Purdue University
Purdue e-Pubs

Aviation Technology Graduate Student Publications

Department of Aviation Technology

4-12-2013

Reducing General Aviation Accidents By Utilizing Airline Operational Strategies

Anel M. Garibay

John P. Young

Reducing General Aviation Accidents By Utilizing Airline Operational Strategies

Submitted to the Faculty of Purdue University, in Partial Fulfillment of the Requirements of the Master of Science degree in Aerospace Management

Anel M. Garibay

John P. Young

April 12, 2013

Abstract

The United States maintains one of the largest and most diverse general aviation (GA) industries. However, GA results in hundreds of fatalities each year; thus, increasing safety and preventing accidents are the core values of the GA industry. This research lays the foundation for more work to be completed in order for GA to remain safe, efficient and have their needs met. The findings explain the current trends of GA accidents compared to commercial aviation, the differences in operational strategies between the two types, efforts that have been made by the Federal Aviation Administration (and others) to improve GA, and finally, recommended alternatives for improving GA safety using commercial aviation operational strategies. As a result of this study, recommendations to the stakeholders in the GA community include: (1) embracing in-cockpit technology to not only enable safer operations in crowded skies, but also permit reliable data collection on GA trends for data-driven decision making; (2) offering valuable incentives for pilots to undergo quality recurrent and safety training, while also eliminating loopholes or incentives that compromise safety; and (3) instituting a system of checks and balances to ensure pilots have a sufficient safety net from human error.

Introduction

With over 200,000 general aviation (GA) (14 CFR Part 91[1]) aircraft in its airspace, the United States hosts the largest and most diverse general aviation community in the world (Duquette & Dorr, 2012; GAMA, 2010). However, unlike its commercial airline (14 CFR Part 121) counterparts, GA operations has a comparatively high accident rate that has remained steady over the years. To address this, the Federal Aviation Administration (FAA), the aviation regulatory body for the U.S., has implemented a new GA safety improvement program to reduce GA accidents by 10 percent over the 2008-2018 period by using a “non-regulatory, proactive, and data-driven strategy to get results” (Spence, 2011; Duquette & Dorr, 2012, p.1). GA accident rates have always been higher than those of the airlines and it has always been a popular perception that (airline) “flying” is the safest mode of transportation, a recognition not shared with GA (Sevillian, 2012; Shetty & Hansman, 2012). One possible reason for this disparity is the difference in operational style between the two types. If airline operations have such excellent safety records, it may be possible to improve GA safety by adopting one or many airline best practices and procedures. The objective of this study is to understand the importance of improving safety protocols in general aviation by determining how general aviation can use similar operational strategies as those of commercial air carriers.

[1] 14 CFR Part 91-General Operating and Flight Rules

Literature Review

General aviation in the United States represents a large majority of the worldwide GA community. Out of 320,000 GA aircraft worldwide, nearly 228,000 of those are registered in the United States (GAMA, 2010). In terms of flight operations in the NAS, only one-third of the operations were commercial operations, while the remaining two-thirds were GA, consisting of private airplanes, business jets, air taxi, etc. (Duquette & Dorr, 2012).

General Aviation accidents result in hundreds of fatalities each year (GAO, 2012). According to the National Transportation Safety Board (NTSB), there has been a slight increase in overall and fatal civil aviation accidents in the U.S. from 2010 to 2011. This figure includes both commercial and GA activity, but scheduled Part 121 air carriers had no contribution to the fatality rate, leaving the majority of all fatal accidents in the GA category (NTSB, 2012a).

Generally speaking, GA has always had a higher accident rate than commercial aviation due to differences in training, experience, technology, and procedures. GA is composed of a wide range of operation: crop-dusting, banner towing, personal flying, corporate flying, etc. (Air Safety Institute, 2010; GAMA, 2010). As a result of this diversity, some types of GA operations are safer than others (GAO, 2001). Similarly, the required type of pilot certificate and training varies with each GA operation type. Furthermore, GA pilots have limited cockpit resources and flight support compared to their airline counterparts (Air Safety Institute, 2010). Airlines are required to have co-pilots, dispatchers, mechanics, loadmasters, and others that help the pilot before, during, and after each flight to enhance safety and maintain a system of checks and balances. In GA operations, a single pilot may conduct all aspects of flight (Air Safety Institute, 2010).

Most GA airports lack the advanced services the airlines are provided at larger airports, such as longer runways, precision approaches, and approach lighting systems (Air Safety Institute, 2010). According to the NTSB, takeoffs and landings are considered the most critical phases of flight and are more prone to result in an accident (NTSB, 2011). Operating out of thousands of airports, GA has more takeoffs and landings on a per hour basis than air carriers (Air Safety Institute, 2010). Additionally, airliners have the capability to fly over or around most weather phenomena because they have the most advanced systems and technologies to help the pilot cope with hazardous situations, where most GA aircraft do not have this capability (Air Safety Institute, 2010).

There are many possible reasons for this higher accident rate, but this review of literature will focus on one aspect: operational support. Pilots often need to make decisions and execute appropriate actions under uncertainty and time pressure. A means used by air carriers to assist pilots in these tasks is through the use of a decision support system (DSS)[2]. The importance of DSS is that the aircraft can safely continue operation while the DSS outlines alternative actions, or suggests an optimal solution (Schroeder & Sarter, 2001).

Another support resource is a dispatcher. The first dispatcher dates back to the 1920's when the Post Office Department established the first airmail radio stations (Krause & Jansen, n.d.). These radio stations were staffed with personnel who provided an early flight following service: departure time, a coded flight plan, and weather observations to the pilots. Today, both airline pilots and dispatchers are held jointly responsible for the safety of every flight by FAR 121.533 (Avjobs, n.d.; Krause & Jansen, n.d.). As a result, every decision in a commercial flight must have joint approval of both the pilot-in-command and the corresponding dispatcher.

Over the years, the aviation industry has reduced accidents through the use of research and analysis of systems. The aviation industry continues to advance in the development of new protocols, methods and technology. This study clearly recognizes the need for more work to be done in order to remain safe and efficient and meet the needs of GA.

