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English Language Proficiency and Aviation Safety

Robert Fowler Jr.
Embry-Riddle Aeronautical University, Robert.Fowler@mtsu.edu

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English Language Proficiency and Aviation Safety

Robert Fowler, Jr.

Embry-Riddle Aeronautical University

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ENGLISH LANGUAGE PROFICIENCY AND AVIATION SAFETY

by Robert Fowler, Jr.

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Graduate Capstone Project

Dr. Denny Lessard

Graduate Capstone Project Chair

Abstract

Scholar: Robert Fowler, Jr.

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The goal of this research study is to determine if aviation incidents and accidents due to deficiencies in English language proficiency have increased in the last 10 years based on data from the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS). In addition, this study will determine whether deficiencies in English language proficiency have a significant impact on aviation safety. There are currently 184,636 student pilots according to the Federal Aviation Administration Airmen Certification System. Included in this number are 11,776 student pilots with a foreign address (Federal Aviation Administration [FAA], 2019). Findings presented at a NASA workshop in 1979 concluded that a major cause of air carrier accidents was due to human error. The specific causes of these accidents involved failures in leadership, decision making and communication (McKeel, 2012). This research study will employ a quantitative analysis using scatterplot graphs and descriptive statistics to see if there are any trends concerning the number of reports related to English language proficiency. A chi-square test for independence will be employed to see if English language proficiency has a significant effect on aviation safety, and a one-way ANOVA will be performed to see if there is a significant difference between the number of reports submitted for Part 91, Part 121 and Part 135 operations. In addition, this research will include a review of the narrative and synopsis sections of these reports to investigate the nature of these English language incidents.

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Chapter I

Introduction

Is there a relationship between aviation English proficiency and safety? This was the focus of research reported in the International Journal of Aviation, Aeronautics, and Aerospace by Baugh and Stolzer (2018). The authors reviewed data from the NASA ASRS to determine if there is evidence of aviation incidents caused by language related communications challenges in General Aviation (GA) and in the GA training environment. The goal of this research was to better understand the relationship between language related communications issues and aviation safety to help improve the effectiveness of GA safety management system (SMS) programs. An effective SMS must be capable of capturing data concerning safety related issues that may lead to incidents and accidents in the future. The authors concluded that English language proficiency issues are underreported, but the data demonstrates that the potential cost of these language related errors is very high. This conclusion was supported by the number of near miss reports (NMAC) submitted to the ASRS involving student pilots (Baugh & Stolzer, 2018).

Federal aviation regulations require an applicant for a pilot certificate to be able to read, speak, write and understand the English language (FAA, 2017). Advisory Circular (AC) 60-28B was published by the FAA to provide guidance to applicants, examiners and training organizations concerning how to evaluate an applicant for the Aviation English Language Standard (AELS). According to AC 60-28B, those responsible for ensuring that applicants continuously demonstrate eligibility include FAA personnel, Designated Examiners (DE), Training Center Evaluators (TCE), flight and ground instructors, check pilots, training facilities and flight schools (FA, 2017). Individuals subject to this requirement include air traffic control (ATC) tower operators, aircraft dispatchers, mechanics and parachute riggers. The AC states

that "AELS will be evaluated before acceptance of a student pilot application or issuance of a student solo endorsement, recommendation or examination of an applicant for an FAA pilot certificate or additional rating, and whenever any individual is tested or checked as required by the Administrator under Title 14 of the Code of Federal Regulations (14 CFR)" (FAA, 2017). This Advisory Circular published by the FAA makes it clear that maintaining English proficiency is critical to aviation safety.

Significance of the Study

Air travel has increased significantly in the last 10 years and so has flight training activity based on the increase in the number of student pilot certificates (FAA, 2018). The increased demand for air travel in Asia, Africa, Europe and South America has led to an increase in flight training worldwide, and many of these international flight students seek training in the United States. According to the FAA, there are 11,776 international student pilots in the United States (FAA, 2019). Many of these international student pilots may not be native English speakers. This could lead to more incidents and accidents caused by English language deficiencies. A better understanding of the nature and extent of this problem will help in the development of assessment tools and education programs aimed at improving aviation English proficiency. The goal of this research is to determine the frequency of these incidents in the last 10 years and whether English language deficiencies have a significant effect on aviation safety.

Problem Statement and Purpose

The problem of English language proficiency and its effect on aviation safety is the focus of this research project. Communication breakdowns related to English language proficiency have contributed to many fatal aviation accidents in the past (Wald, 1996). While this problem

has been recognized by the International Civil Aviation Organization and the FAA, very little has been done to help those responsible for evaluation of aviation applicants. In addition, there are very few quality programs available for applicants to improve aviation English proficiency (Mathews, 2004).

Problems with aviation English proficiency have been a significant factor in many fatal aviation accidents in the past (Wald, 1996). To prevent mishaps due to language problems in the future, we must first understand the nature and magnitude of this problem. The best data source to help us understand this problem is from incident reports written by individuals who have experienced these problems firsthand. The NASA Aviation Safety Reporting System (ASRS) is a safety reporting system that encourages voluntary reporting of safety issues by granting immunity from legal or certificate action for rule violations that are reported promptly, are not deliberate, do not lead to an accident, and are not repeated violations (FAA, 2011). Thousands of safety reports are submitted to the ASRS every year. However, previous research has found that language related issues are under-reported and under-investigated (Baugh & Stolzer, 2018).

This research seeks to answer the following questions concerning English language related aviation incident reports: Has there been an increase in the number of reported aviation incidents due to aviation English proficiency problems in the last 10 years? Is there a significant difference in the number of reported aviation incidents by different operational groups due to aviation English proficiency problems? Does aviation English proficiency have a significant effect on aviation safety? This research study will contribute to the body of aviation safety knowledge through an analysis of English language related ASRS reports submitted from June 2009 to June 2019. This information will help improve reporting of English language related incidents which will help future research concerning this problem.

Hypotheses

- Null Hypothesis 1: The number of reported aviation incidents due to aviation English proficiency problems has not increased in the last 10 years.
- Alternate Hypothesis 1: The number of reported aviation incidents due to aviation English proficiency problems has increased in the last 10 years.
- Null Hypothesis 2: There is no significant difference between the number of reported aviation incidents by different operational groups due to aviation English proficiency problems.
- Alternate Hypothesis 2: There is a significant difference between the number of reported aviation incidents by different operational groups due to aviation English proficiency problems.
- Null Hypothesis 3: Aviation English proficiency does not have a significant effect on aviation safety.
- Alternate Hypothesis 3: Aviation English proficiency does have a significant effect on aviation safety.

The probability of making a Type I error or rejecting a true null hypothesis will be set at significance level .05 ($\alpha = .05$).

List of Acronyms

AC	Advisory Circular
AELS	Aviation English Language Standards
ASM	Available Seat Miles
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
CVR	Cockpit Voice Recorder
CET	College English Test
DE	Designated Examiner
ELPAC	English Language Proficiency for Aeronautical Communication
ELTS	English Language Testing System
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organization
IELTS	International English Language Testing System
IFALPA	International Federation of Air Line Pilots' Associations
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
FAA	Federal Aviation Administration
LPR	Language Proficiency Requirements
LSP	Language for Specific Purposes
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCAA	National Civil Aviation Authority

NES	Native English speakers
NMAC	Near Miss Aircraft
NNES	Non-native English speakers
NTSB	National Transportation Safety Board
PF	Pilot Flying
PM	Pilot Monitoring
SARPS	Standards and Recommended Practices
TCE	Training Center Evaluator
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omnidirectional Radio Range

Chapter II

Literature Review

Accident History - American Airlines Flight 965: On December 20, 1995, American Airlines flight 965 from Miami, Florida to Cali, Columbia crashed into a mountainside near the town of Buga. The crash occurred at 2142 eastern standard time in VMC. The crash site was 33 miles northeast of the Cali VOR. All 163 passengers and crew were killed. The flight from Miami was normal until flight 965 arrived in Cali airspace. The first officer was the pilot flying (PF) and the captain was the pilot monitoring (PM) (Ladkin, 1996).

