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Post-Crash Fires in General Aviation Airplanes

October 7, 2023

Final report

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16. Abstract

In general aviation, fatalities due to post crash fires have been an omnipresent threat throughout the decades. Existing regulations and protocol are largely based on decades old information and technologies. This study attempts to evaluate the modern-day risks and mitigations associated with post-crash fires using contemporary data analytics and the most up to date information available.

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Executive Summary

In general aviation, fatalities due to post crash fires have been an omnipresent threat throughout the decades. Existing regulations and protocol are largely based on decades old information and technologies. This study is an attempt to evaluate the modern-day risks and mitigations associated with post-crash fires using contemporary data analytics and the most up to date information available.

Post-Crash Fires in General Aviation Airplanes

October 27, 2023, Revision 0

Overview

In general aviation, fatalities due to post crash fires have been an omnipresent threat throughout the decades. Existing regulations and protocol are largely based on decades old information and technologies. This study is an attempt to evaluate the modern day risks and mitigations associated with post-crash fires using contemporary data analytics and the most up to date information available.

Historical Efforts to Improve Post-Crash Fire in Small Airplanes

Improvements in small airplane post-crash fire survivability have been identified as a potential safety enhancement for decades. The FAA and industry have collaboratively researched the effectivity of crashworthy fuel systems implementation in small airplanes, and the following summaries will strive to present those efforts as a chronicled compilation to better understand the current state of crashworthy fuel system technologies, research, and design considerations.

1978 - Manufacturing and Testing of Small Airplane Crash Resistant Fuel Tank Technology

In 1978, the FAA funded a full-scale crash test of a typical light twin aircraft to evaluate the performance of numerous configurations of lightweight, flexible, crash-resistant fuel cells and the use of frangible fuel line couplings as documented in the reference 1 technical report. A contractor was tasked to “fabricate and test relatively light-weight, low-cost, crash-resistant fuel cells” as compared to those developed for military applications to “prevent massive fuel spillage in small aircraft survivable accidents.” (pg. A-1). A survivable accident is defined as specified durations and magnitudes of acceleration levels which do not fatally injure the occupants. All materials, fittings, and testing conformed to requirements outlined in MIL-T-27422B per reference 2.

Reference 1 made note that crash-resistant tanks are stiffer than standard bladder cells, and the tanks used in the test series could not be installed in the wing opening normally used for that purpose. Instead, the crashworthy tanks were installed by removing the bulkhead rib at the wing root with the wing removed from the aircraft. The tank was slid into the wing, after which, the rib was riveted back in place, and the wing was reinstalled occupying the space up to the leading edge of the wing.

Different configurations of crash resistant fuel tanks were subjected to a test series comprising of four full-scale tests at the National Aviation Facilities Experimental Center’s catapult facility. Testing of the original bladder cell having no crashworthiness improvements failed catastrophically, spraying out its contents almost instantaneously. All but one configuration of the crash resistant tanks passed. The results demonstrated that effective crash-resistant fuel systems can be constructed which have small weight and volume penalties.

The test series demonstrated that light weight, flexible, crash-resistant fuel cells used with self-sealing, frangible, fuel-line couplings effectively reduce post-crash fuel spills in general aviation aircraft equipped with wing tanks. Wing removal was required to install these crash resistant fuel tanks.

1980 - National Transportation Safety Board (NTSB) Safety Recommendations

In 1980, the NTSB performed a special study of general aviation accidents occurring between 1974-1978, as documented in reference 3. They concluded that of 22,002 accidents, 8% resulted in a post-crash fire. They also concluded that of those which were defined as severe accidents, fatality rates with and without post-crash fire were 59% and 13%, respectively. Therefore, they concluded that fire rather than impact is the major contributor to fatalities. The report resulted in six safety recommendations to the FAA provided in reference 4, specifically:

1. Amend regulations to incorporate flexible, crash-resistant fuel lines and self-sealing frangible fuel line couplings for newly certificated GA aircraft.
2. Amend regulations to incorporate crash-resistant fuel cells for newly certificated GA aircraft having non-integral fuel tank designs.
3. Require after a specified date that newly manufactured GA aircraft comply with these amended regulations.
4. Develop technology and standards for crash-resistant fuel systems for GA aircraft having integral fuel tank designs.
5. Assess the feasibility of requiring the installation of crash-resistant fuel system components, made available in kit form from manufacturers, in existing GA aircraft on a retrofit basis.
6. Continue to develop other means to reduce the incidence of PCF.

1987 - Study of General Aviation Fire Accidents (1974-1983)

The FAA Technical Center sponsored a study of fires and interior materials in general aviation aircraft during accidents and incidents spanning between 1974-1983 to learn trends in general aviation fires and the materials used in aircraft interiors. The reference 5 report concluded that "fire are a minor part of the general aviation accident experience" with fire present in 6.5% of accidents and incidents*.

This report concluded that there is an indication that low winged aircraft accidents had more serious outcomes in fire related accidents than did other airframe configurations; the gasoline and kerosene accidents are an inconclusive characteristic with similar fatality ratios; there is an association between increasing approach speeds and accidents with fire; and the number of exits and exit size information was limited and therefore inconclusive.

*The NTSB introduced the definition of accidents and incidents in 1988 per 49 Code of Federal Regulations (CFR) § 830.2. This subject 2023 study did not present data for accidents and incidents independently.

1985-1999 FAA Rulemaking Activities to Address Post-Crash Fire in Small Airplanes

As a result of the reference 3 NTSB special study and subsequent reference 4 safety recommendations, the FAA issued an Advance Notice of Proposed Rulemaking (NPRM) 85-7 in 1985 to announce their intent to incorporate airworthiness standards for crash resistant fuel systems into 14 CFR § 23 and invite the help of the public to determine the need for rulemaking and associated costs. The Advance NPRM was published in the Federal Register (50 FR 8948) as Notice 85-7 as documented in reference 6. An industry aviation panel known as the General Aviation Safety Panel (GASP) agreed to develop recommendations in support of proposed regulatory changes in response to the ANPRM.

The FAA used these recommendations and subsequently issued the NPRM via Notice No. 85-7A, Docket No. 24494, dated February 28, 1990 reference 6. The following is a summary of the changes proposed by the FAA:

- Retroactive implementation of the below summarized requirements per 14 CFR § 23.2 for airplanes manufactured three years after issuance of the final rule.
- Additions to 14 CFR § 23.967 for fuel tank installations which requires installation of flexible liners in all fuel tanks and which meet tear, impact, and crash-resistant requirements of MIL-T-27422B of reference 2.
- Additions to 14 CFR § 23.993 for fuel systems lines and fittings which implement fuel system leakage requirements in the event of a survivable accident and avoidance with ignition sources.

On December 30, 1999, the FAA withdrew the NPRM following a revised economic evaluation of these safety recommendations which concluded that the costs of the proposed change were not justified by the potential benefits. The FAA also subsequently closed the reference 4 NTSB safety recommendations with no further action.

2002 - Small Airplane Crashworthiness Design Guide

The Small Airplane Crashworthiness Design Guide of reference 7 provides design considerations associated with the development of general aviation aircraft. It was conceived as a condensed version of the US Army Aircraft Crash Survival Design Guide with additional information related directly to the design of general aviation aircraft from research conducted from various groups, including Advanced Crashworthiness Group of the AGATE Alliance. Chapter 10 of the guide pertains to design strategies that can be implemented to eliminate injuries and fatalities in survivable impacts, including those involving post-crash fire.

