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GA Pilot Perceptions of Speech Systems to Transcribe and Submit PIREPs

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GA Pilot Perceptions of Speech Systems to Transcribe and Submit PIREPs

Cover Page Footnote

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Pilot Reports (PIREPs) are an essential source of information consisting of brief weather reports from pilots describing their current in-flight weather conditions. PIREPs can increase the accuracy of current and forecasted weather information. Accurate weather information is critical for safe aircraft operations, large and small, operating in the National Airspace System (NAS). The submission of PIREPs assists pilots in avoiding hazardous weather and preventing weather-related incidents and accidents. Weather-related incidents and accidents resulting from pilots flying under visual flight rules (VFR) and continuing into instrument meteorological conditions (IMC) are typically fatal. Table 1 summarizes the number of accidents and fatalities related to pilots flying VFR into IMC from the Aircraft Owners and Pilots Association (AOPA, 2015, 2016, 2017, 2018, 2021a, 2021b, 2021c), Air Safety Institute, Nall Reports from 2012 to 2018. Many of these accidents could have been avoided if pilots and meteorologists had been provided with accurate and current PIREPs. PIREPs are a critical source of information that allows meteorologists to develop forecasted weather and update their forecasts.

Table 1

VFR into IMC accidents and fatalities from 2012 to 2018, as 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, 2016)	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 accidents resulting in fatalities.

Contributing to the low number of PIREPs is the lack of reporting and dissemination of PIREPs by air traffic controllers. In the National Transportation Safety Board special report, failures of air traffic controllers to enter PIREPs into the PIREP system were classified into four areas: noncompliance with solicitation requirements, inadequate dissemination of weather information, data entry mistakes, and consolidating PIREPs (NTSB, 2017a). The NTSB investigated and described 16 various PIREP dissemination failures that occurred between 2012 to 2016. In two cases, the failure of flight crews to receive PIREPs contributed to the cause of the accidents. In the other cases, although PIREP dissemination failures did not contribute to the accidents, the NTSB found a failure in the PIREP dissemination process.

The NTSB (2017a) made several recommendations to improve the PIREP reporting and dissemination process. One recommendation was to provide a reliable means to electronically accept and enter PIREPs into the PIREP system. The FAA is working to allow PIREP submissions through the Automatic

Dependent Surveillance-Broadcast (ADS-B) system, which would be a reliable electronic means to enter PIREPs into the PIREP system. Pilots may access PIREPs but may not submit PIREPs through the ADS-B system. Developers seek other methods to enable PIREP submissions until the ADS-B system is ready. One particular development is commercially-available speech recognition system (SRS) technology.

Purpose

The purpose of this study was to determine whether pilots would use an SRS to transcribe and submit PIREPs automatically in three distinct flight regimes: (1) flying by instrument flight rules (IFR), (2) flying VFR with flight following, and (3) flying VFR without flight following. A secondary purpose was to determine whether pilots have concerns about how PIREPs are submitted, used, or stored using an SRS to transcribe and send PIREPs automatically.

Research Questions

1. What are pilots' perspectives on using a speech recognition system that can transcribe and submit PIREPs automatically when (a) flying by IFR, (b) flying by VFR with flight following, and (c) flying by VFR without flight following?
2. What differences, if any, are there between the pilots' responses to these three flight regimes?
3. What concerns do pilots have about how PIREPs are submitted, stored, or used?

Literature Review

The NTSB's (2017a) special investigation report on improving pilot weather report submissions and dissemination provides insight into the importance of entering PIREPs into the PIREP system. The report summarizes ATC and pilot issues contributing to the lack of PIREPs being entered into the PIREP system.

Air Traffic Control Issues

Air traffic controllers must enter reported PIREPs into the PIREP system and advise local facilities within their area of control (NTSB, 2017a). Air traffic controllers must also solicit PIREPs when weather conditions are reported below certain standards (FAA, 2019a; NTSB, 2017a). However, their obligations are tempered by their priority, separating and issuing safety alerts to aircraft (FAA, 2019c; NTSB, 2017a). Consequently, air traffic controllers often cannot solicit or disseminate PIREPs locally or enter them into the PIREP system. The NTSB classifies 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 (NTSB, 2017a).

