Wire Strikes and In-Air Obstacle Collisions During Agricultural Aviation Operations

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INTRODUCTION: Wire strikes and in-air collisions with obstacles are a leading cause of accidents in the aerial application industry. While some of these collisions occur due to unseen obstacles, some pilots report being previously aware of the obstacles that they collide with. Whether or not pilots are aware of obstacles pre-collision is an important factor to inform methods of accident prevention.

METHODS: Final reports from the National Transportation Safety Board were analyzed for Part 137 Agricultural Operation accidents that took place between January 2020 and December 2022. A deeper analysis of cases that involved an in-air collision with an obstacle was performed, excluding cases that were attributable to an external cause (e.g., aerodynamic stall). The pilot's awareness of the obstacle pre-accident was inferred from accident narratives if available.

RESULTS: Nearly half of all accidents ($N = 45$ of 107) involved an in-air collision with an obstacle (e.g., wire, tree, pole) as the defining event. In cases where pilot awareness of the obstacle was determinable through the accident report, over half of pilots ($N = 21$ of 39) had previously seen this obstacle yet still made contact with it.

DISCUSSION: In-air obstacle collisions make up a substantial portion of accidents within Part 137 Agricultural Operations. Nearly half of pilots were already aware of the obstacle before collision, indicating that inadequate preparation in scoping the field is not a predominant driver of these events. Instead, these findings suggest that other factors including distractions, high task difficulty, and errors in decision-making may contribute.

KEYWORDS: general aviation, accident analysis, human factors.

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Aerial application or agricultural aircraft operations involve the use of an aircraft to dispense fertilizer, seeds, and crop protection products to directly affect agricultural outcomes.[3] These operations are associated with a number of unique hazards and challenges, including scheduling issues due to seasonal crops, obstacles associated with flight at very low altitude, and high attentional demand for single pilots and dispensing equipment operation. These risks are reflected in accident data, and between 2017 and 2021, there were 290 accidents in Part 137 Agricultural Operations, with 44 of those accidents being fatal.[4] Further, a 2014 National Transportation Safety Board (NTSB) Special Investigations Report on agricultural operations identified safety issues related to lack of operations-specific guidance for fatigue, risk management, and pilot knowledge and skills tests among their list of safety issues in this industry.[5]

Despite many of these safety issues or unique hazards being related to human factors, there is limited research on human factors within agricultural operations. One previous analysis showed that 41 of 44 accidents in Australian agricultural operations from 2000–2005 were related to human performance failures using the Human Factors Analysis and Classification System approach.[2] The most frequently reported occurrence in this analysis was wire strikes, which were involved in 13 of 44 human-factors-related accidents.

Wire strikes and in-air collisions with obstacles are a leading cause of accidents in agricultural operations. Indeed, the

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2014 NTSB Special Investigations Report identified in-flight collision with an obstacle among its top three consistent defining events in historical accident data.[5] Today, in-flight collisions with obstacles continue to be one of the most prevalent defining events in agricultural accidents. Understanding how these accidents occur is critical to preventing future similar accidents. However, no data currently exist to quantify the prevalence of wire strike and in-air obstacle collision accidents, nor the prevalence of pilot awareness of obstacles pre-collision.

It may be presumed that these accidents largely occur due to collision with previously unseen obstacles. However, some pilots report being previously aware of the obstacles that they collide with and have already completed multiple passes on a given field at the time of the accident. Whether or not pilots are aware of obstacles pre-collision in these agricultural aviation accidents is an important factor to inform methods of accident prevention.

The current report describes an analysis of wire strike and in-air obstacle collision accidents in agricultural operations, with a specific focus on whether pilots were previously aware of the obstacle before collision. Results from this research can inform targeted approaches to reduce future wire strike accidents in agricultural operations by informing best practices for avoidance.

METHODS

Final accident reports from the NTSB were retrieved for all Part 137 Agricultural Operation accidents in the United States that took place between January 2020 and December 2022. Final reports and associated dockets from completed investigations were reviewed. Narratives, demographic data, probable cause, and findings were evaluated for overall trends across accidents. A deeper analysis of cases that involved an in-air collision with an obstacle was performed, excluding cases that were attributable to an external cause (e.g., aerodynamic stall, mechanical or computer failure). For cases that involved an in-air collision with an obstacle as the primary cause of the accident, the pilot's awareness of the obstacle pre-accident was inferred from accident narratives if available.

