Increasing General Aviation (GA) Pilot Reports (PIREPs) through Reducing Errors

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Abstract

The purpose of this study was to increase General Aviation (GA) pilot reports (PIREPs) through reducing errors, trust issues, and inaccuracies in PIREP submittals that prevent inclusion in the PIREP system. PIREPs are an essential source for pilots because they contain the most current weather conditions and help pilots avoid flying into unforeseen hazardous weather. PIREPs can also provide vital information to meteorologists who develop aviation forecasts. A Failure Modes and Effects Analysis (FMEA) was conducted to identify failure modes for two PIREP processes consisting of air traffic control (ATC) processes failures and airmen induced issues contributing to the failure to submit PIREPs. After the failure modes were identified, recommended actions to eliminate or reduce the error or error effects were determined. The results, discussion, and future research are also addressed.

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1. Introduction

The purpose of the study was to increase GA PIREPs by reducing errors, trust issues, and inaccuracies in PIREP submittals that prevent inclusion in the National Airspace (NAS). A FMEA was conducted to identify failure modes for two PIREP processes consisting of ATC process failures and airmen-induced issues contributing to a failure to submit PIREPs. An FMEA is a systematic method to evaluate processes and to determine where failures may occur. The FMEA resulted in recommended actions to eliminate or reduce the error or error effects to increase the volume of PIREPs being submitted by air traffic controllers and GA pilots. PIREPs are pilot reports from pilots describing their actual in-flight weather conditions. PIREPs can increase the accuracy of forecasted weather and provide pilots with real-time weather conditions. Submission of PIREPs can allow aircraft to avoid hazardous weather and prevent weather-related incidents and accidents. An accurate weather forecast and current weather are critical for all aircraft operating in the NAS (NTSB, 2017a). PIREPs are an essential source for pilots because they contain the most current weather conditions and help pilots avoid flying into unpredictable hazardous weather. PIREPs can also provide vital information to meteorologists who develop aviation forecasts. Aircraft Owners and Pilots Association (AOPA) identified accidents caused by pilots flying under visual flight rules (VFR) and continuing into instrument meteorological conditions (IMC) that can be fatal (see Table 1) (2015; 2016a, 2017, 2018, 2021a, 2021b, 2021c).

Table 1

VFR into IMC accidents and fatalities from 2012 to 2018 documented by the Nall Reports

Report	Year	Involved	Fatalities
24th Nall Report (AOPA Air Safety Institute, 2015)	2012	23	22 (95.6%)
25th Nall Report (AOPA Air Safety Institute, 2016a)	2013	33	17 (73.9%)
26th Nall Report (AOPA Air Safety Institute, 2017)	2014	22	20 (90.9%)
27th Nall Report (AOPA Air Safety Institute, 2018)	2015	21	20 (95.2%)
28th Nall Report (AOPA Air Safety Institute, 2021a)	2016	13	7 (53.8%)
29th Nall Report (AOPA Air Safety Institute, 2021b)	2017	28	22 (78.5%)
30th Nall Report (AOPA Air Safety Institute, 2021c)	2018	14	13 (92.8%)

Note. The values in parentheses show the percentage of the fatalities.

The failure of pilots to submit PIREPs falls into seven categories: Lack of awareness of the importance of PIREPs, lack of confidence in PIREP format, lack of weather assessment skills, cockpit workload, fear of enforcement action, a cumbersome and time-consuming reporting process, and prior experience with PIREPs not being disseminated (NTSB, 2017a). The failure of air traffic controllers to enter PIREPs into the system is classified into four areas: noncompliance with solicitation requirements, inadequate dissemination of weather information, data entry mistakes, and consolidating multiple PIREPs.

2. Background Information

The NTSB (2017a) discussed the importance of entering PIREPs into the system in their special investigation report: Improving Pilot Weather Report Submissions and Dissemination to Benefit Safety in the NAS. The report identified deficiencies with air traffic controllers and airmen as contributing to the failure of PIREPs to be entered into the system.