Chapter 10.2 provides recommendations pertaining to design of crashworthy fuel systems to reduce fuel spillage and nearby ignitions sources to improve fire protection. “The following design guidelines for controlling spillage and ignition include:

- Tank displacement should not cause the tank to rupture or tear; this minimizes spillage
- The filler cap should either remain attached to the tank or should separate from the tank without spilling fuel
- Fuel lines should either remain attached to the tank or should separate from the tank without spilling fuel
- Fuel lines and components should displace safely or remain stationary safely
- Wing separation or movement should not allow the spillage of fuel
- Fuselage or wing crush should not damage the fuel tanks or lines
- Engine displacement should not permit spillage from fuel / oil lines, filters, reservoirs, etc.”

System components proposed to mitigate the risk of post-crash fire are crashworthy bladders, self-sealing breakaway valves, and frangible fasteners for wires, tanks, and fuel lines.

2006 - Transport Canada Safety Recommendation

The Transport Canada Safety board (TSB) examined Canadian accident investigation data for small airplane accidents occurring between 1976 and 2002 as documented in reference 8. They identified 521 accidents with post-crash fire and concluded that post-crash fire occurs in approximately 4% of accidents involving small aircraft. After further review of the accident data and autopsy reports, they determined 128 (25%) were accidents in which fire or smoke inhalation was identified as either partly or solely the cause of death or serious injury and were, therefore, otherwise survivable accidents.

The TSB identified four conditions which contribute to the risk of thermal injury fatality:

- an ignition source in close proximity to combustible material;
- combustible material such as fuel in close proximity to an occupant;
- compromised occupant egress;
- inadequate or untimely fire suppression.

“PIF and fire-related injuries and fatalities can be mitigated through aircraft design, so as to prevent damage-induced ignition, preserve fuel system integrity, and reduce impact-related injuries in crash conditions. These design concepts, which have been shown to reduce the risk of fire and save lives in the helicopter and automotive industries, could be effectively applied to type-certificated small aircraft and to helicopters certified before November 1994 through improved regulatory standards.”

The TSB recommended the FAA update the value of statistical life which was used in the NPRM, and also renewed calls for amended regulations for both new aircraft designs and retrofit, including:

- methods to reduce the risk of hot items becoming ignition sources
- technology to inert the battery and electrical systems at impact to eliminate high-temperature electrical arcing as a potential ignition source;

- requirements for protective or sacrificial insulating materials in locations that are vulnerable to friction heating and sparking during accidents to eliminate friction sparking as a potential ignition source;
- requirements for fuel system crashworthiness;
- requirements for fuel tanks to be located as far as possible from the occupied areas of the aircraft and for fuel lines to be routed outside the occupied areas of the aircraft to increase the distance between the occupants and the fuel; and (new designs only)
- improved standards for exits, restraint systems, and seats to enhance survivability and opportunities for occupant escape. (new designs only)

The FAA did not change its position on post-crash fire rulemaking and closed the recommendations with no further action.

2017 - General Aviation Joint Safety Committee (GAJSC) Working Group for Safety Enhancement 41

In 2017, GAJSC established a working group comprised of subject matter experts from industry and government to examine crashworthiness and survivability factors in general aviation aircraft. They released a final report documented in reference 9 which identified four key areas to improve survivability, listed in order of priority:

1. Occupant Restraints
2. Survivable volume
3. Impact energy management
4. Post-crash fire

Twenty accidents were reviewed as part of this safety enhancement, and of those, half the accidents resulted in post-crash fire. After a detailed review of each accident, the team identified the following forward-fit solutions to improve post-crash fire survivability:

1. Improve the ability of the fuel tank to maintain its structural integrity, whether through a more robust tank, fuel bladders, or other means.
2. Utilize self-sealing fuel lines and hose connections.
3. Integrate thermal acoustic insulation.
4. Replace existing engine with an electric engine.
5. Use low flammable materials for interior coverings, fabrics, insulation, etc.

The working group did not document retrofit recommendations specific to post-crash fire survivability but noted that restraints and improved survivable volume are likely to yield improved post-crash fire protection.

Data Analysis 1: The Presence of Post-Crash Fire in Small Airplane Accidents

Data Analytics Process

The purpose of this task was to quantify the prevalence of post-crash fire upon impact in small airplane accidents. The primary source of data for this effort was the NTSB database. Data was filtered to include accidents in the US affecting small airplanes over a period of ten years, ranging from 2012 through 2021 and whose final investigation NTSB report is completed. Business jets and homebuilt aircraft were excluded from this analysis.

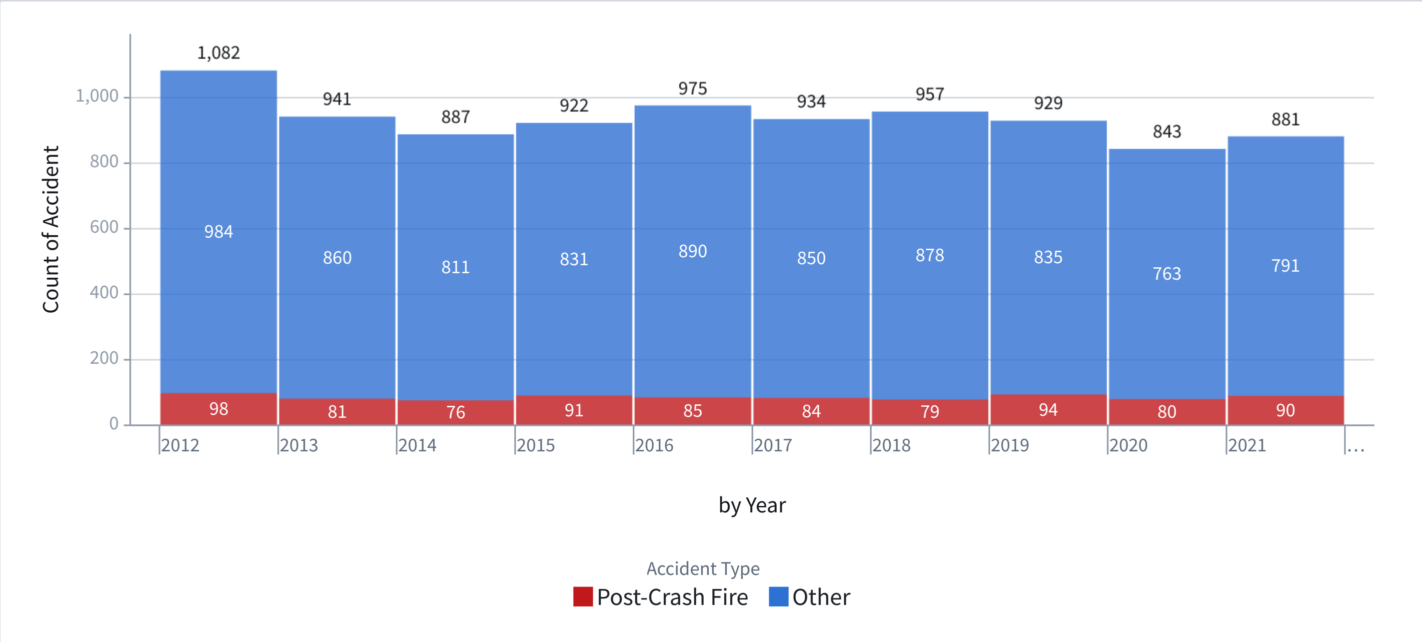
The magnitude of the resulting small airplane accidents over a 10 year period was over 10,000 accidents, and it was impractical to do a review of every accident. Therefore, a statistical approach was taken to identify which accidents had post-crash fire. The team used two cumulative methods to approximate this. First, the team acknowledged that post-crash fires should be classified as a ground fire within the "acft_fire" NTSB metadata field. Second, the team used a "post-crash fire," and variations thereof, text search within the NTSB reports. While this method is effective at finding the majority of accidents, there are bound to be some wording variations which will not be detected by the filter. By combining this text filtering method with the NTSB Ground Fire metadata, the team is confident that the events included in this study include the vast majority of PCF incidents and minimal false matches.

