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Wire-Strikes in Agricultural Operations: A Focus Group Study

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16. Abstract

Agricultural aircraft operations involve the operation of an aircraft regulated under 14 Code of Federal Regulations (C.F.R.) Part 137 to dispense fertilizer, seeds, and crop protection products to affect agricultural outcomes directly (see Agricultural Aircraft Operations, 14 C.F.R. § 137.3). These single-pilot operations are associated with a number of unique hazards and challenges relevant to this report such as maintaining awareness of obstacles associated with flight at very low altitudes or unfamiliar territory. This report describes a focus group study with 22 agricultural operations pilots who collided with a Guy Wire during a routine flight. Researchers transcribed narratives from pilots who volunteered to participate in a focus group during the 2022 Ag Aviation Expo annual convention hosted by the National Agricultural Aviation Association (NAAA). The researchers then analyzed the transcripts using a human factors framework. Notably, the results found that "trim passes" were a key stage of flight during their wire-strike events. Cognitive risk factors that may have affected their performance include situational awareness, decision-making choices, and pressure to perform (internal or external). Participants suggested that better reconnaissance passes would have alerted them to a wire they previously did not know was there or would have made them more confident overall that they were aware of all obstacles while flying passes in the field (i.e., thus minimizing that distraction). Other possible prevention strategies included not spraying the field in the first place due to safety risks, paying better attention to where they were in the field at the time of the collision, and avoiding deviating from the plan and breaking personal rules for flying. Many participants repeated the ideas of focusing on each trim pass and staying present in the moment as well as minimizing distractions.

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List of Abbreviations

Abbreviation	Definition
CAMI	Civil Aerospace Medical Institute
FAA	Federal Aviation Administration
HFACS	Human Factors Analysis and Classification System
IRB	Institutional Review Board
NAAA	National Agricultural Aviation Association
NTSB	National Transportation Safety Board

Abstract

Agricultural aircraft operations involve the operation of an aircraft regulated under 14 Code of Federal Regulations (C.F.R.) Part 137 to dispense fertilizer, seeds, and crop protection products to affect agricultural outcomes directly (see Agricultural Aircraft Operations, 14 C.F.R. § 137.3). These single-pilot operations are associated with a number of unique hazards and challenges relevant to this report such as maintaining awareness of obstacles associated with flight at very low altitudes or unfamiliar territory. This report describes a focus group study with 22 agricultural operations pilots who collided with a Guy Wire during a routine flight. Researchers transcribed narratives from pilots who volunteered to participate in a focus group during the 2022 Ag Aviation Expo annual convention hosted by the National Agricultural Aviation Association (NAAA). The researchers then analyzed the transcripts using a human factors framework. Notably, the results found that "trim passes" were a key stage of flight during their wire-strike events. Cognitive risk factors that may have affected their performance include situational awareness, decision-making choices, and pressure to perform (internal or external). Participants suggested that better reconnaissance passes would have alerted them to a wire they previously did not know was there or would have made them more confident overall that they were aware of all obstacles while flying passes in the field (i.e., thus minimizing that distraction). Other possible prevention strategies included not spraying the field in the first place due to safety risks, paying better attention to where they were in the field at the time of the collision, and avoiding deviating from the plan and breaking personal rules for flying. Many participants repeated the ideas of focusing on each trim pass and staying present in the moment as well as minimizing distractions.

Keywords: agricultural operations, wire strikes, situational awareness, accidents, aviation

Introduction

Aerial application operations, otherwise known as agricultural aircraft operations, involve the operation of an aircraft to dispense fertilizer, seeds, and crop protection products to affect agricultural outcomes directly (see Agricultural Aircraft Operations, 14 C.F.R. § 137.3). 14 C.F.R Part 137 Agricultural Aircraft Operations are associated with unique hazards and challenges including scheduling seasonal crops, maintaining awareness of obstacles associated with flight at very low altitudes, and attending to aircraft-mounted dispensing equipment – all while maintaining the duties of operating a single-pilot aircraft. The National Transportation Safety Board (NTSB) defines an aviation *accident* as an occurrence associated with the operation of an aircraft in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. Part 137 Agricultural Operations accident data reflect these risks with 290 accidents reported between 2017 and 2021, 44 of which resulted in a fatality (NTSB, 2021). Further, a 2014 NTSB Special Investigations Report on agricultural operations identified safety concerns in this industry related to a lack of operations-specific guidance for fatigue, risk management, and pilot knowledge and skills tests (NTSB, 2014).

