline research was to show if either the U.S. major or U.S. regional airlines was more successful in avoiding operational accidents and incidents. The first two research questions facilitated this research process by comparing the two airline groups' accident types. RQ1 compared the airline accidents that resulted in at least one human death. The second RQ compared the airline groups' accidents that resulted in property damage but without a human death. The third RQ contrasted the airline groups' frequency of recorded incidents.

The members of the U.S. Congress have entrusted the NTSB with the responsibility to determine the probable cause for each aviation safety event (Library of Congress, 2008). The NTSB investigated the transportation safety events of all United States carriers and manufacturers (NTSB, 2009). Annually, the NTSB reports all their transportation safety event probable causes to the U.S.

Congress (NTSB, 1996). The NTSB accident investigation group continued to show several of the scheduled airline safety event probable causes as pilot errors (NTSB, 2008). Pilot errors encompass many aspects of the human-machine interactions and its weaknesses (Reason, 2003). Some of these human imperfections or safety questions were pilot situational awareness, task prioritization, task focus, information gathering, problem-solving, decision-making, and timely corrective action (Kern, 1996).

The seven airline accident and incident probable causes were presented in descending order of frequency: crew error, mechanical failure, weather, Air Traffic Control (ATC), maintenance, other, and unknown. Pilot error in the last eight years has accounted for 52% of the fatal airplane accident probable causes (Kebabjian, 2008). Therefore, the airline groups' accident and incident probable causes were separated into two research questions. RQ4 divided the pilot errors from the remaining six probable causes. The remaining six probable causes comprised RQ5's contrast between the major and regional airlines. If either airline type has a safer flight history, the five research questions revealed the safety level and some characteristics of their safety differences.

Restatement of the Problem and Purpose

The frequency of the U.S. domestic scheduled airline flight operations accidents and incidents were considered a problem or safety difficulty by the aviation industry (Air Transport, 2009). The research ascertained 1,391 airline accidents and incidents were recorded between January 1982 and December 2008. The study accidents caused passenger injuries, death, or property damage. The purpose of this descriptive qualitative study was to show the differences of the regional and major airlines operational safety (Boeing, 2008).

Daily, there are more than 28,000 scheduled airline departures within the United States (BTS, 2008). Regional airlines flights carry more than one of every five domestic airline passengers (Regional Airline Association, 2008). Even though airline travel is the safest mode of transportation, airline safety improvements can be encouraged. Safety improvements can reduce human injuries and fatalities for the airline passengers (United Justice, 2008). There are more airline flights today than there were five years ago and there are less total airline accidents and incidents today than there were for the same period (BTS, 2008). The U.S. domestic air carriers have improved their flight safety record; however, incidents and accidents continue to occur during airline flight operations (Kilroy, 2008).

Statement of Research Questions

The research goal was to show whether there were differences in the airline safety events within the U.S. domestic major and regional airline groups. All U.S. major and regional airlines were certified to operate under the jurisdiction of the U. S. Department of Transportation. The certified airlines were studied for statistically significance similarities and differences in their flight safety event occurrences. The following research questions were designed to show if the U.S. regional and major airlines have similar or different safety event histories. The period of the study was the 27 years between January 1982 and December 2008.

The research questions encompassed five categories of safety event investigated information. The airline safety event information was available from the NTSB accident and incident reports (NTSB, 2009). The NTSB investigation teams have assigned event severity classifications to each accident and incident. These classifications were aviation incident, damage, injury, serious, and major severities as defined in chapter one (NTSB, 2009). The research question's variable data were contained within the NTSB accident and incident reports (NTSB, 2009). The research questions enabled showing the similarities and differences of the regional and major airlines' safety history. The safety histories were shown in this airlines' safety event study as human life loss accidents, non-fatal accidents, incidents, pilot errors, and other probable causes.

RQ1: To what extent, if any, does the rate of domestic airline accident losses of life per flight departure differ between U.S. major and regional airlines?

$H1_o$: Airline flight fatalities per flight do not differ significantly between U.S. major and regional airlines.

$H1_a$: Airline flight fatalities per flight do differ significantly between U.S. major and regional airlines.

RQ2: To what extent, if any, does the rate of domestic airline non-fatal accidents per flight departure differ between U.S. major and regional airlines?

$H2_o$: Airline non-fatal accidents per flight do not differ significantly between U.S. major and regional airlines.

$H2_a$: Airline non-fatal accidents per flight do differ significantly between U.S. major and regional airlines

RQ3: To what extent, if any, does the rate of domestic airline incidents per flight departure differ between U.S. major and regional airlines?

$H3_o$: Airline incidents per flight do not differ between significantly U.S. major and regional airlines.

$H3_a$: Airline incidents per flight do differ significantly between U.S. major and regional airlines.

RQ4: To what extent, if any, does the rate of domestic airline pilot errors per flight departure differ between U.S. major and regional airlines?

$H4_o$: Airline pilot errors per flight do not differ significantly between U.S. major and regional airlines.

$H4_a$: Airline pilot errors per flight do differ significantly between U.S. major and regional airlines.

RQ5: To what extent, if any, does the rate of domestic airline safety events' probable causes per flight departure differ between U.S. major and regional airlines?

$H5_o$: Airline safety events probable per flight causes determinations do not differ between U.S. major and regional airlines.

$H5_a$: Airline safety events probable per flight causes determinations do differ between U.S. major and regional airlines.

Aviation history provided evidence of fewer U.S. domestic scheduled airline accidents per departure as the airline's history develops (Boeing, 2008). However, airline operation incidents and accidents continued to occur (Boeing, 2008). The complexity of the airline flight operations included numerous types of accidents and incidents (NTSB, 2008). If there were accident and incident rate differences between the regional and major airlines, possibly some of the differences can reveal safety improvement potential for the other airline group's flight operations.

Description of Research Design

The constructs of this airline safety study showed how the major and regional airlines might have significantly different numbers of accident and incidents. Each of these two airline groups' safety events was shown as a ratio to their respective flight departures. The airline safety variable statistics were downloaded via the Internet and then sorted into the dependent variables of regional and major airline groups. The first three of the research question dependent variables were accidents with losses of life, non-fatal accidents, and incidents data. An additional set of research question dependent variables were sorted to determine the safety events caused by pilot errors, and all other safety event probable causes. The safety events were sorted into the research question variables. The means for the airlines safety events were statistics calculated. The possible airline safety similarities and differences were shown in the answers to the five these research questions. The reliability of the study was affirmed in the consistency or repeatability of the study's measures and data (NTSB, 2009). The level of airline safety event measurement was a ratio or absolute zero level (Trochim, 2001).

The research design was indicate through the deductive reasoning of observation, questions, and then confirmation (Trochim, 2001). The research data included U.S. scheduled airline accidents and incidents from January 1982 through December 2008. A safety event sample was selected randomly from the safety event population. The descriptive statistics method of research was engaged in this airline safety study. Descriptive statistics can have research strengths and weaknesses. A potential weakness can be the assumptions behind the analysis. Poorly defined research assumptions or subjective variable measurements can enable erroneous conclusions (Trochim, 2001). Definitive study variables were strength for describing measured events (Creswell, 2003). The airline safety events in this study were clarified in the NTSB's definitions and they were measures of the domestic airline accidents or incidents. The NTSB trains each accident and incident evaluator in scientific methods of airline accident and incident investigation. The investigators completed their assigned task when they assign a probable cause to the accident or incident (About the NTSB, 2008).

Research validity was confirmed in the NTSB investigators use of NTSB standardized aviation definitions and the use of standardized accident and incident reporting forms. The NTSB accident and incident reporting form had 194 descriptive categories of information. Some of the factual data incorporated were the event location, event time, aircraft specific information, aircraft owner, operator, pilot information, flight plan, accident information, aircraft damage and occupant injury or fatality. The NTSB brief of the each safety event included a probable cause finding (NTSB, 2009).

The National Transportation Safety Board maintained an airline accident and incident history in a data request format (NTSB, 2008). The NTSB website request format enabled safety event location, date range, types of airline operation, category of aircraft, and so forth. Over the 27 years of this airline researched period, the two types of airlines operated a significantly different numbers of daily flights daily per year (BTS, 2008). Therefore, the airline accidents and incidents were addressed on a safety event departure rate per airline group. In addition, each airline type operated different size aircraft and the aircraft were manufactured by different aircraft builders (NTSB, 2009). However, the FAA has the oversight responsibilities of the aircraft manufacturers (FAA, 2008).

The National Transportation Safety Board determined a qualifying airline safety event as either an incident or an accident. The incidents were defined in the FAR definitions (FAR, 2008) and in definition of terms section of chapter one. The first research question showed the loss of life safety events rates for the US regional and major airline groups. An NTSB qualifying loss of life accident was an airline accident that has caused at least one death. The NTSB loss of life safety events can and did include loss of life by a person on the ground (NTSB, 2009).

The major and regional airlines' similarities of non-life loss accidents rates per flight departure were contrasted in RQ2. The NTSB separates the airline accident severities into the following three categories: serious, injury, and major damage. The severities descriptions were listed in an increasing order of event severity. The severity of each airline accident was documented in the NTSB accident and incident database (NTSB, 2009). The third research question contrasted the regional and major airlines airline incident per the respective group's flight departure.

The pilot error probable cause rates for each airline type were compared in the fourth research question. The NTSB Air Safety Investigators determine a probable cause for each airline's accidents or incidents. The probable cause is documented in the NTSB report. The seven potential probable cause categories were flight crew error, mechanical failure, weather, ATC, aircraft maintenance, and unknown or other causes. The frequency of non-pilot error probable causes or the remaining six probable causes of accidents or incidents was the focus of the fifth research question. The probable cause determinations were shown in the NTSB accident and incident documents (NTSB, 2009).

Operational Definition of Variables

The overall aim of this airline safety study was to compare safety events and probable causes between the U.S. domestic major and regional airlines. Principally researching and comparing the safety events that had developed into accidents and incidents for each group of airlines. The study quantified and measurable safety event variables were shown in this airline inquiry (Creswell, 2003). The variables of this study are available in NTSB accident and incident records. The NTSB investigates the scheduled airline safety events and their record the descriptions by the NTSB factual investigations (NTSB, 2009). The accident and incident variable definitions follow.

Air carrier accident. The safety event accident in question two were implemented to show the number of safety event accidents for each of the regional or major airline groups. To determine these dependent variables', the regional and major airline accident histories were retrieved from the NTSB's airline safety event records. The NTSB's airline histories contained sufficient airline event descriptions to determine the population of the safety event accident variables (NTSB, 2009). The scheduled domestic airlines event histories were defined in chapter one's definition of terms. The airline flight departures were retrieved from the Bureau of Transportation Statistics (BTS, 2008). The sum of the domestic air carrier qualifying accidents for each air carrier group was divided by the total number of that group's departures. The calculation provided a rate of each airline group's accidents per departure for that period, representing a ratio measurement of the data. The ratio derived for each airline group enabled descriptive statistics testing in response to each research question (Cozby, 2004).

