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JATE

Journal of Aviation Technology and Engineering 8:1 (2018) 11–19

Fatal General Aviation Accidents in Furtherance of Business (1996–2015): Rates, Risk Factors, and Accident Causes

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Abstract

Introduction: General aviation missions related to furtherance of business potentially carry higher risk (operations in adverse weather, at night, for longer distances) than those undertaken for recreation. The study herein was undertaken to determine fatal accident rates, proportions, and risk factors/causes.

Method: The National Transportation Safety Board aviation accident database was queried for accidents (1996–2015). Annual fleet times were from the general aviation annual activity survey. Statistical analyses used Poisson distributions, proportion testing, and Cohen's Kappa tests.

Results: The fatal accident rate for business operations was three- to six-fold lower than the rate for recreational flights with a decline evident between 1996 and 2015. However, a higher proportion of business-related accidents were fatal (33%) compared with recreational flight mishaps (22%). Business-related, fatal accidents were over-represented for operations of longer flight distance, non-daylight hours, and degraded visibility. The most frequent accident cause categories were a deficiency in pilot skills/experience/systems knowledge (45%) and violation of the federal aviation regulations (e.g. departure into instrument conditions without an instrument flight plan, flight into known/forecast icing) (26%).

Conclusion: Despite the fatal accident rate declining for business-related missions, the proportion of fatal mishaps was higher than that for recreational flights.

Practical application: Towards enhancing safety (a) flight reviews should discuss alternate flight planning to circumvent the hazards of night operations, adverse weather, and fatigue, (b) pilots should be encouraged to participate in additional training, e.g. the FAAST program, and (c) pilots should avail themselves of aviation training devices for maintaining instrument proficiency.

Keywords: general aviation accident, fatal accident, business travel, light aircraft, aviation crash

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http://dx.doi.org/10.7771/2159-6670.1185

Introduction

General aviation (nonrevenue) represents the largest sector of civil aviation and is mostly comprised of piston-engine-powered aircraft (Federal Aviation Administration [FAA], 2015). It includes all flight operations except for scheduled commercial services and the military (FAA, 2015). Such operations and pilot flight checks are regulated by a set of rules set forth in the code of federal regulations (14 CFR Parts 91 and 61.56) (Electronic Code of Federal Regulation, 2015a, 2018). In contrast, operations and pilot re-currency training by commercial entities such as air carriers are governed by a more restrictive set of rules (14 CFR Parts 121 and 135) (Electronic Code of Federal Regulation, 2017c). Moreover, transport category aircraft used by air carriers are certificated to higher safety standards (with respect to redundant systems) (Electronic Code of Federal Regulation, 2017b). Also, organizational safety management systems, while mandatory for air carriers, are rare for general aviation (Electronic Code of Federal Regulation, 2017a). Partly for these reasons, commercial travel is much safer than general aviation, with the latter accounting for 94% of civil aviation fatalities in the USA (Boyd, 2017). In addition to the loss of life, general aviation accidents also impose a substantial financial burden carrying annual costs of \$1.6–4.6 billion in the USA (Sobieralski, 2013).

Whilst the majority of general aviation operations are for recreational purposes (also referred to as personal/private) and hence discretionary, a subset of operations are conducted for the furtherance of business (FAA, 2015). Herein, the term "business" (also referred to as "commerce") excludes operations involving aerial observations, flight instruction, skydiving, ferry flights, banner tows, corporate flights, and public utility.

Due to a fixed schedule often associated with conducting business, these types of missions may necessitate operating in degraded weather (limited visibility), at night, and over longer distances with increased exposure to these accident risk factors (Bazargan & Guzhva, 2007; Groff & Price, 2006; Li & Baker, 1999). Furthermore, general aviation rules do not limit maximum duty times (in contrast with airline operations; Electronic Code of Federal Regulation, 2012) nor do they educate pilots as to the perils of fatigue affecting safe operations as might occur after a long business day. Also noteworthy is that an individual's propensity to take on risk increases with the opportunity for gain (Hunter, 2002) as might be the case with fast-moving business activities. Certainly, this was evident for medical passenger air transport which showed a higher fatal outcome than that not involving such activity (Bledsoe & Smith, 2004; Blumen et al., 2002; Handel & Yackel, 2011).