Noncompliance

Air traffic controllers must solicit PIREPs when certain weather conditions are reported (FAA, 2019a; NTSB, 2017a). Noncompliance with solicitation requirements was partially responsible for a February 2015 aircraft accident in Andrews, Texas. An air route traffic control center (ARTCC) controller operating a frequency for an approach control facility that was temporarily closed did not solicit PIREPs during weather conditions that met the minimum criteria to mandate solicitation from arriving and departing aircraft. Subsequently, an airplane on approach impacted the ground short of the runway because of inflight icing during the approach. Testimony in the air traffic controller's statement (NTSB, 2015) reported that air traffic controllers frequently could not solicit PIREPs because of the high workload (NTSB, 2017a). High workload often occurs during poor weather, when PIREPs are most critically needed.

Failure to Disseminate

Air traffic controllers' failure to disseminate PIREPs after their receipt has also been the cause of aircraft incidents and accidents. Some air traffic controllers enter PIREPs into the PIREP system, while others only distribute PIREPs for aircraft flying in their air traffic control facility. For example, in February of 2014, while in instrument meteorological conditions (IMC), a Commander 690C crashed on final approach to John C. Tune Airport in Nashville, Tennessee (NTSB, 2017a). The aircraft crashed, most likely due to moderate to greater icing conditions. Out of eight icing PIREPs reported to approach control and five to the tower controller, only one was entered into the PIREP system. Although the NTSB found that the lack of PIREP information was not a factor in the cause of the accident, the NTSB found that the failure to enter the PIREPs into the PIREP system prevented an AIRMET from being issued before or after the accident. The meteorologist on duty only received the one PIREP; without knowledge of the other PIREPS, the meteorologist thought it was an isolated icing condition (NTSB, 2017a).

In March 2012, a Learjet 35A encountered severe in-flight icing conditions during approach in Anchorage, Alaska (NTSB, 2017a). The aircraft's windshield was iced over, and the flight crew lost all forward visibility. During landing, the airplane deviated off the runway and into a snowbank. The investigation revealed that 15 minutes before the airplane encountered severe icing conditions, another aircraft seven miles away reported severe icing while on approach to another airport and executed a missed approach to wait until the ice cleared from the windshield. Although the tower reported the information to the Anchorage approach controller, the Anchorage approach controller did not relay the information to the Learjet flight crew (NTSB, 2012a).

In June 2012, the NTSB investigated an accident involving a Learjet 60 in Aspen, Colorado (NTSB, 2017a). A PIREP containing low-level wind shear was disseminated to local traffic, including the flight crew involved in the accident, but was not entered into the PIREP system. The PIREP included a report of a 15-knot loss of airspeed on short final approach that met the classification of an urgent PIREP and should have received priority handling for dissemination (NTSB, 2012b).

Consolidated PIREPs

Air traffic controllers commonly take multiple PIREPs and consolidate them into a single PIREP for dissemination. However, important information is lost when multiple PIREPs are consolidated (NTSB, 2017a). For example, a controller filed a single urgent PIREP for moderate-to-severe turbulence from numerous aircraft types. What might be moderate turbulence for a Cessna 172 might not be for a Boeing 737? By consolidating PIREPs, additional information, such as the time and location of the PIREP, might be lost (NTSB, 2017a). Meteorologists need this PIREP information to update forecasts using inflight updated weather provided by pilots.

Pilot Issues

Pilots encountering unforecasted weather cannot readily report PIREPs because of the cockpit workload. During the NTSB's June 2016 forum, an AOPA manager reported that a preliminary review of the comments of their PIREP survey indicated that pilots report that the process of leaving an ATC frequency, finding the correct flight service station (FSS) frequency, and then communicating with FSS was too time-consuming (AOPA, 2016; NTSB, 2017a). Pilots further described reporting PIREPs with FSS as inefficient because of the time it takes to wait for the FSS to readback the report for accuracy.