Despite that, many of these safety issues are human factors related, there is limited research on human factors within agricultural operations. Notably, 41 of 44 (93%) accidents in Australian aerial application operations from 2000 through 2005 were related to human performance failures when examined using the Human Factors Analysis and Classification System (HFACS) approach (Dell, 2014).[1] The most frequently reported occurrence in this analysis was wire-strikes, which were involved in 13 of the 44 (30%) human factors-related accidents.

Background

Wire-strikes refer to in-flight collisions with power lines or tensioned cables known as Guy Wires, and are a common type of accident in agricultural operations. The 2014 NTSB Special Investigations Report identified in-flight collision with an obstacle, such as wire-strikes, among its top three consistent defining events in historical agricultural accident data (NTSB, 2014). Today, in-flight collisions with obstacles continue to be one of the most prevalent defining events in agricultural accidents. Notably, these accidents frequently occur after the pilot has already flown the same path multiple times (Dell, 2014). For similar in-air obstacle collision accidents that occurred between 2020 and 2022, half of all pilots were already aware of the obstacle before the collision (Baumgartner, 2023). Understanding how these accidents occur is critical to preventing future similar accidents and mitigating their severity when they do occur.

[1] HFACS has been used previously to analyze accidents in both commercial aviation and general aviation (Wiegmann & Shappell, 2001; Wiegmann et al., 2005).

This report describes a focus group study with Part 137 agricultural operations pilots who experienced wire-strike events during a routine flight. Researchers transcribed narratives from pilots participating in the focus groups, and analyzed them using a human factors framework. Results from this research can inform targeted approaches to reduce wire-strike accidents in agricultural operations and provide optimal support in the event that accidents occur.

Methods

Participants

Twenty-two agricultural operations pilots who previously experienced at least one wire-strike accident were recruited from attendees at the 2022 Ag Aviation Expo annual convention hosted by the National Agricultural Aviation Association (NAAA), using snowball sampling with the assistance of the NAAA Education and Safety team. Participants communicated in person or via email with an NAAA representative for scheduling focus group participation.

Participants were included in the study if they self-identified as having experienced a wire-strike event during aerial application operations. Any pilot with ongoing litigation or pending investigation into the wire-strike event was excluded from the study.

Participants were briefed and provided written informed consent prior to focus group sessions. No relationship with the facilitator was establish prior to participation. The Federal Aviation Administration (FAA) Civil Aerospace Medical Institute (CAMI) Institutional Review Board (IRB) approved the study and all procedures in advance (Approval No. 202305).

Focus Group Sessions

Three focus group sessions were held in person. Each focus group was facilitated by a single researcher during the NAAA Ag Aviation Expo annual convention in December 2022, and included as many participants as could be scheduled for each focus group session (i.e., a data saturation approach was not used). Ultimately, each session consisted of between 6 and 10 participants.

To protect anonymity, participants were referred to only by a number identification (e.g., Participant 1). Participants were instructed to preserve anonymity for themselves and other participants during the session. Sessions were audio recorded and professionally transcribed by a third-party contractor, and any identifying information was redacted from the transcripts. Participants were not provided transcripts to review.

The moderator used a standardized script at the beginning of each focus group session to introduce the research team, present the goals of the study, and review the informed consent. Participants initially were asked to indicate whether they primarily flew fixed-wing or rotorcraft aircraft in their agricultural operations. Four specific questions were used to facilitate discussions. The moderator presented these questions both verbally and visually via PowerPoint to participants. Then, each was asked to share their perspectives and opinions related to each question using their previous wire-strike event(s) as reference; some participants referred to more than one event.

- Question 1. What conditions or events contributed to the in-air collision event?
- Question 2. What immediate recovery steps did you take after the collision occurred?
- Question 3. To what degree were you aware of this wire or obstacle before the collision occurred?
- Question 4. What could you have done differently that would have prevented the collision?

Each participant was called upon in random order to respond to each question within each focus group. The focus group moderator developed a method for calling participants that:

- was random in order for participants;
- ensured that every participant would be called to respond to each question (i.e., was fully inclusive); and
- was repeated across the three focus groups.