Methodology

The objective of this study was to understand the importance of furthering safety protocols in general aviation by determining how it can use similar operational strategies as that of commercial airline operations[3]. This study addressed four research questions:

1. *What are the current trends in general aviation accidents compared to commercial aviation?*
2. *What actions have been taken to improve general aviation safety?*
3. *What are the differences in operational support between general aviation and commercial aviation?*
4. *What methods can be used to provide and integrate support services, similar to Part 121, for the general aviation community to enhance user convenience and flying safety?*

Identification of current safety trends between general aviation and commercial aviation was performed by analyzing the National Transportation Safety Board's (NTSB) Aviation Accident Database (relevant sections available in Appendix A and Appendix B). Identification of actions that have been taken to improve general aviation safety was performed through review of documents and reports from the Federal Aviation Administration (FAA),

[2] Decision support systems (DSS) are defined as "computer-based systems designed to help decision-makers use date, knowledge and communications technology to identify problems and make decisions that solve those problems." (I-95 Corridor Coalition, 2012, p.1)
[3] Note that only Part 121 operations are considered as commercial airline operations in this paper

NTSB, the United States Government Accountability Office (GAO), and other groups. The differences in operational support between general aviation and commercial air carriers are identified through a review of documents and reports from GAO, Air Safety Institute, scholarly articles, and the Federal Aviation Regulations (FARs). Potential ways to implement and integrate Part 121-like support services to the general aviation community are identified through review of documents and reports from the FAA, GAO, and other groups from the private and public sectors. The conclusions and recommendations made in this work are derived from publically available sources.

Results and Discussion

The following sections present the results of the study paired with their respective research questions.

Question 1: What are the current trends in general aviation accidents compared to commercial aviation?

There is a public perception that general aviation (GA) is less safe than commercial operations and should be verified with accident statistics. Interpreting accident data collected over a ten-year period (2000-2010) from the NTSB's aviation accident database provides a comparison of accidents, fatalities, and rates between GA and commercial operations. The starting point for this data analysis was comparing the number of accidents for GA and commercial operations. However, because GA generally logs more flight hours than commercial, a direct comparison of the number of accidents between the two is inaccurate. A comparison of accidents by the corresponding number of flight hours normalizes the statistics[4]. Figure 1 provides a comparison of the total accidents per 100,000 flight hours flown between GA and airline operations. In Figure 1, there are more GA accidents per 100,000 flight hours than that of commercial. Over a ten-year period, there was an average of 6.76 accidents per 100,000 GA flight hours compared to 0.18 accidents per 100,000 commercial operations.

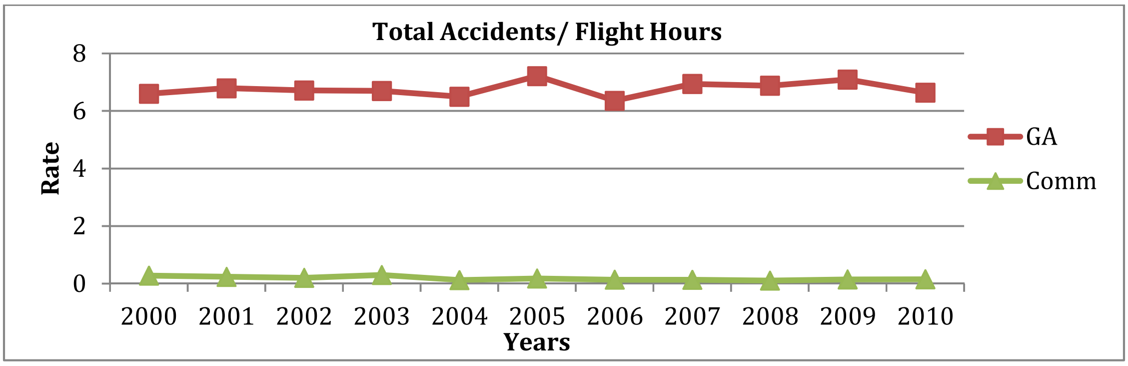

Figure 1- Total Accidents per Flight Hours (Rate)

[4] Normalizing the accident rate by 100,000 flight hours was the only comparable metric between GA and commercial operations. This is because the NTSB accident database compiles data differently between the two operation types. (National Transportation Safety Board, 2012)

Figure 1 includes both fatal and non-fatal accidents within the total accidents. However, it is interesting to see what percentages of those accidents were fatal. Figure 2 and Figure 3 show two different ways of looking at fatal accidents between GA and commercial. **Error! Reference source not found.** depicts fatal accidents only, showing there was still a large difference in accident rates between the two operation types. Note that four years (2002, 2007, 2008, and 2010) saw zero fatal commercial accidents.

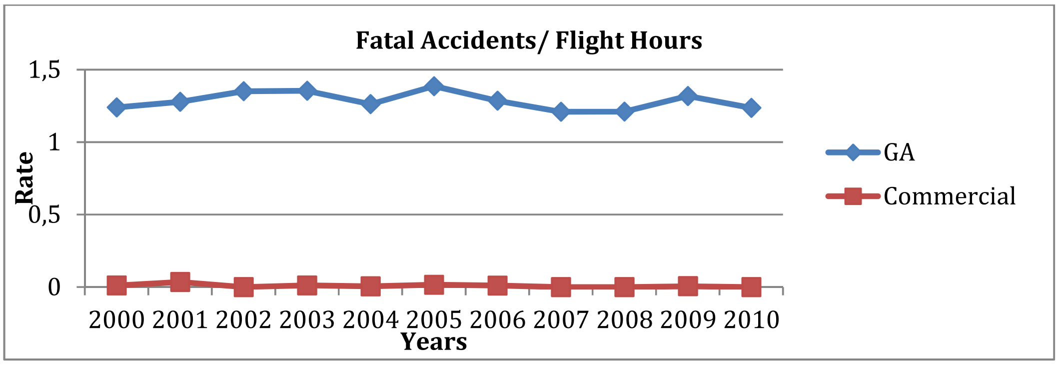

Figure 2- Fatal Accidents per Flight Hours (Rate)

In general, a larger percentage of GA accidents were fatal compared to that of commercial, as shown in Figure 3. While the percentage of fatal commercial accidents were largely erratic, it was consistently less than that of GA, which remained steady around 20%. On average, 19% of all GA accidents were fatal from 2000-2010, compared to 4.30% for commercial accidents over the same time span. It should be noted that the brief spike in fatal commercial accidents in 2001 is accurate, not anomalous, and not due to the September 11 terrorist attacks.