The comments in the AOPA (2016) report regarding cockpit workload were consistent with a prior survey by Casner (2010), suggesting that 189 (58%) of GA pilots reported that they were interested in a quicker, easier way to submit a PIREP (NTSB, 2017a). A later survey conducted by Casner (2014) suggested that GA pilots thought they would be more apt to report PIREPs if they had a cockpit interface that automatically reported flight conditions such as aircraft location, time altitude, aircraft type, wind, and temperature, and also provided menus for selecting the other elements of a PIREP.

Automatic Dependent Surveillance-Broadcast (ADS-B System)

AOPA has pledged its continued support to work with the FAA to facilitate the ADS-B system's use to submit PIREPs (Namowitz, 2020). However, an FAA senior system engineer estimated it would be between 2023 and 2025 before equipment can be ready to allow PIREPs to be submitted through the ADS-B system (NTSB, 2017a). When the ADS-B system can submit PIREPs, private stakeholders must design interface systems to enter PIREP information into the

ADS-B system. This study examines whether that interface can be an SRS that can transcribe and submit PIREPs automatically into the PIREP system. Previous research by Huang and Pitts (2019) evaluated the ability of commercially-available SRSs to recognize weather-related terminology in a GA environment and suggests that training systems to pronounce specific words can significantly increase detection accuracy.

SRSs' current capabilities consist of home/leisure and work/professional systems for command (i.e., perform a calculation, create lists, etc.) and dictation (i.e., write a document, create a message, etc.) uses. A review of SRS trust literature leads us to believe that pilots may have low trust in current SRSs, motivating our focus on the research question. Turner et al. (2006) suggest that mistrust occurs when users experience frustration. This creates the feeling of being vulnerable when using the system with feelings of uncertainty in the system's performance. Turner et al. (2005) suggest that trust is achieved with voice systems when there is satisfaction in using the system, which occurs when the system performance is perceived positively by the user. Turner et al. (2006) suggest that trust is achieved when there is successful usage of the system, which occurs when there is a perceived standard of quality and accuracy. The information in consumer magazines can establish a good reputation for people to trust (de Vries & Midden, 2008). Therefore, the research team explored customer reviews of different versions of Dragon and of Amazon Transcribe to collect anecdotal evidence of individuals' experiences with SRSs and assisted in identifying potential errors that could occur with an SRS.

Methodology

This study assessed whether pilots would use an SRS to transcribe and submit PIREPs automatically. In the current study context, GA pilots were defined as those involved in "civil aviation operations other than scheduled air services and nonscheduled air transport operations for remuneration or hire" (FAA, 2021b). The method of the study was a descriptive survey employing a cross-sectional design. The survey was made available between August 2020 to December 2020. Data for this study was obtained by advertising a survey to GA pilots. The survey questions underwent face and content validity with two GA pilots and a college faculty member. A pilot test was conducted before making the survey available to survey respondents. The survey contained four Likert scale questions inquiring about pilots' views on using an SRS that would transcribe and send PIREPs automatically while flying in three flight regimes: (1) IFR, (2) VFR with flight following, and (3) VFR without flight following. For each flight regime, additional information was obtained through an open-ended follow-up question. The last survey question asked what concerns pilots had in submitting, storing, and using PIREPs.

The Likert scale questions were measured from one to five: very unlikely, unlikely, neutral, likely, and very likely. Potential differences between the flight regimes were identified and generalized to the population. The open-ended questions were coded and analyzed using Spradley's (1979) domain analysis. Major domains were identified and then further partitioned into sections called *cover terms*. The cover terms were, in turn, partitioned into subsections called *included terms*. Once the cover terms and included terms were identified, patterns and themes were identified, coded, and compared with the closed-ended responses.

The target population for the survey was pilots in the United States. The accessible population was (a) pilots of all certification levels that were students at two aviation/aerospace universities and alums at two Universities that offered aviation programs, (b) the people who received the newsletters from a regional FSS that had a PIREP Improvement Work Group of the FAA, University Aviation Association (UAA), AOPA, and Curt Lewis & Associates, LLC, and (c) those who received Plane & Pilot magazine and Flying magazine.

