Peer-Reviewed Research Articles

Characteristics of Pilots Involved in U.S. Air Carrier Accidents Between 1991 and 2010

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Abstract

This study used a case control methodology to analyze and describe the pilot characteristics of major U.S. air carrier accidents between 1991 and 2010. This study applied descriptive statistics and Chi-square for statistical analysis. The major findings of this study indicate that of the 50 accidents analyzed between 1991 and 2010, 96% of the first officers involved in a major U.S. air carrier accident possessed at least 2,000 hours of total flight time. Regarding first officer flight certificates (commercial pilot and ATP), the researchers separated the 1991 - 2010 time period into two time period groups (1991-2000 and 2001-2010).Of the two first officers (4%) with less than 1,500 hours of total flight time, neither was involved in an accident that cited pilot performance as a causal or contributing factor. This finding did not support the notion that a 1,500 hour total flight time requirement will contribute to the safety of air carrier operations conducted under 14 CFR 121. While an ATP certification requirement for first officers will not eliminate the possibility of any future accidents involving commercially certificated first officers, it was not possible to predict whether such a change will contribute to the enhancement of safety for 14 CFR 121 air carrier operations. It is possible there will simply be a redistribution of the number of accidents involving ATP certificated first officers. Results of this study also indicate that crew familiarity (captains and first officers) may have a negative effect on accident rates. The evaluation of captain and first officer cockpit interaction indicated that accident rates were higher in instances of lower crew familiarity in each of the three areas measured; first day of crew pairing, first leg of the day, and during the first pairing together.

Introduction

The demand for air travel in the U.S. grew from 172 million passengers in 1970 to more than 630 million passengers in 2010 (Bureau of Labor Statistics, 2011a; Bureau of Transportation Statistics, 2011a, 2011b, 2011c, 2011d). The Federal Aviation Administration (FAA) has projected the number of passengers to reach "…more-than one billion by 2015, and 1.2 billion by 2020" (Price, 2007).

As a result, the Bureau of Labor Statistics (2011b) has predicted the employment of pilots to grow by 12% between 2008 and 2018. The International Air Transport Association (IATA) has estimated the industry would need 17,000 new pilots annually to meet the industry's projected growth (Kirby, 2007). According to the IATA (2012), if

nothing is done, this will translate into a world-wide shortage of approximately 42,000 pilots by 2020 (ATP Flight School, 2013). "Experts estimate that from now until 2025, airlines around the world will need to hire more than 300,000 new pilots to fly all the new jets – about 19,000 – expected to join the fleet by then; and replace retirees and others who leave" (Kaur, 2007).

While demand for air travel has steadily increased over the past several decades, the total number of pilots certified for commercial operations has remained relatively stable when both groups of Airline Transport Pilot (ATP) and commercial certificate holders are combined. While there has been an overall increase in the total number of ATP certificated pilots, the overall number of commercially certificated pilots has decreased (FAA, 2011a, 2011b).

New Pilot Certification Requirements for U.S. Air Carriers

In 2009, following the crash of a Colgan Air DHC-8, legislation was introduced to increase the minimum flight time and certification requirements for all flight crewmembers serving in 14 CFR 121 air carrier operations defined as regularly scheduled domestic, flag, and supplemental operation airlines (U.S. Government Printing Office, 2013). On October 14, 2009, the U.S. House of Representatives signed H.R. 3371, the "Airline Safety and Pilot Training Improvement Act of 2009", which sought in part, to require all flight crewmembers serving in 14 CFR 121 air carrier operations to hold an ATP certificate and possess at least 1,500 hours of total flight experience (Congressional Record, 2009).

On August 1, 2010, the President of the United States signed H.R. 5900, the "Airline Safety and Federal Aviation Administration Extension Act of 2010", which was adopted by the 111th Congress as Public Law 111-216 (The White House, 2010). Public Law 111-216, Title II, Sec. 216, mandated all flight crewmembers, to include first officers, serving in 14 CFR Part 121 air carrier operations to hold an ATP certificate. Title II, Sec. 217, mandated that in order to qualify for an ATP certificate, an individual shall possess at least 1,500 total hours of flight experience (U.S. Government Printing Office, 2010a). There is, however, a provision within the Act which authorizes the FAA to grant credit for specific academic training courses toward the 1,500 total flight hour requirement if a determination is made "…that allowing a pilot to take specific academic training courses will enhance safety more than requiring the pilot to fully comply with the flight hours requirement" (U.S. Government Printing Office, 2010b).

In the case of the Colgan Air DHC-8 accident, the captain held an ATP certificate and "…had accumulated 3,379 hours of total flying time, including 3,051 hours in turbine airplanes, 1,030 hours as pilot-in-command (PIC), and 111 hours on the [DHC-8] Q400" (NTSB, 2010). The first officer held a commercial pilot certificate and "…had accumulated 2,244 hours of total flying time, including 774 hours in turbine airplanes and on the [DHC-8] Q400" (NTSB, 2010). While the first officer held only a commercial

certificate, both pilots involved in the Colgan Air DHC-8 accident possessed more than 1,500 hours of total flight experience.

The Colgan Air DHC-8 accident raised many concerns among legislators and regulators with regard to existing flight time and certification requirements for pilots engaged in 14 CFR 121 air carrier operations. The decision to increase those requirements appeared to support the notion that commercially certificated pilots and/or pilots with less than 1,500 hours of total flight experience pose a greater level of risk than pilots who hold an ATP certificate and have more than 1,500 hours of flight time. Unfortunately, it was not known whether the flight time, level of certification, or other characteristics of the pilots involved in the Colgan Air DHC-8 accident were characteristic of pilots who were involved in other major U.S. air carrier accidents. Therein lay the problem. What were the pilot characteristics of major U.S. air carrier accidents? With regard to a future increase in flight time and certification requirements for 14 CFR 121 air carrier operations, there was a need to better understand the characteristics of previous air carrier accidents.