2.1 Air Traffic Control Issues

If pilots submit a PIREP to an air traffic controller, the controller must enter the PIREP into the system. Air traffic controllers are also required to advise local facilities of reported PIREPs within their control area (NTSB, 2017a). Additionally, air traffic controllers must solicit PIREPs when conditions are reported below specific weather standards (FAA, 2019a; NTSB, 2017a). However, separating and issuing safety alerts to aircraft is ATC’s primary duty and takes precedence over the requirement to solicit PIREPs (FAA, 2019b; NTSB, 2017a). The NTSB (2017a) classified ATC PIREP failures into four categories: (1) noncompliance with solicitation requirements, (2) inadequate dissemination of both urgent and routine weather information, (3) data entry errors, and (4) inappropriate consolidation of multiple reports.

When certain weather conditions exist, air traffic controllers must solicit PIREPs (FAA, 2019a; NTSB, 2017a). In February of 2015, in Andrews, Texas, an airplane on approach impacted the ground short of the runway because of inflight icing. The air traffic controller did not solicit PIREPs from aircraft arriving and departing the airport when weather conditions met the minimum solicitation requirements. The NTSB found air traffic controllers frequently cannot solicit PIREPs because of the high workload (NTSB, 2015; NTSB, 2017a).

The failure of air traffic controllers to disseminate PIREPs after their receipt may be a causal factor in an incident or accident because a pilot may make a poor adverse weather avoidance decision (NTSB, 2017a). A Denver Air Route Traffic Control Centers (ARTCC) received a PIREP from a Boeing 737 reporting hail potential but failed to respond to an Airbus 320 crew's repeated request for information regarding hazardous weather (NTSB, 2017b). The Airbus 320 encountered hail that resulted in a shattered windshield and airframe damage. The NTSB determined that a contributing factor was the controller's failure to provide the flight crew with the PIREP.

In March 2012, during an approach to land in Anchorage, Alaska, a Learjet 35A encountered severe in-flight icing conditions (NTSB, 2012a). The conditions were so severe that the windshield became obscured with ice, and the airplane veered off the runway during landing and into a snowbank. Another aircraft 7 miles away, while on approach to another airport, encountered severe icing conditions. Although the tower reported the information to the Anchorage approach controller, the controller did not relay the information to the Learjet flight crew (NTSB, 2017a; NTSB, 2012a).

In June of 2012, in Aspen, Colorado, a pilot submitted a PIREP reporting low-level wind shear on final approach (NTSB, 2012b). Although ATC disseminated the PIREP to local traffic, including a Learjet 60 involved in an accident, air traffic controllers did not enter the PIREP in the NAS. The PIREP should have been given priority handling because the PIREP included a report of a 15-knot loss of airspeed on a short final approach that met the classification of an urgent PIREP (NTSB, 2017a; NTSB, 2012b).

To facilitate and save time, air traffic controllers often consolidate multiple PIREPs and enter one PIREP into the NAS (NTSB, 2017a). By consolidating PIREPs, important information is lost. For example, a controller might consolidate several urgent PIREPs reporting moderate-to-severe turbulence from numerous types of aircraft. For example, moderate turbulence for a Cessna 172 might not be considered the same for a Boeing 737. Additionally, by consolidating PIREPs, information such as the time and location of the PIREP might be lost. Meteorologists need this information to update forecasts and are also needed by pilots who are inflight and seeking updated weather.

2.2 Pilot Issues

During the NTSB's (2017a) June 2016 forum on pilot weather reports, an AOPA manager reported that a preliminary review of the comments of their PIREP survey indicates that pilots had to leave an ATC frequency to file a PIREP, finding the correct flight service station (FSS) frequency, and then communicating with FSS was too time-consuming. A review of the AOPA (2016b) survey confirms this impediment. Pilots further described reporting PIREPs with an FSS as inefficient because it takes too long for the FSS to read back the PIREP report for accuracy (AOPA, 2016b; NTSB, 2017a).

The NTSB (2017a) noted that pilots often cannot submit PIREPs because of cockpit workload. This was confirmed by the comments in the AOPA (2016b) report. In a survey by Casner (2010), 159 (58%) GA pilots reported they were interested in a method to submit PIREPs that was quicker and more convenient. In a second survey by Casner (2014), GA pilots said they would be more apt to report PIREPs if they had a cockpit interface that automatically reported parameters such as aircraft location, time altitude, aircraft type, wind, and temperature and also provided menus for selecting the other elements of a PIREP.