The sampling strategies were non-probability convenience and snowball sampling. Two universities sent an email with the survey link to their student pilots, CFIs, and other pilots who are part of the campus communities, including alums, recruited. The FSS PIREP Improvement Work Group of the FAA, UAA, AOPA, and Curt Lewis & Associates, LLC, sent out the survey link in their newsletters to help recruit survey respondents. The link was included in two aviation magazines through articles they published. The sample size was $N = 479$ survey respondents. However, not all survey respondents answered each question (response rates are reported for each question below).

An a priori sample size was calculated to compare the differences between the three flight regimes using a repeated-measures analysis of variance (ANOVA), with a medium effect size (ES), an $\alpha = .05$ (alpha level), and $\beta = .20$ (beta level). Using G*Power, the minimum sample size needed was 24 participants. In connection with what pilots thought about how PIREPs are submitted, stored, and used, an a priori sample size was calculated using a 5% margin of error with a 95% confidence interval with the most conservative population estimates as $p = q = .50$. It showed a required sample of 385 participants (Ary et al., 2010).

Demographic information included respondents' gender, age, pilot category, and certification type. Because non-probability convenience sampling was used, a comparison with the FAA U.S. Civil Airmen database (FAA, 2019b) was made to determine whether the survey sample was representative of the population. The proportion of male and female certificate holders in the United States was comparable to that of males and females who completed the survey (see Table 2). Similarly, the proportion of survey respondents that held pilot licenses (student, recreational, sport, private, commercial, and airline transport pilot) obtained in the United States was proportionate to those documented in the FAA U.S. Civil Airmen database (see Table 3).

Table 2

Percentage of Male and Female Survey Respondents Versus the Percentage of Males and Females Holding a Pilot License Issued by the FAA

Gender	Survey - Percentages	FAA - Percentages
Female	7.68%	7.93%
Male	92.32%	92.07%

Note. Survey percentages exclude missing data and those who preferred not to answer the question.

Table 3

Percentage of License Types Held by Survey Respondents Versus the Percentage of License Types Issued by the FAA

License Held	Survey - Percentage	FAA - Percentage
Student	4.19%	31.32%
Sport	0.02%	.02%
Recreation	1.25%	1.01%
Private	38.5%	25.53%
Commercial	32.0%	15.99%
ATP	26.13%	26.13%

We surveyed various pilots, including GA pilots, so the survey contained a question about the respondents' flight experience. At least half were GA pilots (see Table 4). The survey contained an accompanying open-ended question regarding the respondents' flying experience to determine what type of pilots completed the survey (see Table 5).

Table 4

Respondents' Flying Experience

Flying Experience	Frequencies	Percentages
Pilot that flies for pleasure	223	47.65% (46.56%)
CFI employed by a college	17	3.63% (3.55%)
CFI employed by a flight school that is not a college	46	9.83% (9.60%)
GA pilot enrolled in a college	33	7.05% (6.89%)
GA pilot enrolled in flight training, not a college	17	3.63% (3.55%)
Other (open-ended)	132	28.21% (27.56%)
Total	468	100.00% (97.71%)

Note: Data were missing for 11 survey respondents, N = 479. The results in parentheses include missing data.

Table 5
Respondents' Flying Experience Open-Ended Responses

Certificate		Frequency
	Airline Pilot	28
Professional Pilot	Corporate	8
	Other	11
General Aviation Pilot		42
Student Pilot		1
Military Pilot		6
Certified Flight Instructor		25
Designated Examiner		8
Non-Pilot Aviation Professional		2

Note: Survey respondents were allowed to select multiple options. Each category includes retired pilots. Those who designated just their certificate type were considered GA pilots. The professional pilot category includes cargo pilots. Categories include survey respondents documenting more than one type of flying.

Age demographics confirmed the respondents were not representative of a single pilot age group. Thus, the survey responses were not dominated by a particular age group (see Table 6).

Table 6
Respondents' Age Group

Age	Frequency	Percentage
18-30	68	14.50% (14.20%)
31-40	57	12.15% (11.90%)
41-50	68	14.50% (14.20%)
51-64	143	30.49% (29.85%)
65 and above	133	28.26% (27.77%)
Total	469	100.00% (97.92%)

Note. Data were missing for ten survey respondents, N = 479. The results in parentheses include missing data.