The captain asked several questions during the approach that seemed to indicate confusion and a lack of situational awareness (Ladkin, 1996). While these questions made no sense and should have been a clue to the controller that the crew was confused, the controller said that he could not understand the captain's questions because he was not fluent in the English language. This prevented him from understanding the captain's confusion and providing the information needed to fly the correct approach. In addition, the culture in Columbia may have led the controller to be unwilling to question the captain (Ladkin, 1996).

Accident History – Avianca 052: On January 25, 1990, Avianca Airlines flight 052 from Bogota, Columbia to Kennedy International Airport in New York crashed into a residential area on Long Island, New York after running out of fuel. Seventy-three of the 158 people on board were fatally injured (NTSB, 1990). The flight was directed to hold three times by ATC for a total of one hour and seventeen minutes due to poor weather conditions in the region. The flight crew finally reported that it was running out of fuel and could not make it to the alternate airport of Boston-Logan International. The flight executed a missed approach to JFK and

experienced a total loss of power in all four engines while trying to return for a second approach. The crash site was approximately 16 miles from the airport (NTSB, 1990).

The NTSB determined the probable cause to be the flight crews' failure to manage the aircraft's fuel and their failure to declare a fuel emergency to ATC before running out of fuel (NTSB, 1990). The flight crew also failed to use the airline operational control dispatch system for assistance during an international flight into busy airspace with poor weather conditions. In addition, the NTSB found that there was a lack of standardized understandable terminology for pilots and controllers to communicate minimum and emergency fuel situations. Other safety issues raised in the report included the English language proficiency of the foreign flight crew (NTSB, 1990). The crew did not clearly communicate their fuel emergency to ATC.

International Civil Aviation Organization – English Language Mandate: The International Civil Aviation Organization (ICAO) introduced English language proficiency requirements for all member states in 2003 after accident investigations revealed that English language deficiencies were to blame for several high-profile aviation accidents (Emery, 2014). The ICAO Language Proficiency Requirements (LPR) state that international pilots and air traffic controllers who manage international air traffic must be able to speak and understand the English language for radio communications (Emery, 2014).

ICAO developed the LPR after realizing that aviation safety is compromised when pilots and controllers use nonstandard phraseology. As a result, the LPR states that pilots and controllers responsible for international flights must use only standard radiotelephony phraseology. However, the LPR states that there is also a need for "plain" English language proficiency because standard phraseology is not always able to handle every conceivable

situation that can occur. ICAO defined "plain" language as "the spontaneous, creative and non-coded use of a given natural language" (Emery, 2014).

ICAO – Standards for Testing and Training: The ICAO Language Proficiency Rating Scale requires a minimum proficiency of Operational Level 4 to work international flights. Operational Level 4 covers English language pronunciation, structure, vocabulary, fluency, comprehension and interactions (Alderson, 2009). When the ICAO LPR was published in 2003, member states were given 5 years to comply with the new standards. When ICAO determined that most of the member states would not comply by the deadline, it was extended another 3 years to March 5, 2011 (Alderson, 2009).

ICAO's adoption of stronger LPR's was necessary to improve the safety of international aviation communications. Unfortunately, there was a lack of support to accomplish the task of compliance with the LPR (Mathews, 2004). In response to this need, ICAO held the first Global Aviation Language Symposium, published a manual about language proficiency issues and scheduled regional seminars that focused on ways to develop local training and testing solutions. Unfortunately, market forces and a lack of language training regulation combined with a lack of certification and licensing requirements has resulted in widely varying program quality (Mathews, 2004).

Despite the delays in compliance with the LPR, experts agree that the level of activity in satisfying the new requirements is encouraging. The delays were mostly due to the complex nature of language training, but the deadlines were necessary to keep making progress toward the goal of compliance with the LPR (Werfelman, 2007). Unfortunately, ICAO lacked funds to develop criteria for global language testing and training. Language training and testing programs are an unregulated industry. There is no process for accreditation, and many schools that

specialize in English language training have embraced the LPR as a way to make significant income. Most of these schools are unfamiliar with the aviation industry and the requirements of aviation English. Consequently, there is inconsistency in the quality and effectiveness of programs available in the marketplace (Werfelman, 2007).

A validation study on the development of a test called the English Language Proficiency for Aeronautical Communication (ELPAC) was commissioned by the European Organization for the Safety of Air Navigation (Eurocontrol) in 2006 (Alderson, 2009). Eurocontrol asked the Lancaster Language Testing Research Group to validate ELPAC which was specifically designed to test the English language proficiency of air traffic controllers. Recommendations were made to improve the quality of the test as a result of this validation study. The final report made suggestions to implement quality control measures (Alderson, 2009). This study also included a search for other language tests used to assess air traffic controller language skills. While there were many tests available in the marketplace, there was very little data to prove the effectiveness of these tests (Alderson, 2009).

A survey of tests of aviation English was done by Alderson (2010) to find evidence concerning the quality of available testing products in the marketplace. These testing products are not subject to certification by ICAO. Therefore, the quality of these tests has not been verified. If these tests are inadequate, the consequences to pilots, air traffic controllers and passengers could be catastrophic. Several organizations that claimed to offer testing that could be used to certify pilots and air traffic controllers for English language proficiency were identified. Questionnaires based on guidelines from the European Association for Language Testing and Assessment were developed and sent to these organizations. While five of the organizations provided complete responses to the survey, the overall response rate was very low,

and the quality of the responses was inconsistent. As a result, the author concluded that the reliability and validity of many of the language tests available for certification was suspect (Alderson, 2010).

ICAO Member State Compliance – Attitudes Concerning Mandate: Why did these member states delay compliance with the ICAO LPR? Recent research concerning Korean pilots and air traffic controllers may provide insight into this problem (Kim & Elder, 2015). This research addressed the following question: How is the Korean radiotelephony communication test and the ICAO LPR perceived by Korean pilots and air traffic controllers? The responses to questionnaires from 400 participants were analyzed. The participants were all volunteers consisting of 300 pilots and 100 air traffic controllers. Most of the responders felt that the test did not accurately reflect radiotelephony communication competence. There were frequent complaints about inappropriate and irrelevant content and the overall quality of the test. They also complained about the lack of public data concerning the validity and reliability of the test (Kim & Elder, 2015). Most of the responders expressed a negative view of the ICAO LPR. Three primary reasons were cited for this negative view. First, the responders questioned the reasoning behind the ICAO LPR that recognized English proficiency as the primary cause for accidents in the past. Based on personal experience, many of the responders said that aviation accidents are too complex for any one factor to be cited as the primary cause. The second reason cited by most of the responders was that the ICAO LPR had a greater impact on more senior aviation personnel whose English language proficiency was generally lower than less experienced personnel. They feared the loss of expertise from senior aviation personnel would result in a decrease in safety rather than the intended effect. The third reason given was that the ICAO LPR unfairly penalized non-native English speakers (NNES) and did not consider the

possibility that many native English speakers (NES) do not use standard aviation phraseology (Kim & Elder, 2015). The results of this study revealed significant resistance to the ICAO LPR from Korean pilots and air traffic controllers. This resistance may have contributed to the delay in implementing the ICAO LPR by many of the member states.

Another research study involved a survey of 165 pilots who worked for a Chinese cargo airline to determine their attitudes toward the ICAO LPR and how they prepared for the English language proficiency exam (Zhao, Guo & Gao, 2017). Failing this exam can disqualify a pilot or air traffic controller from working on international flights. Participants in this study were separated into two groups. One group consisted of senior pilots over the age of 38. Most of the pilots in this group were retired Chinese Air Force officers. The second group consisted of junior pilots under the age of 38. All of these junior pilots were university graduates. None of the senior group of pilots had learned English before working for the cargo carrier. The junior pilots had all passed the College English Test (CET) at Band 4. A quarter of the group had attained CET Band 6 before graduating. All the participants had passed the ICAO Level 4 test which is the minimum required to fly international flights. The results of the survey revealed that the participants spent very little time learning English (Zhao, Guo & Gao, 2017). Sixty-seven percent or 111 pilots said they only studied just before taking their exams. Only 11% or 19 pilots claimed that they studied every day. Seventy-two out of 111 pilots who spent time studying English before the exam were senior pilots. Eighteen of the 19 pilots who claimed to study every day were senior pilots. The senior pilots worked harder than the junior pilots to pass the ICAO LPR exam. Most of the participants took training courses that were conducted by professional aviation English trainers, but over two thirds of the participants did not think the training courses helped (Zhao, Guo & Gao, 2017). The researchers recommended developing

different tests and education programs for senior and junior pilots to ensure that each group receives appropriate training and testing based on prior experience. Again, resistance to the ICAO LPR due to inappropriate testing of certain groups may have contributed to the delay in implementation.