To quantify how many ground fires are true post-crash fires following impact and not ignited through other circumstances, e.g. fire while taxiing, the team reviewed individual accident reports and verified that post-crash fires account for an overwhelming number of ground fires. The team then applied a binomial proportion confidence interval using a randomized sample of both fatal and non-fatal ground fires to approximate how many ground fires are post-crash fires. Of 105 randomly sampled accidents, three were not post-crash fires, seven did not have adequate information and were inconclusive, and 95 were confirmed post-crash fires. Therefore, the team conservatively concluded with 95% confidence that between 85% and 96% of ground fires were in fact post-crash fires. It should be noted that, for the purposes of this analysis, the inconclusive accidents were assumed as having no post-crash fire, so the true percentage is likely higher.

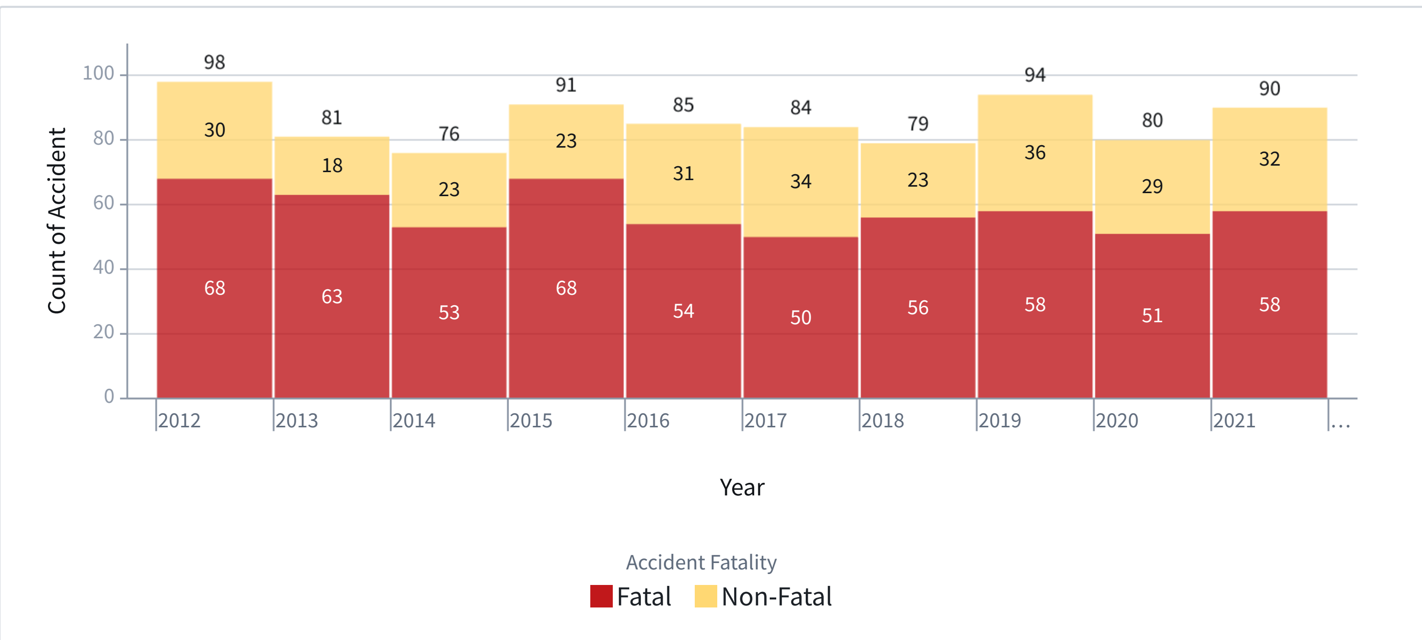
A thorough review of the "post-crash fire" text search results confirmed near perfect success in identifying accidents with post-crash fires. These two data sets, i.e. ground fires and results of the text search, were combined and categorized as small airplane post-crash fire accidents. The additional data added through the text search improves the prescribed confidence and reduces uncertainty that the accidents with post-crash fires are appropriately identified.

Data Analysis Results

The resulting data and assumption that ~90% ground fires are actual post-crash fires was applied to approximate that about 9% of small airplane accidents between 2012 through 2021 had post-crash fire upon impact. The results tabulated annually are shown in ⚓Figure 1. ⚓Figure 2 isolates the accidents with post-crash fire and segments it by those which are fatal or non-fatal. ⚓Figure 2 reveals that 68% of an accidents with post-crash fire have one or more fatality.



⚓Figure 1: All small airplane accidents segmented by those having post-crash fire



⚓Figure 2: All small airplane accidents with post-crash fire segmented by those which are fatal

Data Analysis 2: Enrichment of Post-Crash Fire Accident Data

Data Enrichment Process

The purpose of the data enrichment task was to identify trends, correlations, and relationships between accidents with post-crash fire and fatalities which may have otherwise been preventable. To do this, the team reviewed a randomized sample of 237 fatal accidents with post-crash fire over a 10-year period to further enrich the data to notate when fatalities were due solely to thermal injury, blunt force trauma, drowning, or combinations thereof. The sample of 237 accidents accounted for ~42% of all small airplane fatal accidents with post-crash fire, which is considered statistically large. The NTSB database and accident dockets were the primary source of information for this analysis, along with consultation from the FAA's Civil Aeronautical Medical Institute (CAMI) when autopsy information was missing or unclear.

The team then reviewed each final accident report and associated published material in the docket for every accident to identify the following information:

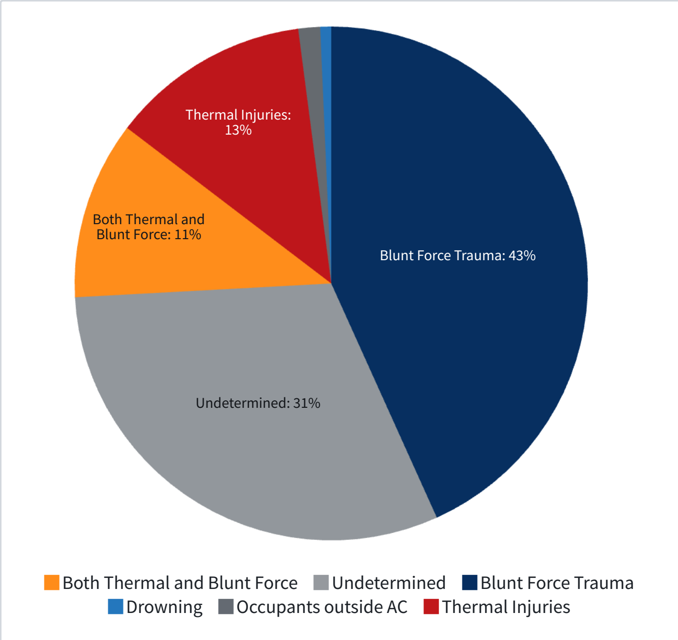
- Verification that there was a post-crash fire. This verification was also used to validate that the "post-crash fire" text filter worked accurately
- Determination of the central location of the fire, if possible
- Notation whether thermal injury contributed to any fatality of an accident
- Determination of the number of fatalities which could be attributed to thermal injury, blunt force trauma, a combination thereof, or other causes
- Notation when the medical information was not conclusive and warranted additional review by CAMI