Participants were allowed to complete their answers for each question without interruption, and the researcher followed up with any additional probing questions for clarification or depth of response. Once all participants responded to a given question, the researcher asked the group if there were any additional comments before moving on to the next question. Sometimes these comments included side conversations between participants, which were not included in the analysis. After all participants responded to each question, the audio recording was stopped and participants were thanked for their participation. Each focus group session lasted between 60 to 90 minutes.

Transcription

A third-party contractor transcribed the audio recordings for each of the three focus groups. Separately, recordings underwent quality assurance checks for accuracy and content. To maintain anonymity and to allow for tracking conversations, each participant was assigned a unique identification code. The code identified the focus group session (e.g., G1) and participant number (e.g., P1). Transcriptions were verbatim and identified the question asked and participant responses. Any inadvertently provided personally identifiable information (e.g., participants referring to others by name) was removed by the transcriptionists and replaced with alternative text (e.g., [name]).

Content Analysis

A conventional qualitative content analysis approach was used to identify contributing factors directly from the de-identified, transcribed text (Hsieh & Shannon, 2005). The explicit and inferred meaning of participants' statements were identified and grouped by factor based on similar content to identify trends (Hsieh & Shannon, 2005; Milne & Oberle, 2005).

For each focus group, transcriptions were separated based on the question asked (i.e., Questions 1-4) in Microsoft Excel®. Three independent raters reviewed and evaluated question responses for common factors. Those factors were used to code transcriptions for all three focus groups (see Table 1). Each rater worked from a separate copy of the data for content coding, where the raters coded each participant response by assigning a "1" when the content met the criteria for a factor. The raters met to confer after an initial round of coding to re-evaluate and refine the factors, and each rater reviewed and coded the transcriptions thematically. The coding scheme allowed raters to code participant responses into multiple factors or to identify where participants responded yes/no, when needed.[2] Researcher statements containing explanatory and off-the-record information were not coded thematically.

Table 1
Factor Categories for Coding, by Question

Question	Factors
What conditions or events contributed to the air collision event?	Flight Stages/Aspects of Flight Internal Risk Factors Environmental Risk Factors Technically Difficult Operations Breaking Their Own Rules Splitting Attention or Distraction Judgment Call Errors Performance Pressures
What immediate recovery steps did you take after the collision occurred?	Assess Situation Assess Damage During Flight Maneuver Aircraft Maintain Airspeed Observe/Maintain/Monitor Gauges Communicate/Radio Head to Airport Assess Damage After Flight
Were you aware of the obstacle before it happened?	Yes/No

[2] Question 3 was coded as binary response. Coders assigned "Yes" for each event, per pilot, wherein pilots indicated that they were aware of the obstacle, and "No" for each event, per pilot, wherein pilots indicated that they were not aware of the obstacle.

Question	Factors
What could you have done differently that would have prevented the collision?	Avoid Deviating From Plan Check Conditions/Situational Awareness Broke Own Rule

Upon completion of the coding, each rater's codes were compiled by question across all focus group sessions to determine rater agreement. For a given participant and question, when two or more raters agreed that a factor was present among the response(s), the codes were marked as "resolved." When only one rater coded a factor for a participant, that code was removed from the data. For Question 3, a "Yes"/"No" response was indicated when two or more raters agreed on the response; otherwise, the response was coded as undetermined (i.e., neither marked "Yes" nor "No"). The frequency of each code was determined using a net sum approach; a given code was counted only once per participant, even if the meaning of the code was referenced multiple times in a given response or across multiple question responses.

Results

Risk Factors Contributing to Wire-Strike Event

The 22 focus group participants reported 31 wire-strike events overall. Eight distinct risk factors were identified to describe participants' responses to Question 1: "*What conditions or events contributed to the in-air collision event?*" These eight factors were grouped into two higher order categories: Situational Risk Factors and Cognitive Risk Factors. Situational Risk Factors refer to environmental conditions and aspects of flight that may increase the risk of a wire-strike event occurring. In order of prevalence, Situational Risk Factors included: (a) technically difficult operations, (b) flight stages/ aspects of flight, (c) internal risk factors and (d) environmental risk factors (Table 2). Alternatively, Cognitive Risk Factors include discrete events that happened during flight that involve different aspects of decision-making and pilot performance. In order of prevalence, Cognitive Risk Factors included (a) splitting attention / distraction, (b) judgement call errors, (c) performance pressures, and (d) breaking their own rules (Table 3).