The purpose of this study was to describe the pilot characteristics of major U.S. air carrier accidents between 1991 and 2010 operated under 14 CFR 121. For the purpose of this study, an accident was included if the following criteria were met: the accident involved a U.S. air carrier operating under 14 CFR 121 between 1991 and 2010 and the NTSB conducted a major investigation. For this study, major investigations are defined as investigations in which the NTSB adopted an aircraft accident report (AAR) or aircraft accident brief (AAB).

A select number of pilot related variables were used to describe the characteristics of major U.S. air carrier accidents in terms of pilot characteristics. According to the NTSB (1994), "previous accident investigations have identified a large set of operational and human performance factors as being related to the occurrence or seriousness of errors". Variables related to the characteristics of pilots included: flight experience; level of certification; duration of employment with the accident air carrier; crew assignment; age, gender, and crew familiarity. Using these pilot related variables, this study compared the characteristics of pilots involved in major accidents citing pilot performance as a causal or contributing factor with the characteristics of pilots involved in major accidents in which pilot performance was not a causal or contributing factor in order to determine whether any significant differences existed.

Studies conducted by the NTSB (1994) and Dismukes et al (2007) pertaining to major U.S. air carrier accidents laid the groundwork for this study. However, both studies were limited to only those accidents citing pilot performance as a causal or contributing factor. This study provides a more recent look at the pilot characteristics of major U.S. air carrier accidents between 1991 and 2010 operated under 14 CFR 121. In addition, this study expands upon the population studied to also include air carrier accidents in which pilot performance was not cited as a casual or contributing factor.

Between 1991 and 2010, there were more than 139 million aircraft departures within the U.S. air carrier industry (BTS, 2011). During that same period, only 747 accidents occurred while operating under 14 CFR 121 (NTSB, 2011). Fifty-one of the 747 accidents were operated under 14 CFR 121 and resulted in an NTSB aircraft accident report (AAR) or aircraft accident brief (AAB). These accidents included scheduled and non-scheduled passenger and cargo flights. Flights originated from airports within the U.S. during various hours of the day and months of the year. There were a number of U.S. air carriers involved, as well as a variety of different types of aircraft.

The NTSB's Aviation Accident Database and Embry-Riddle Aeronautical University's Hunt Library were used to gather the archival data for this study. The NTSB Aviation Accident Database provided access to the factual reports and probable cause reports. The Hunt Library provided access to the NTSB's full aircraft accident reports (AAR) and aircraft accident briefs (AAB), as several of the older reports were not readily available on the NTSB's website.

The researchers identified U.S. air carrier accidents between 1991 and 2010 operating under 14 CFR 121. The NTSB Aviation Accident Database was used to filter the system for: (1) accidents with an event start date of "01/01/1991"; (2) an event end date of "12/31/2010"; (3) investigation type - "Accident"; and (4) operation - "Part 121: Air Carrier". All other fields were left at the default value in order to include all accidents that fit within the limits of the search. This resulted in the identification of 747 "Part 121: Air Carrier" "Accidents" between "01/01/1991" and "12/31/2010".

The researchers identified which accidents resulted in a major investigation. The NTSB's web-based list of aircraft accident reports and aircraft accident briefs were cross-referenced with the Hunt Library's web-based list of reports and briefs. Each of the reports and briefs were assigned a designator by the NTSB which specifies the year in which the report was adopted and a sequential number in which they are ordered. For example, the seventh report to be adopted in 2009 was AAR-09-07. The fourth brief to be adopted in 2007 was AAB-07-04. This enabled the researchers to sequentially check all of the reports for each year between 1991 and 2010. The researchers then reviewed each report to determine which of the accidents involved a U.S. air carrier operating under 14 CFR 121.

This resulted in the identification of 51 accidents that met the criteria required for inclusion in this study (see Table 1). Further analysis revealed that one of the 51 accidents (AAR 09/04) was the result of a ground fire prior to engine start. The information contained within this report focused on the ignition of supplemental oxygen stored within a supernumerary compartment while the aircraft was still parked, prior to engine start. Thus, AAR 09/04 was excluded from this study. This resulted in the selection of 50 accidents. The 50 accidents selected for inclusion in this study are presented in Table 1.

Measurement of the Variables

"Minimizing measurement error is critical. This is best accomplished by developing a well-though-out operational definition of the measurement procedure and by diligently using the operational definition in the research" (Graziano & Raulin, 2007, p. 83). Each of the variables considered in this study were defined in order to provide a reliable means of measurement and were modeled after the definitions established by the NTSB in 1994. In addition to the demographic variables of age and gender, the following were used as variables:

1. Flight experience – flight hours were used as the measurement of flight experience in this study. Flight hours were measured the following way:

    a. Total hours of flying experience – cumulative number of flight hours accumulated in all aircraft at the time of the accident.

    b. Hours of experience in the accident aircraft type – cumulative number of flight hours accumulated in the accident aircraft make and model at the time of the accident, regardless of crew position.

    c. Hours of experience in aircraft type and crew position – cumulative number of flight hours accumulated in specific crew position in the accident aircraft make and model (e.g. B-737 first officer) at the time of accident.

2. Level of certification – this variable was categorized as ATP certificate or commercial certificate.

3. Duration of employment with accident air carrier – this variable categorized on a nominal scale as less than one year of employment with the accident air carrier or more than one year with the accident air carrier.

4. Crew assignment – this variable was categorized as captain flying/first officer monitoring or captain monitoring/first officer flying.