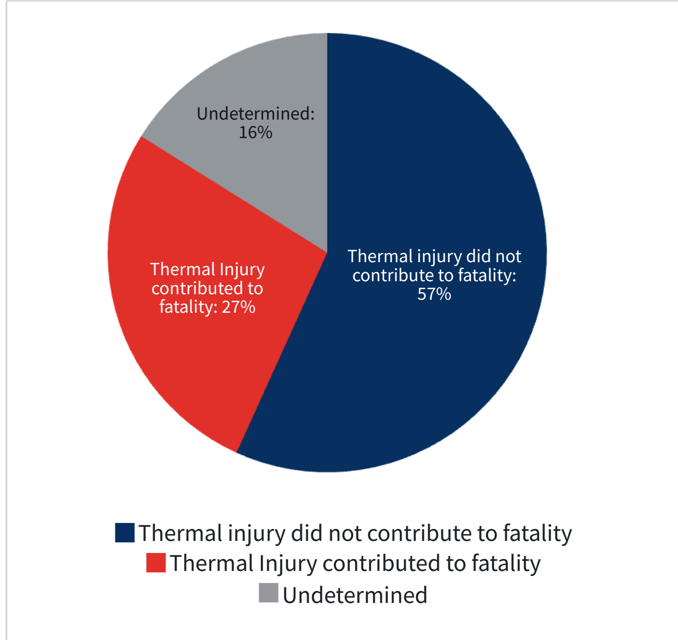
Data Enrichment Results

The results of the data enrichment efforts shown in ⚓Figure 3 reveal that blunt force trauma is the leading cause of fatalities in fatal accidents with post-crash fire (43%). Following that, thermal injury was the sole cause of death in 13% of the fatalities, a combination of thermal and blunt force trauma injuries was the cause of death in 11% of fatalities, and 2% were due to other causes. The cause of death of a significant population of fatalities (31%) could not be determined due to a number of reasons including, but not limited to, the lack of autopsies typically performed on passengers or declined autopsies for personal reasons.

This review revealed that at least 13% of fatalities would otherwise be survivable if there was no fire. It should be noted, that fatalities due to blunt force trauma were not further assessed to consider the severity of the accident and thus determine if mitigations could be put in place which may make the accident otherwise survivable.

⚓Figure 4 presents the results of the analysis on an accident level, and reveals that fire is a contributing factor to a fatality in 27% of accidents, whereas fire did not contribute in 57% of accidents. The effect of fire could not be determined in 16% of accidents.

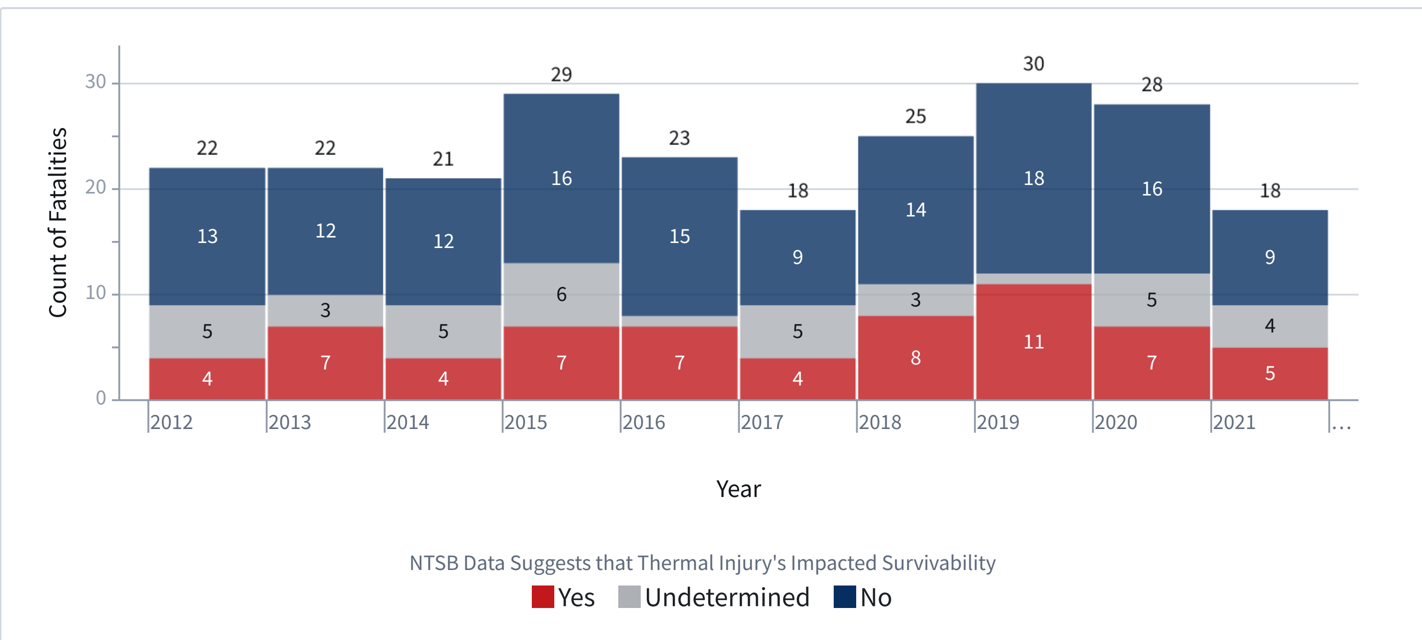




⚓Figure 3: (left) Causes of death by percentage of *all fatalities* in sampled fatal small airplane accidents with post-crash fire

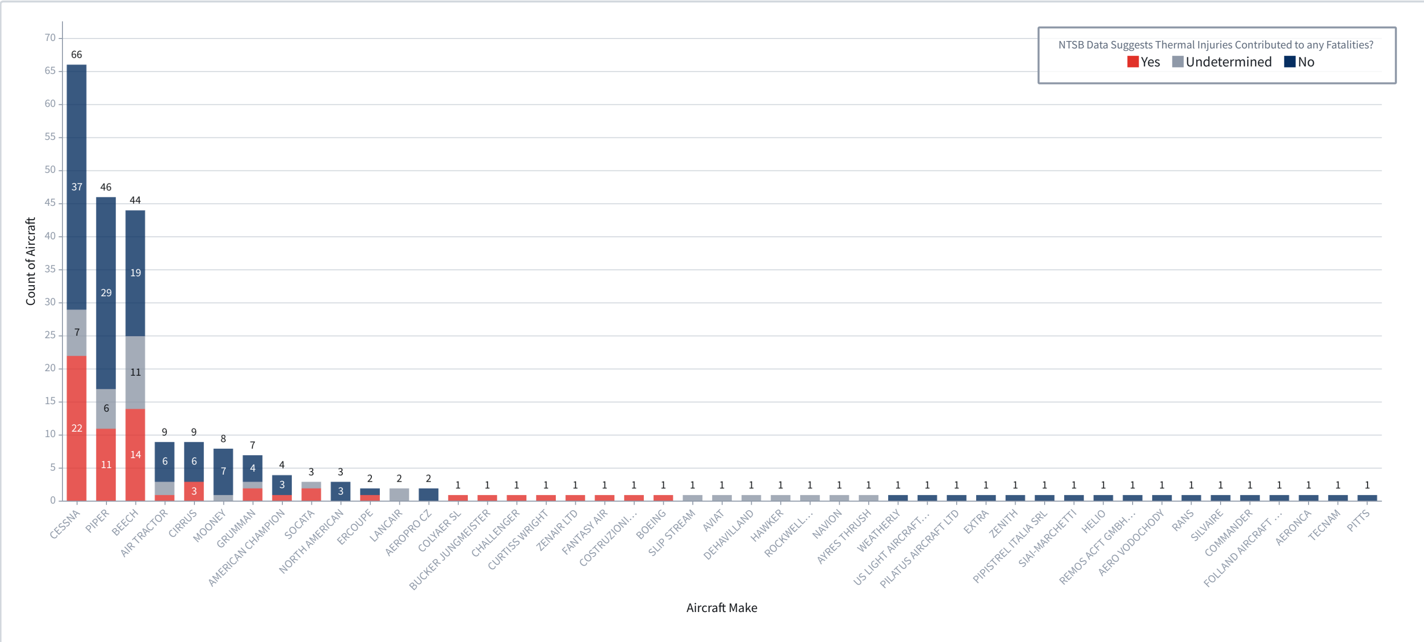
⚓Figure 4: (right) Causes of death by percentage of all *accidents* in sampled fatal small airplane accidents with post-crash fire

