SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigations Division** Form Number: CA 12-57

LIMITED OCCURRENCE INVESTIGATION REPORT – FINAL

Reference Number	CA18/2/3/10277						
Classification	Accident	**Date**	6 March 2023	**Time**	0840Z		
Type of Operation	Agricultural (Part 137)						
Location							
Place of Departure	Smalpunt Airstrip, Free State Province	Place of Intended Landing	Smalpunt Airstrip, Free State Province				
Place of Occurrence	Farm Klein Geluk, Swartfontein, Free State Province						
GPS Co-ordinates	Latitude	28° 00' 44.9" S	Longitude	28° 38' 08.6" E	Elevation	5 626 ft	
Aircraft Information							
Registration	ZS-LEK						
Make; Model; S/N	Ayres Corporation; S2R-T34 (Serial Number: T34-050DC)						
Damage to Aircraft	Destroyed	Total Aircraft Hours	10 213.85				
Pilot-in-command							
Licence Type	Commercial Pilot Licence (CPL)	Gender	Male	Age	73		
Licence Valid	Yes	Total Hours	± 18 690	Total Hours on Type	± 16 690		
Total Hours 30 Days	± 67	Total Flying on Type Past 90 Days	± 168				
People On-board	1+0	**Injuries**	0	**Fatalities**	1	**Other (on ground)**	0

What Happened

On Monday, 6 March 2023, a pilot on-board an Ayres S2R-T34 aircraft with registration ZS-LEK was engaged in a crop-spraying detail at Farm Maria, Free State province. No flight plan was filed for the flight which was conducted under visual flight rules (VFR) by day and under the provisions of Part 137 of the Civil Aviation Regulations (CAR) 2011 as amended.

During the crop-spraying operation, the pilot had maintained radio communication with another pilot on-board a Thrush S2R H80 aircraft with registration ZS-ARC (from the same operator) as per the operator's standard procedure. The ZS-ARC aircraft was operating at another farm, approximately 2 nautical miles (nm) north of ZS-LEK.

According to the aircraft's fuel control and logbook records, the pilot of ZS-LEK uploaded the first chemical load from Smalpunt Airstrip at 0645Z, and the second load at 0715Z, which were sprayed on the crops at another farm. A chemical load of the hopper fitted to the aircraft covers about 50 hectares of field and takes about 40 minutes to spray.

Based on the aircraft's fuel control and logbook records, the pilot returned to Smalpunt Airstrip to uplift the third chemical load, which was for Farm Maria at 0755Z. At around 0840Z, the technical support on the ground responsible for reloading the fertilising chemical contacted both pilots on their radios to find out where the ZS-LEK aircraft was, as it had not returned for the fourth load, which was the last uplift for the day. Smallpunt Airstrip is 7.5 kilometres from Farm Maria.

With no response from the pilot of ZS-LEK, the pilot of ZS-ARC flew to the last position where ZS-LEK was seen, and he was met with a cloud of black smoke. Realising that ZS-LEK had crashed,

the pilot informed the ground crew before diverting to Smalpunt Airstrip to land the ZS-ARC aircraft. The ZS-ARC pilot and the ground crew drove on their vehicles to the accident site.

The aircraft was found in an inverted attitude and consumed by fire. Upon inspection of the wreckage, a high-tension electrical earth conductor wire (top wire) was found entangled to the left landing gear.

The aircraft was destroyed, and the pilot was fatally injured during the accident.

Figure 1: Aerial view of the wreckage distribution with the impression of the aircraft's first impact point on the soya vegetation. (Source: Operator)

Figure 2: A close view of the ZS-LEK aircraft post-accident.

Findings

1. The pilot

1.1. The pilot had a Commercial Pilot Licence (CPL) that was reissued on 7 July 2022 with an expiry date of 31 August 2023. According to available records that were last updated on 2 January 2023, the pilot had approximately 18 690 total flying hours, of which about 16 690 hours were on the aircraft type. The Ayres S2R-T34 aircraft type was endorsed on the pilot's licence.