Table 1
Selected Major U.S. Air Carrier Accidents

NTSB Report	Event Date	City	Carrier
AAR-11/02	27-Jan-09	Lubbock, TX	Empire Airlines
AAR-10/04	20-Dec-08	Denver, CO	Continental Airlines
AAR-10/03	15-Jan-09	Weehawken, NJ	US Airways
AAR-10/01	12-Feb-09	Clarence Center, NY	Colgan Air, Inc
AAR-09/03	28-Sep-07	St Louis, MO	American Airlines
AAR-08/02	12-Apr-07	Traverse City, MI	Pinnacle Airlines
AAR-08/01	18-Feb-07	Cleveland, OH	Shuttle America
AAR-07/07	7-Feb-06	Philadelphia, PA	United Parcel Service
AAR-07/06	8-Dec-05	Chicago, IL	Southwest Airlines
AAR-07/05	27-Aug-06	Lexington, KY	Comair
AAR-07/04	19-Dec-05	Miami, FL	Flying Boat, Inc
AAR-06/03	13-Aug-04	Florence, KY	Air Tahoma, Inc
AAR-06/01	19-Oct-04	Kirksville, MO	Corporate Airlines
AAB-06/02	24-May-03	Amarillo, TX	Southwest Airlines
AAR-05/02	9-May-04	San Juan, PR	Executive Airlines
AAR-05/01	18-Dec-03	Memphis, TN	Federal Express
AAR-04/04	12-Nov-01	Belle Harbor, NY	American Airlines
AAR-04/02	26-Jul-02	Tallahassee, FL	Federal Express
AAR-04/01	8-Jan-03	Charlotte, NC	Air Midwest
AAR-03/02	16-Feb-00	Rancho Cordova, CA	Emory Worldwide Airlines
AAB-02/04	5-Mar-00	Burbank, CA	Southwest Airlines
AAR-02/01	31-Jan-00	Port Hueneme, CA	Alaska Airlines
AAR-01/02	1-Jun-99	Little Rock, AR	American Airlines
AAR-01/01	3-Mar-91	Colorado Springs, CO	United Airlines
AAB-01/01	9-Feb-98	Chicago, IL	American Airlines
AAR-00/03	17-Jul-96	East Moriches, NY	Trans World Airlines
AAR-00/02	31-Jul-97	Newark, NJ	Federal Express
AAR-99/01	8-Sep-94	Aliquippa, PA	USAir (US Airways)
AAR-98/03	5-Sep-96	Newburgh, NY	Federal Express
AAR-98/02	7-Aug-97	Miami, FL	Fine Airlines
AAR-98/01	6-Jul-96	Pensacola, FL	Delta Air Lines
AAR-97/06	11-May-96	Miami, FL	ValuJet Airlines
AAR-97/03	19-Oct-96	Flushing, NY	Delta Air Lines
AAR-97/01	19-Feb-96	Houston, TX	Continental Airlines
AAR-96/07	7-Jan-96	Nashville, TN	ValuJet Airlines
AAR-96/05	12-Nov-95	East Granby, CT	American Airlines
AAR-96/04	20-Dec-95	Jamaica, NY	Tower Air
AAR-96/03	8-Jun-95	Atlanta, GA	ValuJet Airlines
AAR-96/01	31-Oct-94	Roselawn, IN	Simmons Airlines
AAR-95/05	22-Nov-94	Bridgetown, MO	Trans World Airlines

NTSB Report	Event Date	City	Carrier
AAR-95/03	2-Jul-94	Charlotte, NC	USAir (US Airways)
AAR-95/01	2-Mar-94	Flushing, NY	Continental Airlines
AAR-94/06	1-Feb-94	New Roads, LA	Simmons Airlines
AAR-94/04	18-Aug-93	Guantanamo Bay, Cuba	American International Airways
AAR-94/01	14-Apr-93	Dallas Ft Worth, TX	American Airlines
AAR-93/04	30-Jul-92	Jamaica, NY	Trans World Airlines
AAR-93/02	22-Mar-92	Flushing, NY	USAir (US Airways)
AAR-92/05	15-Feb-92	Swanton, OH	Air Transport International
AAR-91/09	17-Feb-91	Cleveland, OH	Ryan International Airlines
AAR-91/08	1-Feb-91	Los Angeles, CA	USAir (US Airways)

5. Crew familiarity – the NTSB (1994) identified two measures of crew familiarity in their study in which a high percentage of accidents seemed to occur. This study measured crew familiarity in the following manner:

    d. First sequence/pairing together – this variable was categorized as the first pairing together or not the first pairing together.

    e. First day flying together (current pairing/sequence) – this variable was categorized as the first day flying together or not the first day flying together on the trip sequence.

    f. First leg of the day – this variable was categorized as the first leg of the day or not the first leg of the day.

Analysis

Descriptive statistics were used to describe the pilot characteristics of major U.S. air carrier accidents in terms of measures of central tendency, variation, range, variance, and percentiles. Chi-square was used to determine statistical differences between variables with nominal data. According to Graziano and Raulin, a chi-square test is appropriate for determining statistical difference between nominal data (2007). Sampling procedures were not required in this study, as all major U.S. air carrier accidents between 1991 and 2010 operated under 14 CFR 121 for which the NTSB conducted a major investigation of the accident were selected.

Findings

Characteristics of the Accident Pilots

Pilot related variables evaluated for this study included: flight experience; level of certification; duration of employment with the accident air carrier; crew assignment; age; gender; and crew familiarity.

Crewmember Age

Crewmember age data was available for all of the captains. The age of captains ranged between 25 and 59 years old with a mean of 47 years of age.

Table 2
Age Distribution: First Officers

	Age
Mean	38.98
Median	38.00
Mode	34.00
Std. Deviation	8.31
Minimum	24
Maximum	57

Age data was available for 49 first officers. The age of first officers ranged between 24 and 57 years old with a mean of 39 years of age.

Table 3
Age Distribution: Captains

	Age
Mean	47.00
Median	48.00
Mode	59.00
Std. Deviation	8.98
Minimum	59.00
Maximum	25.00

Gender of Crewmembers

Gender data was available for all captains and first officers. Forty-seven captains (94%) were male and three (6%) were female. Forty-six first officers (92%) were male and four (8%) were female.