Situational Risk Factors

For Situational Risk Factors, participants repeatedly mentioned technically difficult operations (see Table 2). Overall, 55% of participants (n = 12) reported a technically difficult maneuver or field condition that was associated with their wire-strike event. These included flying a field that has multiple wires, or a field that requires "jumping a wire" described as a pilot briefly flying over a wire located in the middle of a field.

Over half (55%; n = 12) of the participants identified specific flight stages and aspects of flight as being related to the wire-strike event. The most frequent flight stage was making “trim” or cleanup passes around the edge of the field or other part of the field that was missed during the planned and executed flight path. Other stages of flight included wire-strikes occurring when a pilot entered the field or exited the field.

Participants also discussed a number of internal risk factors as contributors to their wire-strike event.[3] These factors included fatigue, heightened emotional states (e.g., excitement about the birth of a child or grief due to loss), being inexperienced or new to flying, and being unfamiliar with the particular aircraft. Altogether, 50% of participants (n = 11) reported some internal risk factor as contributing to their wire-strike event.

Table 2
Situational Risk Factors Contributing to Wire-Strike Events

Factor	Prevalence[4]	Included Cases	Example Comment
Technically difficult operations	55%	Wires in middle of field Field full of wires Difficult parts of field to reach	“…it's [the field] just a wiry mess.” “It was an area that I could only get two passes into the side of a busy road…”
Flight stages/ aspects of flight	55%	Entering field Exiting field Trim pass	“One of them [wire-strike] was obviously exiting the field. And the other two are entering the field.”
Internal risk factors	50%	Fatigue Heightened emotional states (such as grief) Lack of experience Lack of familiarity with aircraft	“…I was at the end of the day too, so you know, probably be a little bit tired…” “…the reason I hit it is because I wasn't, I was flying a 402 and I had flown for 402 for 12 years or something. And then I got a 502. And the 502 in mid-season. And so I didn't know, I didn't have all my amenities in it, basically a radio in this.”
Environmental risk factors	23%	Night flying Poor visual conditions Weather conditions	“The rain hit the windshield and I looked off to see where the rain was. Because it was kind of in the distance coming.”

[3] Although fatigue can be considered a cognitive risk factor, the discussion of fatigue is included here because the focus group participants organically began discussing fatigue in the current context.
[4] Prevalence among participants.

Table 2 also shows that Environmental risk factors were reported by 27% of participants ($n = 6$). These included night flying, flying with poor visual conditions, and the occurrence of distracting weather conditions. Nineteen participants (86%) provided a response indicating at least one of the four Situational Risk Factors contributed to their wire-strike event.

Cognitive and Personal Risk Factors

Cognitive and Personal Risk Factors identified by participants included discrete events that affected situational awareness, decision-making choices, and pressures that, in turn, may have affected pilot performance during flight (Table 3). The most commonly reported Cognitive Risk Factor was splitting attention or being distracted, which was reported by 59% of participants ($n = 13$).

Specific examples of splitting attention / distraction included being focused on another obstacle in the field, being focused on avoiding and protecting owner property such as a garden, thinking about other aspects of work or future work tasks, and having some discrete event (e.g., a radio call) that brought the pilot out of focus.

The next Cognitive Risk Factor reported was making judgment call errors, which was reported by 27% of participants ($n = 6$). Participants in these situations reported that they knew the wire was there, but forgot about it or misjudged the proximity to the wire when trying to maneuver around the obstacle.

Six participants (27%) also reported performance pressures as a risk factor in wire-strike events. Often, these pressures were described in terms of doing the highest quality work possible (e.g., spray all the edges of the field that were previously missed). Other pressures reported by participants included internal pressures to hurry or complete the field in a timely manner.

Finally, two participants (9%) also attributed their wire-strike event to breaking their own established rules. The factor "Breaking their own rules" applies to instances where participants explicitly reported a reference to breaking one of their own personal flight rules, such as flying the first pass at a certain height. Overall, 19 participants (86%) reported at least one of the four Cognitive Risk Factors as contributing to their wire-strike event.