ICAO Member State Compliance – Compliance Verification: The first deadline for implementation of the ICAO LPR was March 2008. When it became apparent that many member states would not be able to meet that deadline, it was extended to March 2011. At that time, ICAO urged its member states to post on the ICAO website their LPR plans for implementation including how the risk would be mitigated until implementation (Abeyratne, 2011). Despite the extension, 137 member states were still non-compliant in January 2011. Forty-three of these non-compliant member states claimed that they were compliant by June 2011 but furnished no evidence of compliance. Indeed, ICAO did not attempt any monitoring or oversight at that time. ICAO never challenged any claim of compliance and did not audit the tests and assessment procedures being employed. According to ICAO, it is the National Civil Aviation Authority's (NCAA) responsibility to monitor compliance with the LPR. This claim was made even though this is not the case with ICAO Safety Audits (Alderson, 2011).

Flight Training and English Proficiency – FAA Requirements: The Federal Aviation Administration (FAA) Aviation English Language Standard (AELS) was designed to be consistent with ICAO Operational Level 4 standards for English language proficiency (FAA, 2017). The FAA requires AELS to be evaluated before issuance of a student pilot certificate, student solo endorsement or whenever any person is tested or checked for a certificate or rating. The FAA AELS states that "The holder of an FAA Certificate or applicant for an FAA certificate or rating should be able to communicate in English in a discernable and understandable manner

with air traffic control, pilots and others involved in preparing an aircraft for flight and operating an aircraft in flight. This communication may or may not involve the use of the radio" (FAA, 2017).

Due to the growing demand for pilots in Asia with China having the greatest need for new pilots, the flight training industry in North America has experienced an increase in the number of student pilots who are not native English speakers (Turner, 2014). Chinese aviation organizations have turned to North America due to airspace restrictions in China as well as the ICAO language proficiency requirement (LPR). Most of the flight schools that accepted these students did not have a reliable means to test students to determine aptitude or English language proficiency. Consequently, many Chinese students who came to North America for flight training failed to complete the training (Turner, 2014). In addition, flight instructors in North America had little experience teaching students who were not native English speakers. A lack of English language proficiency was frequently cited as the reason students failed to progress in flight training even though it was impossible to determine if there were other problems in addition to difficulty with the English language. Unfortunately, there were no reliable tests or assessments to help flight schools select candidates with adequate English language skills (Turner, 2014).

Flight Training and English Proficiency – FAA Testing Guidance: The FAA Advisory Circular (AC 60-28B) describes the process required to ensure any applicant for an FAA certificate and any holder of an FAA certificate demonstrates compliance with the FAA AELS (FAA. 2017). If the airman demonstrates AELS equivalent to the ICAO Operational Level 4 English language proficiency, an endorsement will be affixed to the airman certificate indicating "English Proficient." All applicants and trainees will be evaluated for AELS by an

FAA evaluator. An FAA evaluator is any individual authorized to conduct certification, training, testing, checking or is authorized to issue an endorsement that is required by the Federal Aviation Regulations under CFR 14 (FAA, 2017).

The evaluation process recommended by the FAA in AC 60-28B directs the evaluator to ask the applicant questions concerning the certificate application. In addition, the applicant can listen to the evaluator read a clearance, instructions from the Airplane Flight Manual or a pilots operating handbook, or a weather report and answer questions about what was heard. The evaluator must listen to the response to determine the applicant's ability to meet the AELS (FAA, 2017). Other suggestions include having the applicant to read a portion of a text and asking the applicant to explain and write down what was heard and read. AC 60-28B A.2.3.2 states the following: "Per the above, the evaluator can determine if the applicant understands in English what they heard and read and if they can effectively communicate in English in a discernible and understandable manner. This will determine whether or not the applicant can communicate with ATC, pilots, and others involved in preparing an aircraft for flight and operating an aircraft in flight, with or without radio; therefore, the applicant will or will not be deemed to meet the FAA regulatory English language eligibility requirements to be issued or hold an FAA certificate" (FAA, 2017).

Unfortunately, this guidance is very general and depends on the evaluator's individual judgement which will vary between different evaluators. It is important to note that these guidelines are meant for evaluators who are not professionally trained to teach or evaluate proficiency in the English language. It is no wonder that English language related mishaps and incidents still occur 16 years after ICAO first introduced the English language proficiency requirements for member states in 2003.

Chapter III

Methodology

This research will focus on the effect of English Language deficiencies on aviation safety. A trend analysis will be performed to determine trends in reporting incidents related to aviation English proficiency. In addition, a quantitative analysis will be performed to determine the impact of language problems on aviation safety. A second quantitative analysis will be done to see if there is a significant difference between reports from different operational groups. Data from the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) will be collected concerning incident reports related to problems with aviation English. Separate data will be analyzed from Part 91, Part 121 and Part 135 operators.

Research Design and Procedures

The research design is Ex Post Facto because the analysis is focused on historical data retrieved from the ASRS. The events that led to this data occurred in the past, and this research simply looks back at this historical data to better understand the nature of this problem. The design is also a quantitative analysis of ASRS data using scatter plots to determine any trends in reporting. The chi-square test for independence will be performed to determine the impact of English Language problems on aviation safety. While the chi-square test for independence can determine that there is a relationship between aviation English proficiency and aviation safety, it does not establish a causal relationship. However, we can determine that the two variables are related. Finally, a one-way ANOVA will be performed with a Tukey's HSD to determine if there are significant differences between the number of reports submitted by different operational groups such as Part 91, Part 121 and Part 135, and the frequency of terms used in the narratives will be reviewed to determine the nature of these language related incident reports.

Data Collection Review and Critique

The data for this research was collected from the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS). The ASRS is a voluntary safety reporting system designed to collect, analyze and respond to incident reports from pilots, air traffic controllers and other aviation personnel. The data in the ASRS is de-identified and publicly available. Therefore, approval from the Institutional Review Board (IRB) of Embry-Riddle Aeronautical University was not required. Thousands of reports have been submitted every year since it was implemented in 1975 in response to a study of the National Air Transportation System. The ASRS staff includes experienced pilots, air traffic controllers and aviation mechanics with over 600 years of combined aviation experience and over 200,000 cumulative flight hours. Over 1.5 million safety reports have been submitted to the ASRS since it was implemented making it the largest source of aviation safety data in the world (NASA, n.d.)

Due to the size of this data source, this research was limited to ASRS reports submitted from June 2009 to June 2019 which is 10 years of data. June 2009 was selected as the start date because human factors data was not recorded by ASRS until that time. The total number of safety reports submitted during this time period was 50,885 (Table 1). Individuals who submit reports to ASRS can indicate the specific regulation associated with the reported incident. Therefore, the reports were broken down into four different operational groups to simplify the data. Part 91 reports concern general aviation operations. Reports concerning scheduled airline operations are filed under Part 121 and on-demand charter reports are filed under Part 135. The fourth group was labeled “No Entry” because the report did not include an entry concerning the specific operation involved in the incident report.