Certificates Held

Certificate data was available for all captains and first officers. All captains (100%) held an ATP certificate. This was expected as possession of an ATP certificate is required in order to perform pilot-in-command duties under 14 CFR 121. Twelve first officers (24%) held a commercial certificate and thirty-eight (76%) held an ATP certificate.

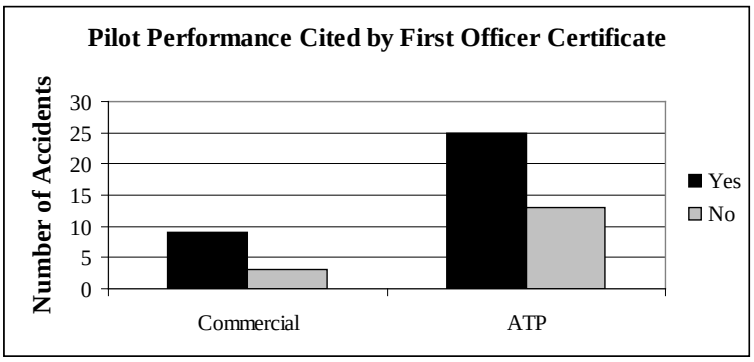

Figure 1. Pilot performance cited by first officer certificate.

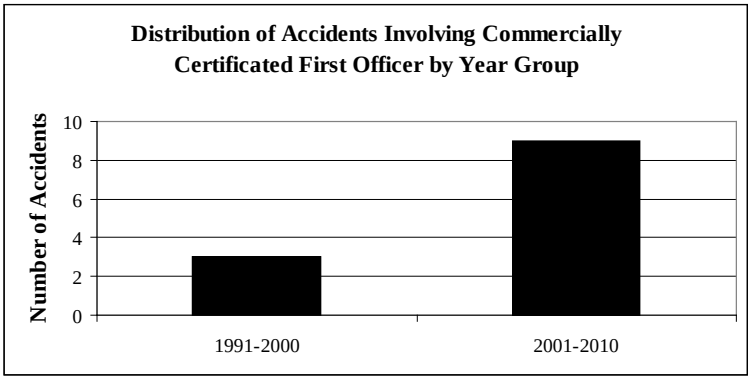

Figure 2. Distribution of accidents involving commercially certified first officer by year Group.

Further analysis revealed that of the twelve accidents involving a first officer whose highest certificate was a commercial certificate, three (25%) occurred between 1991 and 2000 and nine (75%) occurred between 2001 and 2010.

Irrespective of the citing/not citing of pilot performance, there was a significant difference between 1991-2000 and 2001-2010 with regard to the distribution of accidents based upon the highest certificate held by first officers between periods, χ^2 (df = 1, N = 50) = 9.175, p = 0.002.

Figure 3. Highest certificate of first officers by year group.

The reason two distinct year groups have been identified is because between 1991 and 2000, twenty-eight first officers (90%) held an ATP certificate while only three (10%) held a commercial certificate. Between 2001 and 2010, ten first officers (53%) held an ATP certificate and nine (47%) held a commercial certificate.

Duration of Employment

Employment data was available for all of the captains. The accident captains' duration of employment ranged from less than one month to over 30 years of employment with the accident air carrier, with a mean of 12.2 years. Only one captain (2%) had less than one year of employment with the accident air carrier. Forty-nine captains (98%) had more than one year of employment with the accident air carrier. There was not a significant difference between groups with regard to whether the captain had more or less than one year of employment with the accident air carrier, χ^2 (df = 1, N = 50) = 0.480, p = 0.488.

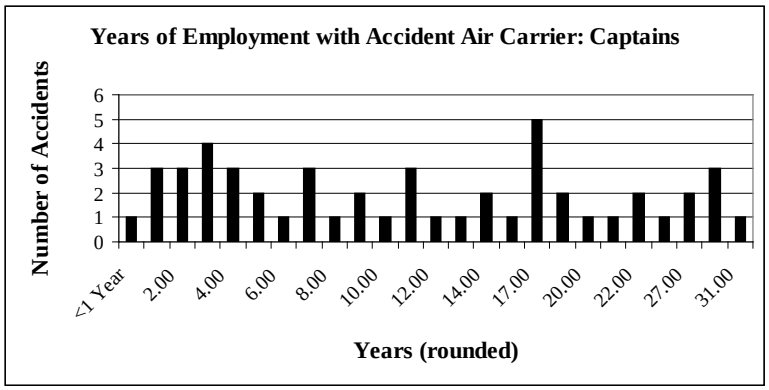

Figure 4. Years of employment with accident air carrier: captains.

Employment data was available for 49 first officers. The accident first officers' duration of employment ranged from less than one month to over 32 years of employment with the accident air carrier, with a mean of 5.4 years. Thirteen first officers (26.5%) had less than one year of employment with the accident air carrier. Thirty-six first officers (73.5%) had more than one year of employment with the accident air carrier. There was not a significant difference between groups of first officers with regard to whether the first officer had more or less than one year of employment with the accident air carrier, χ^2 (df = 1, N = 49) = 0.473, p = 0.492. Nor was there a significant difference between the periods of 1991-2000 and 2001-2010 with regard to first officers' duration of employment, χ^2 (df = 1, N = 49) = 0.406, p = 0.524.

Figure 5. Years of employment: first officers.

Total Flight Time

Total flight time data was available for all of the captains. The least experienced captain had 2,500 hours of total flight time and the most experienced captain had 25,000 hours of total flight time, with a mean of 11,994 hours.

Table 4
Total Time Captain

	Flight Hours
Mean	11993.62
Median	11500.00
Mode	11000.00
Std. Deviation	5741.17
Minimum	2500.00
Maximum	25000.00

There was not a significant difference between groups of pilots with regard to whether the captain had more or less than 1,500 hours of total flight time as 100% of captains had over 1,500 hours of total flight time.