Notwithstanding the potential for greater risk for missions conducted in the furtherance of business, two major changes in general aviation over the last two decades could provide a bulwark against such elevated risk. First, the inclusion of scenario-based training (FAA, 2013, 2017b) designed to manage real-world challenges, risk management, and single pilot resources into *ab initio* training and flight reviews has been encouraged for well over a decade. Second, a surge in the availability of in-flight, near-real-time weather (depicting for example convective activity, airport visibility conditions) transmitted from satellite and ground-based facilities has been evident over a similar period (FAA, 2015).

To the best of our knowledge, no research has been undertaken to investigate the safety of general aviation operations conducted for the purpose of business travel. Accordingly, we undertook a study to determine the fatal accident rate, the proportion of fatal mishaps, and risk factors/causes (1996–2015) involving piston-powered general aviation aircraft operated for the furtherance of business under 14 CFR Part 91.

Methods

Accident Data Source

The National Transportation Safety Board (NTSB) aviation accident Access database (August 1, 2017 release) (NTSB, 2015) was queried for accidents occurring over the period spanning 1996–2015 involving single reciprocating engine-powered (4–6 seat capacity) airplanes (<12,501 lbs) operated under 14CFR 91 regulations (Electronic Code of Federal Regulation, 2015a) for the purpose of business (but excluding the following operations: aerial observations, flight instruction, public utility, skydiving, ferry, banner tow, and corporate flights) or personal/private (also referred to herein as recreational) missions. Homebuilt aircraft, accidents in Alaska, or those occurring with specific aircraft (Helio, Courier, Maule, Stinson, PZLs, and Piper PA 20/22s) typically operated from unimproved surfaces were all excluded. Mishaps in non-moving or taxiing aircraft or in which the pilot in command was a professional employed for his/her services were also excluded from the study. The database provides pilot parameters such as certification, total time and time-in-type, and injury severity outcome in the final report. Accident causes were categorized (Boyd & Stolzer, 2015) using information from the NTSB final report.

For fatal airline accidents, the NTSB database was searched for mishaps in the contiguous USA involving domestic carriers operating under 14CFR 121 for the period spanning 2011–2015.

Fleet Activity

For general aviation, total fleet times (hours) for business or personal/private missions were from the general aviation annual activity survey (FAA, 2015) using data corresponding to single engine, fixed wing aircraft. Fleet activity for

2011 was interpolated from data for the years 2010 and 2012. The U.S. Air Carrier Traffic Statistics (Bureau of Transportation Statistics, 2017) was queried for revenue aircraft hours operated by domestic operators for the period spanning 2011–2015.

Distances Between Airports for Accident Flights

Latitude and longitude coordinates for departure and arrival airports were obtained from the FAA airport data and contact website (FAA, 2017a). Distances (direct) between these airport pairs were determined using a haversine mathematical function (Korn & Korn, 2000) which calculates the great-circle distance across the earth's surface given two coordinates.

Statistical Analyses

A generalized linear model with Poisson distribution was employed to determine if a change in the accident rate was statistically significant using the initial period as referent (Dobson & Barnett, 2008). Total fleet times (hours) were summed for the specified period and the natural log of the summed fleet activities used as an offset.

Proportion testing used contingency tables and a Pearson Chi-Square (2-sided) test to determine where there were statistical differences (Field, 2009).

Normality testing of continuous data was performed using the Kolmogorov–Smirnov test (Field, 2009). A value of $p < 0.05$ was indicative of non-normal distributed data (Field, 2009). Non-Gaussian data were rank-ordered, binned into low, middle, and upper groups, and proportion tested against fatal/nonfatal accident counts.

Fatal accident causes were categorized independently by authors (D.B./S.B.) and inter-rater reliability determined using a Cohen's Kappa test. Disagreement in category assignment was resolved by discussion between both investigators.