3. Methods

An FMEA was conducted to identify failure modes within the two identified PIREP processes, ATC process failures, and airmen-induced issues contributing to the failure to submit PIREPs (NTSB, 2017a; AOPA, 2016b). After the failure modes were identified, recommended actions to eliminate or reduce the error or error effects were developed (Carstens, 2005; Carstens, 2006; Carstens et al., 2014). Failure modes were identified based on the literature and researchers' expertise to identify what can go wrong with a process to include errors, trust issues, and inaccuracies occurring in PIREP submittals. The identified failure modes were assessed by determining the cause of the failure and the effect, and the consequence of each failure. Usually, an FMEA includes three scales to calculate the risk priority number (RPN) value, including severity, occurrence, and detection. Due to trust being identified within the PIREP literature, the FMEA was modified to include a trust rating resulting in the FMEA having four scales. A high RPN symbolizes a process that needs to be changed to reduce the risks presented by the failure mode. Part of the FMEA process includes the identification of recommended actions from a proactive standpoint that, if implemented, could reduce the RPN value. Therefore, the RPN is recalculated based on the recommended action, referred to the post-RPN, which helps assess proposed changes to a process in advance of the recommended action being implemented.

The FMEA spreadsheet was placed into Excel. Each column of the FMEA assisted the research team in analyzing each failure mode through trust, severity, occurrence, and detection scales. Researchers moved through the FMEA spreadsheet by answering the different column questions and assessing the failure modes based on four scales. The FMEA spreadsheet consists of: (a) process, (b) potential failure mode, (c) trust description, (d) trust rating, (e) potential effects, (f) severity rating, (g) potential causes, (h) existing prevention control, (i) occurrence rating, (j) existing detection controls, (k) detection rating, (l) RPN, (m) RPN ranking, (n) recommended actions, (o) new trust rating, (p) new severity rating, (q) new occurrence rating, (r) new detection rating, (s) new RPN, (t) new RPN ranking, (u) effectiveness, and (v) effectiveness ranking.

The process column describes the processes affiliated with a failure mode. The potential failure mode is a description of the failure that can occur. The trust reasoning describes the identified trust issues, on which the trust rating value is assigned. The potential effect refers to the probable outcomes of the failure mode, and the severity of the failure mode is rated accordingly. The potential cause is the reason why the failure can occur. The prevention design, if available, is described based on the identified potential cause of the failure mode. According to the potential cause and prevention design, the likelihood of occurrence of the failure can be determined. The detection control describes the methods used to detect the failure if it happens, and the likelihood that the failure can be detected is assigned a rating. The RPN is the product of the four ratings (i.e., trust, severity, occurrence, detection). Based on the rating provided for each of the four scales, the RPN can range from 1 to 10,000, where the failure mode with the highest risk will have the largest number. The recommended actions describe the proposed actions that may be effective in reducing the risk of the failure mode. Then, a post recommended action RPN rating of trust, severity, occurrence, and detection is calculated based on how well the recommended action can eliminate or reduce the error and error effects affiliated with the failure mode. The post-RPN and the associated ranking uses a stoplight approach in identifying failure modes with a low risk of failure by coding these cells in green. Failure modes with a medium risk are coded in yellow, and those with a high risk are coded in red. If the recommended action is not implemented, then the first RPN should be used in assessing the risks presented by the failure mode within the current PIREP process. There is also a column dedicated to effectiveness. This is an internal tool for the researchers to assess how well the recommended action lowers the risk. Therefore, it is calculated based on how effective the recommended action was at reducing the RPN value. The effectiveness result is presented as a percentage, where a high value indicates high effectiveness. It is calculated by [1 – (post RPN/first RPN)] within each row. The ranking of the effectiveness is also provided. The RPNs, effectiveness, and rankings are each automatically calculated within the FMEA spreadsheet.