Results and Discussion

Descriptive Statistics

Flying IFR

Respondents scored a Likert scale average of 3.20, which indicates they were neutral (3.0 being neutral on the Likert scale) about using an SRS that converts a spoken PIREP into a properly coded submission while flying IFR (see Table 7).

Table 7
The Likelihood a Pilot Would use an SRS That Converts a Spoken PIREP Into the Proper Coded Submission Format While Flying IFR

Likert Scale	Frequency	Percentage
Very Unlikely	44	12.98% (9.19%)
Unlikely	51	15.04% (10.65%)
Neutral	88	25.96% (18.37%)
Likely	103	30.38% (21.50%)
Very Likely	53	15.63% (11.06%)
Total	339	100.00% (70.77%)

Note. Data were missing for 140 survey respondents, *N* = 479. The results in parentheses include missing data.

An open-ended question was included in the survey to obtain additional information on using an SRS while flying IFR. Analysis was performed using Spradley's (1979) Domain Analysis (see Table 8). The domain was using an SRS to submit PIREPs. The cover term was *flying subject to IFR* or *flying IFR*. Included terms could not be identified due to the varied responses. However, the comments resulted in six conjectures (see Table 8). The open-ended comments were consistent with the Likert scale mean of 3.2, meaning the survey respondents, on the whole, were neutral about submitting PIREPs while flying IFR.

Table 8
Coded Data on the Likelihood a Pilot Would be to use an SRS That Converts Their Spoken PIREP Into the Proper Coded Submission Format While Flying IFR

Cover Term	Included Term	Conjectures
Flying IFR	Varied	9.1 Easier to report to ATC
		9.2 Too busy to submit PIREPs
		9.3 Submit PIREPs if convenient
		9.4 Submit PIREPs if the device is easily reached
		9.5 Easier than other methods
		9.6 Use dependent on ease and errors

Flying VFR With Flight Following

Respondents scored a Likert scale average of 3.31, indicating they were neutral (3.0 being neutral on the Likert scale) about using an SRS that coverts a spoken PIREP into the properly coded submission while flying VFR with flight following (see Table 9).

Table 9

The Likelihood a Pilot would use an SRS That Converts a Spoken PIREP Into the Proper Coded Submission Format While Flying VFR With Flight Following

Likert Scale	Frequency	Percentage
Very Unlikely	36	10.56% (7.52%)
Unlikely	47	13.78% (9.81%)
Neutral	94	27.57% (19.62%)
Likely	104	30.50% (21.71%)
Very Likely	60	17.60% (12.53%)
Total	341	100.00% (71.19%)

Note. Data were missing for 138 survey respondents, $N = 479$. The results in parentheses include missing data.

An open-ended question was included in the survey to obtain additional information on using an SRS while flying VFR with flight following. An analysis was performed using Spradley's (1979) Domain Analysis (see Table 10). The domain was using an SRS to submit PIREPs. The cover term was *VFR with flight following*. The included terms were *ATC* and *accuracy*.

The survey respondents provided supporting comments in connection with ATC, an included term for the cover term of *VFR with flight following*. Their comments led to the conjectures of "easier to report to ATC" and "easier to call FSS." Survey respondents provided supporting comments associated with the included term of *accuracy*, which is part of the cover term of *VFR with flight following*. Their comments led to the conjectures of "accurate to report to ATC," "capability to review prior to submission," "willingness to try the SRS," and "willingness to use the SRS."

These comments were consistent with the Likert score mean of 3.31, indicating the survey respondents, on the whole, were neutral about submitting PIREPs while flying VFR without flight following.

Table 10

Coded Data on the Likelihood a Pilot Would use an SRS That Converts a Spoken PIREP Into the Proper Coded Submission Format While Flying VFR With Flight Following

Cover Term	Included Term	Conjectures
VFR with Flight Following	ATC	10.1 Easier to report to ATC
		10.2 Easier to call FSS
	Accuracy	10.3 Accurate PIREP reported to ATC
		10.4 Capability to review prior to submission
		10.5 Willingness to try the SRS
		10.6 Willingness to use the SRS

VFR Without Flight Following

Respondents scored a Likert scale average of 3.10, indicating they were neutral (3.0 being neutral on the Likert scale) about using an SRS that converts a spoken PIREP into the properly coded submission format while flying VFR without flight following (see Table 11).