⚓Figure 5 arranges the sampled fatal small airplane accidents with post-crash fire by year. This chart shows a relatively even and consistent distribution within the random sampled data set. It also indicates that the dataset comprehensively spanned the entire ten-year period.

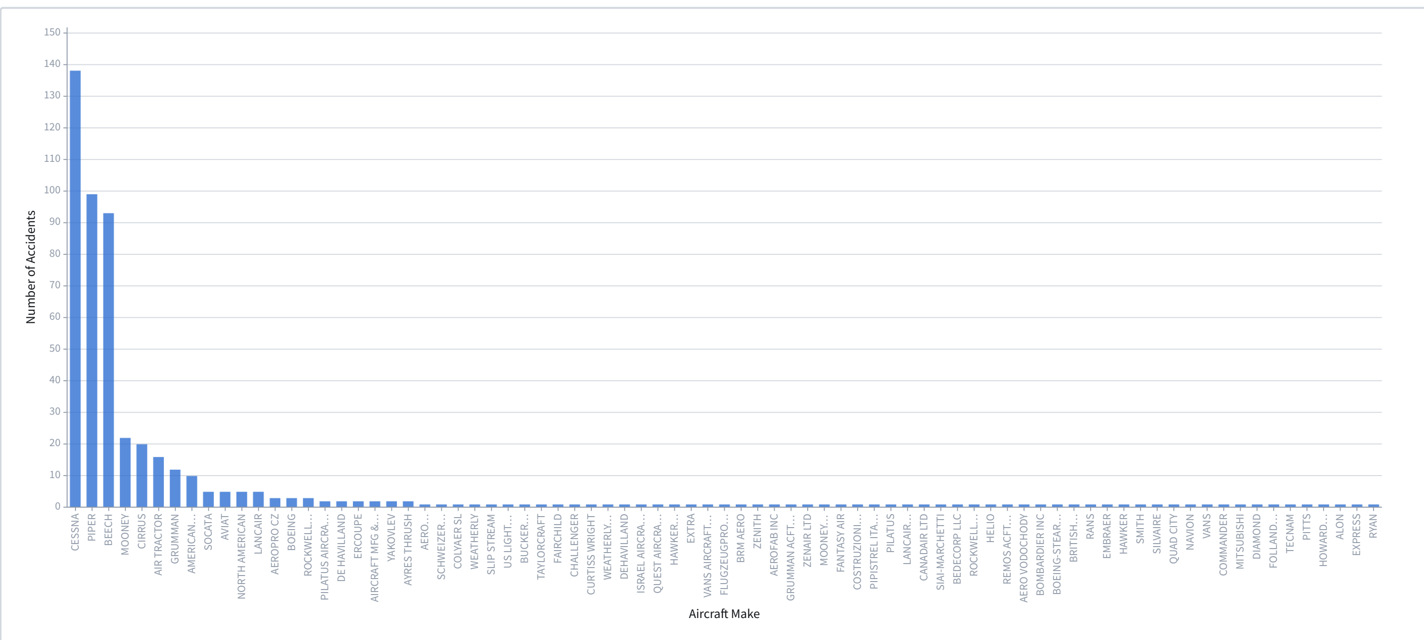


⚓Figure 5: Occupant causes of death in sampled fatal small airplane accidents with post-crash fire arranged by year

⚓Figure 6 presents the distribution of sampled fatal small airplane accidents with post-crash fire by aircraft make. These numbers generally correlate to overall fleet demographics which identify Cessna, Piper, and Beech as the most prevalent small airplane manufacturers registered in the US. Because ⚓Figure 6 is a sampled dataset, ⚓Figure 7 verifies that the distribution of sampled fatal small airplane accidents with post-crash fire by aircraft make is an accurate representation of the overall dataset of fatal small airplane accidents having post-crash fire.

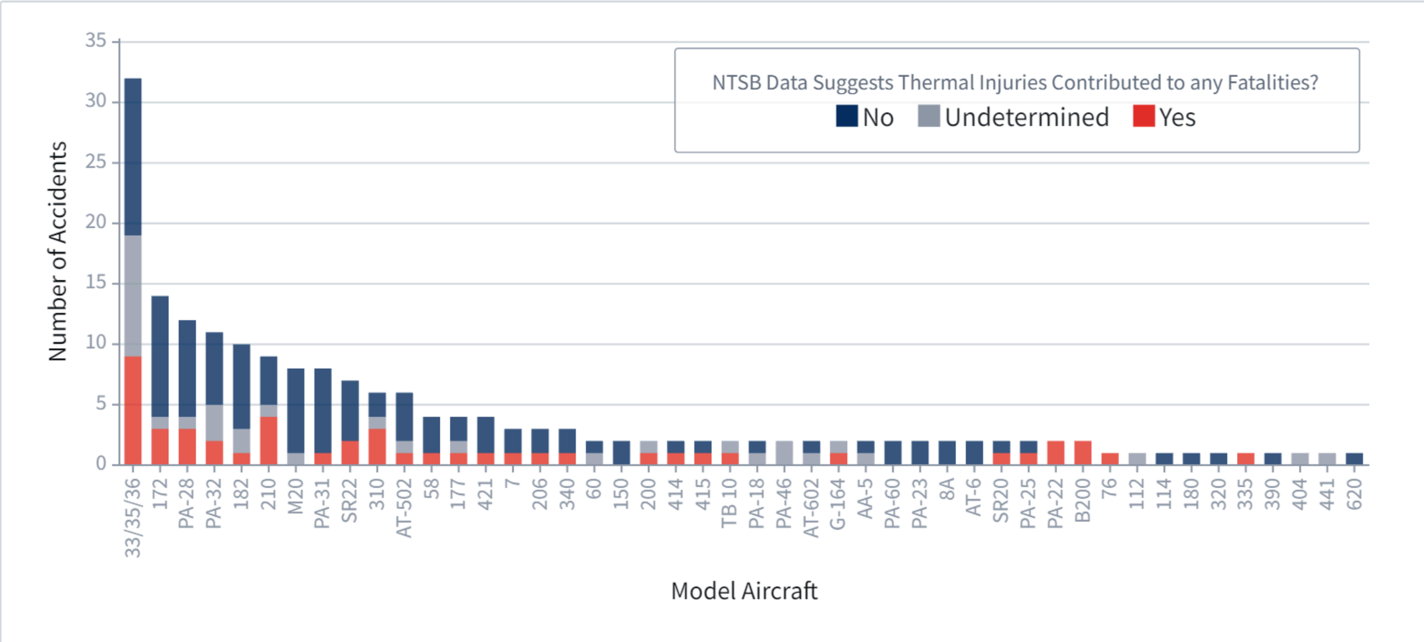


⚓Figure 6: Count of *sampled* fatal small airplane accidents with post-crash fire arranged by make and those which thermal injury(ies) contributed to cause of death