Table 3
Cognitive and Personal Risk Factors Contributing to Wire-Strike Events

Factor	Prevalence[5]	Included Cases	Example Comment
Splitting attention / distraction	59%	Distracted by other obstacles in field Avoiding or protecting other owner property Distracted by future work Some discrete event (e.g., radio call) that brings pilot out of focus	"I remembered from the year before that there was a very small GPS tower in the corner of that field and I was instead of looking around here, coming around the corner, I glanced out to see if it was the field I was thinking with the stick out there in the corner. So my attention was drawn from where it should have been, a little too far ahead…" "Came back, and of course, it was the last field for this customer and we were going to be moving on. I might have been thinking about, you know, okay where we're going from there."
Judgement call errors	27%	Forgetting wire was there Misjudging proximity to wire	"I just flat forgot about it." "And I basically went one pass too long and I thought I could sneak under it and I hit it."
Performance pressures	27%	Doing highest quality work Internal pressure to hurry	"Circled the field and there was a guy picking up cans… if I can just hurry up get this pass, these few passes before he gets there then we won't have to worry about drifting onto him." "I was trying to do a good job and been under a lot of pressure to do good work… Doing a quality job, trimming the field and getting close to the poles. Getting, you know, all the way to the edge of the field."
Breaking their own rules	9%	Explicit reference to breaking personal rules	"It was an area that I could only get two passes into the side of a busy road and I broke my rules. Normally first pass is a power and height to make sure I clear everything."

Immediate Recovery Steps

Participants reported a number of immediate and secondary recovery steps in response to Question 2: "*What were your recovery steps immediately following the air collision event?*" The researchers identified eight immediate recovery steps that were reported by participants; these steps were ranked in order of prevalence in Table 4. The most commonly reported recovery step was related to maneuvering the aircraft, which included instances such as keeping the aircraft flying level or changing altitude to avoid other obstacles. Fifteen participants (68%) reported this immediate recovery step, often mentioned in alignment with the general aviation maxim "Aviate, Navigate, Communicate" (FAA Safety Team, 2018). Along with this immediate focus on continuing to fly the aircraft properly, 6 participants (27%) reported monitoring gauges, 5 participants (23%) reported assessing the situation, and 3 participants (14%) reported maintaining airspeed. Participants across all focus groups reported implementing at least one of eight immediate recovery steps following the air collision event.

Table 4
Immediate Recovery Steps Following Wire-Strike Events

Immediate Recovery Steps	Prevalence[6]	Example Comment
Head to an airport	73%	"…everything was fine so I went back to my primary airport where my mechanic was and landed there." "…went straight to my home base and landed."
Maneuver the aircraft (e.g., change altitude to avoid other obstacles, keep aircraft straight/level)	68%	"I added power and I kept the airplane you know, straight and level…" "Immediately after, like I said, at first I thought I missed it and I as I was slowing down then I realized I didn't. And at that point you don't really have much control other than you do what you've always been taught, fly the aircraft. So I kept flying until the wire broke. Sawed its way out."
Assess damage during flight (e.g., double check, circle back)	45%	"Everything was still going. I thought, what was that? And it took me, a little bit, then I realized I'm holding real hard left aileron to keep this airplane flying straight. And I looked out to my left wing and on the aileron, I had about a four inch hole in the aileron. I could tell the boost tap

[5] Prevalence among participants.
[6] Prevalence among participants.

Immediate Recovery Steps	Prevalence[6]	Example Comment
		on the left aileron was about broke in half, just kind of hanging out there." "…pulled out of the spray pass and thought did I just hit it. I actually flew back around to see if I could see, if I hit it or not and as I was flying I could feel my airplane yawing."
Communicate/radio	27%	"But what do I have underneath the airplane. I can't get ahold of anybody at home, on the radio. So I just start calling on the phone… And then they looked, they said yeah you got your landing gear. Everything looks good but we don't know if he's got air in the tires…"
Observe/maintain/monitor gauges	27%	"And so you start scanning everything and looking. Everything's good. Everything's green, everything's good." "But, it was, immediate, okay is everything operating? Is the engine going to lose power? Or keep running? The controls. I still had controls, I didn't do anything abrupt."
Assess situation (e.g., gain situational awareness, environmental awareness)	23%	"But I just didn't know what to do. Where do I go? What do I do? You know there's so many things going on. And it probably took me thirty seconds before I realized what even happened on my end… It takes a long time for your brain to catch up with you when something like that happens. And you've got a lot to process. A lot. And you're always trying to figure out what to, what to do, do you know. So that's what really surprised on that whole deal, was how long it took me to process what had happened."
Assess damage after flight (i.e., after landing)	14%	"So, fly back to base, land, shut down and do an assessment and do go from there."
Maintain airspeed (e.g., add power)	14%	"…I just cleared the interstate as low as I could, you know, and I felt it slowing down. I added power and I kept the airplane you know, straight and level…"