The four scales use 1, 3, 5, 7, and 10 as the available ratings with the descriptions provided in Table 2. For the trust scale, 1 means calibrated trust, and 3, 5, 7, and 10 are low, moderate, high, and extreme overtrust or undertrust. Calibrated trust symbolizes that the subjective trust in the process agrees with the objective trust measures such as the perceived number of errors match the actual number of errors (Wickens, Hollands, Banbury & Parasuraman, 2016). Therefore, if a process for instance despite an overtrust or undertrust rating, either extreme, is a concern for safety then the process aligns with the purpose of conducting a FMEA. For the severity scale; 1, 3, 5, 7, and 10 refer to none, minor, moderate, major, and catastrophic consequences respectively. The occurrence ratings indicate rare, low, moderate, high, and very high occurrences of the failure depicted moderate, low, and none, respectively.

Table 2

FMEA Rating Description

Ratings	Trust	Severity	Occurrence	Detection
10	Pilots have extreme undertrust/overtrust	Catastrophic consequence	Very high occurrence	Cannot detect failure (0-24%)
7	Pilots have high undertrust/overtrust	Major consequence	High occurrence	Low detect rate (25-49%)
5	Pilots have moderate undertrust/overtrust	Moderate consequence	Moderate occurrence	Moderate detect rate (50-79%)
3	Pilots have low undertrust/overtrust	Minor consequence	Low occurrence	High detect rate (80-89%)
1	Pilots have calibrated trust	No (or positive) consequence	Rare occurrence	Very High detect rate (90-100%)

4. Results and Discussion

4.1 ATC submission PIREP processes failures

The first identified process was ATC failing to forward PIREPs to other facilities in their control area (NTSB, 2017a). This process was assigned ratings for trust, severity, occurrence, and detection of 3, 3, 5, and 10 that corresponded to an RPN of 450. With the recommended action to require air traffic controllers to enter all PIREPs into the NAS system, each rating was reduced to 1, which corresponded to an RPN of 1 with an effectiveness rating of 99.78%.

The second identified process was ATC consolidating PIREPs before entering them into the NAS (NTSB, 2017a). This process was deemed to have ratings for trust, severity, occurrence, and detection of 3, 3, 5, and 10 that corresponded to an RPN of 450. With the recommended action to require ATC to enter all PIREPs into the NAS system, the ratings were all reduced to 1 which corresponded to an RPN of 1 with an effectiveness rating of 99.78%.

The third and final identified process identified by NTSB (2017a), ATC failing to solicit PIREPs, the assigned ratings for trust, severity, occurrence, and detection were 7, 5, 5, and 10 that corresponded to an RPN of 1750. With the recommended action to require ATC to enter all received PIREPs into the NAS, the ratings were all reduced to 1, corresponding to an RPN of 1 with an effectiveness rating of 99.78%.

These recommendations were consistent with the NTSB's recommendations made to the FAA. The NTSB suggested that the FAA develop a best practice guide for disseminating PIREPs for each type of ATC facility (NTSB, 2017a). These actions would guide controllers in the dissemination process. The NTSB also recommended that automation technology capture data elements from the air traffic controller's displays, including aircraft type, time, location, and altitude, to automatically populate these data into the PIREP. The controller would then have to enter the remaining PIREP elements and disseminate the PIREPs. This recommendation would shorten the time it takes for the controller to submit the PIREP so they can focus on traffic separation and safety alerts to aircraft.

4.2 Airmen submission PIREP processes failures

The first identified process was that airmen were not comfortable with what weather to report in a PIREP (NTSB, 2017a). The process was deemed to have trust, severity, occurrence, and detection ratings of 5, 5, 5, and 10 corresponding with an RPN 1250. By providing more extensive PIREP training, the ratings could be reduced to 1, 3, 3, and 10, corresponding to an RPN of 90 and an effectiveness rating of 92.8%.

The second identified process was that airmen had poor experience assessing weather, which discouraged them from filing PIREPs (NTSB, 2017a). This process was assigned trust, severity, occurrence, and detection ratings of 5, 5, 5, and 10, corresponding with an RPN of 1250. By providing more extensive PIREP training, the ratings could be reduced to 1, 3, 3, and 10 for an RPN of 90 and an effectiveness rating of 92.8%.