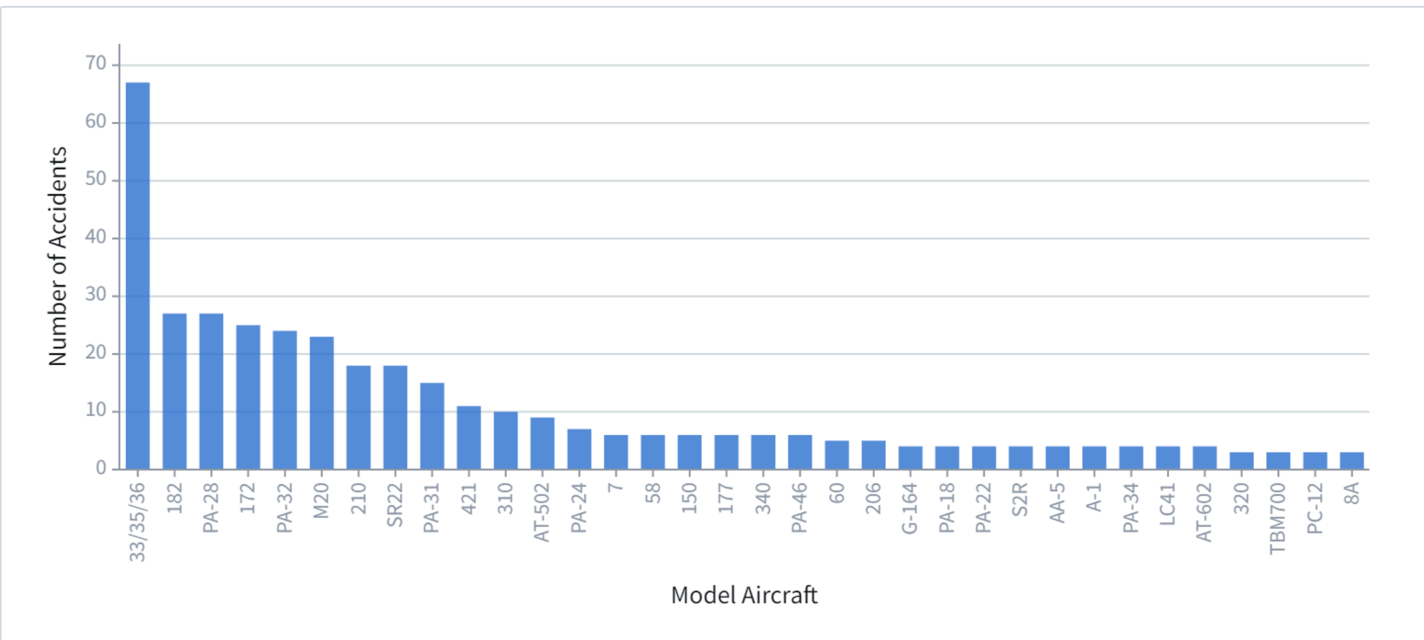


⚓Figure 7: Count of *all* fatal small airplane accidents with post-crash fire arranged by make presented to validate that data randomly chosen for enrichment was representative of the fleet

⚓Figure 8 presents the distribution of sampled fatal small airplane accidents with post-crash fire by model. These numbers generally correlate to overall fleet demographics and correspond to Cessna 172, Piper PA-28, Cessna 182, Beech 33/35/36 as the top four most prevalent small airplane models. Because ⚓Figure 8 depicts a sampled dataset, ⚓Figure 9 verifies that the distribution of sampled fatal small airplane accidents with post-crash fire by model is an accurate representation of the overall dataset of fatal small airplane accidents having post-crash fire.

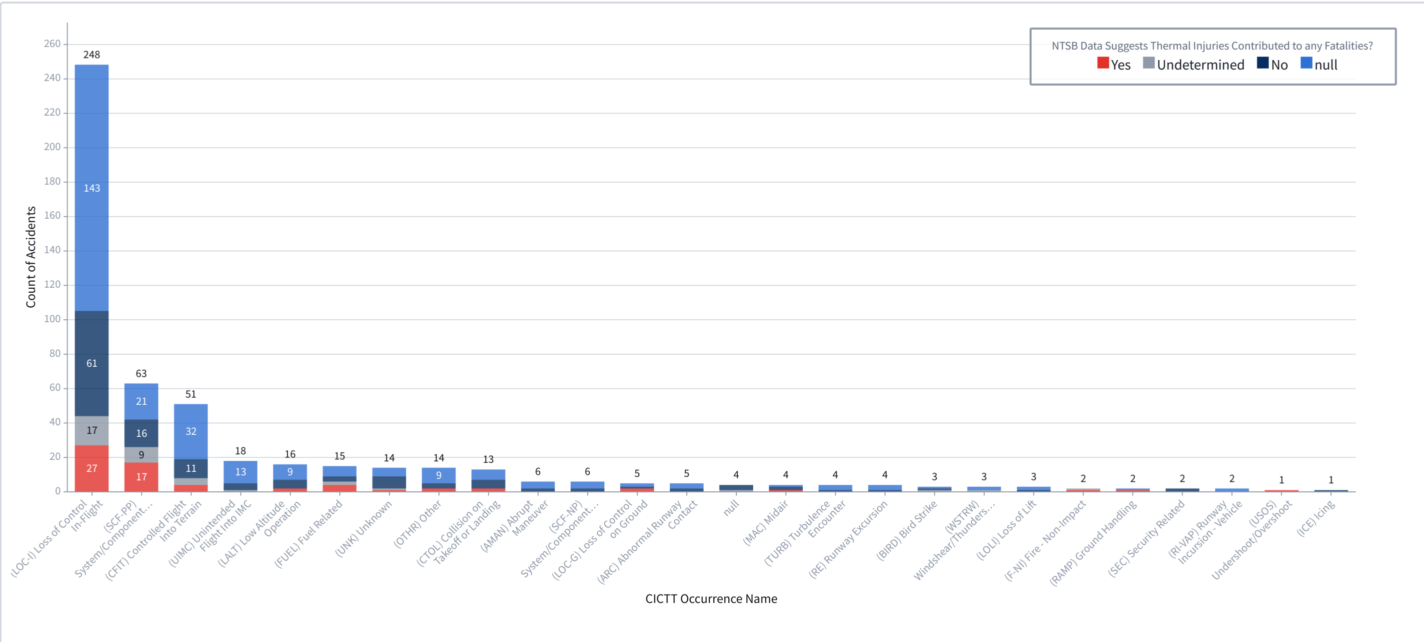


⚓Figure 8: Count of *sampled* fatal small airplane accidents with post-crash fire arranged by model and those which thermal injury(ies) contributed to cause of death