Air carrier accident losses of life. The accident losses of life dependent variables in question three will be employed, thus, showing the number of losses of life accidents for each of the regional and major airline groups. To determine these dependent variables, the regional and major airline accident loss of life event histories were retrieved from the NTSB's airline safety event records. The NTSB's airline histories contained sufficient airline event descriptions to determine the population of the accident loss of life variables (NTSB, 2009). The scheduled domestic airlines event histories were defined in chapter one's definition of terms. The sum of the domestic air carrier qualifying loss of life accidents for each air carrier group was divided by the total number of that group's departures. The airline flight departures for the studied period will be retrieved from the BTS (2008). The calculation provided a rate of accident loss of life per departure for that period for each airline group, representing a ratio measurement of the data. The ratio derived for each airline group allowed descriptive statistics testing in response to research question three (Cozby, 2004).

Air carrier incident. The safety event incidents in question three were selected to show number of safety event tendencies for each of the regional and major airline groups. To determine these dependent variables, the regional and major airline incident histories were retrieved from the NTSB's airline safety event records. The NTSB's airline histories contained sufficient airline event descriptions to determine the population of the safety event incident variables (NTSB, 2009). The scheduled domestic airlines event histories were defined in chapter one's definition of terms. The sum of the domestic air carrier qualifying incidents for each air carrier group was divided by the total number of that group's departures. The airline flight departures for the studied period were retrieved from the BTS (2008). The calculation provided a rate of each airline group's incidents per departure for that period, representing a ratio measurement of the data. The ratio derived for each airline group allowed descriptive statistics testing in response to research question three (Cozby, 2004).

Air carrier safety event pilot errors. The safety event pilot errors in question five were chosen to show number of safety event pilot errors for each of the regional and major airline groups. The pilot errors were one of seven safety event probable causes (NTSB, 2009). Kebabjian's (2008) research suggests 52 percent of the domestic airline safety event probable causes are pilot error. The study separated the U. S. domestic airlines probable cause sources into regional and major airline safety events for airline group probable cause comparison. To determine these dependent variables, the regional and major airline pilot error histories were retrieved from the NTSB's airline safety event records. The NTSB's airline histories contain sufficient airline event descriptions to determine the population of the safety event pilot error variables (NTSB, 2008). The scheduled domestic airlines event histories were defined in chapter one's definition of terms. The sum of the domestic air carrier qualifying pilot errors for each air carrier group was divided by the total number of that group's departures. The airline flight departures for the studied period were retrieved from the BTS (2008). The calculation provided a rate of each airline group's pilot errors per departure for that period, representing a ratio measurement of the data. The ratio derived for each airline group facilitated descriptive statistics testing in response to research question five (Cozby, 2004).

Air carrier safety event. The safety event in question four were favored to show number of safety events as moderated by the existence of probable cause, for each of the regional and major airline groups. To measure this dependent variable, the regional and major airline safety event histories were retrieved from the NTSB's airline safety event records. The NTSB's airline histories contained sufficient airline event descriptions to determine the population of the safety event variable (NTSB, 2009). These scheduled domestic airlines event histories were defined in chapter one's definition of terms. The sum of the domestic air carrier qualifying safety events for each air carrier group was divided by the total number of that group's departures. The airline flight departures for the studied period were retrieved from the BTS (2008). The calculation provided a rate of each airline group's safety events per departure for that period, representing a ratio measurement of the data. The ratio derived for each airline group enabled descriptive statistics testing in response to research question four (Cozby, 2004).

Air carrier type. This independent variable in each question was selected as having a value of either regional or major airline type. The airline type was shown in the NTSB investigators' accident or incident reports (NTSB, 2008). Each airline type value was coded as either zero or a one, respectively. The airline type was a nominal measurement of data for research comparison (Cozby, 2004).

Description of Materials and Instruments

The primary research data materials were the NTSB recorded safety events and the BTS databases of individual airline flight departures. Each download encompassed January 1, 1982 through December 31, 2008. Next an Excel spreadsheet was used to record annual data of the study qualifying major and regional airline groups' accidents, incidents, and probable causes. Within the spreadsheet, the data was sub-divided into the five research questions and qualifying data was sorted to its qualified description. The samples of airline safety events and the probable causes were randomly chosen from the study qualified safety event population. Next the ordinary least squares (OLS) linear regression was used to process the sorted researched airline data to answer the five RQ.

Selection of Subjects

The contrast of U.S. major and regional airlines accident and incidents had not been formerly studied. The flight operations of the studied U.S. domestic airlines operations incorporated the contiguous 48 states, including the District of Columbia and San Juan. Alaska was excluded in the study because of the high accident and incident rate per flight departure. The high safety event rate was due in part to the frequency of low flight visibilities and frequent icing conditions (NTSB, 2009). Hawaii was excluded from the study because its flight operation characteristics are more similar to the international flight operations and its tropical weather conditions. There remained a representative sampling of U.S. domestic airlines for this airline accident and incident study.

The study qualifying domestic airlines consisted of four major airlines and 37 regional airlines. The study qualifying major airlines have been major airlines during the entire 27 years of the study; January 1982 through December 2008. The researched safety event population was the 1,391 U.S. major and regional accidents and incidents during the same period.

The study sample of 500 safety event observations were randomly selected from the NTSB reported 1,391 airline events population. Each observation gave safety event data from one airline group over a period of one year. The airline safety event population was made up of major and regional airline accidents, incidents, and probable causes. The flight safety data was taken from 27 years of airline history. The data was suitably distributed between the U.S. major and regional airline groups. The data includes the total number of departures per airline group and their number of safety events for each year. The events are categorized into fatal accidents, non-fatal accidents, incidents, pilot errors probable causes and all other errors. The NTSB investigators defined the accidents, incidents and their probable causes (NTSB, 2009).

Five research questions were used to determine the research subject particulars. The researched topics were the study qualifying airlines' fatal accidents, non-fatal accidents, incidents, and their probable causes. The probable causes were sorted into pilot errors and the remaining six probable causes described in the NTSB safety event reports. There was no selection of humans or interactions with human subjects.

Procedures

The safety events data was electronically retrieved from the NTSB's FAR Part 121 accident and incident database. The down loaded data included international, all cargo, and unscheduled or charter airlines. All these airline's safety events occurred while they were FAA authorized to operate under FAR Part 121. The study-qualifying major and regional airline groups were sorted out of this downloaded data. Another download of the FAR Part 135 regional airlines was necessary to show the regional accidents and incidents from January 1982 through the mid 1990s. After the mid 1990s regional airlines were required to operate under Part 121. To show their safety events as a ratio of respective departures, the two airline groups' frequency of flight departures was downloaded from the BTS website and sorted to their respective airline group (BTS, 2008). The data transfer was requested and retrieved electronically. The next step was the sorting of the airline safety event records into the 15 different categories of accident and incident descriptions. The study qualified dependent variables of the airline safety events were separated into one of the two airline groups; the study's independent variables. The statistical testing of these airlines group's data revealed their safety patterns and rates of accident and incident. The resulting airline statistics were tested with an ordinary least squares linear regression. This regression tested for each airline group's safety tendencies.

Discussion of Data Processing

The parametric method of statistical study was applied in this airline safety comparison. The OLS test model provided the statistical comparison and showed the major and regional airlines safety histories. The analysis of variance was the statistical method of making simultaneous comparisons between two or more determined means (Trochim, 2001). The OLS test method yields values that were testable to determine if a significant relationship exists between airline groups or the study's independent variables (Business Dictionary, 2008). The safety characteristics of the two airline types were compared for similarities and differences. The relatively low numbers of study qualifying airline accident and incidents still enabled a random sampling of the U.S. airline safety event data (Key, 1997).

The data for these study-qualified variables were downloaded from the NTSB database (NTSB, 2009). The next step was to sort the two airline groups' data and then sort the five research question's data for the two airline groups' data comparison. For a rate of safety event occurrence, the two airline groups' numbers of flight departures were retrieved from BTS (2008) and the safety events were proportioned to the group's number of departures in the millions. The OLS test of the airline safety data enabled a comparison of safety event categories and probable causes for the two U.S. air carrier types. The tabulated airline incident and accident records were sorted into the study's five research questions categories. The resulting categories of airline historical data were the number of human life loss events, the non-fatal accidents, incidents, pilot error probable causes, and the other probable causes. The five hypotheses were tested with the ordinary least square linear regression test. The OLS test results were expressed in the rejection of null hypothesis or rejection of the alternative hypothesis for each RQ.

Methodological Assumptions, Limitations, and Delimitations

The United States airline accidents and incidents have been investigated and evaluated by the NTSB accident investigators (NTSB, 2009). The U. S. Congress mandated NTSB to investigate each transportation accident and incident and then determine a probable cause. The NTSB records of airline accidents and incidents were numerical by design and provided a quantitative data source. Consequently, this aviation safety inquiry of public airline transportation safety history was a quantitative and descriptive research study. The NTSB non-experimental data was collected to compare the major and regional airline incidents and accidents between January 1982 and December 2008 (NTSB, 2009).

Ethical Assurances

The study of U.S. scheduled domestic airlines' accidents and incident employed the non-experimental records retrieved from the U.S. government's databases. Therefore, potential harm to human participants is nil (Trochim, 2001). The data were requested from the National Transportation Safety Board (2008) and the Bureau of Transportation Statistics (2008). The study adhered to the guidelines of the Institutional Review Board at Northcentral University and the ethical guidelines set forth by the American Psychological Association (2002). All the study information described in the research questions are presented in this document.

CHAPTER 4: FINDINGS

The airline research concentrated on the safety of the U.S. domestic scheduled airline flight operations. The U. S. major and regional airlines experienced 1,391 accidents and incidents between January 1982 and December 2008 (NTSB, 2008). The airline accidents have caused destruction of property, individual injury, and loss of life. Conversely, airline incidents were non-destructive by definition; however, it can potentially enlarge in classification to an accident (Turner, 2001). The purpose of this quantitative study was to determine, from historical data, if the major air carriers were more or less inclined to experience accidents and incidents than the regional air carriers. In a review of the available literature, a comparable study of the U.S. major and regional air carriers was not located. To this end, the quantitative analysis of the following research questions and hypothesizes were posed:

RQ1: To what extent, if any, does the rate of domestic airline accident losses of life per flight departure differ between U.S. major and regional airlines?