For the purposes of this analysis, pilots were deemed to have been previously aware of the obstacle if: 1) awareness was explicitly reported in the final report; or 2) awareness was inferred from the final report due to description of having maneuvered around the obstacle in previous passes. A lack of previous awareness of the obstacle by the pilot was determined if this was explicitly stated in the accident report. Cases where previous awareness of the obstacle was undeterminable, such as in the case of most fatal accidents, were coded as "unclear" in the current analysis.

RESULTS

A total of 107 final accident reports from Part 137 Agricultural Operations between Jan. 1, 2020, and Dec. 31, 2022, were identified. Of these accidents, 13 included fatal injuries, 11 included serious injuries, and 19 included minor injuries.

In-Air Obstacle Collisions

Nearly half of all accidents ($N = 48$) included in-air collisions with an obstacle such as a wire, tree, or pole. Of these accidents, only three in-air obstacle collisions were secondary to another immediate accident cause such as an aerodynamic stall or computer/mechanical failure. Therefore, the remaining 45 in-air obstacle collisions were further analyzed for accident trends and pilot awareness of the obstacle (**Table I**).

Of the 45 in-air obstacle collisions, strikes most often occurred with telephone or power lines ($N = 32$). Less frequent obstacles included trees ($N = 6$), poles ($N = 2$), crops ($N = 2$), windmills ($N = 2$), and towers ($N = 1$). These accidents included seven with fatal injuries, eight with serious injuries, and eight with minor injuries. Pilots ($N = 45$ men) were on average 47 yr old (SD: ± 15 yr) with an average of 9156 h (SD: ± 9505 h) of flight time experience (**Fig. 1**).

Previous Awareness of Obstacle

In cases where pilot awareness of the obstacle was determinable through the accident report or investigation docket, over half of pilots ($N = 21$ of 39 accidents) had previously seen this obstacle yet still made contact with it (**Fig. 2**). For some accidents, confirmation of awareness was obtained through explicit mention by the pilots in the final accident reports. For example, pilots noted "Even though I knew that the powerline was there, I neglected to climb high enough to clear the powerline…" (NTSB Accident No. CEN22LA200) or "I was fully aware of the position of the wind turbines and the wires in these fields as I had scouted them very well the day before" (NTSB Accident No. CEN21LA349). Confirmation of prior awareness of the obstacle was also inferred in cases where the pilot had already maneuvered around the obstacle during previous passes along the field. For example, reports were included with statements such as "During his third pass of the morning, he underestimated the top of the corn in the middle by about two feet" (NTSB Accident No. CEN22LA340) or "The accident occurred during the pilot's 21st pass over the field that day, and the pilot had been maneuvering to avoid the wire numerous times prior to the accident" (NTSB Accident No. CEN21LA225).

There were 18 accident reports that indicated that the pilot was previously unaware of the obstacle's location before the in-air collision (Fig. 2). These cases were identified due to explicit mention of this in the accident investigation reports, including comments such as "Upon approaching 1st pass I encountered previously unseen powerlines (obscured by trees and terrain)" (NTSB Accident No. WPR20CA179) and "I did not see the wire until it was too late to jump over it" (NTSB Accident No. CEN21LA148). For 6 of the 45 cases of in-air obstacle collisions, it was unclear from the final accident report or associated docket whether the pilot was previously aware of the obstacle prior to collision.