1.2. The pilot was issued a Class 1 aviation medical certificate on 7 December 2022 with an expiry date of 30 June 2023, with the restriction to wear suitable corrective lenses.

1.3. Registration renewal documents as a pest control operator in terms of the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947) were issued to the pilot on 30 June 2020 with an expiry date of 30 June 2023.

1.4. The pilot attended a course in Crew Resource Management (CRM) for Agricultural Pilots and Operators which consisted of Physical Fatigue / Mental Fatigue modules, offered by a SACAA-accredited training institution. The certificate had a validity date from June 2022 to June 2023.

1.5. According to the logbook and flight folio records, the pilot did not exceed the regulatory maximum flight times for a single pilot operation as stipulated in Part 135.02.9 of the South African Civil Aviation Technical Standards (SACATS) 2011 as amended. Therefore, it is unlikely that the pilot was fatigued at the time of the accident.

1.6. Based on the pilot's flying logbook, he was not familiar with the area of operation as there was no record of him flying in the area prior to the accident.

1.7. The pilot was licensed and qualified for the flight in accordance with the existing regulations.

2. The Aircraft

2.1. The aircraft was issued a Certificate of Release to Service (CRS) following its last 100-hour Mandatory Periodic Inspection (MPI) which was conducted on 15 February 2023 at 10 167.2 airframe hours with an expiry date of 14 February 2024 or at 10 267.2 airframe hours, whichever occurs first. The aircraft had flown a further 46.65 airframe hours since the said inspection. The CRS had, thus, been invalidated as a result of the accident.

2.2. The aircraft had a valid Certificate of Airworthiness (C of A) and was maintained in compliance with the regulations.

2.3. The maintenance records indicated that the aircraft was equipped and maintained in accordance with the existing regulations and approved procedures.

2.4. There were no pre-existing mechanical faults with the engine, or any other aircraft system recorded in the flight folio and defect logs that could have contributed to the accident. Additionally, there were no snags recorded in the flight folio and defect logs with either the navigational or communication systems prior to the accident flight.

3. Wreckage Distribution

3.1. There were no eyewitnesses to the accident. Damage observed on the wreckage indicated that the engine was operating at full power, confirmed by two of the three propeller blades which became dislodged from the flange after impact; they were found buried in the soft ground, each located approximately 2 and 3 metres from the engine.

3.2. Observation of the wreckage indicated that the aircraft was caught on an electric wire with its left main landing gear strut. Metallic striation marks indicative of a wire strike were observed on the leading edge of the left wing and the left gear strut, and a section of the high-tension earth conductor wire was still attached to the landing gear wheel assembly as shown in Figure 3.

Figure 3: Earth conductor (top wire) of high-tension electrical wire is attached to the left landing gear.

3.3. The left landing gear strut was bent at a 90-degree angle from its original position in comparison to the right landing gear.

3.4. The post-accident assessment report of the engine revealed the following (Source: AMO Engine inspection technical report):

- *The engine was running at a high speed at the time of impact.*
- *There was rotary damage on the accessory gearbox drive shaft area, which was sheared off at the compressor connection point.*
- *The inlet section exhibited broken first stage blades in the direction of rotation, indicating the compressor was rotating and was drawing in air on impact.*
- *The power section of the aircraft had torsional deformation which is indicative of a high-power setting on impact.*
- *The fuel control unit (FCU) had sheared off its attachment point, indicative of a sudden stoppage at a high-power setting.*
- *The air filter had ingested dust and debris which was lodged inside it, indicating that there was air intake, and that the engine was still running during impact.*

3.5. Two of the three propeller blades sheared off and were found broken at the root from the propeller hub; they were semi-buried in the soft soil, 3m from the main wreckage at the first point of impact. These blades had no evidence of blade twist, signifying that they were rotating. One of the blades was still attached to the propeller flange and had minimal torsional / twisting damage. None of the blades had an indication of contacting the wire.