Ten participants (45%) reported assessing damage to their aircraft immediately after collision and while still in the air, such as looking out the window at the wings or circling around to see if they could spot the wire that they flew through. Alternatively, three participants (14%) explicitly reported assessing for damage following landing.

Sixteen participants (73%) reported making the decision to fly to a nearby airport (often referred to as "home" or "home base") rather than making an immediate landing. In this group, some participants even reported making an informed decision on which airport to go to, such as in the following scenario:

> "I got an airport 6 miles away. I know it's unattended. It's 6 o'clock in the evening. What do I have underneath my airplane? Do I have landing gear? Do I have anything? …I can go back to this airport. Possibly land there, with no landing gear. And lay out there for God knows how long at this airport because they're not going to come look for me for another probably 45 minutes. And why would they look for me at an airport. So I thought, well okay, I'm going home. I'm going home. At least if I can't get ahold of anybody they're going to see me pancake this thing on the runway and at least get me help."

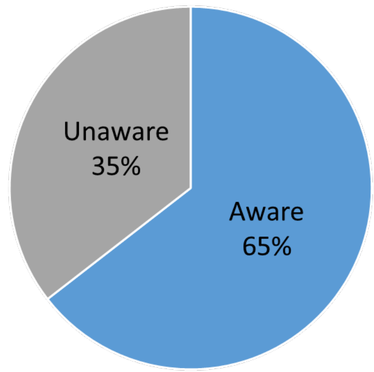
Participants also reported communicating with personnel in the area over radio following their wire strike ($n = 6$). These cases often involved inquiring whether others on the ground could help assess the condition of the aircraft, such as potential damage to landing gear, to assist in landing decisions.

Prior Awareness of Wire

When asked Question 3, "*Were you aware of the obstacle before it happened?,"* participants reported that they were previously aware of the wire before the accident occurred in 20 out of the 31 (65%) wire-strike events reported across focus groups (Figure 1).[7] These participants reported explicit awareness such as, "I was 100% aware of it" and "Yeah I pulled up over that wire, 39 times. I trimmed next to it two times. And I hit it on the 40th time."

[7] Some participants reported on multiple air collision events; these were analyzed separately for this question.

Figure 1
Pilot Pre-Collision Awareness of Wire[8]



Alternatively, participants reported not being completely aware of the wire in 11 of the 31 wire-strikes. For example, one participant reported that they were not "paying close enough attention and didn't see it until the last minute, until it was too late to pull it," while another participant reported that "It was not visible and I did a recon so I never saw it until I was down... I didn't even see it. I felt it. I didn't see it."

Actions That Could Have Prevented a Collision

Three actions were identified from responses to Question 4: "*What could you have done differently that would have prevented the collision?*" In order of prevalence, these actions included: (a) check conditions / situational awareness, (b) avoid deviating from plan, and (c) don't break own rule (Table 5).

Overall, 19 participants (86%) suggested that their wire-strike event could have been prevented with better checking of conditions at the field (e.g., reconnaissance, surveillance) before spraying it to maintain better situational awareness and focus during each pass of the field. Participants also suggested avoiding deviating from their plan (23%; $n = 5$). These reports included examples of pilots changing their minds mid-flight about procedures, such as the direction in which they will fly passes or waiting as planned for the rest of the crew to arrive. Finally, similar to the cognitive factor reported as a contributor to the wire-strike event, three participants suggested that breaking their own rule may have also contributed to wire-strike events.

[8] Responses to this question prompt were coded as a two-alternative choice, as yes (aware) or no (unaware).