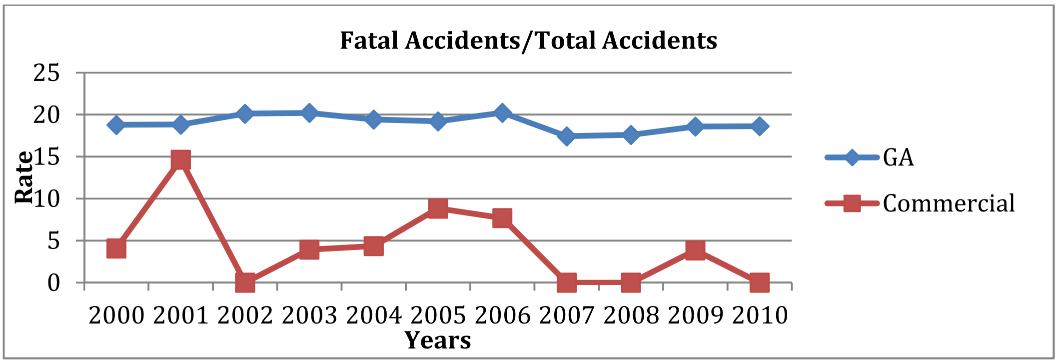

Figure 3- Fatal Accidents per Total Accidents (Rate)

From 2000 to 2010, NTSB statistics show two important trends in the accident rates of GA and commercial operations: GA accident rates are indeed higher than that of airline operations, and GA has consistently maintained an overall accident rate well above that of commercial. Currently, the NTSB investigates around 1,600 GA accidents a year; therefore, understanding the variety of the accidents can help identify the opportunities for improvement

(NTSB, 2012b). While it is not practical to cover all 16,000 GA accidents within the ten-year period, a few representative examples, found in Appendix C, can provide some insight (NTSB, 2012b).

The FAA forecasted an increase in the number of GA and commercial aircraft in the next 20 years, which means increasingly crowded skies (as alluded by NextGen) and the need for additional assurance for safety (FAA, 2012a). The idea that commercial is safer than GA is shown by the imbalance between accident rates between the two operational types. This last characteristic underscores a need to improve GA safety.

Question 2: What are the differences in operational strategies between general aviation and commercial aviation?

One way to determine why commercial aviation is safer than GA is to identify the differences in which they are operated, in terms of what operational resources are available or unavailable to GA. The approach used was based on the FAA's methodology using a "non-regulatory, proactive, and data-driven strategy" to identify operational strategies (Duquette & Dorr, 2012).

Commercial pilots undergo more frequent training than GA pilots, and although the FAA has a set minimum standard for recurrent training and proficiency checks for commercial operators, most (if not all) major carriers go above and beyond the minimum requirements (ALPA, 2011). Airlines have a mix of computer-based, simulator, procedural, and other types of training to keep their crews highly proficient on a specific family of aircraft. For example, United Airlines has a current training cycle that consists of proficiency training at nine months, and a proficiency check at 18 months (ALPA, 2011). In contrast, GA only has a set minimum standard for proficiency check once every 24 months (ALPA, 2011). However, proficiency and currency are only two aspects of how commercial training is different from GA. The combination of recurrent training and liberal contingency planning is one of the ways commercial operations differ from GA, which could be used as an opportunity for improvement.

Another differentiator between the two operational styles is that airline operations and decisions are made jointly between the pilot-in-command and responsible dispatcher (Air Safety Institute, 2010). As a result, all aspects of the flight and any changes in flight plan must be approved by both parties (Avjobs, n.d.). This system of checks and balances ensures proper analysis and execution of decisions to help mitigate pilot error. Similarly, a two-person cockpit, staffed by a pilot and co-pilot, combined with Crew Resource Management,[5] complements this system of checks and balances by allowing the co-pilot to hold the pilot accountable for his or her decisions (American

[5] Crew Resource Management (CRM) can be defined as, "using all available sources-information, equipment, and people- to achieve safe and efficient flight operations." The purpose of CRM is to identify and mitigate threats that can lead to human error. (American Psychological Association, 2004)

Psychological Association, 2004). In contrast, a majority of GA operations are unsupervised, solo (one-pilot), and generally have no system of checks and balances (Air Safety Institute, 2010).

In order for commercial operators to improve existing levels of aviation safety, they have been encouraged by the FAA to create and implement their own Safety Management Systems (SMS) (Dorr & Duquette, 2010). SMS is a method used by many airlines today to enhance safety performance and move beyond mere compliance with regulations (Dorr & Duquette, 2010). While SMS is still in its early implementation stages with many airlines, there are benefits that have and will be seen throughout the future if implemented. Examples of such benefits include: reduction in material loss and/costs (in general), enhancement of productivity, logical prioritization of safety needs, compliance with legal responsibilities for safety, etc. (Bayuk, n.d.). While adoption of a SMS in Part 121 carriers is encouraged by the FAA today, the agency plans require it in the future as an evolution of safety (MITRE Corporation, 2012). Commercial airline pilots and others in flight operations are encouraged to adopt SMS in their duties not only for their safety, but also as an incentive to assure job security (Bayuk, n.d.). This reasonably implies that SMS adoption by GA will be slow, since there is no motivation for GA pilots, unlike those for commercial pilots, and could be the root barrier for successful adoption of SMS in the GA community.

Another example of a differentiator between the two operational styles is that commercial operators are more able to adopt modern technologies both in and out of the cockpit, according to the Air Safety Institute (2010). Having the most advanced systems and modern technologies enables commercial aviation to not only utilize the latest advancements in safety, but also generate and collect large amounts of data for different purposes (Boeing, 2013). The primary rationale for collecting data is to allow operators to identify trends in the system, detect any errors (if any), and finally correct them (GAO, 2012). Lack of information needed to fix an issue acts as a barrier in decision-making and consensus building with the industry/community. As Peter Drucker, a legendary management expert, once said, “If you can’t measure it, you can’t manage it.” (Claremont Graduate University, n.d.) However, large amounts of data are of little use if there is no way of analyzing it and drawing conclusions. Commercial operators collect various data in order to understand and achieve common goals such as improving service, safety, environmental performance, etc. In contrast, GA is less able to capitalize on this because GA owners and operators not only are less likely to adopt the technologies that enable data capture, but also less able to analyze the collected data (GAO, 2012).

From the differences previously cited, it is safe to say that commercial aviation has more resources available for operation, unlike with GA, where there is a lack of resources. Furthermore, although the airline industry has a relatively low accident record, they continuously enhance their safety systems to maintain an excellent safety record. This is primarily achieved through pressure of the public and enforcement from the FAA, in addition to maintaining a positive public image. Overall, flight plan quality and flexibility, available resources, and governmental regulations are the primary differences between GA and commercial operations and where improvements can be made.

Question 3: What actions have been taken to improve general aviation safety?

Federal agencies, as well as aviation stakeholders, have recognized growing concerns on GA's high accident rate. Key stakeholders like the FAA, NTSB, AOPA, and others have attempted to improve and reduce GA accidents. This section defines the actions that have been taken to improve GA safety and the results of those actions.