3.6. When the earth wire conductor was severed, it interrupted the power supply to a nearby community. The power was restored the following day after the lines were repaired.

3.7. The propeller spinner damage indicated that it impacted the ground at a near-vertical position which caused it to deform. There was evidence of scratch marks radiating outwards indicating that the spinner was rotating at high speed on impact. Although the spinner had impact damage, the aircraft operation experts from the aircraft maintenance organisation (AMO) that performed the engine inspection, argued that the nature in which the propeller impacted the ground, which was a vertical impact with high compression loading, caused the propeller blades to rotate freely. The sudden stoppage of rotation upon impact caused two of the blades to shear off completely due to inertia which caused a false indication that there was no engine power on impact as evidenced by the blades.

3.8. The hopper doors dislodged and were found approximately 10m behind the aircraft, indicative of a high-speed impact.

3.9. The ailerons and rudders were still attached to the wings and continuity of flight control wires could not be established when they were moved by hand due to the destroyed cabin section because of the fire. The fire had consumed the canvas material; however, the wires were still intact.

3.10. The flight was conducted under visual flight rules (VFR) by day. The weather conditions at the time of the accident were suitable for crop-spraying operations and did not contribute to the accident.

3.11. The aircraft impacted the ground hard in a near-vertical attitude following a collision with the earth conductor (top high-tension wire). The aircraft came to rest in an inverted attitude and was destroyed by impact forces and a post-impact fire; the pilot was fatally injured during the accident.

4. <u>Identifying Powerlines</u>

4.1. The flight data would have been downloaded from the Universal Serial Bus (USB) flash drive data storage post crop-spraying operation from ZS-LEK's SATLOC system, however, due to the system being destroyed by post-impact fire, it could not be retrieved for the flights that ZS-LEK completed before the crash. The recorded flight data would have included: heading angle, cross-track distance, spray rate and area sprayed amongst other parameters. According to the operator's standard operating procedures (SOP), pilots download the USB information after carrying out their operations.

4.2. The SOP (Issue:1) stipulates applicable Aerial Application / Agricultural Operations as some of the activities the pilot-in-command (PIC) shall carry out (but not limited to the list provided):

Pre-flight Actions:

- *Conduct self-assessment to ensure that he is fit for flight and the planned operation.*
- *Determine suitability of the aircraft for the type of operation.*
- *Take into consideration the planning and risk management applicable to the planned operation.*
- *Identify hazards, analyse the risks, and implement a decision to safely conduct low-level operations and ensuring that the aircraft type and performance are appropriate for the task.*
- *Correctly interpret the treatment area map.*
- *Understand all aircraft limitations applicable to the operation.*
- *Adequately identify potential hazards and operational requirements, assess risks, and apply appropriate risk controls, including power lines, houses, susceptible crops, and environmentally sensitive areas.*
- *Consider taking a command decision on the safety or otherwise of the proposed application, including refusing to undertake an application where the risks are too high.*
- *Selection of application patterns and direction of treatment area taking into consideration safety, efficiency, hazards, and terrain.*

To Conduct Aerial Survey of the Treatment Area:

- *Accurately identify the treatment area and boundaries.*
- *Confirm the map.*
- *Identify hazards on the map.*
- *Identify potential emergency landing area(s).*
- *Check and identify any hazards not on the map, including sun glare, shadow from hills and any other obstacles within the treatment area (tree stumps, etc.).*
- *Identify the requirement to operate in the vicinity of power lines and wires and assess risk thereof.*
- *Identify poles, cross trees, wires, and insulators to assist in power line and wire location.*
- *Identify appropriate spray pattern type and direction for the treatment.*
- *Consider the possible suspension of application if conditions are not appropriate.*

When Operating Aircraft at Low Level During Treatment:

- *Keep constant watch on wind speed and direction.*
- *Remain aware of sun glare and increased risk of collision with obstacles.*
- *If possible, operate adjacent to power lines and wires.*
- *Recognise and consider the effect of rising and descending terrain on aircraft performance.*
- *Establish and maintain appropriate height and speed over treatment area.*