Table 11

The Likelihood a Pilot Would use an SRS That Converts a Spoken PIREP Into the Proper Coded Submission Format While Flying VFR Without Flight Following

Likert Scale	Frequency	Percentage
Very Unlikely	49	14.63% (10.23%)
Unlikely	53	15.82% (11.06%)
Neutral	98	29.25% (20.46%)
Likely	87	25.97% (18.16%)
Very Likely	48	14.33% (10.02%)
Total	335	100.00% (69.93%)

Note. Data were missing for 144 survey respondents, *N* = 479. The results in parentheses include missing data.

An open-ended question was included in the survey to obtain additional information on using an SRS while flying VFR without flight following. An analysis was performed using Spradley's (1979) Domain Analysis (see Table 12). The domain was using an SRS to Submit PIREPs. The cover term was *Flying VFR without flight following*. The included term was *accuracy*. Survey respondents provided supporting statements for the accuracy-included term. Their comments led to conjectures of "playback capability," "the capability to review prior to submission," "willingness to try the SRS," and "willingness to use the SRS." These comments were consistent with the Likert scale mean of 3.10, indicating the survey respondents, on the whole, were neutral about submitting PIREPs while flying VFR without flight following.

Table 12

Coded Data on the Likelihood a Pilot Would use an SRS That Converts Your Spoken PIREP Into the Proper Coded Submission Format While Flying VFR Without Flight Following

Cover Term	Included Term	Conjectures
VFR without Flight Following	Accuracy	11.1 Playback capability 11.2 Capability to review prior to submission 11.3 Willingness to try the SRS 11.4 Willingness to use the SRS

Inferential Statistics

Because the flight regimes were measured on a Likert scale, the results could be generalized to the population using inferential statistics. Although convenience sampling was used, the proportion of male and female pilot respondents is proportionate to male and female pilots documented in the FAA Civil Airmen Database (2019b) (see Table 2). Except for the student pilot category, the proportion of certificate holders in the survey was also consistent with the proportion of certificate holders in the FAA Civil Airmen Database (see Table 3).

A repeated-measures ANOVA was used to analyze the differences between the flight regimes. Although the ANOVA assumption for normality was violated, the large sample size mitigated the lack of normality. Using a Mauchly's analysis, the sphericity assumption was not met, $\chi^2(2) = 43.50$, $p < .01$. Therefore, a Greenhouse-Geisser correction was applied to mitigate the violation. The ANOVA results showed there was a significant difference between at least one of the groups, $F(1.78, 583.35) = 8.26$, $p < .01$, $\eta_p^2 = .03$, power =.95. A Bonferroni analysis confirmed significant differences between flying VFR with flight following and flying VFR without flight following (Table 13).

Table *13*

Flying Condition Pairwise Comparisons Using a Bonferroni Correction

Group Comparisons	$Mean_{Diff}$	Std Err_{Diff}	95% CI	p [a]
IFR – VFR with FF	-.106	.046	[-.217, .005]	.065
IFR – VFR without FF	.103	.060	[-.041, .248]	.258
VFR with FF – VFR without FF	.210[*]	.048	[.095, .324]	<.001

Note. FF = Flight following.

[*]The mean difference is significant at the .05 level.

[a].Bonferroni adjustment to *p* was .016.

Although there were significant differences between flying VFR with flight following and flying VFR without flight following, we conclude those differences have little practical significance. There was little difference in the Likert scores means between these flight regimes. Flying VFR with flight following had a Likert score of 3.31 while flying VFR without flight following had a Likert score of 3.10. The themes from the analysis of the open-ended questions for flying VFR with flight following and without flight following indicated that pilots were neutral about submitting a PIREP using SRSs in these regimes.

Pilot Concerns Regarding how PIREP Information is Submitted, Stored, and/or Used

An additional closed-ended and open-ended question was posed to determine pilots' concerns with submitting PIREPs with an SRS. A descriptive analysis suggested that 71.9% of the survey respondents answering the closed-ended question did not have concerns regarding how PIREPs are submitted, stored, or used with SRS software (see Table 14).