Total flight time data was available for all of the first officers. The least experienced first officer had 1,096 hours of total flight time and the most experienced first officer had 17,734 hours of total flight time, with a mean of 6,838 hours. Only two first officers (4%) had less than 1,500 hours of total flight time. Forty-eight first officers (96%) had more than 1,500 hours of total flight time. Of the two first officers with less than 1,500 hours, one possessed 1,096 hours and the other possessed 1,420 hours of total flight time.

Table 5
Total Time First Officer

	Flight Hours
Mean	6837.92
Median	5407.00
Mode	6500.00
Std. Deviation	4478.40
Minimum	1096.00
Maximum	17734.00

There was a significant difference between groups with regard to whether the first officer had more or less than 1,500 hours of flight time, χ^2 (df = 1, N = 50) = 4.427, p = 0.035. Of the first officers with more than 1,500 hours of total flight time, thirty-four (71%) were involved in an accident citing pilot performance as a causal or contributing factor and fourteen (29%) were involved in an accident not citing pilot performance as a causal or contributing factor. Of the two first officers with less than 1,500 hours of total

time, neither (0%) were involved in an accident citing pilot performance as a causal or contributing factor.

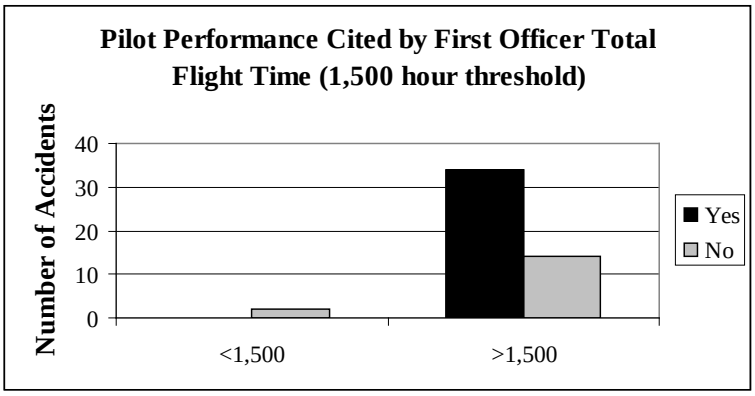

Figure 6. Pilot performance cited by first officer total time (1,500 hour threshold).

The findings suggest that first officers with less than 1,500 hours of total flight time did not contribute to any major U.S. air carrier accidents between 1991 and 2010. This finding may be of particular interest with regard to the total flight time requirements imposed by Public Law 111-216. It is, however, important to point out that it is highly likely there were proportionately very few first officers with less than 1,500 hours of total time who were employed by U.S. air carriers operating under 14 CFR 121 during this period.

Flight Experience in Make/Model

Flight experience in the make/model indicates how many total flight hours of experience the flight crew member had earned in the aircraft type which the accident occurred. Hours of flight time in the accident make and model was available for all of the captains. The least experienced captain had 111 hours in make/model and the most experienced captain had 16,000 hours in make/model, with a mean of 3,113 hours.

Flight experience in make/model and position indicates how many total flight hours of experience the flight crew member had earned as the role in which they were currently serving (captain or first officer). Hours of flight time in the accident make/model and position was available for 46 captains. The least experienced captain had 26 hours as a captain in the accident aircraft make/model and the most experienced captain had 16,000 hours as a captain in the accident aircraft make/model, with a mean of 2,048 hours.

Hours of flight time in the accident make and model was available for all first officers. The least experienced first officer had 20 hours in make/model and the most experienced first officer had 8,060 hours in make/model, with a mean of 1,683 hours.

Table 6
Make and Model: Captain

	Flight Hours
Mean	3112.54
Median	2507.00
Mode	111.00
Std. Deviation	15889.00
Minimum	111.00
Maximum	16000.00

Table 7
Make and Model: First Officer

	Flight Hours
Mean	1682.76
Median	1419.00
Mode	1200.00
Std. Deviation	8040.00
Minimum	20.00
Maximum	8060.00

Table 8
Type and Position: Captain

	Flight Hours
Mean	2048.43
Median	1537.50
Mode	1100.00
Std. Deviation	2536.20
Range	15974.00
Minimum	26.00
Maximum	16000.00

Flight Experience in Make/Model and Position

Hours of flight time in the accident make/model and position was available for 46 first officers. The least experienced first officer had 20 hours as a first officer in the accident aircraft make/model and the most experienced first officer had 8,060 hours as a first officer in the accident aircraft make/model, with a mean of 1,503 hours. Table 7 presents the distribution for first officers in make/model and position.

Flying Assignment

Flying assignment data was available for 49 accidents. Measurements were made in terms of "assigned" duties. In other words, if the first officer was assigned flying duties and the captain took control of the aircraft before, during, or after the accident occurred, the first officer was recorded as the flying pilot.

Table 9
Type and Position: First Officer

	Flight Hours
Mean	1502.87
Median	1110.00
Mode	1200.00
Std. Deviation	1584.64
Range	8040.00
Minimum	20.00
Maximum	8060.00

The captain was performing flying duties and the first officer was performing monitoring duties in twenty-two (45%) of the accidents. The first officer was performing flying duties and the captain was performing monitoring duties in twenty-seven (55%) of the accidents.

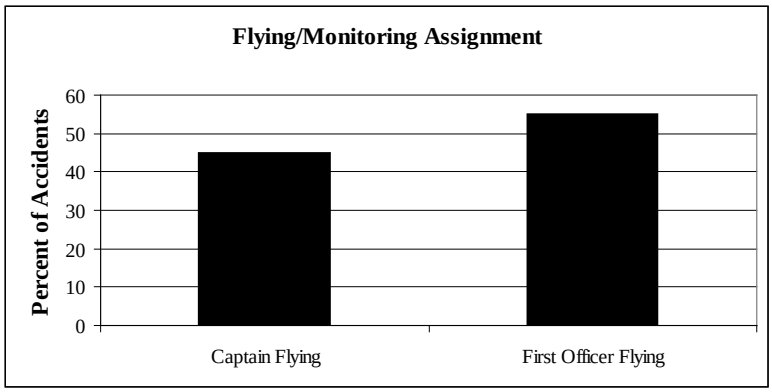

Figure 7. Flying/monitoring assignment.

