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Pilot Reports (PIREPs) Research Roadmap

Daniela Kratchounova, Ph.D.

Jeffrey Dressel, Ph.D.

Terry King

Civil Aerospace Medical Institute

Federal Aviation Administration

Oklahoma City, OK 73125

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16. Abstract This Research Roadmap documents key research questions informed by the National Transportation Safety Board SIR (2017), the CAMI PIREP Summit (2020), a technical report describing the feedback from a sample representing the PIREP end-user populations (pilots and controllers) during the focus groups activities (Kratchounova, 2020), and the PIREP system problem space developed by the Weather Community of Interest (COI) PIREP Special Weather Action Team (SWAT).			
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List of Abbreviations

Abbreviation	Term
AAM-500	Aerospace Human Factors Research Division
ADS-B	Automatic Dependent Surveillance-Broadcast
AIM	Aeronautical Information Manual
AIREP	Air-Report
ANG-C1	Federal Aviation Administration Human Factors Division
AOPA	Aircraft Owners and Pilots Association
ATC	Air Traffic Control
ATO	Air Traffic Organization
CAMI	Civil Aerospace Medical Institute
CAP	Corrective Action Plan
COI	Community of Interest
CONUS	Contiguous United States
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FSS	Flight Service Station
NAS	National Airspace System
NAVAID	Navigational Aid
NLP	Natural Language Processing
NTSB	National Transportation Safety Board
NWS	National Weather Service
PIREP	Pilot Report
PMSP	PIREP Modernization Strategic Plan
SIR	Special Investigation Report
SWAT	Special Weather Action Team
VOR	Very High Frequency Omnidirectional Range

Introduction

Pilot Reports (PIREPs) are reports submitted by pilots that describe observed in-flight weather conditions, per Federal Aviation Regulations (FAR) 91.183, the Aeronautical Information Manual (AIM) 5-3-3, and Advisory Circular 00-45H (Department of Transportation, 1989, 2017, and 2016, respectively). As such, PIREPs often provide timely and sometimes critical weather information to other weather service users. PIREPs are used by pilots for pre-flight planning and in flight to avoid weather hazards; air traffic control (ATC) specialists to make decisions that support safety and flow of air traffic; and National Weather Service (NWS) meteorologists to improve weather models and forecasts.

On March 29, 2017, the National Transportation Safety Board (NTSB) issued a Special Investigation Report (SIR) titled "Improving Pilot Weather Report Submission and Dissemination to Benefit Safety in the National Airspace System" (National Transportation Safety Board, 2017). The NTSB SIR asserts that these problems are widespread due to the prevalence of PIREP issues found across a number of investigations. The NTSB concluded that "For PIREPs to be most effective, they must be numerous, accurate, and made available quickly in the NAS[1]." (National Transportation Safety Board, 2017) To address these concerns, the Federal Aviation Administration's (FAA's) Air Traffic Organization (ATO) added PIREPs to the ATO Top 5 Corrective Action Plan (CAP).

In response to the ATO Top 5 CAP activity, the FAA's Aerospace Human Factors Research Division at the Civil Aerospace Medical Institute (CAMI) conducted focus groups with end user populations (pilots and air traffic controllers), collaborated with stakeholders and MITRE to hold a PIREPs Summit, and committed to providing a PIREPs research roadmap that would inform end-to-end solutions targeted at increasing the number of PIREPs, quality of PIREPs, distribution and accessibility of PIREPs. All documents and presentations as well as dispositions of all the questions submitted by the participants during the summit are posted online at https://cbtopsatcami.faa.gov/summit. Detailed feedback from the six focus groups can be found in the technical report (Kratchounova, 2020).

Through the NTSB SIR, CAMI focus groups study, Virtual PIREPs Summit (June 2020), and special working groups associated with the ATO Top 5 Corrective Action Plan for PIREPs and the Weather Community of Interest (COI), CAMI compiled a list of research questions related to PIREPs solicitation, submission, and dissemination. Additionally, detailed system modernization issues are expected to be addressed in the ATO's PIREP Modernization Strategic Plan (PMSP); however, those issues are outside the scope of this paper. The research questions addressed in this paper are organized into four main research areas:

- Formatting, Data Elements, and User Interfaces

[1] National Airspace System (NAS).