All statistical analyses were performed using SPSS (v24) software. A value of $p < 0.05$ was used as cutoff for statistical significance.

Results

Temporal Trends in Fatal Accident Rate

Operations conducted for the furtherance of commerce potentially carry additional risks (e.g. flights in degraded weather, at night, over longer distances (Bazargan & Guzhva, 2011; Li & Baker, 1999; Rostykus, Cummings, & Mueller, 1998) necessitated by a fixed schedule) when compared with recreational flights which are discretionary in nature. Consequently, we first compared the fatal accident rates for general aviation airplanes operated under 14CFR 91 for the furtherance of business (Figure 1) with the corresponding rate for operations undertaken for recreational purposes (referred to as personal missions by the NTSB). Surprisingly, the fatal accident rate for business operations varied between three- and six-fold (across the four periods) lower than the corresponding rate for recreational flights. For the initial period (1996–2000) the rate of fatal accidents was 3.4 (per million flight hours) for business operations and 10.1 for recreational flights. Although both fatal accident rates were unchanged for the subsequent time period (2001–2005), a statistical decline was evident thereafter using the initial period as referent.

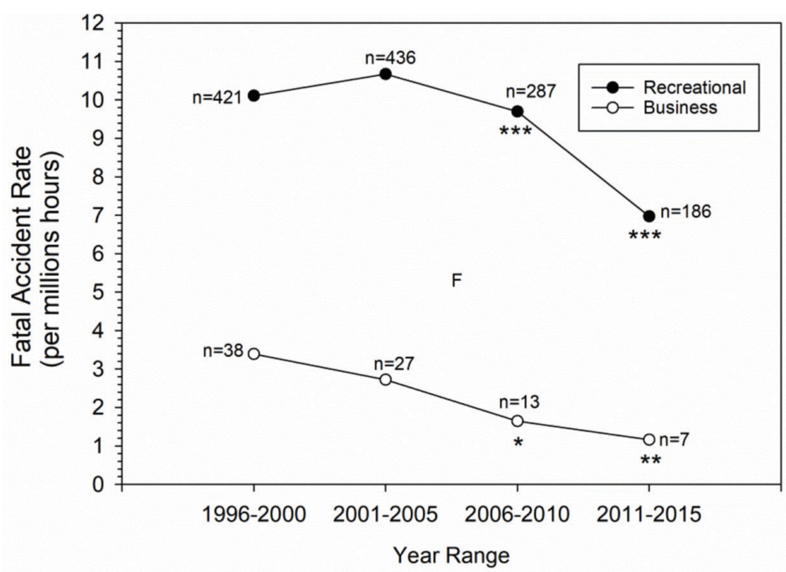

Figure 1. Fatal accident rate for general aviation flights undertaken for furtherance of business or recreational purposes. Fatal accident rates are shown. The rate was calculated using the general aviation fleet time categorized as for the purpose of business or personal/private (recreational) missions summed across the specified period. Parameter n is the accident count for the indicated period. For each group (business or recreational), a Poisson distribution was used to test for differences in fatal accident rate using the initial period (1996–2000) as referent. $^{*}p = 0.024$; $^{**}p = 0.009$; $^{***}p < 0.001$.