Table 5
Steps That Could Have Prevented a Collision

Action	Prevalence	Example Comment
Check conditions / situational awareness	86%	"…what I should have done differently was paid attention the whole time and just knew where I was at." "Not spray the field. I've circled around it several times knowing there was wires all around it, it was close to a power plant, it was wired up as we say. I circled, and circled, and circled trying to pick out all the wires and probably at some point I should have just said there's too much there I need to leave."
Avoid deviating from plan	23%	"This time my plan was to spray it parallel to the wires and get out of there because it was a complex field. And right at the last minute when I'm leaving, I'm like well I got a little bit in the hopper, might not have gotten that in good enough. I'm going to slide back in there. Throw a pass in there and I probably should have done another reconnaissance and thought it through…"
Don't break own rule	14%	"Well I did a couple of things wrong…broke a rule that I told my guys don't do is, I trimmed the field first."

Discussion

Risk Factors for Wire Strikes

Participants identified a number of Situational Risk Factors that they believed may have contributed to their wire-strike events, such as environmental conditions and aspects of flight. For example, the frequency with which "trim passes" were identified as a key stage of flight during their wire-strike events indicates that pilots should be more attentive to potential wire strikes during these passes, or evaluate them pre-flight to assess the potential risk of a wire-strike occurring.

Internal risk factors including heightened emotional states (either positive or negative), lack of experience, or lack of familiarity with the aircraft are important factors that participants reported as having contributed to their wire-strike events. Participants reported that environmental risk factors such as night flying or poor weather, along with technically difficult operations such as flying fields covered in wires, contributed to the wire-strike event. Future research could look explicitly at how much the level of flying experience in general, or within that specific aircraft, may factor into these events.

Participants also reported a number of Cognitive Risk Factors that may have affected their performance and thus contributed to their wire-strike event such as situational awareness, decision-making choices, and pressure (internal or external). Some of these factors can be mitigated partially by emphasizing a positive safety culture, such as mitigating performance pressures to do the best work possible without compromising safety (see Key et al., 2023, for a review of safety culture). This increased emphasis on safety would also need to address pilots' self-imposed performance pressures; wire-strike events tended to involve pilots who were in a hurry or were performing to the highest standard possible. Other factors such as mental distractions also may be addressed through attention management training and reflecting on how any current internal risk factors such as fatigue or heightened emotional states may increase the risk of an event. However, certain Cognitive Risk Factors are not necessarily something that pilots can evaluate effectively pre-flight and, therefore, must constantly monitor these factors during flight. Additionally, risk assessment decisions such as judgment calls or breaking one's own rules occur during flight. However, there are likely times that deviating from a given plan would be the safer decision thereby, highlighting the complexity of decision-making in aviation.

Recovery Steps

Understanding the recovery steps that pilots took immediately following the wire-strike event is critical to promoting successful recovery from these accidents. Participants reported immediately assessing the situation and maintaining control of the flight while in-flight (e.g., adjusting airspeed, maneuvering aircraft, monitoring gauges), as well as later assessing the damage post-flight.

Immediate recovery strategies typically aligned with the general aviation maxim, "Aviate, Navigate, and Communicate" implying that the first priority of the pilot should be continuing to fly and maintaining control of the airplane. Participants reported an immediate focus on maneuvering the aircraft to a safer flight path, regaining situational awareness of the field and their surroundings, and monitoring gauges. Participants reported focusing on communication to ensure a safe landing, also in line with this general maxim.

Of particular interest, the majority of participants (73%) reported that they made the decision to fly to a nearby airport rather than seek immediate landing. These participants even reported making informed decisions about which airport to land at, sometimes choosing a further airport if they felt landing would be safer there (e.g., a nearby airport would have fewer resources to assist with any landing emergencies). One pilot reported that the decision to land at the local airport was based on concerns about damage to the plane. The pilot noted, "I got back home to land on my runway and I suppose I was, I know I was nervous, there's no supposing about it… I knew I didn't have any brakes. Because I had touched my brake pedals." Overall, these results highlight the difficulty of decisions that follow wire-strike events.