For Operations Over and Under Power Lines:

- *Identify power lines both in and outside the treatment area during the aerial survey.*
- *Interpret power line infrastructure cues to aid in the identification of wire run direction.*
- *Accurately assess wire height, including flying parallel to wires to establish clearance height.*

- *Identify other hazards relevant to operations near power lines, such as pole stay wires, crop height, fences or machinery that may pose a risk.*
- *Establish the safe command decision whether to fly over or under a wire.*
- *Terminate approach towards power lines when passage beneath is unachievable.*
- *Consider human factors that may affect operations near power lines, particularly distraction, short-term memory limitations and perceptual blindness.*

4.3. According to the operator, crop-spraying is conducted to achieve optimised efficiency. This means that pilots conduct crop-spraying based on two factors that need to be considered: **efficiency** – *the most efficient way to spray the land; and* ***safety*** – *the safest way to spray the crops.* Therefore, the most probable spray pattern the pilot would have chosen is the longest part of the land (shown as the black line in Figure 4).

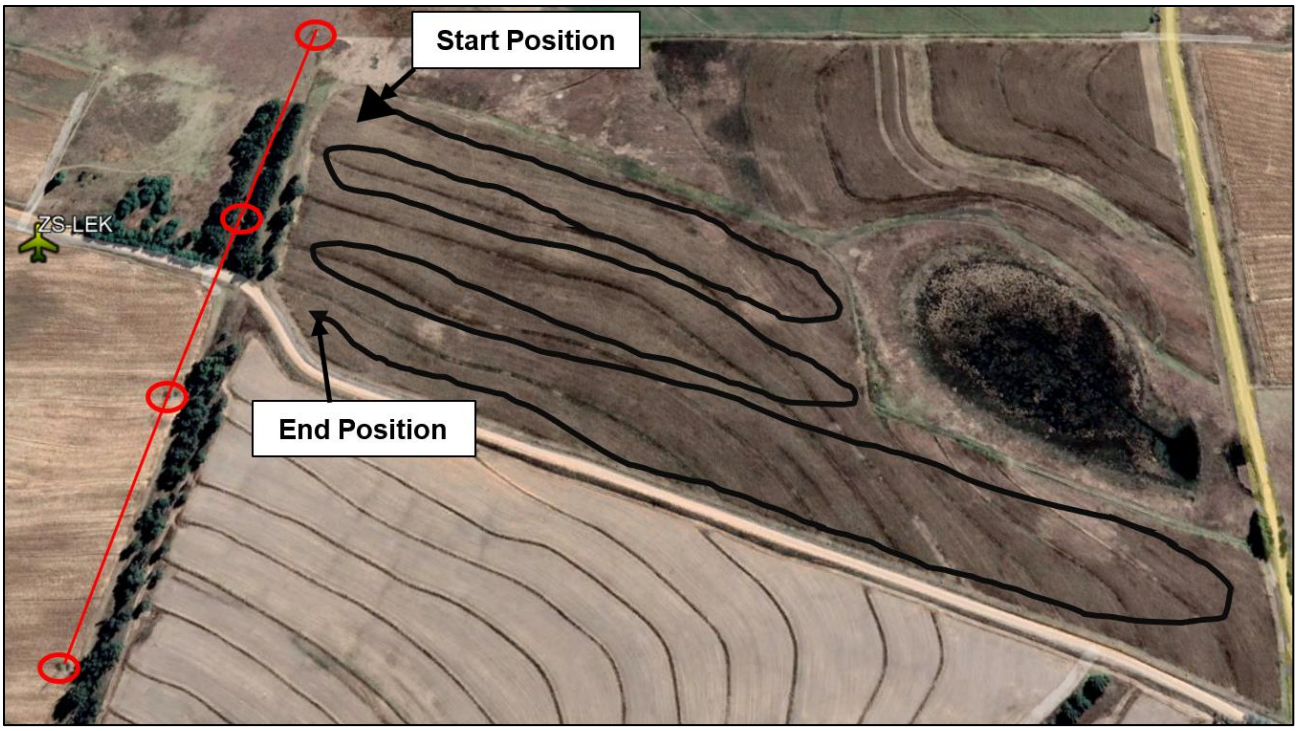

Figure 4: The black line depicts ZS-LEK's most probable flight path before collision with the wire. The red line and circles show power lines and poles. (Source: Google Earth)