The third identified process was that airmen perceived it took too long for FSS to accept a PIREP and too long to read back a PIREP (AOPA, 2016b). This process was assigned trust, severity, occurrence, and detection ratings of 5, 5, 5, and 1, corresponding with an RPN of 125. NTSB (2017a) concluded the following:

> some flight circumstances place demands on the pilot such that he or she must minimize the time spent filing a report. Pilots can reduce time spent filing a report by concisely providing thorough and accurate information, and specialists can help by prioritizing how critical information is obtained from the pilot. The NTSB concludes that the process by which FSS specialists receive and verify verbal PIREP information is having an unintended deterrent effect on reporting because some pilots find the process too time-consuming and, therefore, choose not to submit PIREPs. Therefore, the NTSB recommends that the FAA review the process by which federal and contract FSS specialists receive verbal PIREPs and then simplify procedures to reduce the amount of time the specialists take to obtain the necessary information from pilots. (p. 12)

By limiting the readback information required by pilots, pilots may be more apt to submit PIREPs thereby resulting in new ratings reduced to 1, 1, 1, 1 for an RPN of 1, and an effectiveness rating of 99.2%.

The fourth identified process was that airmen were fearful of an enforcement action for flying into poor weather without having the minimum weather requirements for IMC (NTSB, 2017a). This process was assigned trust, severity, occurrence, and detection ratings of 3, 3, 3, and 10, corresponding with an RPN of 270. By amending the rules to provide immunity from violations for negligently flying into poor weather, the ratings and RPN were unchanged. It was reasoned that unless full immunity was provided, airmen would be reluctant to submit PIREPs if they violated the Federal Aviation Regulations.

The fifth identified process was position and time reporting errors (NTSB, 2017a). This process was assigned trust, severity, occurrence, and detection ratings of 3, 3, 3, and 10, corresponding with an RPN of 270. By providing a pre-call to ATC, the controller can mark the time and location until the full PIREP could be reported; the ratings were reduced to 1, 1, 1, and 1 for an RPN of 1 and an effectiveness rating of 99.63%.

The sixth identified process was that pilots do not believe PIREPs are important (NTSB, 2017a). This process was assigned trust, severity, occurrence, and detection ratings of 3, 3, 1, and 3, corresponding with an RPN of 27. NTSB (2017a) concluded the following:

> One reason that some pilots do not routinely file PIREPs may be that they are unaware of how important all PIREPs—including those of fair weather conditions or conditions consistent with the forecast—are for improving aviation weather products. One survey of 189 GA pilots found a likely

> relationship between pilots' perceived importance of PIREPs and their willingness to submit them (Casner 2010). The survey results also indicated that the pilots surveyed were more likely to submit PIREPs for severe or unexpected weather phenomena than for moderate or as-forecasted conditions. The survey results strongly suggested that pilots believed that the primary purpose of PIREPs was for reporting bad weather. AOPA's review of the responses to its 2016 survey revealed a similar trend: 81% of the pilots who responded said they would rarely to never file a PIREP for as-forecast conditions, and 76% said that they would rarely to never report benign conditions (NTSB 2016b, 21). (p. 6)

By providing pilots training, the ratings were reduced to 3, 1, 1, and 1 for an RPN of 3 and an effectiveness rating of 88.89%.

The seventh identified process was pilots do not believe that air traffic controllers want to accept PIREPs (NTSB, 2017a). This process was assigned trust, severity, occurrence, and detection ratings of 3, 3, 3, and 3, corresponding with an RPN of 81. By having ATC solicit more PIREPs, GA pilots will realize ATC is amenable to accepting PIREPs. Thus, the ratings were reduced to 1, 1, 1, and 1 for an RPN of 1, and an effectiveness rating of 98.77%.

The above recommendations are consistent with the recommendations that the NTSB (2017a) made to AOPA and flight instructors. Those recommendations include for AOPA to update their online PIREP weather course to explain the value of PIREPs and how meteorologists use PIREPs to revise weather. Recommendations to flight instructors through the National Association of Flight Instructors and Society of Aviation Flight Educators include using real-world examples to file PIREPs and practice assessing real-time weather conditions.