- PIREP Submission Numbers
- PIREP Delays and Data Loss, and
- Technology for the Future

Formatting, Data Elements, and User Interfaces examines potential new and novel modes and sensory modalities through which to present PIREP information, the required data elements in PIREPs, and other topics related to the PIREP format.

PIREP Submission Numbers address the ATO Top 5 CAP item to increase the number of PIREPs that are submitted by exploring potential contributing factors to the lower than desired reporting levels.

PIREP Delays and Data Loss area consider factors affecting the propagation of PIREPs through NAS elements as well as ways to improve the timeliness of PIREP dissemination.

Technology for the Future of PIREPs describes research focused on improving the PIREP system resilience, utility, usability and suitability by the use of new and already available technologies that could positively impact the system.

Key Research Questions

The questions that follow were informed by the NTSB SIR (2017), the CAMI PIREP Summit (2020), a technical report describing the feedback from PIREP end-user populations (pilots and controllers) during the focus groups activities (Kratchounova, 2020), and the PIREP system problem space developed by the Weather COI PIREP Special Weather Action Team (SWAT).

Formatting, Data Elements, and User Interfaces

Research questions focus on the potential to modernize the PIREP information format, and user interfaces for input and consumption of PIREP information.

Research Questions

- What constitutes a PIREP currently and how revisiting the definition of PIREPs to allow the integration of modern technologies would advance the system into the future?
- What are the pros and cons of using ‘plain text’ vs. ‘contraction’ formats of PIREP information?
- What is the best presentation format and method to ensure improved utility and usability of PIREP information?

- What combination of presentation format and method can balance standardization and open-ended, free-form, human generated PIREP information most efficiently and effectively?

Background

Pilots submit PIREPs verbally via radio to air traffic control specialists, flight service specialists, or company personnel such as dispatchers, flight coordinators, or other persons authorized to exercise operational control. Pilots also have the option to submit PIREPs electronically through aircraft equipment or through web-based applications using a computer or portable electronic device. Further issues with the submission process include:

- Lack of a simplified method of submitting information: While some pilots view submitting a PIREP to be an informal voice exchange of information rather than a formal process of filing a report that uses a structured format, others view it as a lengthy and cumbersome submission process that uses an outdated format (Kratchounova, 2020).

- Amount of time it takes to submit a PIREP: The NTSB found that "The process by which flight service station specialists receive and verify verbal pilot weather report (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" (National Transportation Safety Board, 2017). While the read-back requirement for verifying verbal PIREPs was removed in 2018, and while pilots generally regard this as an improvement, they still assert it takes too long to submit a PIREP and feel there should be easier PIREP submission methods.

- Risk of missing important information after leaving an ATC frequency: Other concerns expressed by pilots include the length of time it takes to leave an ATC frequency, find the Flight Service Station (FSS) frequency, communicate with a flight service specialist to file a PIREP, and the risk of missing important information or instructions while they are away from the main ATC frequency.

- Perception that ATC does not want to receive routine PIREPs: In a 2016 Aircraft Owners and Pilots Association (AOPA) pilot survey, pilots expressed a perception that while air traffic controllers might pass reports on real-time to adjacent aircraft, they often do not record the information in a way that would ensure it makes it into the system for subsequent dissemination. (Duke et al., 2016). This perception includes the observation that air traffic controllers are often too busy to take and submit formal reports; therefore, pilots are often reluctant to submit PIREPs, especially routine reports.

- Perception that submitting a PIREP is not a priority for either pilots or controllers: Both pilots and controllers who participated in a series of PIREP focus groups pointed out that "filing PIREPs was not seen as a high priority task" for either user group (Kratchounova,

2020). Controllers saw their highest priority tasks as separating airplanes and responding to emergencies, and pilots saw their highest priority tasks as safely flying the airplane and complying with clearances, as appropriate. Neither user group saw filing or soliciting PIREPs as high on their constantly changing list of priorities.

The symbols and encoding used for viewing published PIREP information is often not easily recognized, remembered, or understood by pilots (Kratchounova, 2020). As several pilots who participated in this 2020 focus group activity pointed out, there are other weather resources and platforms that provide a more complete and intuitive visualization than the current PIREP system does. Another focus group finding was that the FAA should concentrate on overhauling and modernizing the outdated PIREPs system by focusing on design simplification and process streamlining. Correctly filling out the current form in a manner that is correct and that will be accepted by the system is an issue that has been cited in numerous reports, surveys, investigations, and forums.