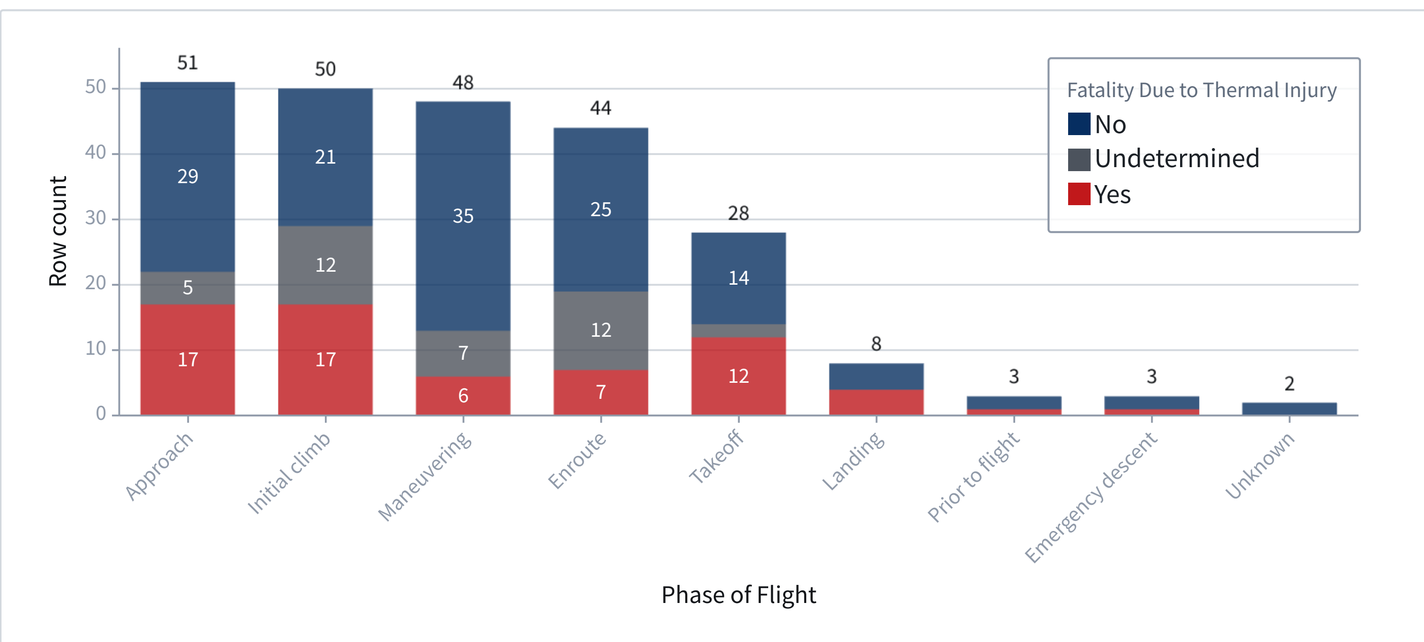
⚓Figure 9: Count of *all* fatal small airplane accidents with post-crash fire arranged by model presented to validate that data randomly chosen for enrichment was representative of the fleet

⚓Figure 10 assigns the corresponding Commercial Aviation Safety Team/International Civil Aviation Organization Common Taxonomy Team (CICTT) code to the defining event occurrence code which is provided in the NTSB meta-data. Fatal accidents with post-crash fire are most often initiated by a Loss of Control-Inflight (LOC-I) event. The second and third most frequent occurrence codes where post-crash fire occur are System/Component Failure - Powerplant (SCF-PP) and Controlled Fight into Terrain (CFIT). The trends of this chart very closely follow the 2010-2020 general aviation safety performance metrics published by the GAJSC per reference 10, which attribute LOC-I, SCF-PP, and CFIT as the top three defining events.



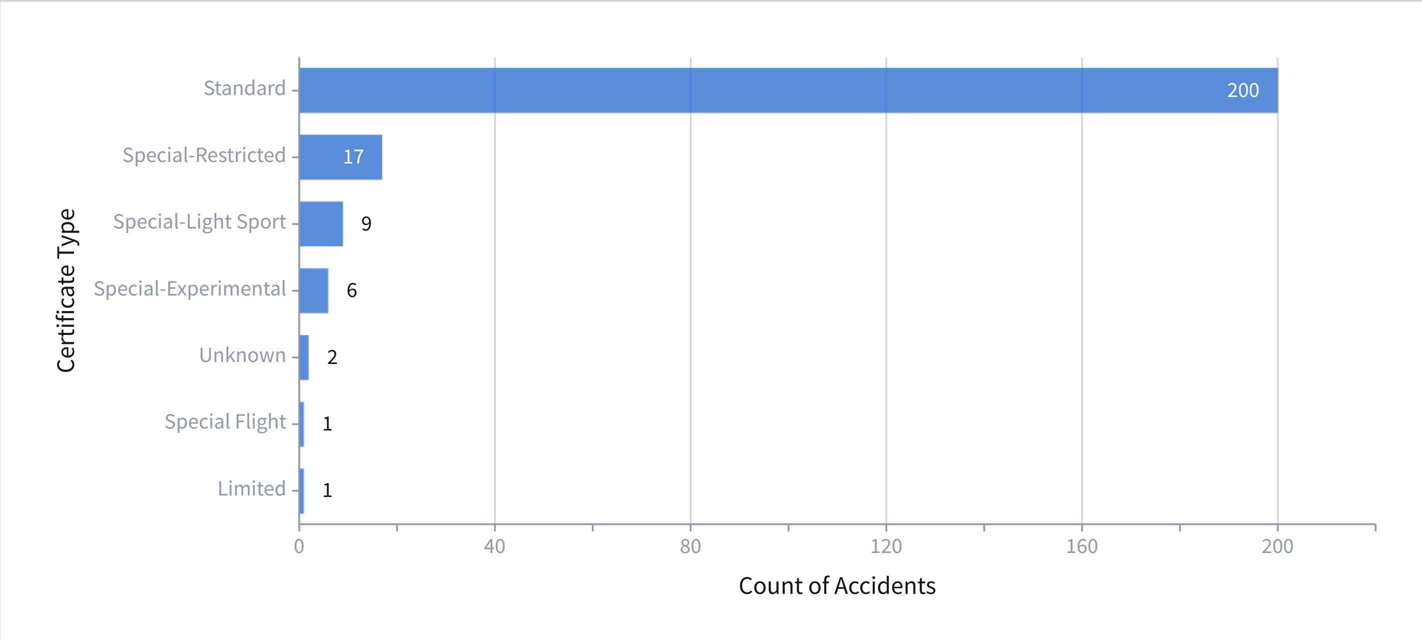
⚓Figure 10: Defining Event CICTT Code of sampled fatal small airplane accidents with post-crash fire

⚓Figure 11 arranges the data by the accident phase of flight which is provided in the NTSB meta-data. Fatal accidents with post-crash fire are relatively evenly distributed between all airborne phases of flight, with thermal injury related fatalities also occurring in all phases.