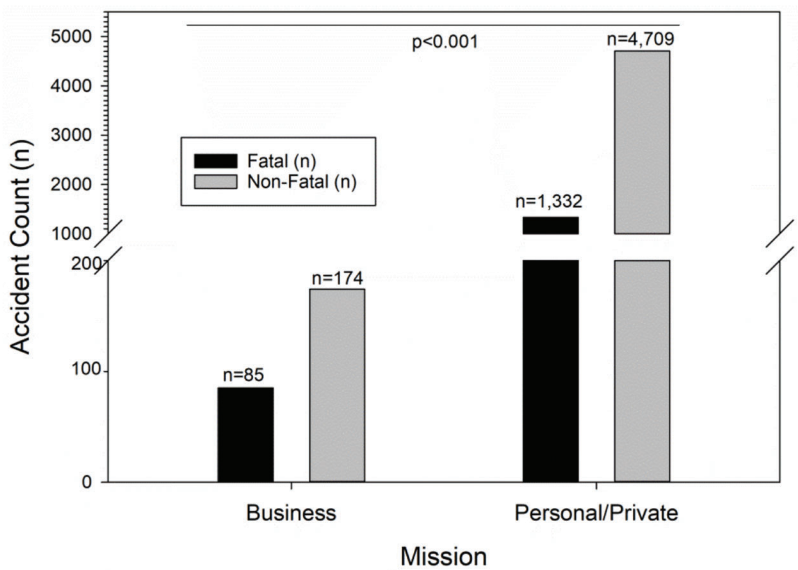

Figure 2. Comparison of the proportion of fatal accidents for flights conducted for the furtherance of business with those undertaken for personal/private missions. Shown are fatal and nonfatal accident counts (*n*) for flights conducted for business or personal/private missions determined for the period spanning 1996–2015. Proportion testing was with a Chi-Square test.

The decline in fatal accident rates for both types of general aviation operations (recreational and business) should nevertheless be put into perspective. Thus, the business fatal accident rate, lowest for the most recent period (2011–2015), was still elevated 38-fold in comparison with fatal airline mishaps (14CFR 121) incurred by domestic carriers over the corresponding period.

Business Missions Carry a Higher Proportion of Fatal Accidents

The proportion of mishaps with a fatal outcome was then compared for operations conducted for either recreation or commerce. Of 6,041 general aviation accidents (fatal and nonfatal combined) identified as recreational and occurring over the study period, 22% were fatal (Figure 2). In contrast, a higher proportion (33%) of fatal mishaps was evident for general aviation operations conducted for the furtherance of business. This over-representation of fatal accidents for business-related missions was statistically significant ($p < 0.001$). Thus, although the fatal accident rate was lower for business operations than the corresponding rate for recreational flights, the proportion of mishaps for which an occupant(s) perished was higher.

Comparison of Flight Histories/Pilot Certification for Fatal Accidents Undertaken for Recreation or Furtherance of Commerce

As stated above, the lower fatal accident rate (Figure 1) for flights undertaken for business missions was surprising. Towards explaining this finding, flight history and pilot certification were compared for both groups of accident pilots as advanced certification and greater flight experience have been previously reported as enhancing general aviation safety (Li, Baker, Grabowski, & Rebok, 2001; Li, Baker, Quiang, Grabowski, & McCarthy, 2005). Indeed, pilots involved in flights for the furtherance of business had more experience as evident by a two-fold greater total flight time (Table 1). In a similar vein, a larger percentage (73 versus 51%) of pilots operating with a business mission held an instrument rating. Conversely, the overwhelming majority (71–79%) of pilots involved in accidents for both types of missions held private pilot certifications rather than advanced ratings.

Risk Factors and Accident Causes for Fatal Accidents Undertaken for the Furtherance of Business

Considering the higher proportion of fatal accidents for flights in pursuance of commercial activities, we then sought to identify risk factors and accident causes for such mishaps. Previous studies (Bazargan & Guzhva, 2007, 2011; Boyd, 2015) have identified several risk factors (e.g. degraded visibility, night operations, flight distance) for a fatal outcome of a general aviation accident. Indeed, flights planned with a longer distance or during non-daylight hours were over-represented for fatal outcome (Table 2). Likewise, there was a disproportionate number of fatal accidents for operations in degraded visibility (i.e. instrument conditions). Interestingly, of 40 accident flights in instrument conditions, while 34 involved instrument flight rules (IFR)-rated pilots, only 25 were operating on an IFR flight plan.

An accident cause category was then assigned to fatal mishaps involving general aviation flights undertaken for a business-related mission as described previously (Boyd &

Table 1
Flight history/certification for pilots involved in fatal accidents.