The Federal Aviation Administration

As GA continues to maintain an unchanging accident rate, the FAA has made an effort to improve the GA safety issue through a five-year strategic approach based on risk management, safety promotion and communication, outreach and engagement, and training (GAO, 2012). Using this approach, the FAA hopes to see a possible culture change in GA regarding flight safety (Duquette & Dorr, 2012). Because this approach was just started in 2011, the results of FAA efforts are still undetermined. Articles from the Experimental Aircraft Association (EAA) indicate that GA's safety record is off to a "worrying start" since the fiscal year began on October 1, 2012 (EAA, 2012)[6]. As part of this five-year approach, the FAA claimed to strengthen its connection with different aviation associations (GAO, 2012). However, it is difficult to measure its effectiveness and the FAA officials claimed there are no performance metrics in place to gauge this five-year plan (GAO, 2012). Performance measures are important because they monitor accomplishments toward desired goal(s). The only indicator, or strategy in place that is available and semi-reliable, would be to see the changes in trends of the GA fatal accident rates (GAO, 2012).

The General Accounting Office (GAO) performed a thorough analysis in 2001 of GA trends in accidents and how the FAA and industry groups responded to those trends (GAO, 2001). The results of the GAO analysis were similar to what is seen today in GA. For example, the GAO 2001 report indicated that GA accident rates were

[6] In October and September of 2012, there were a total of 55 fatal GA accidents (compared to 44 during the same time in 2011), and in the beginning of December alone there were nine more (EAA, 2012). The total number of fatalities is still to be determined until the NTSB has written the reports (EAA, 2012).

about 20 times higher than that of commercial aviation (GAO, 2001). The results of pilot-error (relating to procedure, skill, and judgment mistakes) were the number one cause of GA accidents for both GAO reports (GAO, 2001; GAO, 2012). In response to this finding, the FAA provided additional education and training programs through the Internet, hosted seminars, began the "Safer Skies" program (a major initiative to reduce the number of fatal accidents), and reinforced safety oversight by enhancing certification and training procedures for flight instructors (GAO, 2001). Furthermore, the FAA performed an evaluation of GA pilot attendance at the safety seminars, which resulted in a lack of GA pilot attendance (GAO, 2001). Overall, there was a lack of available data and there were no performance measures to indicate progress of FAA efforts (GAO, 2001).

In 2008, the FAA unveiled a 10-year plan to reduce GA accidents by about 10 percent by 2018 (from a baseline of 1.12 accidents per 100,000 flight hours to 1.00 accident per 100,000 flight hours) (GAO, 2012). This is different from the 5-year plan mentioned previously in that the 10-year sets an end goal to improve GA safety while the 5-year plan sets a general strategy to improve GA safety. As of 2011, the results indicate that the FAA is not meeting its goal according to a 2012 Government Accountability Office report. With three years into the program, the accident rate was 1.17, an increase from the 2008 1.12 baseline. Interestingly, the FAA renewed is contract with the General Aviation Joint Safety Committee[7] (GAJSC) (GAO, 2012). This decision was made despite the concerning results of the 2001 GAO report, which revealed issues with GAJSC regarding lack of data and member participation (GAO, 2001). Furthermore, according to an FAA official, GAJSC has floundered in the past and its prior efforts were topic driven and based on expert opinion rather than data analysis (GAO, 2012).

National Transportation Safety Board (NTSB)

In the aviation industry, the NTSB is concerned with GA safety and stated that it is on its "Most Wanted List" (NTSB, 2012c) As a result, the NTSB has recognized the trend of accidents and identified several recommendations for the FAA, which provide better training for pilots and aircraft mechanics, and define new ways of screening risky behavior (NTSB, 2012c). The NTSB notes that summer is the peak season for GA activity and therefore a great opportunity to renew the efforts of reducing GA accidents (Hersman, 2012). Although the NTSB does not have regulatory power, they have held safety forums that discussed raising awareness of the high GA accident rate, recurring safety issues in certain areas, promoting and facilitating the safety issues, and determining how to address the issues to improve GA. However, enlisting participation from the GA community is a challenge

[7] General Aviation Joint Safety Committee (GAJSC), a "government-industry partnership that focuses on analyzing general aviation accident data to develop effective intervention strategies." (GAO, 2012, p.24)

(GAO, 2012). Many GA pilots fail to take advantage of the free resources made available to them, such as education and training to further their knowledge in air safety (a critical component to improving GA safety). The FAA is collaborating with the NTSB to better implement actions to improve GA safety (GAO, 2012).

Next Generation Air Transportation System (NextGen)

One of the most promising programs that could improve aviation safety is FAA’s concept of operations for the Next Generation Air Transportation System (NextGen) (FAA, 2011a). NextGen is the transition of the current ground-based navigation system to a satellite-based one, using a combination of technologies (GAO, 2012). One such technology will notify pilots of the precise locations of other airplanes around them, increasing situational awareness and enhancing safety (McHale, 2010). The FAA has also been working closely with manufacturers in defining what equipment GA operators will need to have in order to support NextGen (GAO, 2012). As a result, this collaboration will not only accelerate the adoption of NextGen in GA, but also improve overall GA safety by streamlining the integration and certification process. While this is primarily an FAA initiative, it is a combined effort of many governmental agencies and private industry, and deserves special mention here.

Aerospace Industry

Other industry associations, such as Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), the National Business Aviation Association (NBAA), and General Aviation Manufacturers Association (GAMA), have been actively involved in finding ways to address the GA safety problem. AOPA formed the Air Safety Foundation, which holds one of the largest accident databases, hosts seminars, provides free online courses, and conducts in-depth accident analysis and research on several GA topics (AOPA Foundation, n.d.d). AOPA’s view on GA safety is mostly aligned with the FAA’s (an industry-wide effort), but the organization’s efforts have noticed a lack of GA pilots in the voluntary training and education sessions previously mentioned (AOPA, 2012). The Foundation’s Director of Education, Paul Deres, stated that not even its own members take advantage of the free safety programs, which almost all are available online (AOPA, 2012). He also recognized that the fatal accident rates remain nearly unchanged, as well as the primary cause of those accidents (AOPA, 2012). The Association states that the safety culture of GA cannot be changed simply through online material and dissemination of information (AOPA, 2012). AOPA’s current efforts include hiring seven new fulltime positions within the organization that will collaborate at the state and local levels to not only assure GA safety, but also continue reaching out to GA pilots (AOPA, 2012; Brown, 2012).

EAA is currently working with the FAA to figure out new methods to collect and analyze data to reflect the actual experiences of accidents within the different areas of GA (EAA, n.d.). GAMA also works closely with the federal agencies to assure they have the necessary resources to conduct a timely yet thorough accident or incident investigation (GAMA, 2010). Overall, the industry associations are actively involved in a risk-based approach: promoting safety by disseminating safety information and ways to improve oneself as a pilot through additional training. Industry associations are trying their best to reach out to the community in order to safeguard the future for GA, and before the fear of more restrictive measures occurs (AOPA Foundation, n.d.b).