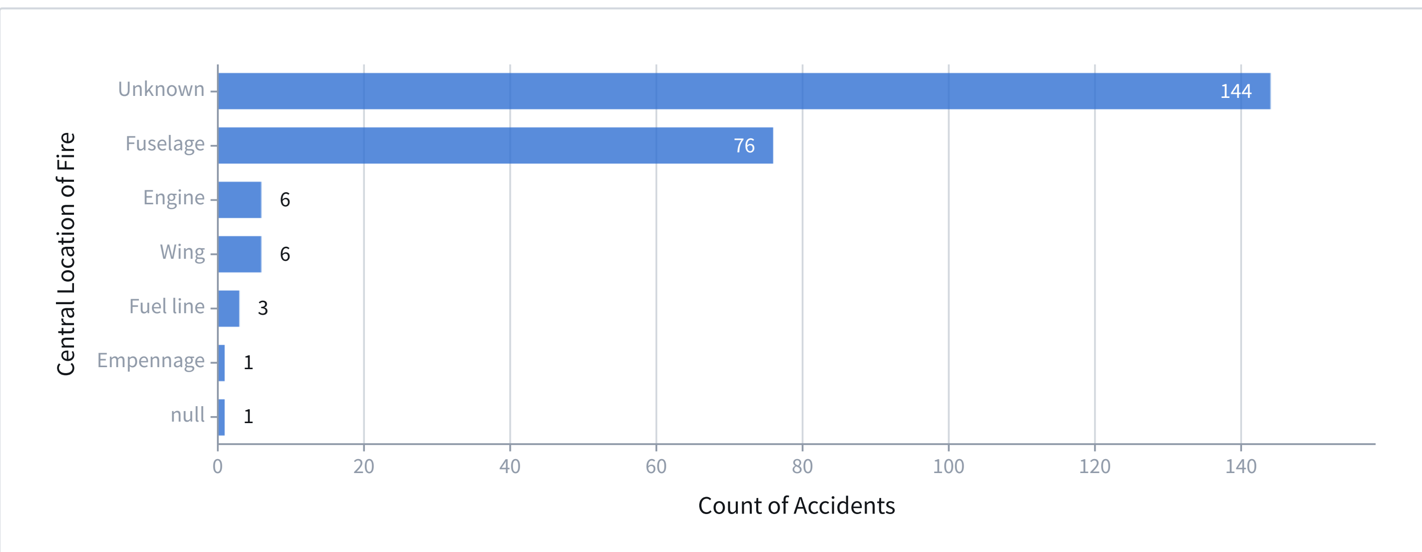
⚓Figure 11: Phase of flight the accident occurred in *sampled* fatal small airplane accidents with post-crash fire

⚓Figure 12 shows the distribution by airworthiness certification for the sampled fatal small airplane accidents with post-crash fire. This information is often provided within the text of NTSB documentation and is tabulated below as enriched data.



⚓Figure 12: Airworthiness Certificate Type for the *sampled* fatal small airplane accidents with post-crash fire

⚓Figure 13 depicts the team's best efforts to enrich the data with the central location of the fire using information provided in the NTSB docket and final reports. The reviews reveal that, although such information would likely assist in better understanding the nature of post-crash fires, identifying this information is both unlikely, difficult, and more often than not cannot be determined.



⚓Figure 13: Data enrichment findings of central location of fire for the *sampled* fatal small airplane accidents with post-crash fire

⚓Table 1 compares the findings of this data analysis to those documented in the historical reports discussed above. A comparative review reveals that the statistics associated with post-crash fire have been consistent since at least 1974.

⚓Table 1: Comparison of the subject data analysis to historical reports

	2012-2021 Subject Analysis	1976-2002 2006 TSB Analysis (Ref 8)	1974-1978 1984 NTSB Report (Ref 3)
Small Airplane Accidents in which PCF Occurs	9%	4%	8%
Small Airplane Accidents with PCF which are fatal	68%		59%
Fatal *accidents* with PCF in which thermal injury contributed to any fatality	27% (65/237)	25%** (128/521)**	
Fatalities in accidents with PCF in which thermal injury contributed to the fatality	24%	28%	

**Includes Serious Injury

Benchmarking of Available Crashworthy Fuel System Technologies

Several sources were queried to identify voluntarily retrofittable crashworthy fuel system technologies. These sources included aviation insurance working groups, General Aviation Manufacturers Association (GAMA), FAA personnel, as well as internet searches. While some technologies conceptually exist, there are very limited design modifications available which are FAA-certified and approved for installation.

Conclusions

In conclusion, the presence of post-crash fire and its effect on survivability has remained consistent since the 1970s. Minimal changes to the designs of small airplanes and their fuel systems have been made over the decades to mitigate the effect of or prevent fire. This data analysis approximates that post-crash fire occurred in 9% of all small airplane accidents from 2012-2021. Of the 9% of accidents where a post-crash fire occurred, 68% were fatal (accounting for all causes of death).

Blunt force trauma rather than thermal injury was the leading cause of fatalities in fatal accidents with a post-crash fire. Blunt force trauma accounted for 43% of fatalities, over 3 times higher than the 13% of fatalities attributable to thermal injuries. A combination of blunt force trauma and thermal injuries accounted for another 11% of fatalities.

Although numerous research activities have identified design strategies to limit the effect of fire upon impact, little has been done to tangibly incorporate such strategies in the fleet. Testing has demonstrated that safety enhancements, such as crash resistant fuel tanks, improve the crashworthiness of the fuel systems. However, innovation, product development, certification, and market distribution is necessary to realize these safety gains in the fleet. There are minimal options of FAA certified design modifications which can be voluntarily implemented to mitigate post-crash fire.

Rules proposed via reference 6 to improve fuel system integrity were withdrawn because the costs of the proposed changes were not justified by the potential benefits. Although the 2012-2021 small airplane post-crash fire statistics are consistent with those used to initiate and withdraw rulemaking activities in the 1990s, one variable where a noteworthy change has occurred is the statistical value of human life, which increased from $1M (1990) to $12.5M (2022) as documented in reference 11. It is unclear if the updated statistical value of human life would change the results of the economic analysis which resulted in the withdrawal of the NPRM in 1999, but is identified for consideration.

The current state of post-crash fire in small airplanes consistently persisted through the decades. Without intervention through regulatory means or an FAA and industry commitment to develop retrofittable crash resistant technology, these statistics are likely to persist into the future.

Recommendations for Future Work

The logic used in this study started with fatal accidents involving post-crash fire. There are numerous causal factors in the chain of events leading to this outcome that are recommended for further evaluation. These include preventing the fatality in the presence of fire, preventing the fire from occurring in the event of an accident, and preventing the accident from occurring altogether. The following recommendations for each causal factor are provided for further consideration:

- *Prevent the fatality in the presence of fire.* This analysis revealed that blunt force trauma rather than thermal injury was the leading cause of fatalities in fatal accidents with a post-crash fire. A detailed review of fatalities due to blunt force trauma to quantify survivability gains of implementing either new or existing technology, e.g. shoulder belts, inflatable seat belts, etc., may identify ways to improve occupant evacuation and survivability and is recommended for further evaluation.
- *Prevent the fire in the event of an accident.* Although aircraft structural and mechanical design features were not fully assessed in this study, the investigation revealed that certain make/model aircraft may have inherently low post-crash fire rates. For example, the Cessna 208 Caravan and Kodiak 100 presented few accidents with post-crash fire. This may be due to a variety of reasons, one of which may be integral design features which mitigate the effect of fire, such as the location of these aircrafts' fuel selector valves. These airplanes have fuel selector valves located at the inboard fuel rib and emergency procedures to close the valves in the event of a forced landing, possibly reducing the likelihood of fire. Therefore, a detailed evaluation of the effect of specific aircraft structural and mechanical design features may identify best design practices to be applied in future aircraft designs.
- *Prevent the accident altogether.* The NTSB identified LOC-I as the leading accident event occurrence code for fatal accidents with post-crash fire as shown in ⚓Figure 10. Government and industry have been working to reduce LOC-I events through voluntary safety enhancements developed and promoted through safety organizations such as the GAJSC, see reference 9. Based on the results of this study, reduction in post-crash fires would benefit from the continuation of their efforts.

In summary, there are many events which contribute to a fatal airplane accident with post-crash fire, each of which offer an opportunity to prevent fatalities from occurring.

This report can be viewed in ASPIRE through the following URL: https://aspire.faa.gov/shares/links/vgcd7podsagkg

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