There was not a significant difference between groups of pilots with regard to which pilot was performing the flying duties and which pilot was performing the monitoring duties, χ^2 (df = 1, N = 49) = 1.169, p = 0.280.

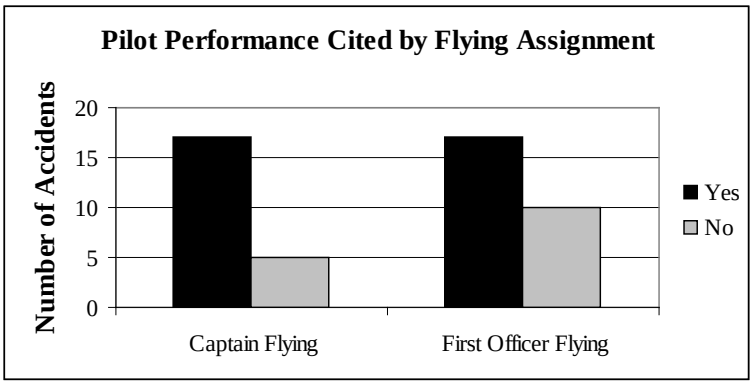

Figure 8. Pilot performance cited by flying assignment.

Crew Familiarity

Crew familiarity was measured in terms of (1) first day of pairing on the current sequence/pairing; (2) first leg of the day on the current pairing; and (3) whether the accident sequence pairing was the first pairing together.

First day of pairing on the current/accident sequence/pairing was available for 46 accidents. Twenty-five accidents (54%) occurred during the first day of crew pairing. Twenty-one accidents (46%) occurred on a day following the crew's first day flying together.

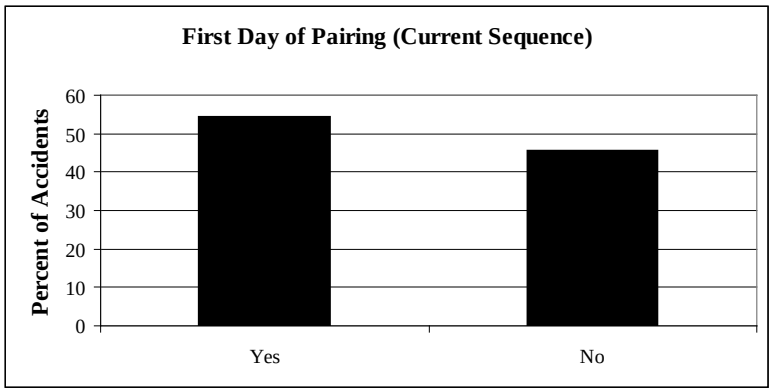

Figure 9. First day of pairing (current sequence).

There was not a significant difference between groups with regard to whether the accident occurred on the crew's first day of pairing on the current sequence/pairing, χ^2 (*df* = 1, *N* = 46) = 0.009, *p* = 0.923.

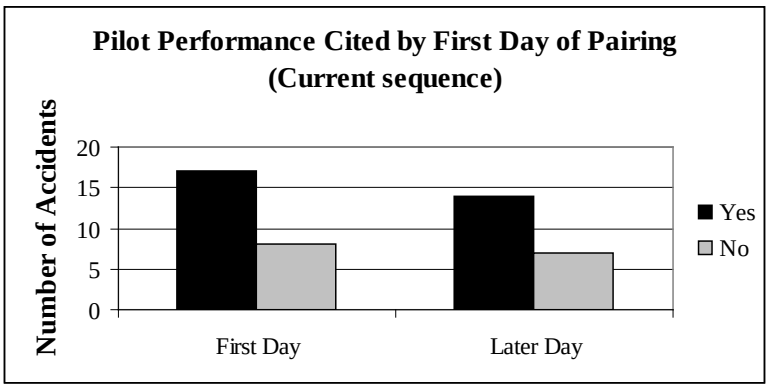

Figure 10. Pilot performance cited by first day of pairing (current sequence).

First leg of the day data was available for 49 accidents. Twenty-nine accidents (59%) occurred during the first leg of the day. Twenty accidents (41%) occurred after the crew had already completed at least one leg that day prior to the accident leg. It is important to note that not all trip sequences involve multiple legs per day. It is possible that a portion of the accidents that occurred during the first leg of the day involved a trip sequence with only one leg that particular day.

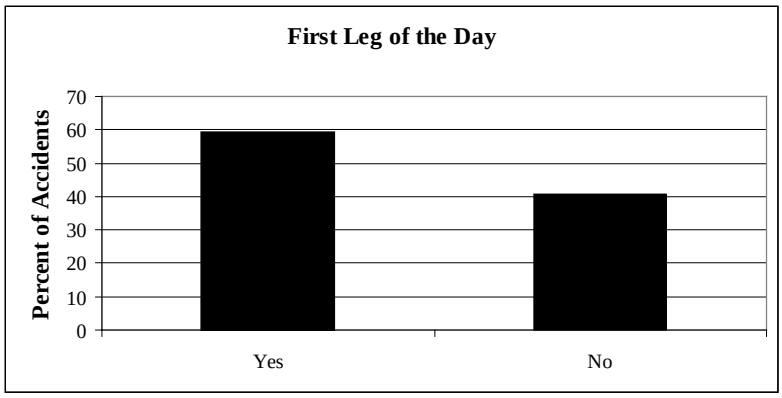

Figure 11. First leg of the day.