$H1_o$: Airline flight fatalities per flight do not differ significantly between U.S. major and regional airlines.

$H1_a$: Airline flight fatalities per flight do differ significantly between U.S. major and regional airlines.

RQ2: To what extent, if any, does the rate of domestic airline non-fatal accidents per flight departure differ between U.S. major and regional airlines?

$H2_o$: Airline non-fatal accidents per flight do not differ significantly between U.S. major and regional airlines.

$H2_a$: Airline non-fatal accidents per flight do differ significantly between U.S. major and regional airlines

RQ3: To what extent, if any, does the rate of domestic airline incidents per flight departure differ between U.S. major and regional airlines?

$H3_o$: Airline incidents per flight do not differ between significantly U.S. major and regional airlines.

$H3_a$: Airline incidents per flight do differ significantly between U.S. major and regional airlines.

RQ4: To what extent, if any, does the rate of domestic airline pilot errors per flight departure differ between U.S. major and regional airlines?

$H4_o$: Airline pilot errors per flight do not differ significantly between U.S. major and regional airlines.

$H4_a$: Airline pilot errors per flight do differ significantly between U.S. major and regional airlines.

RQ5: To what extent, if any, does the rate of domestic airline safety events' probable causes per flight departure differ between U.S. major and regional airlines?

$H5_o$: Airline safety events probable per flight causes determinations do not differ between U.S. major and regional airlines.

$H5_a$: Airline safety events probable per flight causes determinations do differ between U.S. major and regional airlines.

The five hypotheses were tested with the ordinary least square linear regression test. The test can be used to show the existence of similarities or differences among several population means (Aczel, 2002). For each null hypothesis, all five departure-safety event types were regressed on the major dummy and conditioning variables to the third degree. The null hypothesis is true when the linear regression has an alpha level of 5% or greater. An alpha level of less than 5% would confirm the alternate hypothesis.

Findings

The study's airline research population was retrieved from the archives of the U.S. National Transportation Safety Board records (NTSB, 2009). For the study, a 500 sample of observations were randomly selected from the population of 1,391 airline accidents and incidents. Each of the 27 years of safety event observations was separated into the major or regional airline groups as defined in chapter one. The flight safety data was taken from U.S. domestic major and regional airlines flight operation from January 1982 through December 2008. The researched major and regional airline groups' safety events were shown in ratio to the respective airline groups' flight departures for the studied period. The data includes the number of safety events for each year and the corresponding number of departures. The airline departures statistics were downloaded from the U.S. Bureau of Transportation Statistics (BTS, 2009). The studied years follow the deregulation of the U.S. airline industry (Deregulations of Act of 1978, 2008).

The safety event and departure frequency data were sorted between the study qualifying U.S. domestic scheduled major and regional airlines. The study qualifying major airlines operations were the U.S. domestic airlines that operated flights as major air carriers during each of the researched 27 years (BTS, 2008). The study qualifying major carriers were American Airlines, Delta Airlines, Northwest Airlines, and United Airlines. The regional qualifying airlines operations include the U.S. domestic flights of Air Illinois, Air West, Air Wisconsin, American Eagle, Aspen, Atlantic Southeast Airlines, Avair, Bar Harbor, Britt, Chaparral, Chautauqua, Cologan, Comair, Command, Commutair, Cape, Copa, Executive, Express, Freedom, GoJet, Great Lakes, Metro, Pinnacle, Piedmont, PSA, Mesa, Mesaba, Regions, Republic, Shuttle, SkyWest, Simmons, Trans States, and Wings West. The research data included all the safety events and the total number of departures for the two airline types beginning in January 1982 through December 2008.

The first three research questions separate airline safety events into three distinct sets of data. The three airline safety events were fatal accidents, nonfatal accidents, and incidents. The remaining two research questions showed separate sets of safety event probable causes. The fourth research question concentrates on the safety event pilot errors of the two airline groups. The last research question contains the remaining six types of safety event probable causes for airline groups' comparison. All the RQ safety events and probable causes were compared in a ratio to the respective airline group's flight departures. Table 1 shows the number of major and regional airline departures in the millions, the randomly selected safety events, and the safety event probable causes.

Table 1

Descriptive Statistics for the Study Variables by Airline Type

Variable	Total	Min	Max	Mean	SD
		Major Airlines			
Departures (millions)	45.930	1.803	5.400	3.674	0.938
Fatal Accidents	11	0	4	0.889	1.155
Non-Fatal Accidents	131	4	18	10.519	4.611
Incidents	203	3	34	16.259	7.669
Pilot Error	340	10	48	27.222	8.838
Safety Event Causes	76	1	14	6.111	3.523
		Regional Airlines			
Departures (millions)	33.043	0.588	5.122	2.643	1.633
Fatal Accidents	24	0	6	1.926	1.730
Non-Fatal Accidents	137	5	18	10.926	3.452
Incidents	138	2	22	11.000	5.385
Pilot Error	288	11	40	23.037	8.026
Safety Events Causes	95	1	18	7.593	5.063

Analysis and Evaluation of Findings

The two airline groups' accident and incident data were randomly sampled from the airline 27 years of safety event and probable causes populations. The least squares linear regression analysis tested for similarities and differences between the U.S. major and regional airlines' three types of safety events and two groups of probable causes. In each RQ, the airline group's linear table described the real-world airline safety events and their probable causes as defined in Appendix B. The regression line value for each RQ data was also plotted. The regression model dummy variables were used to differentiate between the two airline types and to moderate the impact of time. The least squares linear regression test was used to determine the applicable hypothesis of each RQ. The regression results for each RQ were presented in Tables 2 through 6. The regression results were discussed in the text following each table. The significance level of the RQ's null hypothesis affirmation was set at 5%. Therefore, when the significance level is less than 5%, the alternate hypothesis is favored.

Findings for RQ1

The RQ1's least squares linear regression results in Table 2 indicate that over time there was a significant regression towards fewer major airline fatal accidents. The regression results show the estimated coefficient for the each airline type. A significant regression was indicated particularly for the major airline, as confirmed by the positive beta estimate. The linear regression model analysis was calculated as a predictive value of 1.2% and then evaluated at the

5% predictive significance value. From the linear regression test, the results showed that there was a significant difference between the airline groups' number of fatal accidents. Therefore, RQ1 null hypothesis was rejected. The alternative hypothesis was favored. During the 27 years studied, it was determined that the U.S. major airlines have fewer fatality accidents per departure than the U.S. regional airlines.

Table 2

Linear Regression Test for Fatal Airline Accidents (RQ1)

Source	Beta	SE Beta	β Estimate
Time	-1.75	1.14	-0.34
$Time_2$	2.20	2.73	2.58
$Time_3$	-0.95	1.70	-2.16
Airline Type	0.34	0.11	0.52

Findings for RQ2

The airline non-fatal accidents' linear regression yielded a predictive value of 71.5 %, above the 5% significance level. The results show that there was a significant trend in the regression for the number of non-fatal airline accidents. A significant regression was indicated particularly for the major airline, as confirmed by the positive beta estimate. The null hypothesis was confirmed for RQ 2. Consequently, the test determined that during the research period, the non-fatality accidents per departure were similar for the U.S. major and regional airlines.

Table 3

Linear Regression Test for Non-Fatal Airline Accidents (RQ2)

Source	Beta	SE Beta	β Estimate
Time	-3.27	1.36	-1.68
$Time_2$	7.19	3.27	22.03
$Time_3$	-3.97	2.04	-23.50
Airline Type	0.05	0.13	0.20

Findings for RQ3

Research Question three's linear regression results below for the airline incidents comparison reveals a predictive value of 0.02%. The linear regression percent is notably below the research significance level of 5 %. Therefore, there was a noteworthy regression toward fewer incidents between the airlines groups over time, principally the major airlines. The significant difference was moreover indicated by the negative beta estimate. The linear regression test results showed that there was a significant difference in the number of incidents between the airline types, and consequently, the RQ 3 null hypothesis was rejected. The alternative hypothesis was favored and it was determined that the U.S. regional airlines have more incidents per departure than the U.S. regional airlines.

Table 4

Linear Regression Test for Airline Incidents (RQ3)

Source	Beta	SE Beta	β Estimate
Time	0.63	1.01	0.57
$Time_2$	-4.11	2.43	-22.06
$Time_3$	3.05	1.51	31.65
Airline Type	-0.37	0.10	-2.63

Findings for RQ4

The fourth RQ linear regression results in Table 5 show that there was a considerable regression towards fewer pilot errors probable causes between the airline groups. Although none of the regression coefficients was individually significant at the 5% level. A significant regression was indicated particularly for the major airline, as confirmed by the positive beta estimate. However, the linear regression test resulted in a 21.8% predictive level. Therefore, there was no significant difference in the number of pilot errors probable causes between the two airline types. Consequently, the alternate hypothesis was rejected for RQ 4. The study shows that the number of pilot errors probable causes per departure for the U.S. major airlines were similar to the U.S. regional airlines.

Table 5

Linear Regression Test for Pilot Errors (RQ4)

Source	Beta	SE Beta	β Estimate
Time	-0.24	1.08	-0.13
$Time_2$	-1.83	2.58	-6.09
$Time_3$	1.51	1.61	9.72
Airline Type	0.17	0.11	0.74

Findings for RQ5

Research question five's linear regression results were represented in Table 6, and the linear regression calculation indicates there was 7.4% regression probability towards fewer other safety events probable causes. Particularly for the major airlines, as indicated by the negative beta estimate and a significance level set at 5%. The linear regression test results indicated that there was no significant difference in the number of other safety events probable causes between the airline types. Consequently, RQ 5's null hypothesis was confirmed. The 27-year study indicates that the number of other safety events probable causes per departure for the U.S. major airlines were similar to the U.S. regional airlines.

Table 6

Linear Regression Test for Safety Event Errors (RQ5)

Source	Beta	SE Beta	β Estimate
Time	-1.72	1.12	-1.88
Time$_2$	0.86	2.69	5.66
Time$_3$	0.50	1.67	6.29
Airline Type	-0.24	0.11	-2.10

Summary

A few of the U.S. domestic major and regional airline flights were involved in operational accidents and incidents during the last three decades (NTSB, 2009). A potential source of flight safety improvement ideas may result from determining the major and regional airlines' safety event similarities and differences. Five research questions were constructed to indicate the two airline groups' safety similarities or differences. This airline safety research encompassed the most recent 27 years of U.S. domestic scheduled airline accidents and incidents history. These airline safety events were retrieved from the NTSB transportation safety archives.