Awareness of Wire Obstacles

Whether or not the pilot was previously aware of the wire obstacle before the collision has important implications for prevention strategies. Participants reported already being aware of the wire in 65% of wire-strike events. This is in line with a previous analysis of in-air obstacle collision accident reports, where about half of pilots were aware of the obstacle before the collision (Baumgartner, 2023). Together, these results indicate that better surveying the field and other pre-flight preparations would have been effective mitigation strategies in some, but not all, wire-strike events. For cases where pilots are already aware of the obstacle, other prevention strategies such as those described below may be more effective.

Prevention Strategies

The focus groups reported a number of strategies that participants believe would have prevented their collisions with wires. As noted above, some of these reports were related to better field scouting, where participants suggested that better reconnaissance passes could have alerted them to a previously unseen wire, or would have made them more confident overall that they were aware of all obstacles while flying passes in the field (i.e., thus minimizing that distraction). Besides improving awareness of the position and orientation of wires, other suggestions for preventing wire-strike events included not spraying the field in the first place due to safety risks or paying better attention to where they were in the field at the time of collision. Many participants mentioned this idea of staying present, minimizing distractions, and focusing on each current pass. While the individual facets of situational awareness proposed here are specific to the conditions of each event, the overarching suggestion of staying “in the moment” and taking each pass at a time may be useful advice for pilots.

Additional strategies for preventing wire-strikes included avoiding deviating from the plan and breaking personal rules for flying. Both of these strategies relate to the prevalence of wire-strikes occurring during non-normal flight conditions, such as during clean-up “trim” passes or following in-the-moment decisions to deviate from a flight path. Breaking personal rules were also explicitly mentioned as a contributing factor to wire-strike events, and could interact with other contributors such as performance pressures (e.g., doing a good job cleaning up the edge of a field) or judgment call errors. Overall, these prevention strategies highlight the importance of pilots following their own pre-defined plans and trusting their own safety expertise and instincts.

Limitations

There are several limitations in the current study worth noting. First, survivorship bias is a factor, and the current results should be interpreted from the lens of wire-strike accidents that were not fatal (Wald, 1943). According to NTSB data, 15% of reported wire-strike accidents in Part 137 agricultural operations were fatal (NTSB, 2021). Similarities noted in the current sample might involve distinct human factors causes than those of fatal accidents, which cannot be compared in the current study.

Given the sensitivity of the topic and the lack of accurate base rate information pertaining to wire-strike events, it is difficult to get the full picture of the scope of human factors issues involved. An accurate fatality rate of wire-strike events may be difficult to determine, as wire-strikes may go unreported if damage to the aircraft or other property is minimal. As well, the sample only includes participants that were willing to discuss their accidents. Pilots that were uncomfortable discussing their experiences in a focus group setting may also have experienced other contributing factors not discussed here.

The nature of the focus group itself can affect the quality of group interactions and discussions. For example, one person may drive the conversation leading to single-minded responses, especially in groups with a high propensity for information sharing (Gigone & Hastie, 1993; Kitzinger, 1995). Group characteristics such as size and experience also can influence responses within the group (Frey & Fontana, 1991; Gigone & Hastie, 1993; Kitzinger, 1995). The moderator's style (e.g., direct or active, indirect or passive) and disposition (e.g., sensitive or outward personality), also can influence responses within the group (Fern, 1982; Frey & Fontana, 1991).

Finally, focus group questions did not include any events or circumstances prior to takeoff (e.g., flight planning, level of experience, familiarity with the field, ground inspection); it is not clear how a discussion of such circumstances during the focus group could affect the findings. Furthermore, the raters' lack of knowledge about operational rules makes it difficult to assess whether an action caused the pilot to deviate from their plan versus break their own rule. For example, if operational rules only address how pilots operate the aircraft (e.g., weight and balance, fuel load), then any missteps involving these operations would be in violation of the operational rules and not personal rules.

Conclusion

Altogether, the current study provides insight into "how" and "why" wire-strike events occur during agricultural operations. Participants identified a number of human factors related issues in these operations, including Situational and Cognitive Risk Factors, which could inform pilot decision-making in all stages of flight. Reported recovery steps and proposed preventive strategies offer valuable insight to pilots to help mitigate and recover from these events. Further, participants frequently reported being aware of the wire pre-collision. This highlights the need to scope the human factors issues involved in wire-strike events properly, ultimately to minimize or prevent such events in the future.

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