Table I. In-Air Obstacle Collision Accidents in Agricultural Operations.*

NTSB NUMBER	OBSTACLE TYPE	AWARE OF OBSTACLE?	HIGHEST INJURY LEVEL	PILOT AGE	PILOT FLIGHT TIME (est)	NOTE
CEN22LA387	Wire	Yes	None	31	1020	
CEN22LA366	Wire	Yes	None	32	1100	
CEN22LA359	Tree	No	Minor	45		
CEN22LA350	Wire	No	None	37	4104	
CEN22LA345	Wire	No	None	32	1010	
CEN22LA340	Crop	Yes	None	37	814	
CEN22LA342	Wire	Yes	None	48	2641	
CEN22LA371	Windmill	Yes	None	34	4300	
CEN22LA248	Pole	Yes	None	75	24,000	
CEN22LA226	Pole	Yes	Serious	57	16,000	Awareness inferred from previous passes in field.
CEN22LA200	Wire	Yes	Minor	48	2890	
WPR22LA140	Wire	No	Minor	62	2336	
CEN22LA006	Wire	No	Minor	25	2941	
CEN21LA421	Wire	Yes	None	25		
WPR21LA338	Wire	Yes	None	40	3349	
WPR21LA333	Tree	No	Serious	67	29,000	
CEN21FA368	Wire	Yes	Fatal	63		Awareness inferred from previous passes in field.
CEN21LA356	Wire	No	Serious	29	1600	
CEN21LA354	Wire	Yes	Serious	24	1037	
CEN21LA350	Wire	No	Minor	66	27,652	
CEN21LA349	Wire	Yes	Serious	54	7321	
CEN21LA348	Wire	Yes	Serious	31	3360	
WPR21LA310	Windmill	No	Serious	61	3041	
CEN21LA339	Wire	No	Minor	53		
CEN21LA452	Wire	No	None	47		
CEN21LA313	Crop	Yes	None	27	1865	
CEN21LA318	Tower	Unclear	None	42	11,428	
ERA21LA270	Wire	No	None	34	2554	
CEN21LA283	Tree	Unclear	Serious	66	27,100	
CEN21LA225	Wire	Yes	Fatal	47	4500	Awareness inferred from previous passes in field.
ERA21FA200	Wire	Yes	Fatal	57	6670	Awareness inferred from previous passes in field.
WPR21LA130	Wire	Unclear	Minor	36	10,000	
CEN21LA148	Wire	No	None	56	14,639	
CEN21LA113	Wire	Unclear	Fatal	68	30,000	
CEN21LA005	Tree	Unclear	None	32	1090	
ERA20LA330	Tree	Yes	Fatal	67	31,000	Awareness inferred from previous passes in field.
CEN20CA347	Wire	Yes	Minor	65	18,671	
CEN20CA311	Wire	No	Minor	28	1880	
CEN20CA312	Wire	Yes	None	48	11,997	
CEN20CA300	Wire	No	None	42	7700	
ERA20LA220	Wire	No	Fatal	65	19,340	
WPR20CA179	Wire	No	None	55	9693	
WPR20CA171	Wire	No	Minor	65	17,021	
CEN20LA143	Tree	Unclear	Fatal	46	10,000	
CEN20LA109	Wire	Yes	None	53	7867	

*These results are from the analysis of the 45 final NTSB accident reports from 2020–2022 that involved an in-air obstacle collision as the primary cause of the accident in Part 137 Agricultural Operations.

DISCUSSION

This brief report describes characteristics of a particularly frequent type of accident in the Part 137 Agricultural Aviation industry, in-air obstacle collisions. Though wire strikes and similar in-air obstacle collisions are known to be consistent defining events in historical agricultural accident data,[2] little research has examined the human factor issues associated with these accidents to understand why they occur. The current study therefore evaluated common characteristics of these accidents using final reports from NTSB investigations from Jan. 2020 to Dec. 2022, with a particular focus on whether the pilot was already aware of the obstacle pre-collision.

Overall, these findings confirm the prevalence of in-air obstacle collisions, which accounted for nearly half of all defining events in accidents from this sample. The most frequently hit obstacle in these accidents were wires, though some instances of hitting trees, poles, windmills, crops, and towers were noted. The vast majority of these collisions were also not attributable to another immediate event, such as an aerodynamic stall or computer/mechanical failure. Further, these accidents were prevalent across a range of pilot demographics, including pilots

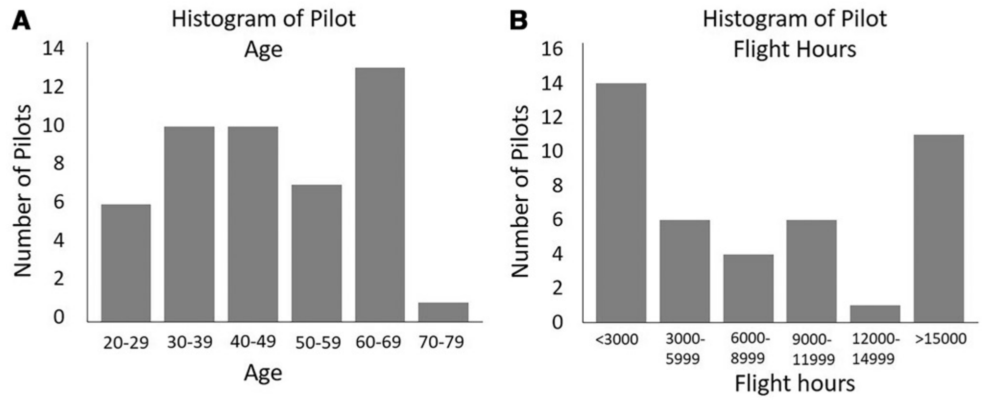

Fig. 1. Demographics of pilots who experienced in-air obstacle collisions. A) Ages of pilots included in NTSB final accident reports for the 45 evaluated in-air obstacle collisions are shown in a histogram. B) A histogram shows the range of flight hours attributed to the pilots who experienced in-air obstacle collisions.