In addition to searches based on operational groups, the ASRS database can be searched based on specific dates, report numbers, flight conditions, flight phase as well as several other search categories. If a special search item is not listed, the database will allow a search based on specific words in the narrative and synopsis of the report. Previous research concerning language issues in general aviation operations and pilot training employed search terms that included the words English, foreign, communications, misunderstanding, language and accent (Baugh & Stolzer, 2018). A search of the database was performed based on these terms without limiting the data to Part 91 and flight training operations as the previous research had done. This search returned 3,513 reports. Unfortunately, searching for words in the narrative and synopsis of the reports is imprecise because many of the reports had nothing to do with English language problems. Searches were performed using just one of the search words. This revealed that using the words foreign, communications, misunderstanding and language did not return many reports about language issues. However, searching for the words English or accent resulted in the most relevant data. Therefore, a search of the database was performed requesting only reports that included the words English or accent in the narrative and synopsis from June 2009 to June 2019, and 312 reports were returned. Separate searches were done for reports filed under Part 91, Part 121, and Part 135. In addition, a search was done for reports that were filed with no entry for the operation. These reports were reviewed to delete any that were not related to language problems. The final analysis revealed 247 ASRS incident reports from June 2009 to June 2019 that were related to English language problems. The breakdown is displayed in Table 1 and a scatter plot of the data is displayed in Figure 1. Descriptive statistics were calculated for the time period and revealed that the mean number of reports due to English language problems for the time period was 24.7. The standard deviation was 6.86.

Limitations of the Collected Data

The data collected from the ASRS is limited in several ways. The safety reports that are submitted to the ASRS are completely voluntary. As such, some pilots may be reluctant to voluntarily submit reports about English language incidents. In addition, some of these reports may have been coded inaccurately. The search criteria included the words English or accent in the narrative and synopsis, and some reports that were related to a language problem may not have been coded with these words. As a result of these limitations, incidents due to English language issues are probably underreported. Finally, reports due to human factors were not tracked in the system before June 2009. As a result, data for just 6 months of 2009 was collected and analyzed.

Chapter IV

Results

Trend Analysis

Descriptive statistics were calculated with 10 years of data from the ASRS concerning incident reports related to English language problems. The mean number of all language related incident reports from 2009 to 2019 was 24.7 and the standard deviation was 6.864. The descriptive statistics for the total number of language related incident reports are shown in Table 2 and Figure 1 below.

The data was divided into four groups representing language related incident reports for Part 135, Part 91, and Part 121 operators. The fourth group represents language related incident reports which did not have an entry identifying the type of operations involved. These are labeled “No Entry” in Table 2. Scatter plot graphs for Parts 121, 91 and 135 language related

Table 1

ASRS Incident Reports (2009-2019)

		Part 121			Part 91			Part 135			No Entry			Total	
Year	**Not ESL**	**ESL**	**Total**	**Not ESL**	**ESL**	**Total**	**Not ESL**	**ESL**	**Total**	**Not ESL**	**ESL**	**Total**	**Not ESL**	**ESL**	**Total**
2009	2242	10	2252	816	5	821	115	0	115	211	0	211	3384	15	3399
2010	3542	11	3553	1176	5	1181	193	1	194	565	8	573	5476	25	5501
2011	3479	18	3497	1333	6	1339	202	1	203	599	8	607	5613	33	5646
2012	3085	11	3096	1394	8	1402	219	0	219	334	4	338	5032	23	5055
2013	2833	15	2848	1168	6	1174	190	1	191	259	2	261	4450	24	4474
2014	2757	18	2775	1233	7	1240	199	1	200	358	4	362	4547	30	4577
2015	3520	19	3539	1573	7	1580	309	2	311	539	2	541	5941	30	5971
2016	3125	6	3131	1593	5	1598	307	0	307	371	1	372	5396	12	5408
2017	3009	17	3026	1542	6	1548	254	1	255	385	0	385	5190	24	5214
2018	3463	20	3483	1416	6	1422	269	1	270	461	4	465	5609	31	5640
Totals	**31055**	**145**	**31200**	**13244**	**61**	**13305**	**2257**	**8**	**2265**	**4082**	**33**	**4115**	**50638**	**247**	**50885**

Table 2

Summary Statistics

Part	Incident Type	N	Min	Max	Mean	SD
91	Non-Language	10	816	1593	1324.4	237.56
	Language Related	10	5	8	6.1	.9944
	Total	10	821	1598	1330.5	237.88
121	Non-Language	10	2242	3542	3105.5	419.14
	Language Related	10	6	20	14.5	4.696
	Total	10	2252	3553	3120.0	420.70
135	Non-Language	10	115	309	225.7	59.76
	Language Related	10	0	2	.8	.6324
	Total	10	115	311	226.5	59.98
No Entry	Non-Language	10	211	599	408.2	129.95
	Language Related	10	0	8	3.3	2.907
	Total	10	211	607	411.5	132.03
Totals	Non-Language	10	3384	5941	5063.8	755.06
	Language Related	10	12	33	24.7	6.864
	Total	10	3399	5971	5088.5	758.39

incident reports are shown in Figures 2, 3 and 4 respectively. Part 121 operators submitted the largest number of reports with a mean of 14.5 and a standard deviation of 4.696. The mean number of reports submitted by Part 91 operators was 6.1 with a standard deviation of .9944.

The mean number of reports submitted without an entry for the type of operation was 3.3 with a standard deviation of 2.907, and the smallest number of language related incident reports was submitted by Part 135 operators with a mean of just .8 and a standard deviation of .6324.

The total number of language related incident reports displayed in Figure 1 shows a slight trend up supporting alternative hypothesis 1. The total number of reports was influenced primarily by Part 121 operators who submitted the largest number of reports out of the 4 groups. According to the FAA, Part 121 scheduled carrier operators flew 10,170,000 flights in 2018 compared to 5,952,000 Part 91 general aviation flights (FAA, 2018). Since Part 121 operators flew roughly 4.2 million more flights than Part 91 and Part 135 put together, it makes sense that they would file more incident reports as well. It is also likely that more Part 121 operators report violations and incidents to the ASRS because they have more incentive to take advantage of the immunity granted to pilots who report unintentional violations and safety issues. A violation could lead to negative professional consequences for the Part 121 operator.

According to the FAA (2019), the number of Airline Transport Pilot certificates has seen a steady rise since 2009. The number of Student Pilot certificates has also seen a steady increase (see Figure 8). While the number of scheduled carrier flights has essentially decreased since 2009, the available seat miles has increased significantly according to the United States Department of Transportation (FAA, 2018). Available seat miles (ASM) is calculated by multiplying the number of seats on an aircraft by the stage length of the flight. Air carrier capacity is measured in ASM's. Since 2009, air carriers have increased the size and capacity of their aircraft. In addition, average stage length has increased (FAA, 2018).