5. Conclusion

Many aviation accidents and incidents are caused by pilots flying into hazardous weather (AOPA, 2015). Accidents caused by GA pilots who are not instrument rated and fly into IMC can be fatal. Unforecasted turbulence is primarily responsible for injuries to passengers and crew onboard air carriers (NTSB, 2017a). The best source of PIREPs comes from pilots and air traffic controllers. However, pilots are often not comfortable with the PIREP format or what weather to report in the PIREP. They have poor experience assessing weather, so they are discouraged from submitting a PIREP. Pilots believe the reporting process is cumbersome and time-consuming and that air traffic controllers do not want to accept PIREPs. Some pilots fear an enforcement action if they inadvertently fly into poor weather and therefore will not submit a PIREP. Flight deck workload often prevents pilots from submitting PIREPs. Pilots often do not want to leave the ATC frequency to contact FSS. Air traffic controllers also contribute to the lack of PIREP submission because of an imperfect dissemination process, the consolidation of PIREPs, and the lack of time to solicit PIREPs. By creating solutions identified through conducting a FMEA, potential failures can be identified, and by implementing the solutions these failures can be proactively and reactively mitigated.

The purpose of the study was to increase GA PIREPs by reducing errors, trust issues, and inaccuracies in PIREP submittals that prevent inclusion in the NAS. The methods for this study included a literature review and conducting an FMEA to identify failure modes with the PIREP process that includes recommended actions to eliminate or reduce the error or error effects. The FMEA research resulted in recommended actions that were consistent with NTSB recommendations to increase PIREPs in eliminating or reducing the error or error effects with the failure modes identified. Thereby, the RPN was reduced in the majority of processes and affiliated subprocesses for ATC process failures and airmen-induced issues contributing to a failure to submit PIREPs.

Several future research areas have been identified. First, research should be conducted to determine if the recommendations made by the NTSB (2017a) to AOPA have been implemented. The recommendations include whether AOPA updated their online PIREP course content to include scenario-based training that illustrates the value of PIREPs, explain how meteorologists use PIREPS, provide guidance on how to assess the weather, and demonstrate various ways to submit a PIREP. Second, research should be conducted to determine if the recommendations made by the NTSB to flight instructors have been implemented. Recommendations to flight instructors include providing students with real-world examples of PIREPs, explanations on how PIREPs are used and benefit the NAS, examples of various ways to submit PIREPs, and assessing the weather. Third, research should be conducted to further determine if other recommendations made by the NTSB have been implemented. Those recommendations include whether procedures have been implemented to reduce the amount of time to submit a PIREP. Whether automated pilot weather report data-collection tools have been implemented and whether best practice procedures have been implemented regarding the dissemination of PIREPs. A fourth research area identified would be to assess the impact of pilot trust of speech recognition capabilities in general software on perceived reliability and validity of speech recognition and "hands minimized" PIREP submittal tools. A fifth future research area would be developing and testing a speech recognition prototype PIREP submission tool for pilots that mitigates PIREP submission errors. This research would involve calculating word error rates and word information loss with regard to the tool. Overall, the researchers identified recommended actions and will continue to explore how to further increase GA PIREPs through reducing errors, trust issues, and inaccuracies in PIREP submittals that prevent inclusion in the NAS.

7. References

AOPA Air Safety Institute (2015). 24th Joseph T. Nall Report: General Aviation Accidents in 2012. https://www.aopa.org/-/media/Files/AOPA/Home/Pilot-Resources/Safety-and-Proficiency/Accident-Analysis/Nall-Report/15-FN-0022-1-24th-Nall-V6.pdf

AOPA Air Safety Institute (2016a). 25th Joseph T. Nall Report: General Aviation Accidents in 2013. https://www.aopa.org/-/media/Files/AOPA/Home/Training-and-Safety/Nall-Report/25thNallReport.pdf

AOPA (2016b). Pilot Report Survey. http://download.aopa.org/advocacy/0417_2016_pilot_report_survey_final_report.pdf