There was not a significant difference between groups of pilots with regard to whether the accident occurred on the first flight-leg of the day, χ^2 (df = 1, N = 49) = 0.108, p = 0.742.

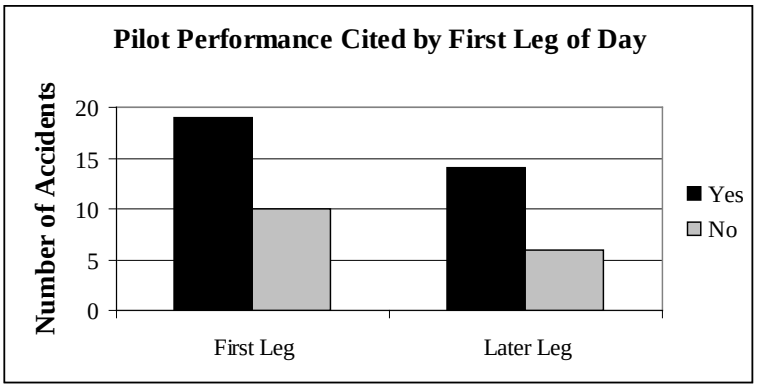

Figure 12. Pilot performance cited by the first leg of the day.

Data related to whether the accident crew had flown together in the past on another pairing sequence was available for 24 accidents. Thirteen flight crews (54%) had been paired together on at least one pairing, other than the accident pairing, in the past. For eleven flight crews (46%), the accident sequence pairing was the first time the crewmembers had been paired together.

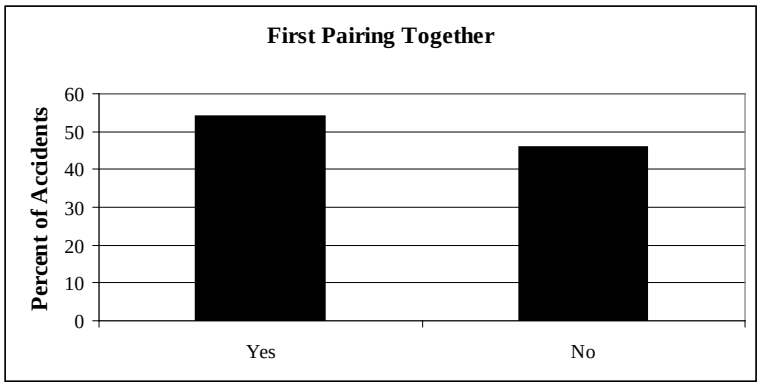

Figure 13. First pairing together.

There was not a significant difference between groups of pilots with regard to whether the accident occurred during the first pairing between pilots, χ^2 (df = 1, N = 24) = 0.511, p = 0.475.

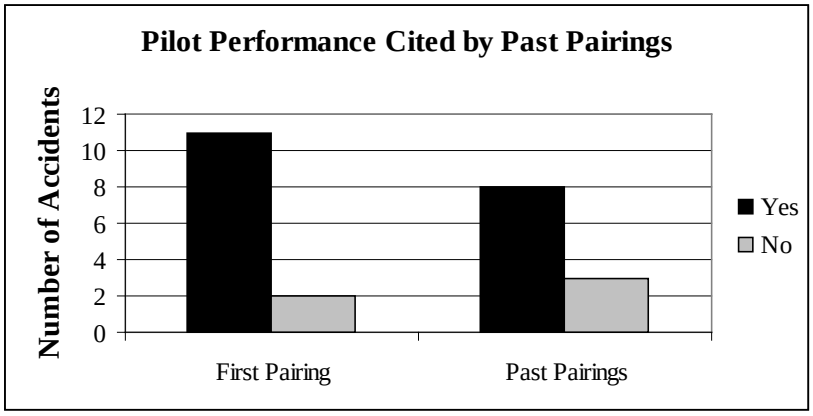

Figure 14. Pilot performance cited by past pairings

Discussion

The age of captains ranged between 25 and 59 years old with a mean of 47 years and the age of first officers ranged between 24 and 57 years old with a mean of 39 years. Forty-seven (94%) of the 50 captains were male and three (6%) were female. Forty-six (92%) of the 50 first officers were male and four (8%) were female. The disproportionate number of males was most likely the result of an underrepresentation of women in aviation. As a result, 43 (86%) of the 50 flight crews were comprised of an all-male crew of pilots. Seven (14%) of the fifty crews were comprised of both a male and female pilot

and none of the accidents (0%) involved an all-female crew of pilots. There was not a significant difference between groups with regard to the composition of crews by gender.

All of the captains (100%) held an ATP certificate. This was expected as possession of an ATP certificate is required in order to perform pilot-in-command duties under 14 CFR 121. Twelve (24%) of the 50 first officers were commercially certificated and 38 (76%) were ATP certificated. While there was not a significant difference between those accidents citing pilot performance as a causal or contributing factor and those not citing pilot performance during the cumulative period between 1991 and 2010, there was a significant difference between the 1991-2000 and 2001-2010 year groups irrespective of the citing/not citing of pilot performance. Between 1991 and 2000, only three (10%) of the 31 accidents involved a commercially certificated first officer. However, nine (47%) of the 19 accidents which occurred between 2001 and 2010 involved a commercially certificated first officer. This finding suggests a significant shift in the distribution of major U.S. air carrier accidents involving commercially certificated first officers during the later period. It was unknown what the actual employment distribution was among ATP and commercially certificated first officers who were involved in 14 CFR 121 air carrier operations during either period. However, this finding may be of particular interest with regard to the certification requirements imposed by Public Law 111-216.

The accident captains' duration of employment ranged from less than one month to over 30 years of employment with the accident air carrier, with a mean of 12.2 years and the accident first officers' duration of employment ranged from less than one month to over 32 years of employment with the accident air carrier, with a mean of 5.4 years. Only one (2%) of the captains had less than one year of employment with the accident air carrier. However, 13 (26.5%) of the 50 first officers had less than one year of employment with the accident air carrier. There was not a significant difference between groups with regard to duration of employment and citing/not citing of pilot performance.