The first two RQ showed the frequency of accident contrasts in the major and regional airlines flight operations. The accidents in the study were separated into fatal and non-fatal. RQ1 compared the airline groups' fatal accidents and RQ2 compared the non-fatal airline accidents of the groups. The third RQ encompassed the remainder of the airline safety events, contrasting the incidents frequencies per group. These incidents were categorized as safety events without human fatality, human injury or aircraft physical damage. The next two questions showed the airline groups' differences in the accident and incident probable causes. The pilot error probable causes were separated from the other six and contrasted in the RQ 4. The fifth RQ evaluated the airline groups' differences of the remaining six safety event probable causes. The fifth RQ probable causes sources included: Air Traffic Control, maintenance, mechanical, weather, other and unknown causes.

The least squares linear regression statistical test was applied in this study. It was designed to show the probable differences among random samples of the two or more groups. The two airline groups in this study were randomly sampled from the airline safety events and probable causes populations. The linear regression test of the major and regional airlines indicated two RQ null hypotheses were rejected in favor of the alternate hypothesis. The other three RQ null hypotheses were confirmed. First, the two affirmed alternate hypothesis were the comparison of the US major and regional airlines' fatal accidents and incidents. Their probability factors were 1.2% and 0.05% respectively and they were less than the 5% significance level. Consequently, the fatal accidents and all incidents of the airline groups were dissimilar. The U.S. domestic major airlines have significantly less fatal accidents and non-destructive incidents per departure than the U.S. domestic regional airlines.

The linear progression calculations for the non-fatal accidents were 71.5%, the probable causes were 21.8%, and the six other probable causes were

7.4% significance levels. Consequently, all RQ 2, 4, and 5 favored their null hypotheses. These three RQ compared the non-fatal accidents and both safety event probable cause RQ.

The linear regression test of the U.S. domestic airlines' safety events and probable causes indicated the airline groups had both similarities and differences. The safety statistics of the randomly selected airline groups' probable causes and non-fatal accident rates were statistically similar. The research finding shows the rate of the major airlines fatal accidents and incidents were less than the regional airlines. Consequently, the major airlines may be considered a safer flight operation than the regional airlines.

CHAPTER 5: IMPLICATIONS, RECOMENDATIONS, AND CONCLUSIONS

The United States domestic major and regional airline safety histories were contrasted in this study. The study of both airline groups encompassed their flight accidents, incidents, and the safety events' probable causes. The research revealed some of the complexities of operating transport aircraft within the limited domestic airspace and the flight crew's need to avoid natures' meteorological hazards. Added to these airspace and weather operational constrictions were the aircraft mechanical problems and an occasional pilot situational disorientation (Kern, 1996).

The United States domestic flight transportation system had more than 28,000 scheduled airline departures per day in 2008 (BTS, 2008). The regional airline flights carried more than one of every five domestic airline passengers during 2007 (Regional Airline Association, 2008). Most of the flight safety challenges of these airline operations have been safely met or resolved; as a result, many airline incidents and accidents have been avoided (Boeing, 2008). However, on 1,391 occasions throughout the last 27 years of U.S. domestic scheduled airline operations, the airline flight safety challenges have developed into aviation accidents, incidents, and their resulting statistics (NTSB, 2009).

The objective of this airline safety event study was to show the safety histories of the U.S. domestic major and regional airline's flight operations. This research determined whether the two airline groups' safety event and their probable causes were statistically similar or dissimilar. To determine the safety event similarities or dissimilarities, five research questions were constructed, researched, analyzed and evaluated. The researched airline accidents and incidents occurred during the 27 years from January 1982 through December 2008.

The United States domestic major and regional airlines safety records were studied for their respective airline group's accident and incident frequencies. The international flight operations of both airline groups were excluded from the study because few of the regional airlines operated international passenger service. The studied domestic flight operations took place in the 48 contiguous United States of America and Porto Rico. Alaska's safety events were excluded because of the high accident rate in bush flying operations, numerous icing conditions and frequent low visibilities. Hawaii's safety events were withheld from the study because of their relatively uneventful flight operations (NTSB, 2009). The study qualifying scheduled airlines' safety event histories were available from the NTSB's airline accident and incident investigation records. The airline safety event investigations and the resulting records have high validity because the NTSB is responsible to the U. S. citizens through the U. S. Congress (NTSB, 2009).

The study qualifying domestic airlines consists of four major and 37 regional airlines. The major airlines began their flight operation during the late 1920s and early 1930s (Pachis, 1982). However, the regional flight operations began in the1960s, under CFR Part 135. The Part 135 flight operational rules were a less safety challenging set of aviation regulations than the current CFR Part 121 (FAA, 2009). The regional airlines continued their flight operation under

CFR Part 135 until the mid 1990s, when they were required by the FAA to be recertified and operate in compliance with CFR Part 121 (FAA, 2009). Thus, by the mid 1990s both airline groups were operating under the same regulations.

Another operational difference of the airline groups was the size of aircraft each group operates. The regional airlines consistently flew the smaller aircraft of the two groups and this flight equipment difference was represented in the range of aircraft seating capacity. The regional airplane seats ranged from two to 70 seats (RAA, 2008). Within the studied period, the major air carriers operated aircraft with approximately 70 to 416 passenger seats (The Travel Insider, 2008).

The two airline groups also have a history of different numbers of flight departures. The total departures were particularly different in the early 1980s, because many of the current regional airlines had began flight operations after the U.S. Congress deregulated the U.S. airlines in November 1978 (BTS, 2009). However, when considering a flight operation comparison of the major and regional airline safety events, the ratio of safety events per departure was useful.

The focus of the study was the flight safety similarities and differences of the U. S. two domestic airline groups. The NTSB (2009) safety event database was the study's source of the airlines' safety history. These NTSB airline safety event records contained the event date, location, safety event severity, the FAR the airline operated under, make and model of the flight vehicle, and the probable cause source of the accident or incident. During this research, there was no selection or interactions with human subjects.

The research methodology focused on the logical way the study reveals the historical information pertinent to the research questions. The airline safety event data method worked from the general to the more specific or deductive reasoning. The study began with the idea that one of the airline groups may have a lower accident rate than the other airline group. The concept of safety differences was the focus of the five researchable hypotheses. These five hypotheses were tested with the least squares linear regression test. As the numbers of each airline group's safety events were sorted and measured, each hypothesis was tested for a null or alternative hypothesis result (Trochim, 2001).

The research questions showed the major and regional airlines accident and incident histories in five RQ. The ratio of safety events per flight departure applied to each airline group's operational statistics. The first RQ compared the two-airline group's history of accidents; the accidents that caused at least one human death. Each of the two-airline group's fatal accident samples for the studied periods was proportioned to its respective flight departures. The resulting ratio was shown in chapter four to answer the first RQ of safety event similarities or dissimilarities. The second RQ compared each of airline group's non-fatal accidents during the same period. The third RQ compared the airline group's incidents or the non-fatal and non-destructive safety events.

Research questions four and five were designed to compare the respective airline groups' safety events probable causes. The NTSB defined the seven probable causes of the airline accidents and incidents. The probable causes were pilot decision or action errors, aircraft component mechanical failures, airline maintenance mistakes, Air Traffic Control (ATC) personnel errors, metrological caused safety events, other causes and unknown accident and incident causes. The NTSB investigated each airline safety event and determined its probable cause (NTSB, 2009). The NTSB investigators determined safety event probable causes. In this study the probable causes were separated into pilot errors in RQ four and the remaining six accidents and incidents probable causes were combined into RQ five. Each of the airline group's five RQ comparisons were compared as a ratio of the accidents, incidents, or probable causes to the respective airline group's number of departures in the millions. The studied 27-year period followed the implementation of the Airline Deregulation Act of 1978 (Library of Congress, 2009).

The ordinary least squares linear regression (OLS) was employed to test each hypothesis. This linear regression test was developed as a descriptive and qualitative research method (Trochim, 2001). The U. S. major and regional airlines statistics were compared on flight departure ratio of the respective airline group. The airline comparisons included losses of life accidents, non-fatal accidents, incidents, safety event pilot errors, and remaining six safety event probable causes. The study's constructs supported the research plan validity (Trochim, 2001). The reliability of the study is affirmed in the consistency or repeatability of the study's measures (NTSB, 2008). The level of airline accident and incident measurement is a ratio or an absolute zero level (Trochim, 2001).

The airline data transfer was requested and achieved electronically. The next step was the sorting of the airline safety records into the 15 different categories of accident and incident descriptions. These descriptions were sorted into the one of the five suitable RQ. To produce a rate of accident and incident comparison, the statistics of the domestic scheduled major and regional airline departures were retrieved from the U.S. Bureau of Transportation Statistics (BTS, 2008). The statistical testing of this data revealed safety patterns and rates of accidents and incidents for each airline group. The independent variables of the two basis groups of airlines were separated into one of the qualifying major and regional airline groups.

Five hundred airline accident and incidents were randomly sampled from the population of 1,391 study qualifying airline safety events (Key, 1997). The airline safety research used the OLS linear regression testing. It is a statistical method of making simultaneous comparisons between two or more means (Trochim, 2001). The linear regression statistical research method yields values that can be tested to determine if a significant relation exists between the study variables (Business Dictionary, 2008). The linear regression characteristics of the two airline types were compared for flight safety similarities and differences. Consequently, this aviation safety inquiry of public airline transportation statistics used quantitative and descriptive research methods.

The first two RQ compared the frequency of the U.S. major and regional airlines' accidents. The accidents in the study RQ were divided into fatal and non-fatal. RQ1 compared the airlines' fatal accidents and the second RQ compared the non-fatal airline accidents of the airline types. The third RQ encompassed the remainder of the airline safety events, contrasting the incidents of the two airline groups. The incidents were characterized as safety events without human fatality, human injury or aircraft substantial damage. The next two questions showed the airline groups' differences in the accident and incident probable causes. The pilot error probable causes were separated from the other six and studied in the RQ 4. The fifth RQ considered the airline groups' differences in the remaining six probable causes. The RQ 5's probable causes included; Air Traffic Control, maintenance, mechanical, weather, other and unknown causes.

The statistical test applied in this study was the OLS linear regression. It was designed to show the similarities or differences among samples of the two groups. The two airline groups in this study were randomly sampled from the airline safety events and probable causes populations. The linear regression test of the major and regional airlines indicated two of the five RQ null hypotheses were rejected in favor of the alternate hypothesis. The other three RQ null hypotheses were affirmed.

First, the two affirmed alternate hypothesis were the comparison of the U.S. major and regional airlines' fatal accidents and incidents. These two safety event characteristics tested dissimilar using the least square linear regression. The U.S. domestic major airlines have significantly less fatal accidents and non destructive incidents per departure than the U.S. domestic regional airlines.