PIREP Submission Numbers

These questions explore potential contributing factors leading to lower than desired rates of PIREP submissions, a key element of the ATO Top 5 CAP. Answers may lead to promising mitigations of these issues.

Research Questions

- Are pilots (and other handlers of PIREP information) aware of the importance of all PIREPs?
- What type of pilot training is provided regarding PIREPs?
- How can training regarding PIREPs be improved for student pilots?
- How can PIREPs-related training throughout a pilots' career be improved?
- What challenges are there for pilots in following the current PIREP format?
- Do pilots lack confidence in their weather assessment abilities? If so, why?
- In the context of PIREP processes, what are the impacts of task load and task prioritization for both pilots and controllers?
- How does fear of enforcement action impact PIREP submissions?
- What impact does past experience with PIREPs not being disseminated have on pilots' likelihood to submit PIREPs? In this context, what can be done to improve PIREP dissemination?

Background

Cockpit workload, task saturation, and task priority can be a major obstacle for collecting and submitting detailed and accurate PIREPs – both for PIREPs submitted verbally and for those submitted via an aircraft system or other type of application. This can become an issue during critical phases of flight, in inclement weather conditions, in areas of high traffic volume, during periods of frequency congestion, and when tasks, procedures, and configuring the aircraft demand increased pilot attention. Workload and task saturation may prevent a pilot from filing an accurate and timely PIREP or from filing a PIREP altogether. Noting the time, location, altitude, and other factors associated with specific weather phenomena can be difficult when workload is high. The NTSB noted in several investigations that the actual time, location, and altitude recorded by onboard flight data recorders differed substantially from the PIREPs that were submitted (National Transportation Safety Board, 2017). By the time pilot workload becomes manageable enough to submit a PIREP, the aircraft may be miles from the occurrence, and the pilot may no longer accurately remember the information required to be filed with the PIREP.

Timely feedback is an important element in reinforcing the need for pilots to submit PIREPs early and often. The NTSB (2017) cites lack of timely feedback or dissemination of PIREPs back to the cockpit as a barrier to pilot submission of PIREPs. The NTSB and several surveys conducted by the AOPA note that it is a common perception among pilots that PIREPs are not being timely and accurately (both in terms of content and geographical position) disseminated after they are submitted. Some pilots have noted that the PIREPs they submitted never appeared in the PIREP system. During the 2020 Virtual PIREPs Summit, it was noted that the FAA should consider creating a feedback system for pilots that captures PIREPs with significant inaccuracies or PIREPs that weren't accepted into the system. The rationale for this suggestion is that errors will continue to occur, but they cannot be corrected if they are not captured, evaluated, and communicated back to the users of the system. Pilots may lose interest in providing PIREPs when they do not receive timely feedback or when it appears the PIREPs they submit never make it into the system.

PIREP Delays and Data Loss

These research questions focus on identifying factors that may lead to PIREPs being disseminated in a less than adequate time frame, or not being disseminated at all. These research questions may reveal potential mitigations.

Research Questions

- What are sources of procedural issues associated with delays and data loss?
    - What can be done to promote or facilitate timely PIREP dissemination?

    - What can be done to improve or mitigate shortcomings with legacy PIREP data-entry user interfaces and procedures at Air Traffic Control facilities and some Flight Service Stations?

- How could the FAA promote company/operator practices that benefit both the company and other NAS users? Is there a net gain of information, when all users share information?
- Are PIREP submission methods when pilots submit to the company/operator different than submission methods to the NAS via ATC or FSS? If different, is one or the other method preferred by pilots?

Background

As pilots fly through conditions for which submitting a PIREP may be warranted, they may experience higher workload than during clear conditions, and may be unable to provide PIREP information immediately. In some cases, a pilot may manage workload by submitting the PIREP after returning to more manageable weather conditions, or even after landing. This presents an issue of a pilot needing to recall, or to calculate, the geographic location of the weather phenomena being reported.