The least experienced captain had 2,500 hours of total flight time and the most experienced captain had 25,000 hours of total flight time, with a mean of 11,994 hours. The least experienced first officer had 1,096 hours of total flight time and the most experienced first officer had 17,734 hours of total flight time, with a mean of 6,838 hours. Only two first officers (4%) had less than 1,500 hours of total flight time and neither were involved in an accident citing pilot performance as a causal or contributing factor. The findings suggest that first officers with less than 1,500 hours of total flight time did not contribute to any major U.S. air carrier accidents between 1991 and 2010. This finding may also be of particular interest with regard to the total flight time requirements imposed by Public Law 111-216. It is, however, important to point out that it is highly likely there were proportionately very few first officers with less than 1,500 hours of total time who were employed by U.S. air carriers operating under 14 CFR 121 during this period.

The least experienced captain had 111 hours in make/model and the most experienced captain had 16,000 hours in make/model, with a mean of 3,113 hours. The least experienced first officer had 20 hours in make/model and the most experienced first officer had 8,060 hours in make/model, with a mean of 1,683 hours. In regard to pilot experience in the accident aircraft and crew position, the least experienced captain had 26 hours as a captain in the accident aircraft make/model and position and the most experienced first captain had 16,000 hours as a captain in the accident aircraft make/model and position, with a mean of 2,048 hours. The least experienced first officer had 20 hours as a first officer in the accident aircraft make/model and position and the most experienced first officer had 8,060 hours as a first officer in the accident aircraft make/model and position, with a mean of 1,503 hours.

With regard to flying assignment, the captain was performing flying duties and the first officer was performing monitoring duties in 22 (45%) of the accidents. Twenty-five (54%) of the 46 accidents for which data was available occurred during the first day of crew pairing on the current pairing/sequence and 29 (59%) of the 49 accidents for which data was available occurred during the first leg of the day. Of the 24 accidents for which data was available, 13 (54%) of the accident crews had been paired together in the past on at least one other pairing/sequence other than the accident pairing/sequence.

With regard to causal and contributing factors, 34 (68%) of the 50 accidents included in this study cited pilot performance as a causal or contributing factor. Furthermore, these 50 accidents indicated additional contributing factors to include; environment as a causal or contributing factor 15 (30%), mechanical factors 12 (24%), or other persons 23 (46%) as a causal or contributing factor. A comparison between the 1991-2000 and 2001-2010 year groups indicated there was not a significant difference between groups with regard to the involvement of pilot performance, environmental factors, mechanical factors, or other persons as a causal or contributing factor.

Of the 50 accidents investigated in this study, all fifty captains (100%) had at least 2,500 hours of total flight time and forty-eight first officers (96%) had at least 2,000 hours of total flight time at the time of the accident. There were only two first officers (4%) with less than 1,500 hours of total time, having 1,096 and 1,420 hours respectively, and neither were involved in an accident citing pilot performance as a causal or contributing factor. These findings do not support the notion that a 1,500 hour total flight time requirement will contribute to the safety of 14 CFR 121 air carrier operations, as neither (0%) of the first officers with less than 1,500 hours of total flight time were involved in a major U.S. air carrier accident which cited pilot performance as a causal or contributing factor.

Conclusion and Recommendations for Further Research

Results of this study indicate that crew familiarity may have a negative effect on accident rates. Crew familiarity was measured in terms of (1) first day of pairing on the

current sequence/pairing; (2) first leg of the day on the current pairing; and (3) whether the accident sequence pairing was the first pairing together. Evaluation of crew familiarity indicated that accident rates were higher in instances of lower crew familiarity in each of the three areas measured. The majority of accidents occurred on the first day of pairing (54%), the first leg of the day (59%), and during the first pairing together (54%).

Upward pressures on the demand for air travel will result in upward pressures on the demand for labor. As witnessed in 2006 and 2007, several air carriers were forced to reduce minimum flight time hiring requirements in order to hire a sufficient number of pilots. Under the Airline Safety and Federal Aviation Extension Act of 2010, air carriers operating under 14 CFR 121 will potentially lose access to the more than 100,000 commercially certificated pilots with an instrument rating, according to FAA data, or approximately 45% of the potential labor supply under existing regulations (FAA, 2011c). This is a significant number of personnel and could have potentially negative consequences given the cyclical nature of the aviation industry.

Furthermore, while an ATP certification requirement for first officers will not eliminate the possibility of any future air carrier accidents involving commercially certified first officers, it is not possible to predict whether such a change will contribute to the enhancement of safety for 14 CFR 121 air carrier operations. It is possible there will simply be a redistribution of the number of accidents involving ATP certificated first officers.

Study findings suggest a significant shift in the distribution of major U.S. air carrier accidents involving commercially certificated first officers during the later period. It was unknown what the actual employment distribution was among ATP and commercially certificated first officers who were involved in 14 CFR 121 air carrier operations during either period. Further research could assist in identifying employment distribution among ATP and commercially rated first officers between the period of 1991 and 2010 and in particular when comparing the two time period groups (1991-2000 and 2001-2010) analyzed by this study.

Future studies could also include further analysis into crew familiarity issues and their correlation to accident rates. While it is not surprising that limited crew familiarity may have a negative effect on accident rates, additional research may identify solutions that can improve accidents related to crew familiarity issues. Additionally, further research should explore the potential affects that new pilot certification requirements will have on the future commercial pilot workforce. The literature indicates a continual increase in demand for air travel and the need for pilots. Will new pilot certification affect this prediction of future increased in demand for air travel and additional pilots? The commercial pilot workforce may be ill-prepared to react to consequences of new pilot certification requirements.

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