These findings acknowledge that the FAA, as well as other key stakeholders, have recognized the growing concern on GA's high accident rate. All have embarked on several initiatives to meet the goal of reducing the accident rate within the industry, which revolved mainly around three areas: technology, training and education, and safety promotion, which fits the FAA's "non-regulatory, proactive, and data-driven strategy." (Duquette & Dorr, 2012) However, with the efforts made, overall changes in the accident rate have not been seen. Although federal agencies and industry associations have put in significant effort, convincing those that are not participating in free opportunities, such as refresher courses, remains a challenge.

Question 4: What methods can be used to provide and integrate operational strategies, similar to Part 121, for the general aviation community to enhance user convenience and flying safety?

Historical data shows that commercial aviation is far safer than general aviation. These two operational types differ in many ways and those differences could be the reason why one is safer than the other. The vast number of operational differences between commercial and GA has been offered previously as opportunities to improve the safety of the latter. In this section, a clear set of recommendations to improve GA safety is derived from what was learned in the previous sections. It is important to highlight that modeling what commercial aviation has done to improve its safety in GA is not a new idea. GAJSC was formed in the late 1990s as a result of the successes of the joint government-industry Commercial Aviation Safety Team (CAST), which reduced the commercial fatal accident rate by 83 percent from 1998 to 2008 (GAO, 2012).

As a result from this study, stakeholders in the GA community agree that safety improvements should revolve around three areas: technology, training and education, and safety promotion. Therefore, the Part 121-style strategies presented here are categorized into these three areas. However, the recommendations offered here do not consider any related socio-political issues since they are outside the scope of this study.

Technology

According to the FAA, equipping GA aircraft with new technologies can significantly reduce accidents (GAO, 2012). ADS-B is leading the list of promising technologies to be incorporated into the NAS. The ADS-B system consists of two fundamental services: ADS-B Out and ADS-B In (FAA, 2011a). The former broadcasts aircraft identification, real-time position, and velocity to controllers and other aircraft, while the latter is designed to accept ADS-B transmissions so pilots and controllers can utilize the information broadcasted by ADS-B out (FAA, 2011a). Accelerating the adoption of ADS-B in GA can enhance safety as seen from previous large-scale tests in Alaska. The enormous success of ADS-B in Alaska (nearly 50% decrease in accident rates) underscores the importance of equipping the nationwide GA fleet with ADS-B avionics (McHale, 2010). Furthermore, data generated by a nationwide fleet of ADS-B out enabled aircraft enables NAS stakeholders to make data-driven decisions on the operation, safety, and progress of GA.

The FAA already mandates ADS-B out equipage on a majority of GA aircraft by 2020 as part of the NextGen initiative, but there are also advantages to mandating ADS-B in equipage as well (FAA, 2011a). By requiring majority of aircraft to have ADS-B In, a larger portion of the GA population can take advantage of the wealth of up-to-date information that the already mandated ADS-B out offers. Since large commercial jetliners are slated to be ADS-B in equipped already, this will bring a majority of the NAS fleet to a unified standard. While mandating ADS-B in for GA aircraft is a regulatory action, it is an extension of an existing mandate that provides valuable benefits to pilots. Furthermore, while ADS-B in/out provides the information to GA pilots, supplemental training should be provided so that they can leverage it for increased situational awareness.

Training and Education

The majority of general aviation accidents are caused by pilot error, one of which is caused in part by a lack of quality recurrent training (GAO, 2012). Recurrent training is important in order to stay proficient, shorten the decision making time during normal or emergency situations, and increase safety; however, recurrent training is not always cost effective or an optimal use of time (Mayhew, n.d.). A flight simulator or flight training device (FTD) is an inexpensive and effective way for GA pilots to remain proficient (Mayhew, n.d.). The use of flight simulators as a recurrent training tool has proven very effective in the airline industry, as well as in the military, and is incorporated into their flight training standards (Willinger, 2012). Compared to training in an actual aircraft, simulators allow pilots to train on and explore risky maneuvers or unexpected situations that may be dangerous to perform in an actual aircraft (Willinger, 2012). Additionally, simulators are cost effective and provide an economic advantage over training in an actual aircraft, since operating costs (fuel, maintenance, insurance, etc.) in actual aircraft are higher than those of a simulated aircraft. Although airlines have more advanced simulators equipped with 180-degree visual systems and motion platforms, a generic or aircraft-specific flight simulator can help enhance safe flying and reduce GA accidents (Willinger, 2012).

In addition to targeting pilot error, the FAA has initiated several efforts to address issues associated with pilot testing and training (GAO, 2012). Initiatives that encourage pilots to remain vigilant and proactive towards safety issues, like the Wings program, are invaluable toward the FAA's effort. However, they can be detrimental when safety itself is sacrificed for the sake of the program. Currently, GA pilots can be exempt from a bi-annual flight review upon successful completion of the Wings program (GAO, 2012). While incentivizing attendance is a good idea, the incentives should not be loopholes to avoid safety audits. Specifically for the Wings example, bi-annual flight reviews should be mandatory regardless of what safety programs the pilot has attended. In place of the exemption, other valuable incentives, like prepaid fuel cards, can be offered instead. Generally speaking, incentives that exempt pilots and aircraft from important safety audits should be reviewed. Furthermore, additional valuable incentives (outside of exemptions) should be used to encourage pilot attendance at safety seminars and meetings.

Situational Awareness

Human error is inevitable, but taking a proactive measure through a system of checks and balances can reduce them. When pilots first learn to fly, their training is structured around a similar system to ensure they have the necessary knowledge to cope with different settings (Landsberg, n.d.). However, this system of checks and balances ends at completion of training unless the pilot chooses otherwise and requests further paid supervision (Landsberg, n.d.). In commercial aviation, a system of checks and balances exists notably in the form of a co-pilot and dispatcher. The system is employed during every operation to ensure that all flights are operated safely and that no single person has complete autonomy in the flight (Avjobs, n.d.). The idea of creating a similar system of checks and balances for GA operations is a promising opportunity to improve safety.

Statistics compiled by Robert E. Breiling Associates, an accident analysis firm, confirmed that "a single-pilot operation creates a higher workload and greater demand on the pilot skill…and that two heads are better than one." (Landsberg, n.d., p.1) For example, creating a "co-pilot social network service" can be a proactive measure to enhance safety. This network service offers the pilot the opportunity to invite another pilots who are interested in collaborating (or "partnering up") when flying, creating a two-man cockpit with similar checks and balances as those in commercial operations. Another way of creating a system of checks and balances is through a paid dispatch service. Similarly to the airline ops, the dispatcher is very familiar with navigation facilities, weather, and operational limits of an aircraft (Avjobs, n.d.). They maintain situational awareness of each flight and serve as an enroute advisor or safety officer to the pilot flying (Avjobs, n.d.).