Parameter		Mission	
		Business	Recreational
Pilot certification	Count (*n*)	83	1,292
	PPL (%)	71	79
	Commercial-CFI (%)	22	17
	ATP (%)	7	4
Total flight time	Count (*n*)	85	705
	Median (hours)	1,008	511
	Q1 (hours)	545.6	238
	Q3 (hours)	2,300	1,140
Flight time in aircraft make/model	Count (n)	49	711
	Median (hours)	123	150
	Q1 (hours)	75	45
	Q3 (hours)	475	418
Instrument-rated	Count (*n*)	85	1,311
	Yes (%)	73	51
	No (%)	27	49

Notes. Pilot certifications: PPL, private pilot; Commercial-CFI, commercial or certified flight instructor; ATP, airline transport pilot. Instrument-rated is restricted to pilots holding this rating for airplanes. *n*, accident count; Q, quartile.

Table 2
Risk factors for fatal accidents for flights undertaken for business-related missions.

Risk factor	Group	Nonfatal (*n*)	Fatal (*n*)	Chi-Square (2-sided) *p* value
Planned flight distance	Lower third (<122 nm)	60	17	0.028
	Middle third (123–258 nm)	45	32	
	Upper third (>258 nm)	48	29	
Lighting	Daylight	145	53	0.001
	Other-than-daylight	27	29	
Visibility	Instrument conditions	11	29	<0.001
	Visual conditions	157	53	

Notes. Parameters for a fatal outcome for accident flights undertaken with a business mission are shown. For flight distance, accident flights were rank-ordered based on planned distance, binned into low, middle, and upper groups and proportion tested against fatal/nonfatal accident counts. Instrument conditions were defined as a horizontal visibility less than 3 statute miles and/or a vertical visibility of less than 1,000 feet above ground level. Visual conditions were those for which visibility exceeded the stated horizontal and vertical parameters for instrument conditions.

Stolzer, 2015) and in Table 3. In some instances, categories were aggregated. Of 85 fatal accidents, a NTSB accident cause was determined for 74 mishaps. Each accident was reviewed independently by two of the authors (D.B./S.B.) based on information in the NTSB final report. A high agreement in accident category assignment was evident between both researchers (Cohen's Kappa = 0.915). The most common accident cause category (45%) was a deficiency in pilot skills/experience/systems knowledge followed by violation of the federal aviation regulations (FARs) (26%) per the code of 14CFR 91 (Figure 3).

The "deficient pilot skills/experience/systems knowledge" category of accidents was subcategorized (Table 4). The overwhelming number of accidents aggregated into either poor basic stick and rudder skills (42%) or instrument proficiency (42%). A similar strategy undertaken for fatal accidents involving regulatory FAR violations (Table 5) showed that intentional continued flight into instrument conditions by pilots lacking an instrument rating (or out of currency) represented the most prevalent subcategory of FAR violations (37% of accidents). Departure into instrument conditions without an instrument flight plan (21%) or flight into known and/or forecast icing per 14CFR 91.13 (21%) represented the next two most common subcategories of FARs violations.

Discussion

Herein, we report the surprising finding of a lower fatal accident rate for general aviation operations conducted in pursuance of business when compared with the corresponding rate for recreational flights for the 1996–2015 period. This encouraging finding should however be put into context. First, the proportion of fatal accidents in furtherance of business was not only higher than the corresponding proportion for mishaps involving recreational flights but also

Table 3
Accident cause categories.

Accident cause category	Explanation
Checklist/flight manual not followed	Self-explanatory and includes nonadherence to V speeds
Improper/inadequate maintenance/inadequate inspection	Improper or inadequate maintenance or inadequate inspection by maintenance facility
Inadequate inflight planning/decision making	Self-explanatory
Inadequate preflight planning/inspection/procedure	Failure to undertake comprehensive preflight planning or aircraft preflight inspection or a procedure associated with the latter
Violation of FARs	Departure into instrument conditions without an IFR flight plan, intentional flight into instrument conditions by pilots without instrument rating or out of currency, flight into known/forecast icing (14CFR 91.13a), nonadherence to 500/1,000 ft above non/congested area, no use of oxygen above 12,500 ft MSL, descending below prescribed minimums of instrument approach procedure
Malfunction	Excluding those attributed to improper/inadequate maintenance/inspection
Lack experience/systems knowledge	Lack of experience or lack of systems knowledge on part of the pilot for the accident aircraft
Pilot skill deficiency	Pilot skill (e.g. hand/foot–eye coordination for landing or take-offs), failure to adhere to IAP vectors, unable to fly plane by reference to instruments, incorrect fuel selector placement, inadequate visual lookout