The three remaining RQ favored their null hypotheses. The RQ compared the non-fatal accidents and the safety event probable causes. The linear regression of RQ2 favored the similarity of the two airline group's non-fatal accidents. In RQ four, the pilot error probable causes were separated from the remaining six safety event probable causes. These six remaining probable causes were described in RQ five. However, the linear regression test of RQ four and five shows all seven probable causes of the safety events per airline group's departures have statistically occurred at a similar rate.

The linear regression test of the U.S. domestic major and regional airlines' safety events and probable causes indicated both similarities and differences. The similar safety statistics of the randomly selected airline groups' probable causes and non-fatal accident rates were shown. The overall finding was the rate of the major airlines fatal accidents and incidents were less than the regional airlines. Consequently, the major airlines may be considered a safer flight operation than the regional airlines.

Implications

The studied U.S. domestic airlines have 28,000 departures per day in 2008 (BTS, 2009). The overall finding was that rate of the major airlines fatal accidents and incidents were less than the regional airlines. Consequently, the major airlines may be considered a safer flight operation group than the regional airlines. It is possible and feasible to improve the U.S. domestic airlines flight safety. The regional airlines will be the primary focus of the recommendations to follow.

The imperfections of the human investigators can affect the accident and incident facts. Also, the investigation has to occur after the safety event occurs and before the crash or incidents materials can be modified. The event evidence may be modified before the civil jurisdiction or NTSB investigation team arrives on the scene. These investigation limitations potentially erode the documentation quality of the post-safety event facts. The aviation industry can to strive to make the most of all safety information sources, thus, benefiting the traveling public's safety.

Recommendations

The following recommendations are presented in an effort to improve all airline safety and especially the U.S. domestic regional airlines. The literature review in chapter two can be further searched for human ideas to improve the U.S. airlines' future safety. These airline study's safety improvement recommendations are pertinent to three segments of aviation: the consumer, the airline industry, and scholarly research.

Recommendations for the consumer. The most available and simplest airline safety information sources available to the public are newscasts and periodicals. These reports are generally presented following a major accident. However, most non-fatal accidents and incidents information is only made available to the flying public through personal research. The consumer could self inform themselves through their local library or Internet searches. Information is readably accessible to the public; airline safety information is available and can be found by those individuals who will search for answers to their questions (eHow, 2009).

Recommendations for the Airline industry. The airline safety research shows the safety event histories of the U.S. air carrier types have significant operational accident and incident differences. The further airline industry research of the regional airline employee hiring policies may show trends of safety detractions in the regional airline industry. Another safety research possibly is some aircraft operated by the regional airlines may not be manufactured within the transport regulations or transport safety oversight.

The third recommendation is to study the Aviation Safety Reporting System (ASRS) for airline safety improvements. The National Aeronautical Space Administration (NASA) provided this database of volunteer aviation safety reports. This industry wide reporting program is available for research from National Aeronautics and Space Administration (NASA, 2008). A fourth recommendation for possible study is the regional airlines' flight crewmembers' flight experience and education. This possible crewmember flaw may show potential Human Resources policy changes. Potential changes may enhance airline flight safety.

Recommendations for the further research. A potential safety improvement source may be to survey the government's airline oversight personal. The surveys could be prepared and sent to the first line federal regulation enforcement personnel. The potential airline safety improvements may not be addressed sufficiently during the airline regulations enforcement process.

A survey designed to protect the privacy and venerability of the FAR regulation enforcement personnel may indicate some additional safety improvement ideas. The priority or focus of the study should be the safety improvement of U. S. public transportation.

Another part of airline industry to study may be the possible differences between some airlines operational methods. A future study could separate the airline safety data into individual years. Comparing the individual safety events may show safety improvements that can be traced to the policies of one or more of the individual airlines. Safety patterns could be analyzed for safety improvements and implementation of feasible safety policies within other air carriers.

The third research recommendation is related to the regional airlines' fatalities history. Separating and researching the individual regional airline's fatalities over a number of operational years may reveal safety patterns. The airline industry may be a source of potential flight safety research for flight safety improvement. A fourth research possibility to study is the NTSB documented contributing probable causes. The study of probable and contributing causes of airline accidents and incidents may reveal effective safety improvement changes. A fifth focus of research into the regional airline incidents and possible ways to reduce their occurrence may provide safety improvements. As referenced earlier in this manuscript, many incidents enlarge into accidents (Boeing, 2008). Determining trends and designing incident reduction may contribute to safer air transportation.

A sixth future research consideration is a more specific safety event viewpoint. The National Transportation Safety Board's records show a reduction of accident and incident rates in both regional and major airlines over the past 27 years. Additional airline safety research comparing annual accident rates per all air carriers may reveal safety differences for either or both airline groups. The study of individual airline's accident and incident rates may potentially determine safer flight operations methods. When a testable safety difference is determined, the comparison of operational policies or Standard Operating Procedures (SOP) may reveal areas of potential safety improvement for some additional air carriers.

A seventh airline study consideration could investigate regional airlines safety history during their operation under FAR Part 135: prior to mid 1990's. Comparing the post 1990's safety events with the earlier operations period may yield reasons for flight safety improvements. A potential safety improvement example could be that the regional airlines that operate nine or less seat capacity aircraft and operate turboprop aircraft that are exempt from the more regulated Part 121 flight services (Wells & Rodrigues, 2003). This additional research could show whether the change to a more regulated FAR 121 influenced a safer domestic regional air carrier service. The NTSB accident and incident records could be used as the primary historical data source.

Conclusions

During this airline groups study, the five RQ compared with the linear regression test, the U.S. domestic major and regional airline safety events: the fatal accidents, non-fatal accidents, all airline incidents and their probable causes. The airline groups' history of nonfatal accidents and the safety event probable causes statistically tested as similar in occurrence per frequency of flight departure. However, the linear regression comparison of the airline accident with at least one fatality and the entire investigated incidents indicated a significant difference in the two airline group's safety. Both human-fatal accidents and all incidents of the regional airlines had a significantly higher rate of safety event occurrences. Therefore, during the study period of January 1982 through December 2008, the US scheduled domestic accidents and incidents per departure of the U.S. domestic major airlines are significantly safer than the U.S. domestic regional airlines.

Over the 27 years of this airline study, the operational safety has improved (NTSB, 2009). The regional airlines for the first five years of the study experienced 18 fatal crashes. The last five years of the study, the regional airlines fatal accidents were reduced to three. The major airlines experienced one fatal accident in the first five years and one fatal accident in the most recent five years. Both airline groups have increased their departure frequencies (BTS, 2008). Airline safety has room for improvement.

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APPENDIXES

Appendix A

Aviation Glossary

Accident – an occurrence associated with the operation of an aircraft where because of the operation of an aircraft, any person (either inside or outside the aircraft) receives fatal or serious injury or any aircraft receives substantial damage. The occurrence is also not caused by the deliberate action of one or more persons and that leads to damage or injury. The NTSB divides accidents into four categories: major, serious, injury, and damage.

1. Major - an accident in which a 14 CFR 121 aircraft was destroyed, there were multiple fatalities, or there was one fatality and a 14 CFR 121 aircraft was substantially damaged.
2. Serious - an accident in which there was either one fatality without substantial damage to a 14 CFR 121 aircraft, or there was at least one serious injury and a 14 CFR121 aircraft was substantially damaged.
3. Injury - a nonfatal accident with at least one serious injury and without substantial damage to a 14 CFR 121 aircraft.
4. Damage - an accident in which no person was killed or seriously injured, but in which any aircraft was substantially damaged.

ADA of 1978 – Airline Deregulation Act of 1978; United States Congress deregulated the U. S. airlines. The stated goals of ADA included:

(1) The maintenance of safety as the highest priority in air commerce.
(2) Placing maximum reliance on competition in providing air transportation services.
(3) The encouragement of air service at major urban areas through secondary or satellite airports.
(4) The avoidance of unreasonable industry concentration which would tend to allow one or more air carriers to unreasonable increase prices, reduce service or exclude competition;
(5) And the encouragement of entry into air transportation markets by new air carriers, encourage the entry into additional markets by existing air carriers, and the continued strengthening of the smaller air carriers.

ADAM- Aircraft Discrepancy Analysis Metrics developed by Department of Aviation Technology at Purdue University as a flight safety enhancement instrument.

AIDS – Accident / Incident Data System – The FAA's Aviation Data Systems Branch is responsible for the collection, storage, and distribution of aviation safety data.

ASM - This refers to how many seat miles were actually available for purchase on an airline. If none of the seats on the plane is sold, then the ASM indicates the overall airline seat capacity.

ASRS -The Aviation Safety Reporting System, or, is a voluntary system that allows pilots and other airplane crew members to confidentially report near misses and close calls in the interest of improving air safety. The confidential and independent nature of the ASRS is the key to its success, since reporters do not have to worry about any possible negative consequences of coming forward with safety problems. The ASRS is run a neutral party the NASA. Moreover, it has no power in enforcement. The success of the system serves as a positive example that is often used as a model by other industries seeking to make improvements in safety.

ATA - The Air Transport Association is a trade organization of the largest U. S. airlines. The ATA was formed in 1936 and it is headquartered in Washington, D.C. ATA numbers are used to identify parts of an aircraft in a standard way.

ATC - Air Traffic Control - A service operated by the DOT/FAA authority to promote the safe, orderly, and expeditious flow of air traffic.

BTS - The Bureau of Transportation Statistics - The part of the United States Department of Transportation that collects, compiles, analyzes, and makes accessible information on the nation's transportation systems. BTS improves the quality and effectiveness of DOT's statistical programs through research, development of guidelines, and promotion of improvements in data acquisition and use.

CAT - Clear-Air Turbulence is unreliable rapid vertical movement of air that is mostly unpredictable. CAT is generally associated with 50 knots or faster air moving horizontally at the higher altitudes.

CFIT - Controlled Flight into Terrain describes an accident whereby an airworthy aircraft, under pilot control, inadvertently flies into terrain, an obstacle, or water. Boeing engineers developed the term in the late 1970s. The pilots are generally unaware of the danger until it is too late. Pilots with any level of experience, even highly experienced professionals, may commit CFIT. Pilot fatigue or disorientation may play a role. The incidents often involve impact with significantly raised terrain such as hills or mountains, and may occur in conditions of clouds or otherwise reduced visibility. CFIT often occurs during aircraft descent to landing, near an airport. CFIT may be associated with equipment malfunction. If the malfunction occurs in a piece of navigational equipment, it may mislead the crew into improperly guiding the aircraft despite other information received from all properly functioning equipment, or despite clear sky visibility that should have allowed the crew to easily notice ground proximity. In other cases, the usually minor malfunction does not affect the overall airworthiness of the plane, but may distract the crew from properly guiding the plane.