Conclusion and Recommendations

It is difficult to believe that improvements in U.S. GA safety have stagnated, according to an analysis by the European Aviation Safety Agency (Commission and EASA , 2012). However, NTSB data shown in Figure 1 corroborates that observation. Steadily high accident rates in GA compared to commercial aviation underscore a need to improve GA safety. The goal of this study was not for GA to reach an equivalent level of safety as that of commercial aviation, but to present ideas to improve safety. Specifically, the focus is to see where GA can learn from Part 121 operations in order to identify appropriate measures to prevent repetitive errors and increase GA safety. The ongoing efforts from the FAA and other aviation stakeholders should not only continue but also suggest further areas of improvement. In general, flight plan quality and flexibility, available resources, and governmental regulations are the primary differences between GA and commercial operations. The work done here recommends that stakeholders in the GA community:

- Embrace in-cockpit technology to not only enable safer operations in ever-more crowded skies, but also permit reliable data collection on GA trends for data-driven decision making.
- Offer valuable incentives for pilots to undergo quality recurrent and safety training, while also eliminating loopholes or incentives that compromise safety.
- Institute a system of checks and balances to ensure that pilots have a sufficient safety net from human error.

The above three recommendations are broadly defined and examples have been suggested. The road to improving GA safety is a long one filled with logistic, bureaucratic, and political obstacles. The data explored in this study could lead to ideas and inspiration that would build on the foundation for a safer future in general aviation.

References

Air Safety Institute. (2010). *The Joseph T. Nall report of accident trends and factors.* Frederick: AOPA.

ALPA. (2011). *Inadequate pilot training and compromised safety by United Airlines within the process of merging the Continental and United Airlines' FAA operating certificates into a merged single operating certificate (SOC).* Air Line Pilots Association.

American Psychological Association. (2004, Feburary 4). *Making air travel safer through crew resource management (CRM)*. Retrieved from http://www.apa.org/research/action/crew.aspx

AOPA Foundation. (n.d.a). *About the AOPA foundation*. Retrieved from http://www.aopa.org/foundation/about.html

AOPA Foundation. (n.d.b). *Growing and nurturing the pilot population: Safeguarding the future of GA*. Retrieved from http://www.aopa.org/foundation/pilots.html

AOPA Foundation. (n.d.c). *Improving general aviation's image*. Retrieved from http://www.aopa.org/foundation/ga-image.html

AOPA Foundation. (n.d.d). *Promoting safety: Keeping pilots safe*. Retrieved from http://www.aopa.org/foundation/air-safety.html

AOPA. (2012, June 21). *NTSB keen to improve GA safety, training*. Retrieved from http://www.aopa.org/training/articles/2012/120621ntsb-keen-to-improve-safety-training.html

Avjobs. (n.d.). *Flight dispatcher career overview*. Retrieved from http://www.avjobs.com/careers/detail.asp?RecID=72

Bayuk, A. (n.d.). *Aviation safety management systems as a template for aligning safety with business strategy in other industries.* Philadephia: American Society of Safety Engineers.

Boeing. (2013). *Innovating technologies and creating insights to deliver industry-first capabilities*. Retrieved from http://www.boeing.com/boeing/commercial/aviationservices/information-services/

Brown, S. (2012, December 18). *Coast-to-coast efforts boost safety, economies in 2012*. Retrieved from http://www.aopa.org/advocacy/articles/2012/121218coast-to-coast-efforts.html

Claremont Graduate University. (n.d.). *About Peter F. Drucker*. Retrieved from http://www.cgu.edu/pages/292.asp

Commission and EASA . (2012, November 18). *http://www.europe-air-sports.org/fileadmin/user_upload/GA-roadmap-2012-11-19.pdf.* Retrieved from http://www.europe-air-sports.org/fileadmin/user_upload/GA-roadmap-2012-11-19.pdf

Commission and EASA. (2012, November 18). *Roadmap for regulation of general aviation.* Retrieved from http://www.europe-air-sports.org/fileadmin/user_upload/GA-roadmap-2012-11-19.pdf

Dorr, L., & Duquette, A. (2010, November 4). *FAA proposes safety management systems for airlines.* Retrieved from https://www.faa.gov/news/press_releases/news_story.cfm?newsid=12118

Duquette, A., & Dorr, L. (2012, June 19). *Fact sheet – general aviation safety*. Retrieved from http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=13672

EAA. (2012, December 5). *FAA worried about GA safety stats*. Retrieved from http://www.eaa.org/news/2012/2012-12-05_FAA-worried-about-GA-safety-stats.asp

EAA. (n.d.). *Government relations briefing: Transforming general aviation-five year strategy*. Retrieved from http://www.eaa.org/govt/briefingTransformingGA.pdf

FAA. (2012b). 14 CFR 121.427 - Recurrent training. In *Code of Federal Regulations* (Vol. 3, pp. 159-160). Washington, DC, USA: US Government Printing Office.

FAA. (2012a, March 7). *FAA aerospace forecasts FY 2012-2032: general aviation (tables 28-31) & U.S. commercial & foreign flag carriers (tables 5-23)*. Retrieved from http://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/aerospace_forecasts/2012-2032/

FAA. (2011a). *FAA's nextgen implementation plan.* Retrieved from http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf

FAA. (2013, Feburary 2). *Safety: The foundation of everything we do*. Retrieved from https://www.faa.gov/about/safety_efficiency/

FAA. (2011b). *Transforming general aviation safety five-year strategy*. Flight Standards Service, General Aviation and Commercial Division, AFS-800, Washington.

GAMA. (2010). *General aviation statistical databook and industry outlook.* Washington DC: General Aviation Manufacturers Association.

GAO. (2012). *General aviation: Additional FAA efforts could help identify and mitigate safety risks.* GAO Report, United States Government, Washington.

GAO. (2001). *General aviation: Status of the industry, related infrastructure, and safety issues.* GAO Report, United States Government, Washington.

GAO. (2011). *Initial pilot training: Better management controls are needed to improve FAA oversight.* GAO Report, United States Government, Washington.

Government Accountability Office. (2012). *General aviation: Additional FAA efforts could help identify and mitigate safety risks.* United States Government, Government Accountability Office. Washington: Government Accountability Office.

Hersman, D. A. (2012, June 19). *General aviation safety: Climbing to the next level.* Washington, DC, USA.

I-95 Corridor Coalition. (2012). *Travel information decision support system.* Ardmore: KMJ Consulting, Inc.