Figure 1

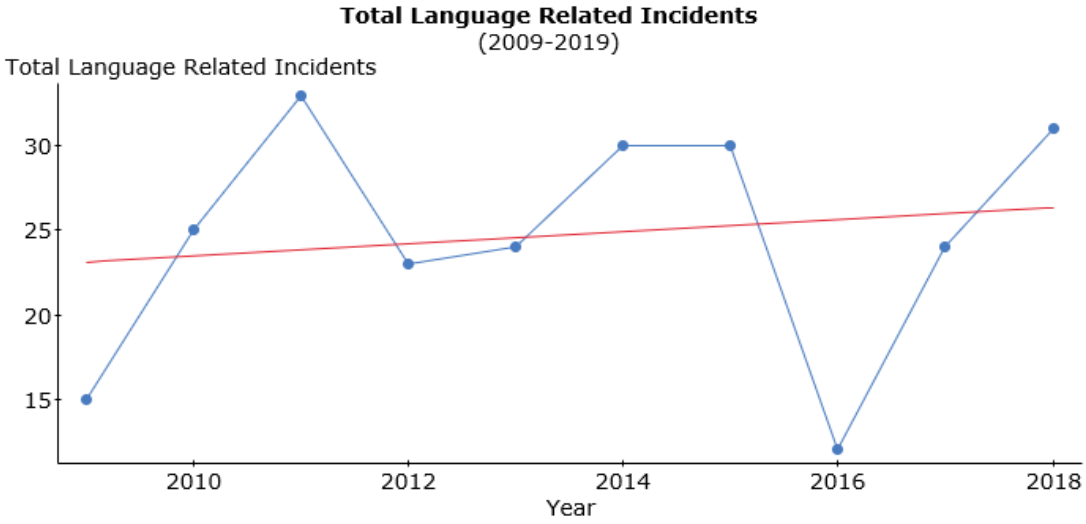


Figure 2

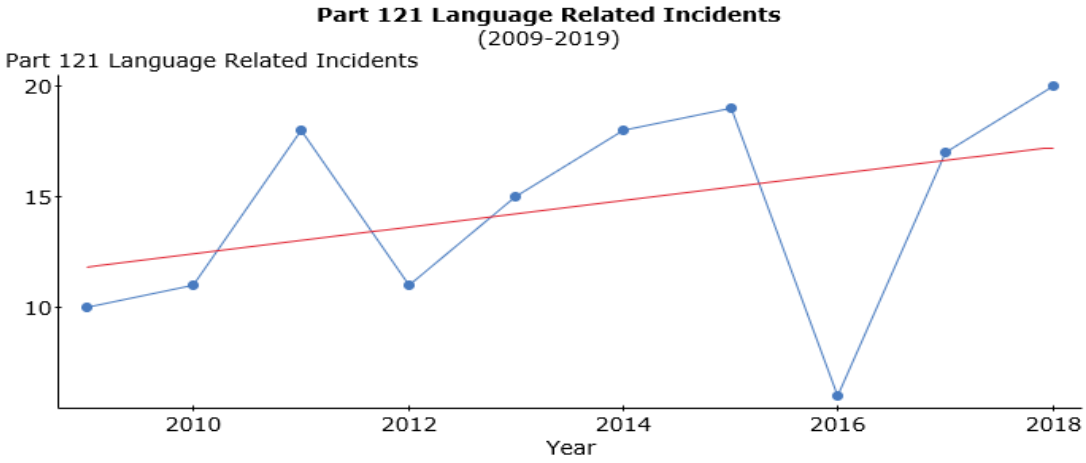


Figure 3

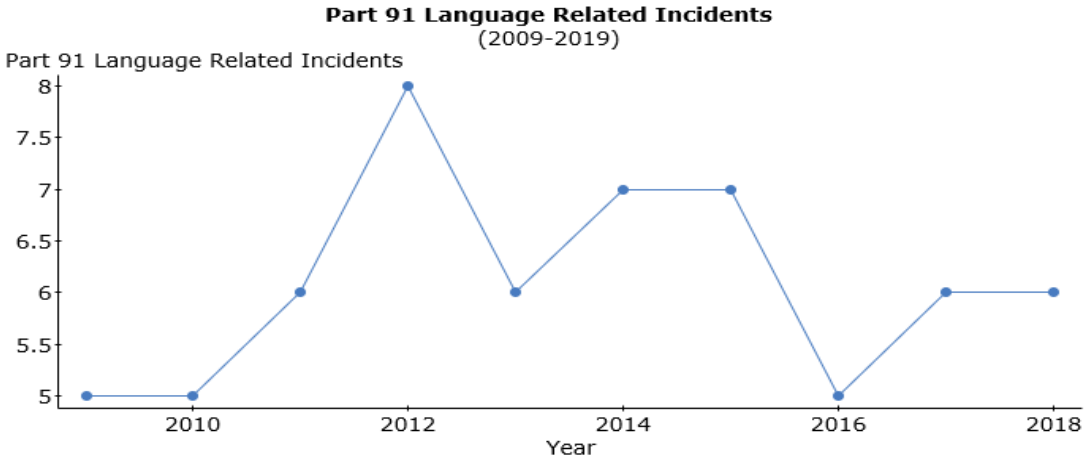


Figure 4

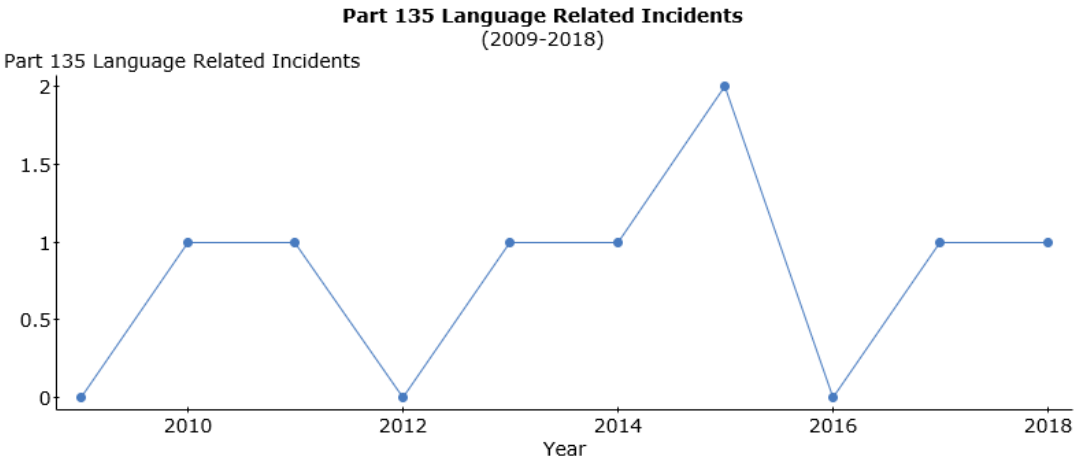


Figure 5

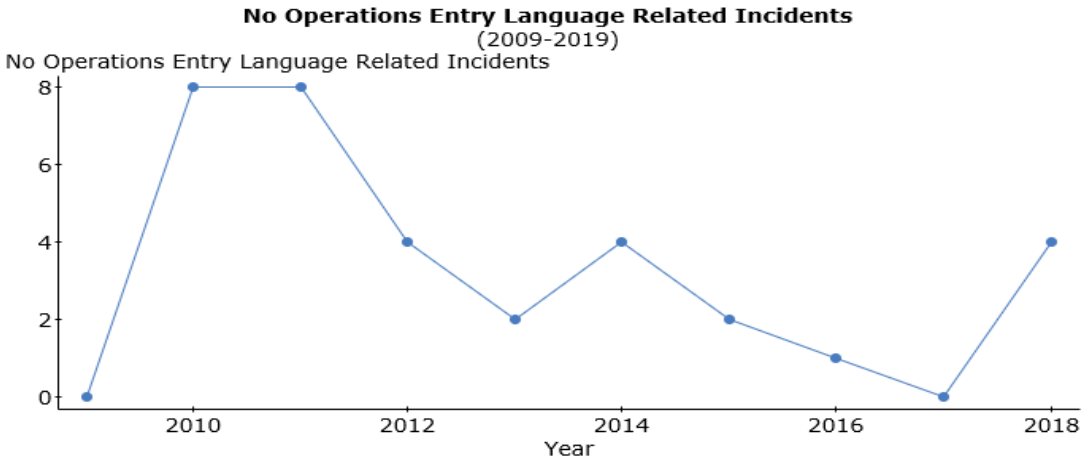


Figure 6

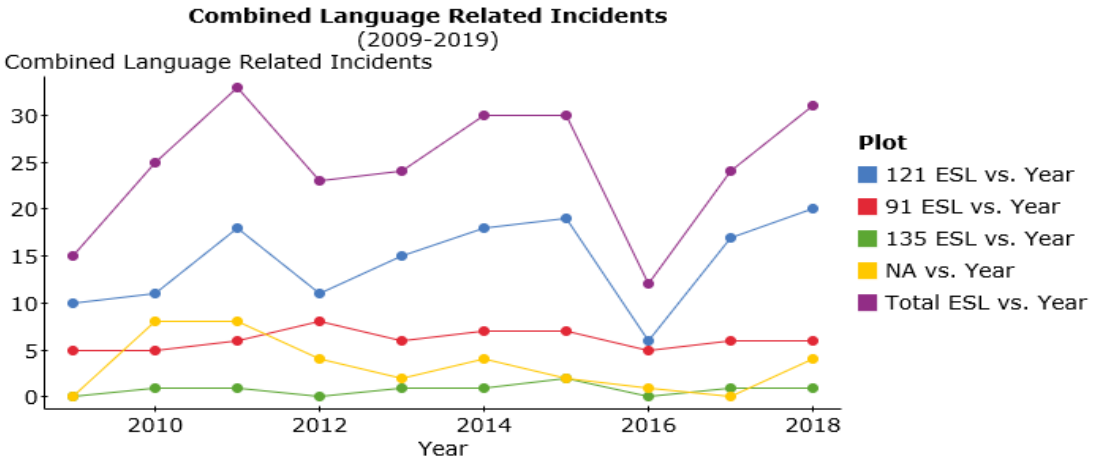
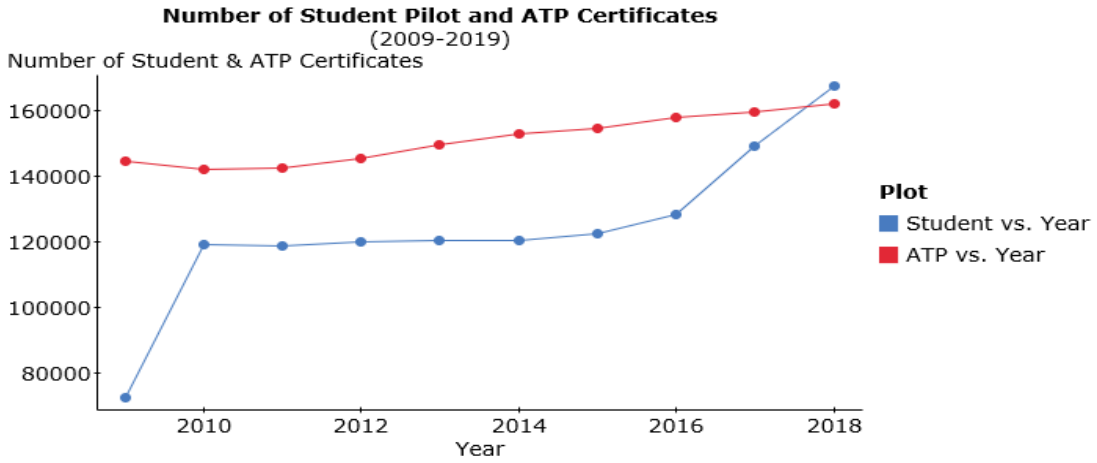
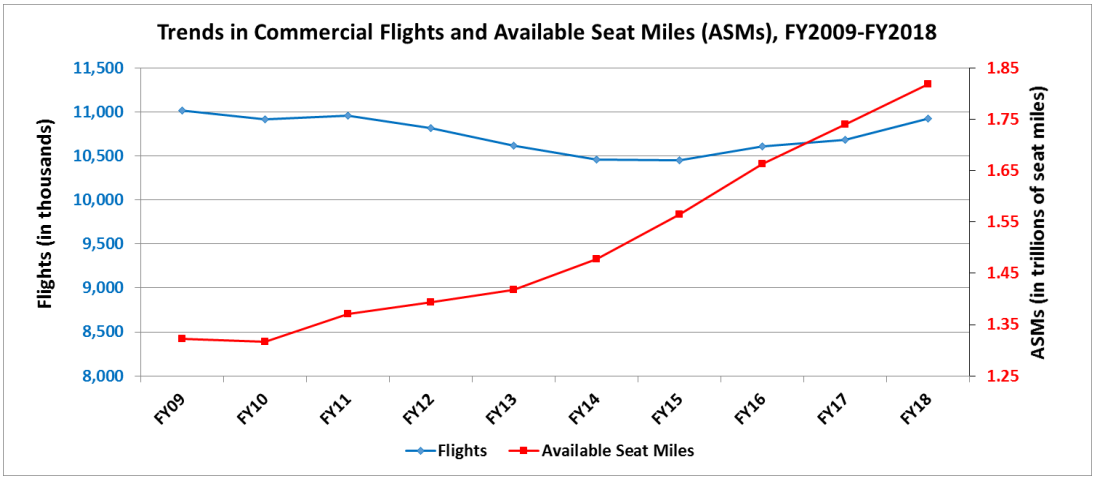


Figure 7



Source: Federal Aviation Administration, Air Traffic by the Numbers, June 2019.

Figure 8



Source: U.S. Dept. of Transportation, Bureau of Transportation Statistics, T100 Segment Data, March 4, 2019.

Since 2009, the number of flights decreased by 0.9 percent. However, the number of passengers increased by 28.3 percent (see Figure 9). ASM's increased in the same period by 37.6 percent (FAA, 2018). Larger aircraft flying longer flights could lead to more potential conflicts in the air. The increase in student pilots and the large number of international student pilots could increase the chances for incidents due to English language problems.

Analysis of Variance

A One-Way ANOVA was performed with Statcrunch statistical software to determine if there was a statistically significant difference between operational groups. A One-Way ANOVA makes four assumptions. The sample taken from the population is a simple random sample. The samples are independent from one another. The variable considered is normally distributed for each population and the standard deviations of the variable considered are the same for all populations. The first two assumptions were satisfied because the four samples were randomly selected from the population of ASRS incident reports and the samples were independent of one another. A QQ plot of residuals or differences between the observations and the mean of the samples was generated to determine the normality of the population and the equal standard deviations assumptions. The plot was roughly linear which satisfies the third and fourth assumptions (Figure 9).