Commuter Airline - An air carrier operator operating under 14 CFR 135 that carries passengers on at least five round trips per week on at least one route between two or more points according to its published flight schedules that specify the times, day of the week, and places between which these flights are performed. The aircraft that a commuter operates has 30 or fewer passenger seats and a payload capability of 7,500# or less operated by the appropriate authority to promote the safe, orderly, and expeditious flow of air.

CRM - Crew (or Cockpit) Resource Management training originated from a NASA workshop in 1979 that focused on improving air safety. The NASA research presented at this meeting found that the primary cause of the majority of aviation accidents was human error, and that the main problems were failures of interpersonal communication, leadership, and decision making in the cockpit. A variety of CRM models have been successfully adapted to different types of industries and organizations, all based on the same basic concepts and principles. It has recently been adopted by the fire service to help improve situational awareness on the fire ground.

CVR - Cockpit Voice Recorder is a flight recorder used to record the audio environment in the flight deck of an aircraft for the purpose of investigation of accidents and incidents. This is typically achieved by recording the signals of the microphones and earphones of the pilot's headsets and of an area microphone in the roof of the cockpit. Where an aircraft is required to carry a CVR and utilizes digital communications the CVR is required to record such communications with air traffic control unless this is recorded elsewhere. It is at present a requirement that the recording duration is a minimum of thirty minutes, but it is recommended that it should be two hours.

DM - Decision-making is the cognitive process leading to the selection of a course of action among variations. Every decision-making process produces a final choice. It can be an action or an opinion. It begins when we need to do something but do not know what. Therefore, decision-making is a reasoning process that can be rational or irrational, and can be based on explicit assumptions or tacit assumptions. Common examples include shopping, deciding what to eat, when to sleep, and deciding whom or what to vote for in an election or referendum. Decision-making is said to be a psychological construct. This means that although we can never "see" a decision, we can infer from observable behavior that a decision has been made. Therefore, we conclude that a psychological event that we call "decision making" has occurred. That is, based on observable actions, we assume that people have made a commitment to affect the action. Structured rational decision-making is an important part of all science-based professions, where specialists apply their knowledge in a given area to making informed decisions. For example, medical decision-making often involves making a diagnosis and selecting an appropriate treatment. Some research using naturalistic methods shows, however, that in situations with higher time pressure, higher stakes, or increased ambiguities, experts use intuitive decision making rather than structured approaches, following recognition primed decision approach to fit a set of indicators into the expert's experience and immediately arrive at a satisfactory course of action without weighing alternatives.

DOT - Department of Transportation of the United States is the most common name of the government agency devoted to transportation. It oversees interstate travel. All U. S. states and many local agencies also have similar organizations.

EFIS - Electronic Flight Instrument System is a flight deck display system presenting flight information including command from FMC and real-time information such as attitude, heading, position, planned route and flight track, etc. It is composed of EADI (Electronic Attitude Display Indicator) and EHSI (Electronic Horizontal Status Indicator), or on some aircraft PFD (Primary Flight Display) and ND (Navigation Display). Either displays lateral or vertical flight information. FMS is not an FMS component, though it is an important interface between FMS and pilots.

Enroute Air Traffic Control Services - Air traffic control services provided aircraft separation on IFR flight plans, generally by radar centers, when these aircraft are operating between departure and destination terminal areas. When equipment, capabilities, and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft traffic.

FAA - The Federal Aviation Administration is an agency of the United States Department of Transportation with authority to regulate and oversee all aspects of civil aviation in the U. S. The Federal Aviation Act of 1958 created the group under the name "Federal Aviation Agency," and adopted its current name in 1967 when it became a part of the United States Department of Transportation.
The Federal Aviation Administration's major roles include:

(1) Regulating U. S. commercial space transportation
(2) Encouraging and developing civil aeronautics, including new aviation technology
(3) Regulating civil aviation to promote safety
(4) Developing and operating a system of air traffic control and navigation for both civil and military aircraft
(5) Researching and developing the National Airspace System and civil aeronautics
(6) Developing and carrying out programs to control aircraft noise and other environmental effects of civil aviation

FAR - Federal Air Regulations

- FAR Part 91 - General Aviation (portions apply to all operators)
- FAR Part 119 - Certification: Air Carriers and Commercial Operators
- FAR Part 121 - Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft Domestic operation Any scheduled operation conducted by any person operating any turbojet powered airplanes, or airplanes having a passenger-seat configuration of more than 9 passenger seats, excluding each crewmember seat, or airplanes having a payload capacity of more than 7,500 lb. at the following

locations between any points within the 48 contiguous states of the United States.
FAR Part 135 - Air Taxi Operators and Commercial Operators
FAR Part 141 - Pilot School

FDR - Flight Data Recorder is a flight recorder used to record specific aircraft performance parameters. A separate device is the cockpit voice recorder (CVR), although some versions (including the original) combine both in one unit. Popularly, though usually falsely, known as the black box used for aircraft mishap analysis, the FDR is also used to study air safety issues, material degradation, and jet engine performance. These FAR regulated "black box" devices are often used as an aid in investigating aircraft mishaps, and its recovery is second only in importance to the recovery of victims' bodies. The device's shroud is usually painted bright orange and generally located in the tail section of the aircraft.

Ferry Flight- A flight for the purpose of:
(1) returning an aircraft to base
(2) Delivering an aircraft from one location to another;
(3) Moving an aircraft to and from a maintenance base

FL - Flight Level - A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet—flight level 250 represents a barometric altimeter indication of 25,000', flight level 255 and indication of 25,500'.

Flap - A movable, usually hinged airfoil set in the trailing edge of an aircraft wing, designed to increase lift or drag by changing the camber of the wing or used to slow an aircraft during landing by increasing drag

Flare - A maneuver performed moments before landing in which the nose of an aircraft is pitched up to minimize the touchdown rate of speed.

Flight Envelope - An aircraft's performance limits, specifically the curves of speed plotted against other variables to indicate the limits of speed, altitude, and acceleration that a particular aircraft cannot safely exceed or be less than.

Flight Plan - Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an FSS or an ATC facility.

Flight Safety Foundation - An independent, nonprofit, international organization engaged in research, auditing, education, advocacy, and publishing to improve aviation safety. The Foundation's mission is to pursue the continuous improvement of global aviation safety and the prevention of accidents. The Foundation's objectives are to: (1) Pursue the active involvement and participation of the diverse elements of global professional aviation; (2) Anticipate, identify and analyze global aviation safety issues and set priorities; (3)

Communicate effectively about aviation safety; and, (4) Be a catalyst for action and the adoption of best aviation safety practices.

FMS - Flight Management System is the database with navigation, aircraft performance and center of gravity information that the pilots can input and request EFIS presentation of requested navigation information. If FMC is taken as the "head" of the system that does the calculation and gives out command, the AFS; Auto Flight System is the system who accomplishes it. AFS is composed of AFDS (A/P-Autopilot-F/D-(Flight Director) and A/T-(Auto throttle).

FMC - Flight Management Computer is the core of FMS that works as a head of the whole system. Its primary function is to give out real-time lateral navigation information by showing the route programmed by the pilots, as well as other pertinent information from the navigation database, such as standard departure, airways, and arrival procedures. This information combined with the location of the aircraft creates a moving map display. The FMC calculates performance data and predicted vertical profile. The calculations are based on weight of the aircraft, cost index and cruise altitude, preferably with predicted wind. FMC calculates a most fuel-efficient vertical path that AFS would follow if AFS were engaged and both of vertical navigation and Lateral navigation are engaged.

FMS - A flight management system is a computerized avionics component found on most commercial and business aircraft to assist pilots in navigation, flight planning, and aircraft control functions. It is considered to be composed of three major components: FMC (Flight Management Computer), AFS (Auto Flight System), and Navigation System including IRS (Inertial Reference System) and GPS.

FSS - Flight Service Station - Air traffic facilities which provide pilot briefing, enroute communications and VFR search and rescue services, assist lost aircraft and aircraft in emergency situations, relay ATC clearances, originate Notices to Airmen, broadcast aviation weather and NAS information, receive and process IFR flight plans, and monitor navigation aids. In addition, at selected locations, FSSs take weather observations, issue airport advisories, and advise Customs and Immigration of transborder flights.

Glass Cockpit - The aircraft's control cabin has all-electronic, digital, and computer-based, instrumentation.

GPS - Global Positioning System is a satellite-based navigation system.

Green Light - A carryover expression from days when aircraft for the most part had no radios, and communication from a control tower was by means of a light-gun that beamed various green, red, and yellow signals to pilots in the air and on the ground. Each ATC tower control has this light gun available to communication to an aircraft's with radios is inoperative.

Gross Weight - The total weight of an aircraft when fully loaded for takeoff and limited by aircraft structural, engine performance, takeoff or landing runway length, and runway contamination (slush, ice, or snow).

Ground Control - Airport tower control, normally administered by radioed instructions from air traffic control to coordinated aircraft ground movements.

GS - Glide Slope is:
(1) The angle between horizontal and the glide path of an aircraft.
(2) A tightly-focused radio beam transmitted from the approach end of a runway indicating the minimum approach angle that will clear all obstacles; one component of an instrument landing system (ILS).

IFR - Instrument Flight Rules- governing flight under instrument meteorological conditions (IMC).

ILS - Instrument Landing System- A ground based navigation system enabling

ILS - equipped aircraft to receive radio signals from a runway location. An ILS is categorized as a precision approach to a runway because it provides vertical navigation in relation to the runway-landing zone in addition to lateral navigation of non-precision runway approaches. The clouds may be as low as 200 feet above the runway and as low a one-half statute mile visibility (600 feet horizontal visibility and zero ceiling with special aircraft and ground equipment and pilot qualifications).

IMC - Instrument Meteorically Conditions - Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than minima specified for visual meteorological conditions (VMC).

Incident - An occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operations.

LOSA - Line Operation Safety Audit - Funded through a grant from the Federal Aviation Administration Human Factors Division, AAR-100, and the research project has been involved in the study of crew performance during normal flight operations since 1994. The methodology we have developed, called the Line Operations Safety Audit (LOSA), utilizes trained observers riding in cockpit jump seats to evaluate several aspects of crew performance. At the core of the LOSA, process is a model of threat and error management, which provides a framework for data collection. In-flight observers record the various threats encountered by aircrew, the types of errors committed, and most importantly, they record how flight crews manage these situations to maintain safety. Our observers also collect data on CRM performance and conduct a structured interview to ask pilots for their suggestions to improve safety. These combined data sources provide the airline conducting the LOSA with a diagnostic snapshot of safety strengths and weaknesses in normal flight operations. On the research end, the large LOSA dataset maintained by the University of Texas Human Factors Research Project, which allows the study of crew performance issues across a number of different airlines within the commercial airline industry.