AOPA Air Safety Institute (2017). 26th Joseph T. Nall Report: General Aviation Accidents in 2014. https://www.aopa.org/-/media/Files/AOPA/Home/Training-and-Safety/Nall-Report/26thNallReport2017.PDF

AOPA Air Safety Institute (2018). 27th Joseph T. Nall Report: General Aviation Accidents in 2015. https://www.aopa.org/-/media/Files/AOPA/Home/Training-and-Safety/Nall-Report/27thNallReport2018.pdf

AOPA Air Safety Institute (2021a). 28th Joseph T. Nall Report: General Aviation Accidents in 2016. https://www.aopa.org/training-and-safety/air-safety-institute/accident-analysis/joseph-t-nall-report/28th-nall-report

AOPA Air Safety Institute (2021b). 29th Joseph T. Nall Report: General Aviation Accidents in 2017. https://www.aopa.org/training-and-safety/air-safety-institute/accident-analysis/joseph-t-nall-report/nall-report-figure-view?category=all&year=2017&condition=all&report=true

AOPA Air Safety Institute (2021c). 30th Joseph T. Nall Report: General Aviation Accidents in 2018. https://www.aopa.org/training-and-safety/air-safety-institute/accident-analysis/joseph-t-nall-report/nall-report-figure-view?category=all&year=2018&condition=all&report=true

Carstens, D. S. (2005, July) Human Factors in Medicine: Task and Error Analysis, Proceedings of the Human-Computer Interaction International 2005, Las Vegas, NV. CD-ROM [invited paper].

Carstens, D. S. (2006) Error analysis leading technology development, Theoretical Issues in Ergonomics Science, 7(6), 525-549.

Carstens, D.S., Rodriguez, W. & Wood, M.B. (2014). Task and Error Analysis Balancing Benefits over Business of Electronic Medical Records, International Journal of Electronic Healthcare, 7(4), 331-348.

Casner, S., M. (2014). Increasing participation in the pilot weather reporting (PIREP) system through user interface design. Journal of Aviation Technology and Engineering, 4:1, 11-19. https://docs.lib.purdue.edu/jate/vol4/iss1/2/

Casner, S. M. (2010). Why don't pilots submit more pilot weather reports (PIREPs)? The International Journal of Aviation Psychology, 20(4), 347-374. https://www.tandfonline.com/doi/abs/10.1080/10508414.2010.487015

Federal Aviation Administration (FAA). (2019a). FAA Order Number JO 7110.65Y, Change 3, Paragraph 2-6-2. https://www.faa.gov/documentlibrary/media/order/atc.pdf

Federal Aviation Administration (FAA). (2019b). FAA Order Number JO 7110.65Y, Change 3, Paragraph 2-1-1. https://www.faa.gov/documentlibrary/media/order/atc.pdf

National Transportation Safety Board (NTSB). (2015). Accident Investigation, CEN15LA137. https://data.ntsb.gov/Docket?ProjectID=90694

National Transportation Safety Board (NTSB). (2017a). Special Investigation Report: Improving Pilot Weather Report and Dissemination to Benefit Safety in the National Airspace System. https://www.ntsb.gov/safety/safety-studies/Documents/SIR1702.pdf

National Transportation Safety Board (NTSB). (2017b). Accident Investigation, OPS15IA020. https://data.ntsb.gov/Docket?ProjectID=91756accident report

National Transportation Safety Board (NTSB). (2016b). PIREPs: Pay It Forward … Because Weather for One is Weather for None. Transcript of Forum, Day 2 (June 22). Washington, DC: NTSB.

National Transportation Safety Board (NTSB). (2012a). Accident Investigation, ANC12IA024. https://data.ntsb.gov/Docket?ProjectID=83048

National Transportation Safety Board (NTSB). (2012b). Accident Investigation, CEN12LA345. https://data.ntsb.gov/Docket?ProjectID=83888

Wickens, C., Hollands, J., Parasuraman, R. & Banbury, S. (2016). Engineering Psychology & Human Performance. 4th Edition, New York, NY: John Wiley & Sons. (ISBN-13: 978-0205021987 or ISBN-10: 0205021980).