The mean number of incident reports for the Part 135 group was .8 (sd = .2), for the Part 91 group was 6.1 (sd = .31), for the Part 121 group was 14.5 (sd = 1.48) and for the No Entry group was 3.3 (sd = .91). These means do differ significantly using a One-Way ANOVA, $F(3,36) = 44.50$, $p<.0001$ (Table 3 & 4). Post hoc comparisons were conducted using the Tukey HSD test ($p = .05$). The Part 121 group submitted significantly more incident reports than the Part 91, 135 and No Entry groups. The difference between Part 135 and Part 91 groups was statistically significant, but there was no significant difference between the Part 135 group and the No Entry group or between the Part 91 group and the No Entry group (Table 5). This result supports alternative hypothesis 2 which states that there is a significant difference in the number of language related incident reports submitted between operational groups.

Chi-Square Test for Independence

A chi-square test for independence was performed with Statcrunch statistical software with the data in Table 6. We can use the chi-square test for independence when the data is from a simple random sample, the variables are catigorical and the values can be displayed in a contingency table such as Table 6. Our contingency table has two columns and four rows. To determine the degrees of freedom (df), we multiply the number of rows (N) minus 1 by the number of columns minus 1. Therefore, (N-1) X (N-1) or (4-1) X (2-1) = 3. So df = 3. With a df = 3 and a chi-square value of 9.8305538, the P-value (0.0201) is less than the significance level of 0.05 (Table 7). This supports alternate hypothesis 3 that there is a relationship between English language proficiency and aviation safety. The chi-square test for independence does not establish a causal relationship between English language proficiency and aviation safety. It only supports the existence of a relationship between the two variables.

Review of Narrative Terms

Figure 10 shows the frequency of specific terms used in the ASRS incident reports. The top four terms were English, confusion, language and accent. The term confusion was used 223 times. In other words, confusion was the predominant result of many of these language related incidents. The word accent was mentioned in the incident reports 113 times. In many of these reports, the accent of the pilot or air traffic controller was a significant factor. Proficiency depends on both the ability to understand the English language and to be understood. The ICAO LPR makes it very clear that pronunciation, stress, rhythm and intonation must not interfere with ease of understanding.