Navigation System -An aircraft navigation system is mainly composed of IRS (Inertial Reference System) or AHRS (Attitude Heading and Reference System) and GPS (Global Positioning System), as well as existing physical land based NAVAIDs such as VOR-DME. The IRS or AHRS provides raw information that is crucial to flight, such as aircraft attitude and heading. The Navigation System sends navigation information to the FMC to calculate, to the AFS to control the aircraft, and to the EFIS system to display navigation in front of the pilot.

METAR - Acronym in FAA pilot briefings and weather reports simply means an "aviation routine weather report," but nobody seems certain about the original acronym source. The format was introduced by the French on 1 Jan 1968, but was not adopted by USA and Canada until 1 July 1996, and is thought to be a contraction from MÉTéorologique ("Weather") Aviation Règuliére ("Routine"). FAA and NOAA specifically define METAR as "an approximate translation from the French."

MSL - Mean Sea Level - The average height of the surface of the sea for all stages of tide; used as a reference on the aircraft flight deck for mountain or obstacle elevations, and differentiated from AGL (Above Ground Level).

NAS - National Airspace System - The common network of US airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and human resources and material. Included are system components shared jointly with the military.

NASA -The National Aeronautics and Space Administration is an agency of the United States government, responsible for the nation's public space program. The National Aeronautics and Space Act established it on July 29, 1958. In addition to the space program, it is also responsible for long-term civilian and military aerospace research. Since February 2006, NASA's self-described mission statement is to "pioneer the future in space exploration, scientific discovery, and aeronautics research. NASA administers the ASRS aviation safety program.

NDB - Non-Directional Beacon-An LF (Low Frequency), MF (medium Frequency), or UHF (Ultra High Frequency) radio beacon transmitting non-directional signals whereby the pilot of an aircraft equipped with direction finding equipment can determine his bearing to or from the radio beacon and "home" on or track to or from the station. When the radio beacon is installed in conjunction with the Instrument Landing System (ILS) marker, it is normally called a Compass Locator.

NTSB - National Transportation Safety Board is an independent organization responsible for investigation of accident involving aviation, highway, marine, pipelines, and railroads in the United States. It is charged by the U. S. Congress to investigate every civil aviation accident in the United States, as well as significant accidents in other modes of transportation (such as the Big Bayou Canot train disaster near Mobile, Alabama). The organization is also in charge of investigating cases of hazardous waste releases that occur from modes of transportation.

NTSB database - The NTSB aviation accident database contains information from 1983 and later from civil aviation accidents and selected serious incidents within the United States, or from U. S. registered aircraft elsewhere in the world. Generally, a preliminary report is available within a few days of an accident. Factual information is added when available, and when the investigation is completed, the preliminary report is replaced with a final description of the accident and its probable cause. Full narrative descriptions may not be available for dates before 1993, cases under revision, or where NTSB did not have primary investigative responsibility.

Part 121 –Operating requirements for Domestic, International, supplemental airline operators.

Part 135 – Operating requirements for commuter (regional) and on demand operations.

PIC - Pilot in Command – PIC is the pilot responsible for the operation and safety of an aircraft during flight time.

PRIA - Pilot Records Improvement Act of 1996 (PRIA) requires that a hiring air carrier pilot under FAR part 121 and 135, or a hiring air operator under FAR part 125, request, receive, and evaluate certain information concerning a pilot/applicant's training, experience, qualifications, and safety background, before allowing that individual to begin service with their company as a pilot. This process allows the entity to make a more informed hiring decision.

RTO - A Rejected TakeOff is the safety situation in which the PIC decides to abort the takeoff of an airplane. There can be many reasons for deciding to perform a rejected takeoff, but they are usually due to suspected or actual technical failures, like an engine failure such as a compressor stall occurring during the takeoff run. A rejected takeoff is normally performed only if the aircraft's speed is below the takeoff decision speed known as V_1, which for larger multi-engined airplanes is calculated and posted before each flight. Below the decision speed, the airplane should be able to stop safely before the end of the runway. Above the decision speed, the airplane may overshoot the runway's supporting surface if the takeoff is aborted. Therefore, a rejected takeoff is normally not performed above this speed, unless there is reason to doubt the airplane's ability to fly. If a serious aircraft failure occurs or it is suspected above V_1 but the airplane's ability to fly is not in doubt, the takeoff is continued despite the (suspected) failure and the airplane will attempt to land again as soon as possible.

Safety Event Severities - A flight operational incident, or an accident that results in property damage, human injury, or death.

Skid - Too shallow a bank in a turn, causing an aircraft to slide outward from its ideal turning path (uncoordinated turn). A skid is corrected with rudder flight control input.

SRK- The Skill, Rule and Knowledge based classification; understanding human behavior and error. J. Rasmussen (1979) of the Risø Laboratory in Denmark developed an influential classification of the different types of information processing involved in industrial tasks. This scheme provides a useful framework for identifying the types of error likely to occur in different operational situations, or within different aspects of the same task where different types of information processing demands on the individual may occur.

Slats - Movable vanes or auxiliary airfoil extensions, usually set along the leading edge of a wing and can be retracted at certain angles of attack or airspeed.

Slip - Too steep a bank in a turn, causing an aircraft to slide inward from its ideal turning path (uncoordinated turn). A slip is corrected with rudder flight control input.

SPSS - (originally, Statistical Package for the Social Sciences) was released in its first version in 1968, and is among the most widely used programs for statistical analysis in social science. Market researchers, health researchers, survey companies, government, education researchers, and others use it. In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation (a metadata dictionary is stored with the data) are features of the base software. SPSS places constraints on internal file structure, data types, data processing and matching files, which together considerably simplify programming. SPSS datasets have a 2-dimensional table structure where the rows typically represent cases (such as individuals or households) and the columns represent measurements (such as age, sex, or household income). Only two data types are defined, numeric and text (or "string"). All data processing occurs sequentially case-by-case through the file. Files can be matched one-to-one and one-to-many, but not many-to-many.

Standard Atmosphere - An arbitrary atmosphere established for calibration of aircraft instruments and aircraft performance (airfoil and engine). Standard Air Density is 29.92 inches of mercury, 0 feet MSL, and temperature of 59° F, equivalent to an atmospheric air pressure of 14.7# per square inch.

Standard Rate Turn - A turn in which the heading of an aircraft changes 3° per second, or 360° in two minutes.

SOP - A Standard Operating Procedure is a set of instructions having the force of a directive, covering those features of operations that lend themselves to a definite or standardized procedure without loss of effectiveness.

Study Data - The United States accident and incident NTSB recorded data.

SUA - Special Use Airspace - Airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature and/or wherein limitations may be imposed upon aircraft operations that are not a part of those activities:

> Alert Area - Airspace that may contain a high volume of pilot training activities or an unusual type of aerial activity, and neither of which is a hazardous to aircraft. Alert Areas are depicted on aeronautical charts for the information of non-participating pilots. All activities within an Alert Area are conducted in accordance with Federal Aviation Regulations, and pilots of participating aircraft as well as pilots transiting the area are equally responsible for collision avoidance.
> Military Operations Area (MOA) - Airspace established outside of Class A airspace area to separate or segregate certain non-hazardous military activities from IFR traffic and to identify for VFR traffic where these activities are conducted.
>
> Prohibited Area - Airspace designated under FAR Part 73 within which no person may operate an aircraft without the permission of the using agency.
> Restricted Area - Airspace designated under FAR Part 73, within which the flight of aircraft, while not wholly prohibited, is subject to restriction. Most restricted areas are designated joint use and IFR/VFR operations in the area may be authorized by the controlling ATC facility when it is not being utilized by the using agency. Restricted areas are depicted on enroute charts. Where joint use is authorized, the name of the ATC controlling facility is also shown.
> Warning Area - A warning area is airspace of defined dimensions extending from three nautical miles outward from the coast of the USA that contains activity that may be hazardous to non-participating aircraft. The purpose of such warning area is to warn non-participating pilots of the

potential danger. A warning area may be located over domestic or international waters or both.

V - Velocity used in defining aircraft air speeds:

VA = Maneuvering Speed
VD = Maximum Dive Speed (for certification only)
VFE = Maximum Flaps Extended Speed
VLE = Maximum Landing Gear Extended Speed
VLO = Maximum Landing Gear Operation Speed
VNE = Never Exceed Speed
VNO = Maximum Structural Cruising Speed
VS0 = Stalling Speed Landing Configuration
VS1 = Stalling Speed in a specified Configuration
VX = Best Angle of Climb Speed
VXSE = Best Angle of Climb Speed, one engine out
VY = Best Rate of Climb Speed
VYSE = Best Rate of Climb Speed, one engine out

VFR - Visual Flight Rules that govern the procedures for conducting flight under visual conditions. The term is also used in the US to indicate weather conditions that are equal to or greater than minimum VFR requirements. Also used by pilots and controllers to indicate a type of flight plan.
VMC - Visual Meteorological Conditions - Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling equal to or better than specified minima.

VOR - VHF Omni Range. A ground-based navigation aid transmitting Very High Frequency (VHF) navigation signals 360° in azimuth, on radials oriented from magnetic north. The VOR periodically identifies itself by Morse code and may have an additional voice identification feature. Voice features can be used by ATC or FSS for transmitting information to pilots.

VORTAC - VOR + TACAN (Tactical Air Navigation); combined azimuth and Distance Measuring Equipment (DME) radio navigation aids.

VSI - Vertical Speed Indicator - A panel instrument that gauges rate of climb or descent in feet-per-minute (fpm). It is also called a rate of climb Indicator.

Wing Stall - Aircraft wing stall is gradual loss of lift when the wing's angle of attack increases to a point where the flow of air breaks away from a wing or airfoil, causing it to be inefficient and unable to remain at the current altitude. The stall is a maneuver initiated by the steep raising of an aircraft's nose, resulting in a loss of velocity and a potential abrupt drop.

YAW - Of the three axes in flight, this specifies the side-to-side movement of an aircraft on its vertical axis, as in skewing. Compared to pitch and roll.