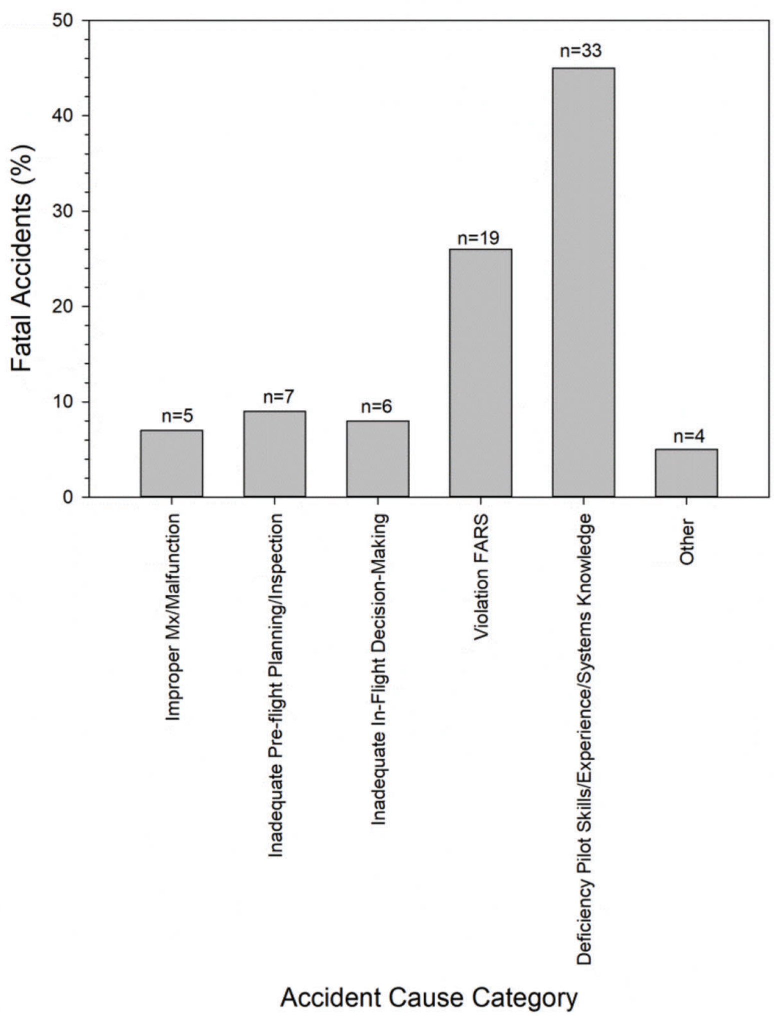

Figure 3. Accident cause category for fatal accidents involving flights conducted for furtherance of business. The percentage of mishaps (fatal only) in each accident category is shown with 100% representing the count. Other, checklist/flight manual not followed, pilot fatigue.

well above that for general aviation as a whole (Li & Baker, 2007; Neuhaus, Dambier, Glaser, Schwalbe, & Hinkelbein, 2010). Second, it should be emphasized that the safety of general aviation operations involving business activities still pales in comparison with airline operations (conducted under 14CFR 121), the latter showing a 38-fold lower fatal accident rate. That said, we recognize that a single non-survivable accident involving a transport category aircraft could dramatically change such data.