Figure 9

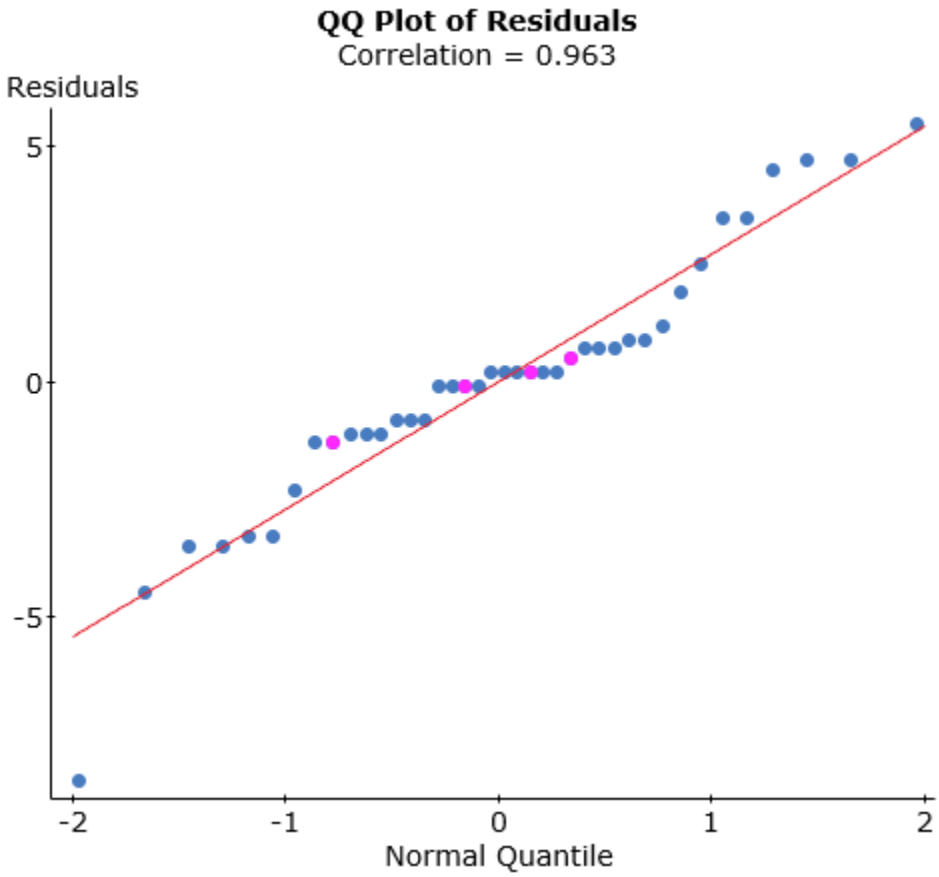


Table 3.

Analysis of Variance results:

Column	n	Mean	Std. Dev.	Std. Error
Part 135	10	0.8	0.63245553	0.2
Part 91	10	6.1	0.99442893	0.31446604
Part 121	10	14.5	4.6963343	1.4851113
No Entry	10	3.3	2.9078438	0.91954095

Table 4

ANOVA table

Source	DF	SS	MS	F-Stat	P-value
Columns	3	1064.675	354.89167	44.500522	<0.0001
Error	36	287.1	7.975		
Total	39	1351.775			

Table 5

Tukey HSD results (95% level)

Part 135 subtracted from

	Difference	Lower	Upper	P-value
Part 91	5.3	1.8986343	8.7013657	0.0009
Part 121	13.7	10.298634	17.101366	<0.0001
No Entry	2.5	-0.90136571	5.9013657	0.2145

Part 91 subtracted from

	Difference	Lower	Upper	P-value
Part 121	8.4	4.9986343	11.801366	<0.0001
No Entry	-2.8	-6.2013657	0.60136571	0.1379

Part 121 subtracted from

	Difference	Lower	Upper	P-value
No Entry	-11.2	-14.601366	-7.7986343	<0.0001

Table 6.

Chi-Squared Test on Language Related Incidents			
Regulation	**Not ESL**	**ESL Related**	**Total**
Part 135	2257	8	**2265**
Part 91	13244	61	**13305**
Part 121	31055	145	**31200**
No Entry	4082	33	**4115**
Totals	**50638**	**247**	**50885**

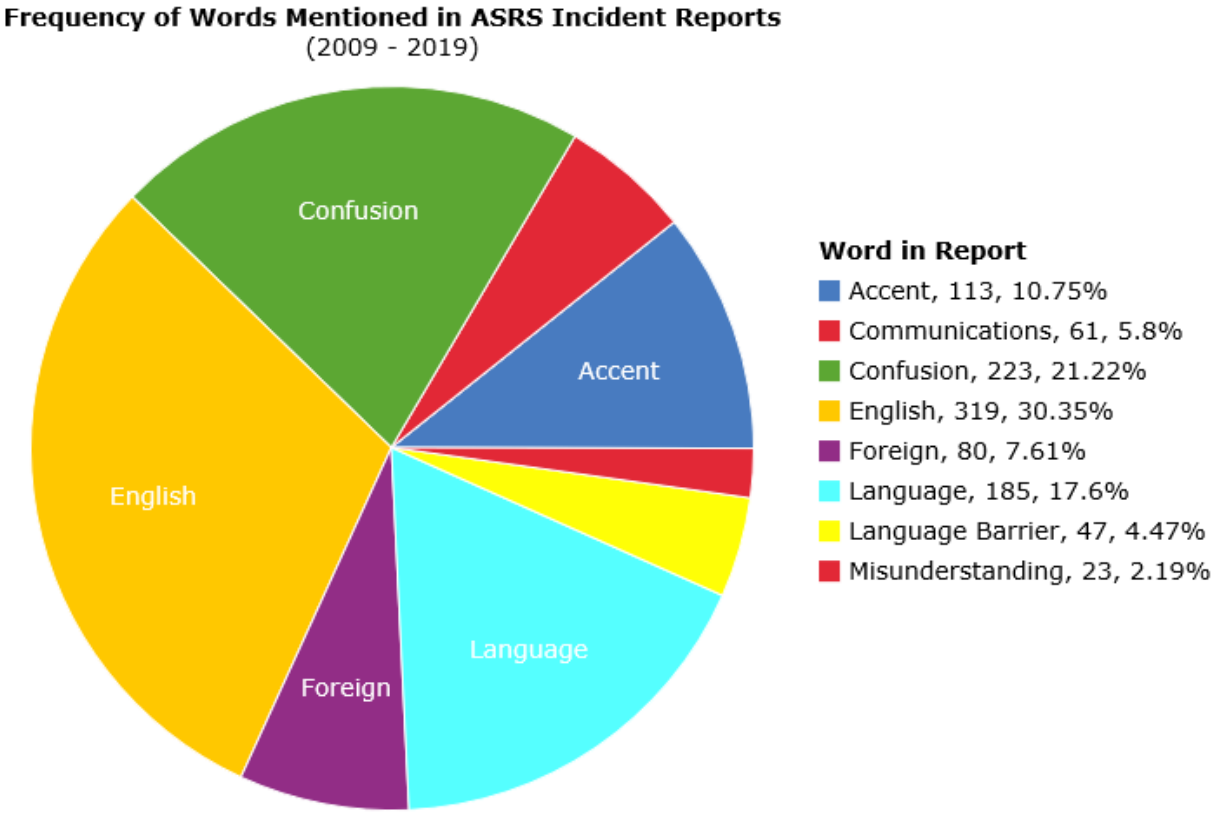
Table 7. Contingency table results:

Ops	Not ESL	ESL	Total
Part 135	2257 (99.65%) (4.46%) (4.44%) (2254.01)	8 (0.35%) (3.24%) (0.02%) (10.99)	2265 (100%) (4.45%) (4.45%)
Part 91	13244 (99.54%) (26.15%) (26.03%) (13240.42)	61 (0.46%) (24.7%) (0.12%) (64.58)	13305 (100%) (26.15%) (26.15%)
Part 121	31055 (99.54%) (61.33%) (61.03%) (31048.55)	145 (0.46%) (58.7%) (0.28%) (151.45)	31200 (100%) (61.31%) (61.31%)
No Entry	4082 (99.2%) (8.06%) (8.02%) (4095.03)	33 (0.8%) (13.36%) (0.06%) (19.97)	4115 (100%) (8.09%) (8.09%)
Total	50638 (99.51%) (100%) (99.51%)	247 (0.49%) (100%) (0.49%)	50885 (100%) (100%) (100%)

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	3	9.8305538	0.0201

Figure 10



Chapter V

Discussion

ASRS data show that problems with the ICAO LPR continue to be an issue that compromises safety in the National Airspace System (NAS). While the total number of ASRS reports filed due to English language deficiencies is relatively small compared to the total number of reports filed in the last 10 years, there is still a significant risk of a catastrophic accident occurring because a pilot or air traffic controller does not meet the ICAO LPR. Unfortunately, aviation English language deficiencies will become more common in the future with an increase in the number of pilots who are not native English speakers operating in the NAS.