Appendix B

Linear Graphs of the Study Variables by Airline Type

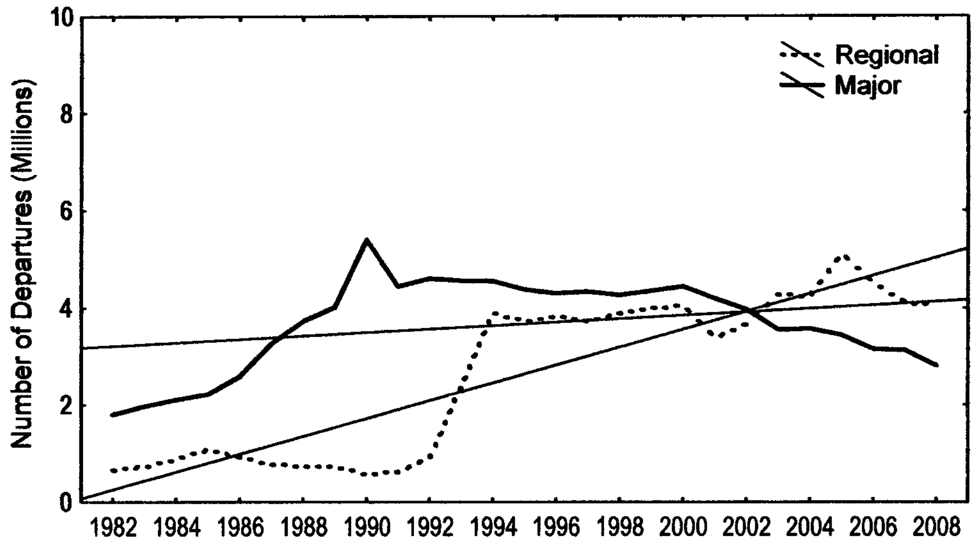

Figure 1. Departures over the Study Period by Airline Type

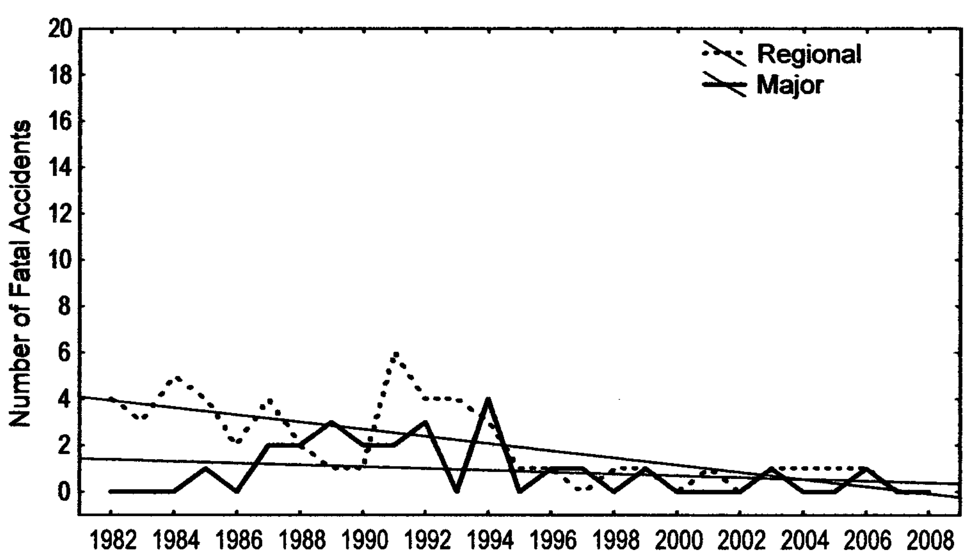

Figure 2. Fatal Accidents over the Study Period by Airline Type

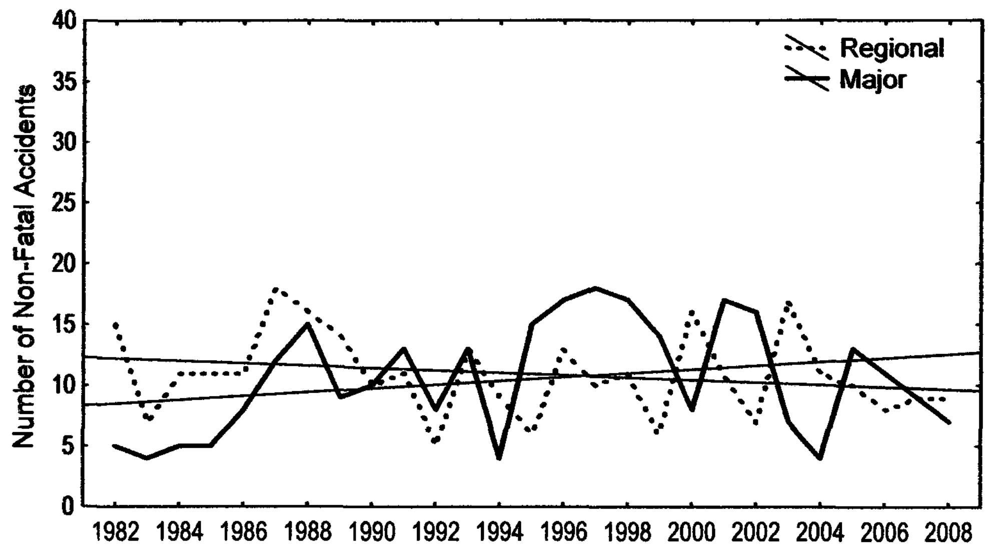

Figure 3. Non-Fatal Accidents over the Study Period by Airline Type

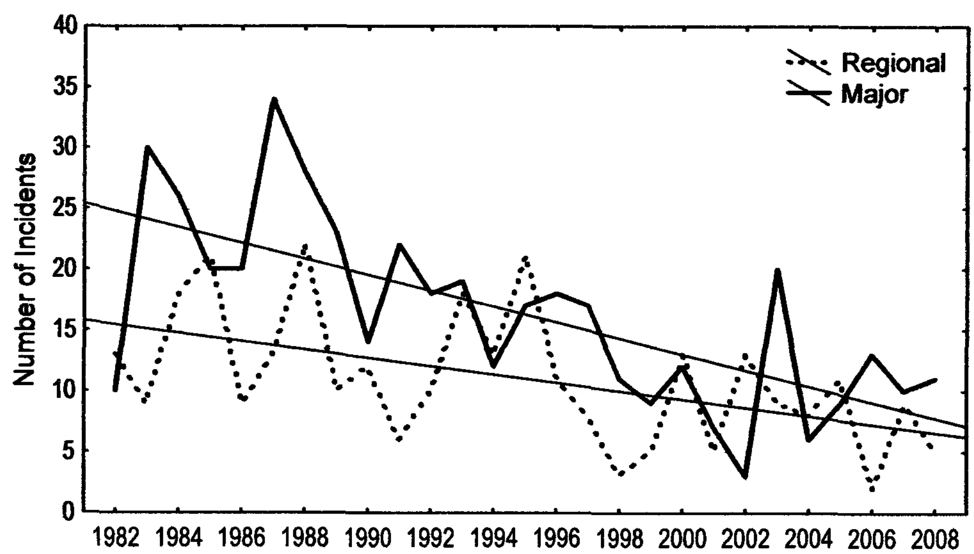

Figure 4. Incidents over the Study Period by Airline Type

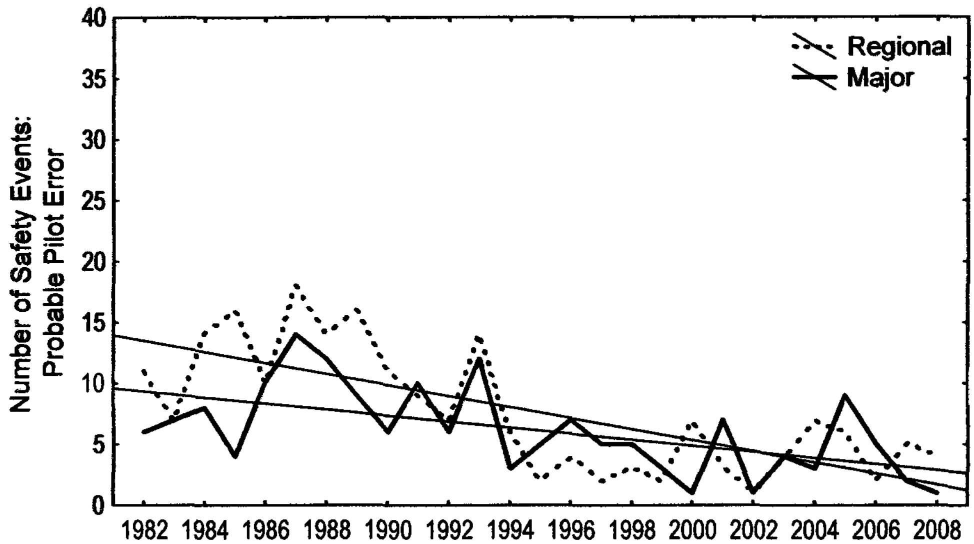

Figure 5. Probable Pilot Error over the Study Period by Airline Type

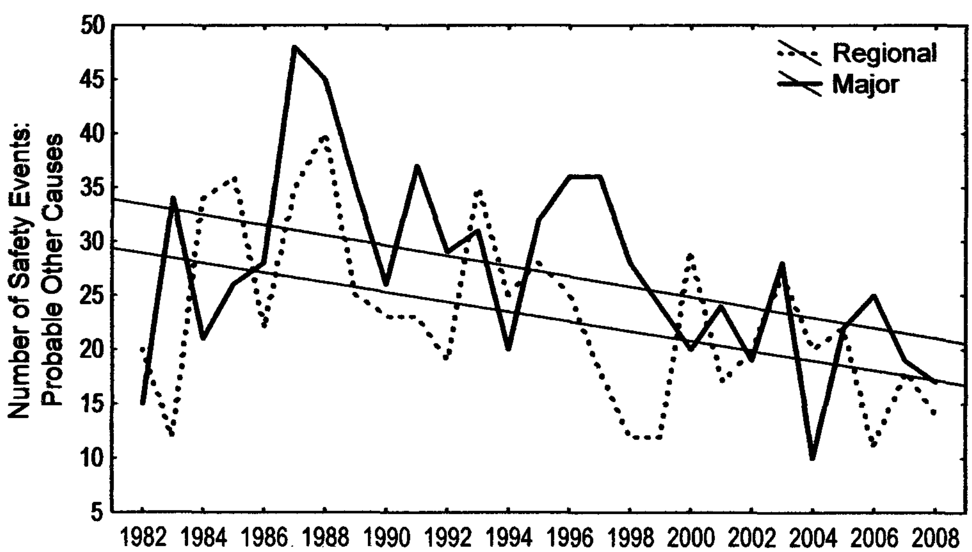

Figure 6. Other Probable Causes over the Study Period by Airline Type