Additionally, NTSB investigations (2017) describe circumstances that sometimes result in an Operations Supervisor being burdened with tasks such that they are unable to provide adequate support to ATCSs in maintaining awareness of the need to solicit and disseminate PIREP information in a given area or sector.

Technology for the Future of PIREPs

These research questions describe key factors recommended to be explored to ensure that technological solutions and improvements to the submission, handling, dissemination, and presentation of PIREP information appropriately apply human factors standards and practices in their design. Many issues fall within the scope of the ATO's PMSP, however, the questions described here explore the human-factors aspects to be considered, whereas the PMSP will devote more focus to the overall system design.

Research Questions

- How to protect the important human elements of a PIREP (e.g., remarks section) while also advance the level of automation in gathering weather phenomenon information and aircraft position information?
    - How can Automatic Dependent Surveillance-Broadcast (ADS-B) systems, and information communicated with those systems, be leveraged in the PIREP process?

- How can new and already existing technologies improve the user experience in the submitting, handling, and disseminating PIREP information?
- What new user interface modes and modalities could improve the user experience in the end-to-end PIREP system?

Background

Casner (2010) found that general aviation pilots estimated they would be more likely to submit PIREPs if they had an improved cockpit interface, such as a display that captured in a single button-push parameters such as aircraft location, time, altitude, aircraft type, wind, and temperature, and provided menus for selecting the other elements of a PIREP.

Similarly, the NTSB (2017) concluded that an effective automated PIREP-submission and data-collection tool, reliably available and capable of accepting data from all pilots, operators, and other users who meet the registration criteria and want to participate, would improve the quantity of PIREPs available to support safety of flight for all users in the NAS.

There are two types of reports of actual weather conditions encountered while in flight. An Air-Report (AIREP) is a fully automated routine report generated by the airplane on-board avionics of in-flight weather conditions such as wind and temperature. A PIREP is reported by a pilot to indicate encounters of hazardous weather such as icing or turbulence. Both are transmitted in real-time via radio to a ground station.

PIREPs and AIREPs are encoded differently. AIREP format is more common outside the contiguous U.S. even though there are some AIREPs over the Contiguous United States (CONUS). The location is specified by latitude and longitude, which is better for international routes. PIREPs are preferred over the CONUS where the location is based on distance and direction to a known Navigational Aid (NAVAID) such as a VOR[2].

The notion of a hybrid system that takes advantage of both AIREPs and PIREPs is very powerful because it would be able preserve the very important human element of observations made by the pilot (as opposed to an automatic sensor) as well as the free-form comments found in PIREP's remarks section. More often than not, the remarks at the end of a PIREP are the most descriptive, informative, and useful part of it.

In light of these findings, research is recommended to explore the feasibility and workload impact to pilots of potential new mechanisms for pilot submission of PIREP information. Such mechanisms may include natural language processing (NLP), artificial intelligence, or machine learning applications, for converting pilot speech to text (or other data formats), and automated or partially automated (i.e., auto-completed) forms. Such automated forms may, for example, automatically fill data fields such as aircraft type, and, upon initiation

[2] Very High Frequency Omnidirectional Range (VOR).

from a pilot, may automatically denote the time and geographic location of the conditions being reported. Additional research may explore the correlation between pilot reported turbulence severity and automated turbulence severity reporting (i.e., via accelerometers or other sensors of g-force), and as such, feasibility for use in automated PIREP submission tools.

Cross-Cutting Research Areas

Common themes of questions and necessary research emerge when considering these user groups use of PIREP information. These areas are:

- Cognitive Workload – this theme cuts across all issues discussed, as research should be conducted to ensure any changes to the PIREP do not adversely affect cognitive workload.
- Technology – this cross-cutting theme explores the potential for technological solutions to improve PIREP issues affecting pilot, air traffic control, and flight service specialist user groups.
- Training – this theme is a broad cross-cutting category for questions regarding the potential for training to address PIREP issues affecting all user groups.

Discussion

This roadmap should not be viewed as a static document or definitive, but rather as a living document that outlines top research questions that should evolve as more research is conducted. Doing so will continue to identify the necessary research necessary to inform end-to-end solutions targeted at increasing the number of PIREPs, quality of PIREPs, distribution, and accessibility of PIREPs.

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