The types of errors that can occur as a result of English language deficiencies range from minor to catastrophic as demonstrated by high profile accidents such as American Airlines Flight 965 in Columbia (Ladkin, 1996) and Avianca Airlines Flight 052 in New York (NTSB, 1993). Research concerning the nature of communication errors reported to the ASRS found that there were three types of communication errors (Cardosi, Falzarano & Han, 1998). The first type is a read back and hear back error where the pilot reads back an ATC instruction or clearance incorrectly without being corrected by the air traffic controller. This type of error was made 47% of the time. The second type of error is when a pilot fails to read back air traffic control instructions or clearances. These errors were made 25% of the time. The third type of communication error is called a hear back error II. These errors occurred when the controller did not notice when he or she made an error in the instructions or clearance transmitted to the pilot. This happened 18% of the time (Cardosi, Falzarano & Han, 1998).

While this research did not specifically investigate errors due to problems with English language proficiency, the factors that were commonly found to contribute to these errors could be made worse by pilots or controllers who are deficient in aviation English. These factors included similar call signs on the same frequency, pilot expectations which can lead a pilot to accept a clearance that was expected rather than the actual clearance, and air traffic controllers with high workloads. The errors committed as a result of these communication issues included altitude deviations, loss of standard separation, operational errors, pilots landing on the wrong runway and runway incursions (Cardosi, Falzarano & Han, 1998).

According to Prinzo, Hendrix & Hendrix (2008), the data available concerning communication problems associated with aviation English deficiencies is limited. This lack of data makes it impossible to measure the effectiveness of the LPR because there was no data to

compare before and after implementation. This has also made it impossible to evaluate educational and assessment tools developed by ICAO member states to comply with the new requirements. Prinzo, Hendrix and Hendrix (2008) wanted to document communication problems by the type of operator (domestic or foreign), type of communication problem and the frequency with which the communication problem occurred to establish a baseline of data for future comparison after implementation of the ICAO LPR. Analysis of approximately 50 hours of audio recordings of pilot-controller voice communications revealed that pilots who were not native English speakers spent more time in radio communications, made more transmissions and experienced more communication problems than pilots who were native English speakers. In many of these cases, the extra time spent on the radio was due to a controller who was unable to understand a pilot's accent (Prinzo, Hendrix & Hendrix, 2008). Obviously, the ability to be understood is just as important as the ability to understand the English language.

Pilots and air traffic controllers experience communication difficulties whether they are native English speakers or not. Research has demonstrated that there is a relationship between flight condition and communication accuracy for both native and non-native English speakers. Molesworth and Estival (2014) found that pilots who were native English speakers made fewer overall communication errors than pilots who were not native English speakers, but there was very little difference between the groups when radio transmissions were very difficult, and the task was very familiar to the pilots. However, when the task was unfamiliar, the pilots who were not native English speakers made more communication errors than the native English speakers. In addition, low time pilots who were not native English speakers committed more errors when pauses were absent from radio transmissions (Molesworth & Estival, 2014). In other words, a non-native English speaker's ability to understand English radio communications was influenced

by the absence of periodic pauses in the transmissions. How the words were spoken made a difference for the pilots who were not native English speakers.

The definition of intelligibility is the ability to understand spoken words. If a pilot is unintelligible on the radio when communicating with air traffic controllers, the result could be catastrophic. Prosody is the intonation and rhythm of speech which has an influence on the intelligibility of the spoken word (Trippe & Baese-Berk, 2018). Pilots who are not native English speakers may be especially influenced by prosody as Molesworth and Estival (2014) discovered in their study which found that non-native English speakers made more errors when pauses were absent from radio communications. To achieve ICAO level 4 language proficiency, the pilot or air traffic controller must satisfy the following requirements for pronunciation: "Pronunciation, stress, rhythm and intonation are influenced by the first language or regional variation but only sometimes interfere with ease of understanding" (Trippe & Baese-Berk, 2018). In other words, the accent of the pilot or air traffic controller must not interfere with intelligibility. An analysis of ATC recordings of 312 international flights into the Bangkok International Airport in Thailand revealed that accent can hinder understanding in communication between pilots and ATC (Tiewtrakul & Fletcher, 2010). The research found that misunderstanding may vary depending on many different factors. The results of this research also show that accent is especially critical when there are two non-native English speakers trying to communicate in the English language.

Conclusion

The goal of the ICAO LPR was to ensure that pilots and air traffic controllers who work on international flights maintain an acceptable level of English language proficiency given that English was designated the official language of international aviation by ICAO in 1951.

However, ICAO did not introduce the Language Proficiency Requirement (LPR) until 2003 after it became apparent that English language deficiencies played a role in several high-profile aviation accidents. The deadline ICAO set for compliance with the LPR was 5 years later in 2008, but the deadline was extended to 2011 when most of the ICAO member states were unable to meet the original deadline. Member states had difficulty complying with the LPR due to the complex nature of language issues and the scarcity of aviation English education and assessment programs. Although ICAO member states have acknowledged compliance with the LPR, there is no way to verify compliance because ICAO has left verification up to the National Civil Aviation Authorities (NCAA). In addition, there is no way to verify the quality of existing education and assessment programs because the field is unregulated.

It has been eight years since ICAO member states were required to comply with the LPR for all air traffic controllers and pilots who work on international flights, and yet the number of reported incidents due to language problems has shown an upward trend according to ASRS data from the last 10 years. In addition, this data shows that there is a definite relationship between aviation English proficiency and aviation safety. The data also reveals that Part 121 scheduled carriers submit significantly more language related incident reports than Part 91 and Part 135 operators. Finally, an analysis of the report narratives revealed that non-native English accents were a significant factor in most of the reports, and the most frequent result cited by these reports was confusion.

Recommendations

Several issues were noted in the literature concerning language related safety issues in aviation. First, the data concerning language related safety issues in aviation is limited because programs such as ASRS do not include a report category for language related safety incidents.

In order to capture this data now, it is necessary to search for terms that may be related to these incidents. However, many of these terms are used to describe unrelated issues. Safety reporting systems such as ASRS should include a subcategory under human factors to better identify incident reports concerning English language issues.

Data concerning language related incidents and accidents may also be limited because accident investigators do not fully understand how language problems can lead to a mishap. To address this problem, a manual is being developed to help aviation accident investigators recognize when language problems have resulted in a serious incident or accident. This handbook is designed to provide the aviation accident investigator with guidance and tools to increase awareness and understanding because language issues are frequently overlooked as a significant human factor. The authors of this manual feel that it is not possible to make recommendations to improve aviation safety without a clear understanding of these factors (Mathews, Carson & Valdes, 2019). When it is published, this manual will help accident investigators identify language related factors and improve the database for future research.

ICAO does not verify that member states have complied with the LPR. While ICAO member states have stated that they have complied with the LPR, ICAO never required anything to verify compliance. Instead, ICAO leaves it up to the National Civil Aviation Authority to verify compliance (Alderson, 2011). ICAO should verify compliance with the LPR to ensure that the education and assessment programs used by each member state meets minimum standards.

The FAA requires flight instructors and others who are not English language experts to certify pilots for English language proficiency. While the FAA has provided guidance to aviation instructors and examiners, international student pilots who speak English as a second

language may not be properly evaluated because aviation instructors and examiners are not trained language experts. ICAO and the FAA should require applicants to pass a certified assessment program in aviation English to resolve this problem. Unfortunately, the quality of aviation English education and assessment programs is inconsistent because it is an unregulated field and programs are not required to be certified in any way. These programs should be evaluated and certified by ICAO and the FAA to ensure consistency, quality and relevance.

Finally, pilots and air traffic controllers felt that the English language training programs offered to them were not helpful and the testing was inappropriate and irrelevant. Again, some of the ICAO member states are developing their own programs or contracting with vendors who claim to have programs that satisfy the LPR. These programs are totally unregulated, and certification is not required. Certification of these programs by ICAO and the FAA would resolve this issue.

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