The lower fatal accident rate for general aviation operations involving the furtherance of business was unexpected since a fixed timetable agenda may lead to operating in degraded weather, at night, over longer distances—all accident risk factors (Bazargan & Guzhva, 2007; Groff & Price, 2006; Li & Baker, 1999)—not to mention the possibility of fatigue. Several possibilities may help explain this safety disparity. First, based on the accident data, pilots whose mission was business-related were more experienced in terms of total flight time. Indeed, a prior study (Li et al., 2005) had reported that general aviation pilots with less than 500 hours total time were more likely to be involved in a general aviation accident than those with in excess of 500 hours. Additionally, the observation that a greater proportion of pilots operating in pursuit of commerce activities were instrument-rated would likely enhance safety for flights in degraded visibility (Groff & Price, 2006). The possibility that the lower fatal accident rate was a statistical quirk due to over-reporting of business time for the general aviation annual survey (FAA, 2015) is unlikely. In fact, the opposite is more plausible. Thus, for insurance purposes, the accident risk for an owner-flown airplane used for business travel is assessed higher by underwriters (Vilches, 2017) (with an associated increase in insurance premiums) when compared with aircraft used solely for personal/private missions. Accordingly, there is a financial disincentive for pilots to declare business-related flight time.

Table 4
Subcategories of pilot skill/experience/systems knowledge deficiencies for fatal mishaps.

Pilot skill/experience deficiency subcategory	Count (*n*)	%
Instrument proficiency	18	18.2
Stick and rudder	67	67.7
Visual lookout	5	5.1
Other	9	9.1

Notes. Instrument proficiency refers to flying the aircraft by sole reference to the flight instruments. Stick and rudder refers to basic pilot skills in controlling the airplane. Other refers to lack of currency, fuel selector incorrect position, departure from unimproved surface. *n*, fatal accident count.

Our findings also beg the question as to the reason(s) underlying the temporal decline in fatal accident rates for general aviation aircraft operated for business-related activities (and for that matter those conducted for recreational purposes) over the twenty-year study period. A combination of factors may have promoted this downward trend. First, the FAA Industry Training Standards (FAA, 2013) which place emphasis on managing real-world challenges including scenario-based training (FAA, 2017b), risk management, and single pilot resources for both in *ab initio* (individuals undergoing primary training) and re-currency training may have contributed to gains in safety. Indeed, the introduction of this program *circa* 2004 precedes the decrease in fatal accident rates evident thereafter. Second, an increasing prevalence of onboard portable weather data (FAA, 2015) may also have reduced fatal mishap rates. Supporting this latter contention, in a flight simulator study (Ahlstrom, Ohneiser, & Caddigan, 2016), pilots with portable weather data showed higher cognitive engagement, increased weather situation awareness, and made larger route deviations from adverse weather compared with pilots without weather data. Lastly, it is possible that insurance company dictums regarding simulator/instructional flights requirements for aircraft owners (which may be more stringent than the FAA requirements) may also have had a positive impact on safety.

Our findings regarding risk factors for a fatal accident for flights whose mission was business-related were much in line with prior studies. Thus, fatal accidents were over-represented for flights with a longer planned distance resonating with an earlier study (O'Hare & Owen, 2002) reporting that cross-country flights carried a four-fold higher risk of a fatal outcome compared with non-cross-country flights. In the context of business flights these findings also raise the specter of pilot fatigue since pilots may elect to depart after a day of commerce-related activities.

Table 5
Subcategorization of violation of FARs for fatal accidents.

Violation of FARs subcategory	Count (*n*)	%
Intentional flight into IMC without IFR certification/out of instrument currency	7	37
Flight into known/forecast icing	4	21
Departure into instrument conditions without IFR flight plan	4	21
Other	4	21

Notes. Instrument conditions (IMC) are as per Table 2. IFR, instrument flight rules. Lack of currency refers to the failure to complete six instrument approaches and holds in a six-month time frame at the time of the fatal accident. Other includes (i) failure to use supplemental oxygen above 12,500 ft (MSL), (ii) not maintaining a minimum altitude of 500 or 1,000 ft above nonpopulated and populated areas respectively, (iii) descent below the minimum descent height or minimum descent altitude as published in an instrument approach procedure. *n*, fatal accident count.