Jones, T. L., & Takemoto, P. (2010, June 24). *Alaska controllers use next generation air transportation technology to improve safety.* Retrieved from http://www.faa.gov/news/press_releases/news_story.cfm?newsId=11540

Krause, T., & Jansen, J. (n.d.). *Early flight dispatch history*. Retrieved from http://www.dispatcher.org/early-dispatch-history

Landsberg, B. (n.d.). *Safety is issue number one in flight training.* Retrieved from http://www.aopa.org/learntofly/startfly/safe.html

Mayhew, N. (n.d.). *Training fact sheet - recurrent training.* Retrieved from http://www.ihst.org/portals/54/insights/Training_Recurrent.pdf

McHale, J. (2010, June 25). *Alaska controllers use nextgen ADS-B technology to improve safety*. Retrieved from http://www.avionics-intelligence.com/articles/2010/06/alaska-controllers.html

MITRE Corporation. (2012, January). *Safety management system newsletter.* Retrieved from http://www.mitrecaasd.org/SMS/doc/SMS_Newsletter_2012JAN_United_uncontrolled.pdf

NBC. (2006). *American Airlines grounds fleet of MD-80s* . NBC. msnbc.com news services.

NTSB. (n.d.). *About the NTSB.* Retrieved from http://www.ntsb.gov/about/strategic_plan/about_ntsb.html

NTSB. (2012a, April 27). *Annual aviation statistics for 2011 released: No fatalities on U.S. airlines or commuters, general aviation accidents increased*. Retrieved from http://www.ntsb.gov/news/2012/120427.html

NTSB. (2010a, March 3). *CEN09FA230.* Retrieved from http://www.ntsb.gov/aviationquery/brief.aspx?ev_id=20090327X80718&key=1

NTSB. (2010b, April 22). *CEN09FA393.* Retrieved from http://www.ntsb.gov/aviationquery/brief.aspx?ev_id=20090629X01338&key=1

NTSB Forum. (2012, June 19-20). *General aviation safety: Climbing to the next level*. Retrieved from http://www.ntsb.gov/news/events/2012/GA_safety/index.html

NTSB. (2012c). *NTSB most wanted list fact sheet.* Retrieved from www.ntsb.gov/safety/mwl_2012_fact_sheet/ga_safety.pdf

NTSB. (2012b, April 27). *Review of accident data: Table 10 accidents, fatalities, and rates, 1992 - 2011, U.S. general aviation*. Retrieved from http://www.ntsb.gov/data/aviation_stats.html

NTSB. (2011). *Runway safety*. Retrieved 2012, from http://www.ntsb.gov/safety/mwl-4.html

Schroeder, B., & Sarter, N. (2001). Supporting decision making and action selection under time pressure and uncertainty: The case of in-flight icing. *Human factors. , 43* (4), pp. 573-83.

Sevillian, D. (2012). Technology engineering and management in aviation: Advancements and discoveries. 74. Hershey, PA: Information Science Reference.

Shetty, K., & Hansman, J. (2012). Current and historical trends in geneal aviation in the United States. 73-74. Retrieved from MIT International Center for Air Transportation.

Spence, C. (2011, March 21). *FAA launches GA safety improvement plan.* Retrieved from http://www.generalaviationnews.com/2011/03/faa-launches-ga-safety-improvement-plan/

The Office of Research Integrity. (n.d.). *Data collection*. Retrieved from http://ori.dhhs.gov/education/products/n_illinois_u/datamanagement/dctopic.html

Willinger, T. (2012, June 19). *NTSB general aviation safety forum: Simulator use in general aviation training.* Retrieved from http://www.ntsb.gov/news/events/2012/GA_safety/presentations/Todd_Willinger.pdf

Appendix A

Table 6. Accidents, Fatalities, and Rates, 1992 through 2011,
for U.S. Air Carriers Operating Under 14 CFR 121, Scheduled Service (Airlines)

		Accidents		Fatalities					Accidents per 100,000 Flight Hours		Accidents per 1,000,000 Miles Flown		Accidents per 100,000 Departures	
Year		**All**	**Fatal**	**Total**	**Aboard**	**Flight Hours**	**Miles Flown**	**Departures**	**All**	**Fatal**	**All**	**Fatal**	**All**	**Fatal**
1985		17	4	197	196	8,265,332	3,452,753,000	6,068,893	0.206	0.048	0.0049	0.0012	0.28	0.066
1986	*	21	2	5	4	9,495,158	3,829,129,000	6,928,103	0.211	0.011	0.0052	0.0003	0.289	0.014
1987	*	32	4	231	229	10,115,407	4,125,874,000	7,293,025	0.306	0.03	0.0075	0.0007	0.425	0.041
1988	*	27	3	285	274	10,521,052	4,260,785,000	7,347,575	0.247	0.019	0.0061	0.0005	0.354	0.027
1989		20	5	124	123	10,597,922	4,337,234,000	7,267,341	0.189	0.047	0.0046	0.0012	0.275	0.069
1990		19	4	11	9	11,524,726	4,689,287,000	7,795,761	0.165	0.035	0.0041	0.0009	0.244	0.051
1991		21	3	60	47	11,139,166	4,558,537,000	7,503,873	0.189	0.027	0.0046	0.0007	0.28	0.04
1992		15	3	29	27	11,732,026	4,767,344,000	7,515,373	0.128	0.026	0.0031	0.0006	0.2	0.04
1993		22	1	1	0	11,981,347	4,936,067,000	7,721,870	0.184	0.008	0.0045	0.0002	0.285	0.013
1994	*	18	4	239	237	12,292,356	5,112,633,000	7,824,802	0.138	0.033	0.0033	0.0008	0.217	0.051
1995		30	1	160	160	12,776,679	5,328,969,000	8,105,570	0.235	0.008	0.0056	0.0002	0.37	0.012
1996		31	3	342	342	12,971,676	5,449,997,000	7,851,298	0.239	0.023	0.0057	0.0006	0.395	0.038
1997		43	3	3	2	15,061,662	6,339,432,000	9,925,058	0.285	0.02	0.0068	0.0005	0.433	0.03
1998		41	1	1	0	15,921,447	6,343,690,000	10,535,196	0.258	0.006	0.0065	0.0002	0.389	0.009
1999		40	2	12	11	16,693,365	6,689,327,000	10,860,692	0.24	0.012	0.006	0.0003	0.368	0.018
2000		49	2	89	89	17,478,519	7,152,260,000	11,053,826	0.28	0.011	0.0069	0.0003	0.443	0.018
2001	*	41	6	531	525	17,157,858	6,994,939,000	10,632,880	0.216	0.012	0.0053	0.0003	0.348	0.019
2002		34	0	0	0	16,718,781	6,927,954,000	10,276,107	0.203	-	0.0049	-	0.331	-
2003		51	2	22	21	16,887,756	7,015,935,000	10,227,924	0.302	0.012	0.0073	0.0003	0.499	0.02
2004		23	1	13	13	18,184,016	7,604,248,000	10,782,989	0.126	0.005	0.003	0.0001	0.213	0.009
2005	32	34	3	22	20	18,712,191	7,843,717,000	10,910,460	0.182	0.016	0.0043	0.0004	0.312	0.027
2006	32	26	2	50	49	18,647,896	7,851,864,000	10,627,481	0.139	0.011	0.0033	0.0003	0.245	0.019
2007	32	26	0	0	0	19,014,677	8,024,313,000	10,734,170	0.137	-	0.0032	-	0.242	-
2008	32	20	0	0	0	18,551,362	7,813,371,000	10,271,446	0.108	-	0.0026	-	0.195	-
2009	32	26	1	50	49	17,160,572	7,248,702,000	9,542,493	0.152	0.006	0.0036	0.0001	0.272	0.01
2010	32	27	0	0	0	17,222,996	7,352,374,000	9,462,310	0.157	-	0.0037	-	0.285	-
2011	32	28	0	0	0	17,285,000	7,456,000,000	8,910,000	0.162	-	0.0038	-	0.314	-