both young and old and pilots with extensive or few total flight hours. However, the histogram of pilot flight hour time (Fig. 1B) demonstrates a U-shaped distribution of flight experience in pilots involved in these collisions. Given the prevalence of pilots that had either <3000 h flight time or >15,000 h flight time, this suggests that contributing factors may include pilot inexperience and pilot complacency, respectively. However, it should be noted that without wider demographic information about agricultural pilots, it is unclear whether this U-shaped distribution simply corresponds to the overall flight hour distribution in the agricultural pilot population.

Of note, about half of all pilots involved in these in-air obstacle collisions were previously aware of the obstacle before collision. Typically, this was evident from the investigation report that noted that the pilot was aware of the obstacle through prior scouting, discussions with the property owner, or having previously flown passes on the field around the obstacle. These findings imply that other factors, including distractions, high task difficulty, and errors in decision-making, may contribute to these frequent accident types. Mitigations that solely focus on awareness and preflight preparations around the field will not be sufficient in combatting these accidents. Instead, a human-factors-informed approach, such as additional training or targeted advertisements on pilot complacency,[1,6] may be key in promoting awareness of the causes behind these collisions and preventing future accidents.

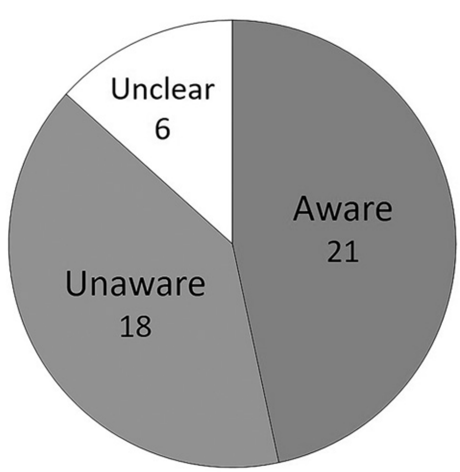

Fig. 2. Previous awareness of obstacle before in-air obstacle collision. Pilot awareness of obstacles before in-air collision was assessed through final accident reports. Pilots were categorized as either being previously aware of the obstacle (*N* = 21), unaware of the obstacle (*N* = 18), or awareness was undeterminable through the accident report (*N* = 6).

One major limitation of the current analysis is that the true prevalence of wire strikes and in-air accident collisions may be hard to determine. Events may go unreported if damage to the aircraft or other property is minimal. Therefore, the true scope of this issue and associated characteristics may not be fully represented within NTSB final accident reports, and more research is necessary to fully evaluate this accident type.

Overall, these preliminary findings indicate that future research into the causes of wire-strike events and in-air obstacle collisions within agricultural operations is necessary given the prevalence of these accidents and lack of current research.

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REFERENCES

1. Bahner JE, Hüper AD, Manzey D. Misuse of automated decision aids: complacency, automation bias and the impact of training experience. Int J Hum Comput Stud. 2008; 66(9):688–699.
2. Dell G. Aerial agriculture accidents 2000–2005: the human factors and system safety lessons. In: Anca JM, editor. Multimodal safety management and human factors: crossing the borders of medical, aviation, road and rail industries. Burlington (VT): Taylor & Francis Group; 2014: 113–129.
3. Federal Aviation Administration. Agricultural aircraft operations. 1965; 30 F.R. 8106. [Accessed 25 Sept. 2023]. Available from https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-137.
4. National Transportation Safety Board. Annual summary of US civil aviation accidents (2017–2021). [Accessed January 31, 2023]. Available from https://www.ntsb.gov/safety/data/Pages/Data_Stats.aspx.
5. National Transportation Safety Board. Special investigation report on the safety of agricultural aircraft operations. Washington (DC): National Transportation Safety Board; 2014; Report No.: NTSB/SIR-14/01.
6. Parasuraman R, Manzey DH. Complacency and bias in human use of automation: an attentional integration. Hum Factors. 2010; 52(3):381–410.