Table 14
Do Pilots Have any Concerns About Using a PIREP SRS Regarding how Information is Submitted, Stored, or Used with an SRS software?

	Frequency	Percentage
Yes	93	28.10% (19.42%)
No	238	71.90% (49.69%)
Total	331	100.00% (69.11%)

Note. Data were missing for 148 survey respondents, N = 479. The results in parentheses include missing data.

To generalize the results to the population, the sampling error was calculated. The sampling error is the discrepancy between the known sample proportion and the unknown population value (Ary et al., 2010). Using the following formula with p = .2810 and q = .7190 and a sample size of 331, the sampling error was .0247.

$$SE = \sqrt{\frac{p \times q}{n}} = .0247$$

p = proportion agreeing
q = proportion not agreeing (1 - p)
n = sample size

Using a sampling error of .0247 multiplied by 1.96, the 95% confidence interval is +/- 4.842%. There is 95% confidence that the population proportion is between 67.06% and 76.74%. We can conclude that 67.06% and 76.74% of the population would not be concerned about how PIREP information is submitted, stored, and/or used.

An open-ended question was included in the survey to determine the respondents' specific concerns. Using Spradley's (1979) Domain Analysis (see Table 15), the domain was other concerns with PIREPs. The cover terms that were identified in the question were: *submitted* and *used*. The included term for *submitted* was *legal liability*. The included term for *how PIREPs were used* was *accuracy* and *usage for other purposes other than flying*.

For the cover term *submitted*, survey respondents provided supporting comments with respect to the included term, *legal liability*. This led to further conjectures of "fear of incrimination," "PIREP not submitted if the ceilings are below minimums for VFR flight when flying VFR," "PIREPS should be exempt from enforcement action by the FAA," "PIREPs must be anonymous," and "fear of voice stored/analyzed by the NSA."

Regarding the cover term *used*, concerning the included term *accuracy*, a conjecture that emerged was a concern regarding the accuracy of the PIREP transcription. This led to the conjectures of "use if accurate," "use if reliable," "fear of relying on SRS," and "fear of consequences/errors with SRS."

Table 15
Coded Data on Whether Pilot has any Concerns About Using a PIREP SRS Regarding how Information is Submitted, Stored, or Used?

Cover Term	Included Term	Conjectures
Submitted	Legal Liability	13.1 Fear of incrimination 13.2 PIREP not submitted if the ceilings are below minimums for VFR flight when flying VFR 13.3 PIREPS should be exempt from enforcement action by the FAA 13.4 PIREPs must be anonymous 13.5 Fear of voice stored/analyzed by the NSA.
Used	Accuracy and Usage	13.6 Use if accurate 13.7 Use if reliable 13.8 Fear of relying on SRS 13.9 Fear of consequences/errors with SRS

Conclusion

With the FAA moving towards allowing pilots to submit PIREPs through the ADS-B system, it is incumbent upon private stakeholders to design interfaces that pilots would find intuitive to operate. While pull-down screens to enter information might be a robust interface, pilots cannot use this type of interface during high workload situations. This will delay the PIREP reporting and decrease certain PIREP parameters, such as location and time. The FAA should work with industry stakeholders to incorporate an SRS that converts a spoken PIREP into the proper coded submission format. Although survey respondents were neutral about using SRSs, the open-ended comments indicated they were willing to try such a system.

Recommendations

There are several areas of future research identified from carrying out this project. First, research on enhancing SRSs that accurately transcribe and send PIREPs through the ADS-B system should be further explored. Studies should be conducted to understand what would make pilots more willing to use SRSs. These studies could also serve as a follow-up to the survey conducted as part of the current research through interviewing pilots to understand the challenges and perceived strengths and weaknesses of using SRSs to transcribe and send PIREPs.

Although only 28.1% of the participants had concerns about how PIREPs are submitted, stored, and used, many of those participants had issues with an enforcement action by the FAA or legal liability to a third party. Therefore, another recommendation for practice is for immunity of liability in addition to that currently provided by the Aviation Safety Reporting System (ASRS). The FAA may want to consider immunity of liability to third parties. The research results provide evidence that these additional recommendations would encourage airmen to submit more PIREPs.

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