Notes

Flight hours, miles, and departures are compiled by the Federal Aviation Administration.

Since March 20, 1997, aircraft with 10 or more seats used in scheduled passenger service have been operated under 14 CFR 121.

Years followed by the symbol * are those in which an illegal act was responsible for an occurrence in this category. These acts, such as suicide and sabotage are included in the totals for accidents and fatalities but are excluded for the purpose of accident rate computation. Table 12 contains a list of illegal act occurrences involving US air carriers for the period covered by this table. Other than the persons aboard aircraft who were killed, fatalities resulting from the September 11, 2001 terrorist acts are excluded from this table.

Appendix B

Table 10. Accidents, Fatalities, and Rates, 1992 through 2011, U.S. General Aviation

	Accidents		**Fatalities**			**Accidents per 100,000 Flight Hours**	
Year	**All**	**Fatal**	**Total**	**Aboard**	**Flight Hours**	**All**	**Fatal**
1976	4018	658	1216	1203	30,476,000	13.17	2.16
1977	4079	661	1276	1265	31,578,000	12.91	2.09
1978	4216	719	1556	1398	34,887,000	12.08	2.06
1979	3818	631	1221	1203	38,641,000	9.88	1.63
1980	3590	618	1239	1230	36,402,000	9.86	1.69
1981	3500	654	1282	1261	36,803,000	9.51	1.78
1982	3,233	591	1187	1171	29,640,000	10.82	1.96
1983	3,075	555	1,068	1,061	28,673,000	10.67	1.92
1984	3,017	545	1,042	1,021	29,099,000	10.28	1.84
1985	2,739	498	956	945	28,322,000	9.63	1.74
1986	2,581	474	967	879	27,073,000	9.49	1.73
1987	2,494	446	837	822	26,972,000	9.18	1.63
1988	2,388	460	797	792	27,446,000	8.65	1.66
1989	2,242	432	769	766	27,920,000	7.97	1.52
1990	2,242	444	770	765	28,510,000	7.85	1.55
1991	2,197	439	800	786	27,678,000	7.91	1.57
1992	2,110	450	866	864	24,780,000	8.51	1.81
1993	2,064	401	744	740	22,796,000	9.03	1.74
1994	2,021	404	730	723	22,235,000	9.08	1.81
1995	2,055	412	734	727	24,906,000	8.21	1.63
1996	1,908	361	636	619	24,881,000	7.65	1.45
1997	1,840	350	631	625	25,591,000	7.17	1.36
1998	1,902	364	624	618	25,518,000	7.43	1.41
1999	1,905	340	621	615	29,246,000	6.5	1.16
2000	1,837	345	596	585	27,838,000	6.57	1.21
2001	1,727	325	562	558	25,431,000	6.78	1.27
2002	1,715	345	581	575	25,545,000	6.69	1.33
2003	1,741	352	633	630	25,998,000	6.68	1.34
2004	1,617	314	559	559	24,888,000	6.49	1.26
2005	1,671	321	563	558	23,168,000	7.2	1.38
2006	1,523	308	706	547	23,963,000	6.35	1.28
2007	1,653	288	496	491	23,819,000	6.93	1.2
2008	1,569	276	495	486	22,805,000	6.87	1.21
2009	1,480	275	479	470	20,862,000	7.08	1.32
2010	1,439	268	454	451	21,688,000	6.63	1.23
2011	1,466	263	444	433	22,514,000	6.51	1.17

Notes

Flight hours are estimated by the Federal Aviation Administration. Miles flown and departure information for general aviation operations is not available.

Suicide, sabotage and stolen/unauthorized aircraft cases, included in "Accidents" and "Fatalities" but excluded from accident rates in this table are: 1992 (2 acc., 1 fatal acc.); 1993 (5, 4); 1994 (3, 2); 1995 (10, 6); 1996 (4, 0); 1997 (5, 2); 1998 (6, 4); 1999 (3, 1); 2000 (7, 7); 2001 (3, 1); 2002 (7, 6); 2003 (4, 3); 2004 (3, 0); 2005 (2, 1); 2006 (2, 1); 2007 (2, 2); 2008 (2, 0); 2009 (3, 0); 2010 (2, 1); 2011 (0, 0)

The 706 total fatalities in 2006 includes the 154 persons killed aboard a foreign registered Boeing 737 aircraft operated by Gol Airlines when it collided with an Embraer Legacy 600 business jet over the Brazilian Amazon jungle.

49 CFR Part 830.1 pertains to accidents that involve civil aircraft and certain public aircraft of the United States Òwherever they occur.Ó For the year 2011, the total number of accidents includes 19 U.S. registered (N-numbered) aircraft accidents that occurred outside the United States, its territories, or its possessions.

Appendix C

These two accident case studies were highlighted in the Nall Report (2010) and furthered researched through NTSB reports.

Accident Case Study #CEN09FA230 (Air Safety Institute, 2010; NTSB, 2010a)

Cessna 337C departed a private strip during night conditions. Shortly after takeoff, witnesses on the ground described the engines as running rough and eventually quit, causing the aircraft to crash. The pilot, having a total of 23,260 hours of total flight time, died in the crash. Examining the sequence of events, NTSB determined that the aircraft ran out of fuel in flight due to the pilot's inadequate fuel planning.

Accident Case Study #CEN09FA393 (Air Safety Institute, 2010; NTSB, 2010b)

Piper PA32R-300 attempted to takeoff on a grass airstrip during the day in VFR conditions. An employee who helped load the plane stated the plane seemed overloaded and noticed that the crew was "in a hurry to leave." The NTSB investigation revealed that the pilot took off without flaps and 188 pounds overweight. The subsequent report concluded that the probable cause of the crash was "the pilot's poor judgment/decision making."