Indeed, the majority of accidents (82%) involving flights undertaken in furtherance of business were on a weekday and, of these, 35% and 8% departed after 16:00 and at/before 07:00 hours respectively (local time). Unfortunately, general aviation regulations (14CFR 91) do not educate pilots as to the insidious perils of fatigue nor do they prescribe rest limits as mandated for airline crews (Electronic Code of Federal Regulation, 2012) even though such operations could be regarded as careless or reckless under 14CFR 91.13. In addition to the potential for fatigue, late day departures also invoke the possibility of night operations which again carry an elevated risk of a fatal accident outcome as per the current study and prior reports (Boyd, 2015; Li & Baker, 1999). Finally, and again consistent with prior reports (Bazargan & Guzhva, 2007; Li & Baker, 1999), operating in degraded visibility also carried a higher risk of a fatal outcome.

Deficiencies in stick and rudder skills and instrument skills accounted for the majority of fatal accidents. These findings could reflect, in part, the relatively infrequent flight pilot checks for general aviation operations. Under 14CFR 61.56 flight reviews (Electronic Code of Federal Regulation, 2018), which can be completed in a minimum of one hour air time, are required only once every 24 calendar months. In stark contrast, re-currency training, required annually for air carrier flight crews, involves ground school, maneuvers/observations, and line-oriented flight training (Electronic Code of Federal Regulation, 2015b) typically conducted over a multi-day period. As to deficiency in instrument skills, the difficulty in maintaining such proficiency has been well recognized for over 30 years and a concern for instrument-rated pilots themselves (Weislogel, 1983). The last decade has witnessed the market introduction of relatively affordable advanced aviation training devices suitable for maintaining such proficiency. Alas, there are no current data as to the use of such devices by IFR-rated pilots for maintenance of instrument skills.

Regarding FAR violations as causal for some fatal accident flights undertaken for business travel, it is likely that a subset (departure/intended continued flight into instrument conditions without an IFR flight plan or in the absence of the instrument rating and flight into known/forecast icing) were motivated by what has been referred to as "goal seduction" (Bearman, Paletz, & Orasanu, 2009). In that study involving interviews of 28 pilots as to challenging flights, the investigators found that unsafe practices were motivated by a variety of "strong situations" which included financial pressure and time constraints. We suspect that similar pressures exist for pilots operating commerce mission-related flights leading to the aforementioned FAR violations.

The study was not without limitations. First, it was a retrospective study and, as such, flight history and certification data used towards explaining the disparity in fatal accident rates were only available for the accident population rather than the entire cohort (accident and non-accident) of pilots. Second, since scenario-based training in *ab initio* training and flight reviews is not presently mandatory and participation rates not monitored, its contribution to the decline in fatal accident rate is speculative. Finally, we did not explore the possibility that the higher proportion of fatal accidents for flights conducted in pursuit of business activities was a consequence of the use of aircraft with higher stall speeds translating into greater occupant impact forces in an accident (Freitas, 2014).

In conclusion, while the fatal accident rate for general aviation flights undertaken pursuant to business activities has declined over the last two decades, the proportion of fatal mishaps is higher than that for recreational flights and well above that of general aviation as an aggregate (Kenny, 2015; Li & Baker, 2007). Since the cause of such fatal accidents is attributed, in part, to deficiencies in pilot skills, pilots should be encouraged to participate in additional training (e.g. via the FAA Safety Team program) as well as avail themselves of advanced aviation training devices towards maintaining instrument proficiency. Equally important, flight reviews for pilots who partake in these types of operations should (i) include a discussion of the safety hazards of fatigue and night operations (as a consequence of longer flights and at the end of the day) and (ii) encourage pilots to incorporate (and invoke) alternate travel options for weather situations exceeding the capabilities of the pilot/airframe, two components poorly covered in the present flight review (FAA, 2018). The aforementioned recommendations could be via integration into a safety management system shown to be successful in lowering accident risk for 14CFR Part 121/135 operations (International Helicopter Safety Team, 2009). Indeed, scalable and more simplified models supporting the owner-operator (International Helicopter Safety Team, 2009) could be applicable to 14CFR Part 91 operations in the furtherance of business, e.g. in risk management (e.g. fatigue and night operations as per the findings in the current study).

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