5. Human Factors – Situational Awareness

Situational awareness is a mental state of alertness that involves perceiving, processing, and predicting the event to prevent an unexpected incident from happening.
(Source: https://www.usfa.fema.gov/blog/cb-110520.html)

Risk mitigation strategies associated with low-level flying rely heavily on the level of situational awareness maintained by the pilot. Strategies used to establish and maintain adequate situational awareness include reading the physical structure indicators (i.e., orientation of insulators, presence of bucked arms and sighting two or more poles), self-discipline, pre-flight briefing, pre-flight reconnaissance and observation, memory and awareness, appropriate flying techniques, maintenance of a good visual scan and consideration of weather factors. Additionally, pilots need to guard against deviating from low-flying routes and areas previously checked for wires. (Source: ATSB – Aviation Research and Analysis Report – Wire-strike Accidents in General Aviation: Data Analysis 1994 to 2004, September 2006)

5.1. During the crop-spraying detail, the aircraft would have been flown about 3m – 5m above ground level (AGL) and the pilot would have had to apply full power and pitch the aircraft's nose up to clear obstacles. The power lines, which blended with terrain and located behind the trees were adjacent to the aircraft's flight path. Therefore, due to the profile of the nose-up pitch, it would have been difficult to see obstacles that would have been easily identified if the aircraft's profile was horizontal.

5.2. It is likely that the pilot's concentration was degraded after the final track on Farm Maria, which led to the loss of situational awareness, and forced the pilot to deviate from the planned route. Also, awareness of the previously checked wires was lost and, as a result, the pilot was unable to recognise the top tension wire when attempting to fly over the power lines from a low height.

5.3. According to another agricultural pilot, the wire cutter is designed to cut through the wire if it connects at a right angle and if the aircraft is at a moderately high forward speed. The size of the wire was not established, however, the wire comprised eight strands of 2mm thickness each.

Probable Cause

Collision with high-tension earth wire during a pull out after completing a crop-spraying detail.

Contributing Factors

Loss of situational awareness, which caused the pilot to momentarily not factor in that the earth wire was in his flight path.

Safety Actions

None.

Safety Messages

Pilots engaged in aerial work (crop-spray detail, game calling, etc.) are advised to always familiarise themselves with the hazards that are likely to change in the environment (the position of the sun) in their areas of operation prior to engaging in aerial operations. The AIID encourages pilots to review aeronautical charts and to conduct a reconnaissance flight at a higher altitude before conducting low-altitude operations.

The latest version of maps with obstacles location is not a guarantee that all obstacles are properly identified. Consider all types of wires; thin wires are particularly difficult to see and could be tucked behind trees and other natural or artificial obstacles.

Pilots and operators are advised to engage with power supply entities to gain access to the latest coverage maps that would assist in outlining wires that may have been added.

About this Report

The decision to conduct a limited investigation is based on factors including whether the cause is known and the evidence supporting the cause is clear, the level of safety benefit likely to be obtained from an investigation and that will determine the scope of an investigation. For this occurrence, a limited investigation has been conducted, and the Accident and Incident Investigations Division (AIID) has relied on the information submitted by the affected person/s and organisation/s to compile this limited report. The report has been compiled using information supplied in the initial notification, as well as from follow-up desk top enquiries to bring awareness of potential safety issues to the

industry in respect of this occurrence, as well as safety action/s that the industry might want to consider in preventing a recurrence of a similar occurrence. *All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.*
Purpose
In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011 and ICAO Annex 13, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or liability.
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Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa