SOUTH AFRICAN CIVIL AVIATION AUTHORITY

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

LIMITED OCCURRENCE INVESTIGATION REPORT – FINAL

Reference Number	CA18/2/3/10395						
Classification	Accident	**Date**	27 November 2023	**Time**	1528Z		
Type of Operation	Training (Part 141)						
Location							
Place of Departure	New Tempe Aerodrome (FATP), Free State Province	Place of Intended Landing	New Tempe Aerodrome (FATP), Free State Province				
Place of Occurrence	Open field near Krugersdrift Dam, approximately 10 nautical miles (nm) north-west of FATP						
GPS Co-ordinates	Latitude	28º 49' 25" S	Longitude	025º 57' 07.4" E	Elevation	4247 ft	
Aircraft Information							
Registration	ZU-IIL						
Make; Model; S/N	The Airplane Factory, Sling 2 (Serial Number: 212)						
Damage to Aircraft	Substantial	Total Aircraft Hours	2675.9				
Pilot-in-command							
Licence Type	Student Pilot Licence (SPL)	Gender	Male	Age	40		
Licence Valid	Yes	Total Hours	34.9	Total Hours on Type	34.9		
Total Hours 30 Days	9.9	Total Flying on Type Past 90 Days	19.7				
People On-board	1+0	**Injuries**	0	**Fatalities**	0	**Other (on ground)**	0
What Happened							

On Monday afternoon, 27 November 2023, a student pilot on-board a Sling 2 aircraft with registration ZU-IIL was on a training flight from New Tempe Aerodrome (FATP) in Bloemfontein, Free State province, with the intention to perform precautionary landing exercises or simulated engine failures in the general flying area (GFA) and, thereafter, return to FATP. The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

The student pilot reported that the aircraft contained 90 litres (l) of Unleaded 95 Octane fuel in the tanks. Around 1451Z, the student pilot opened the throttle to 5 800 revolutions per minute (RPM) and took off to the GFA to perform the precautionary landing exercises. After completing the exercises, the student pilot routed back to FATP for a full stop landing. Whilst en route to FATP near Krugersdrift Dam at 5 200 feet (ft) above mean sea level (AMSL) and climbing to 6 000ft, he noticed that the coolant temperature on the instrument panel was in the yellow arch (caution). The student pilot instantly reduced the engine power from 5 800 RPM to 5 000 RPM and levelled off the aircraft at 5 300ft to assess if the engine temperature would reduce. During this time, the Electronic Flight Instrument System (EFIS) screen indicated low fuel pressure, and the engine spluttered soon after and eventually stopped after a few seconds.

The student pilot turned the aircraft to the left away from the dam and, thereafter, attempted to restart the engine, but without success. He then broadcasted a Mayday call on frequency 121.5-Megahertz and glided the aircraft in the direction of an open field for landing. During the landing roll, the right main landing gear impacted an ant hill, which resulted in the landing gear attachment bolt unhinging from the landing gear assembly. The student pilot was unable to bring the aircraft to a stop; he then pulled back the control column whilst initiating turns to break the speed. At around 1528Z, the aircraft eventually came to a stop on an open field, approximately 10 nautical miles (nm) north-west of FATP. The aircraft's right main landing gear was substantially damaged. The student pilot disembarked from the aircraft unharmed, and he called his flight instructor on his mobile phone to seek assistance.

The weather information below was obtained from the pilot questionnaire.

Wind Direction	270º	Wind Speed	2kts	Visibility	10km
Temperature	38ºC	Cloud Cover	CAVOK	Cloud Base	CAVOK
Dew Point	6ºC	QNH	Unknown		

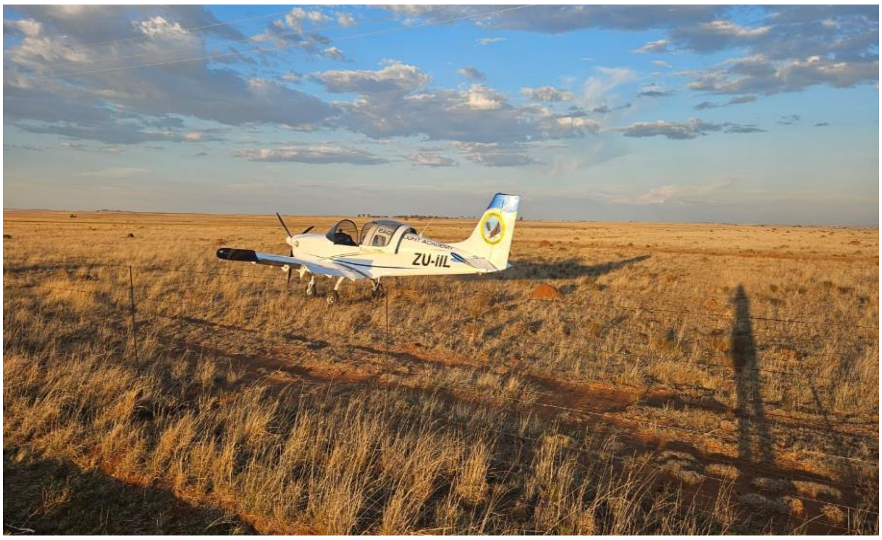

Figure 1: The aircraft at the accident site. (Source: Pilot)

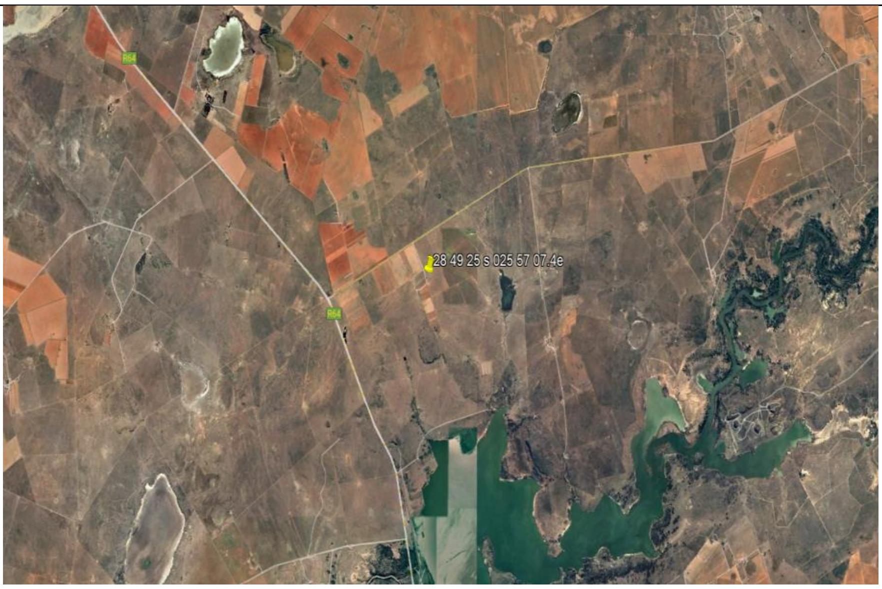

Figure 2: An aerial view of the accident site. (Source: Google Earth)

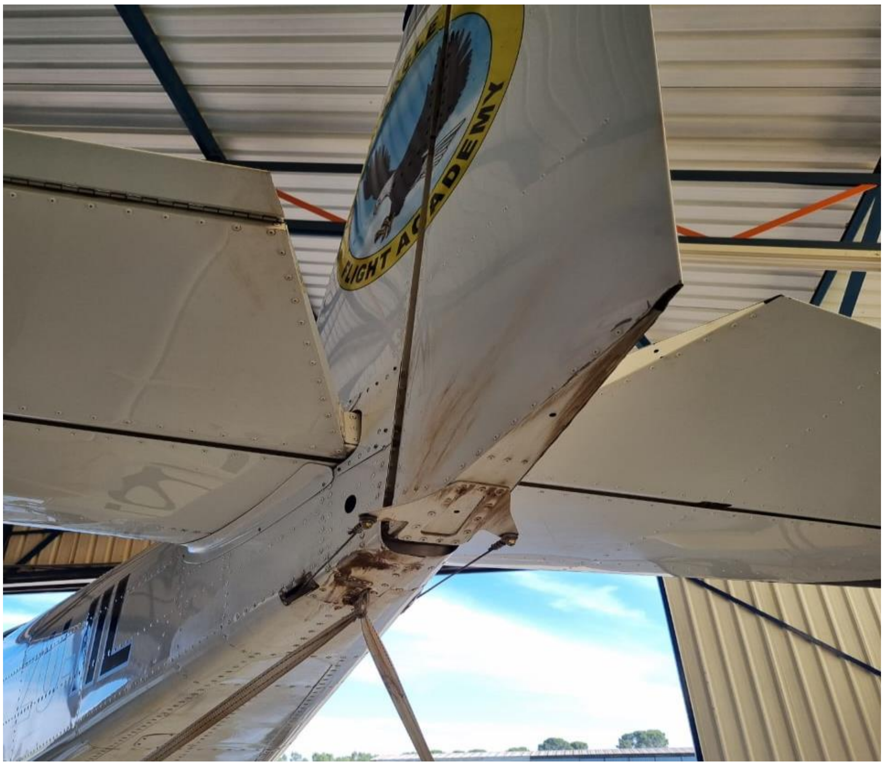

Figure 3: Scrape marks on the under skin of the tail section. (Source: Pilot)

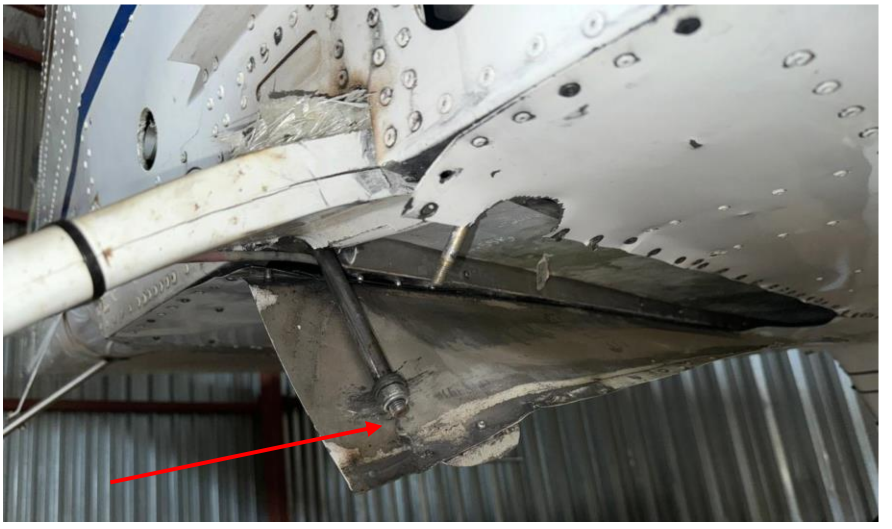

Figure 4: The landing gear attachment bolt that dislodged from the landing gear assembly and the damaged landing gear strut. (Source: Operator)

Post-accident inspection:

An aircraft maintenance engineer (AME) conducted an inspection on the fuel system at the accident site and nothing abnormal was noted. The student pilot stated that the aircraft had 90 litres of fuel when he took off and, after the accident, there was 81 litres remaining; thus, the aircraft had adequate fuel in the tanks. A small amount of fuel was strained from the aircraft, which was gold-yellow in colour. The fuel was inspected, and it was found free of dirt.

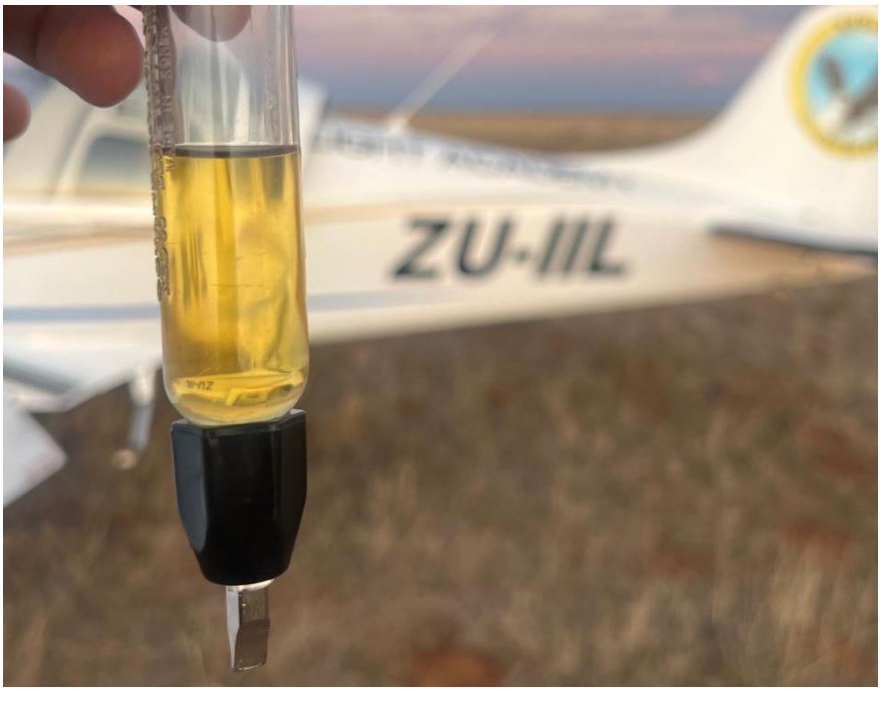

Figure 5: The fuel sample drained from the left-wing port. (Source: Operator)

Later in the afternoon, the AME started the engine, and it met all the parameters as outlined in the operator's manual. No maintenance or adjustments were conducted to address the engine defects before the engine start and during the engine run.

ZU-IEI

On the same day at approximately 1500Z, a flight instructor and the student pilot on-board a Sling-2 aircraft with registration ZU-IEI from the same flying school as ZU-IIL took off from FATP with the intention to conduct circuits on Runway 01. The flight instructor stated that the aircraft had a total of 70 litres. The flight instructor and the student pilot took off from Runway 28 and joined left downwind Runway 01 because there was glider activity on Runway 18. On late left downwind Runway 01, before turning left base at approximately 5300ft, the engine fluctuated and ran rough. The flight instructor stated that he took control of the aircraft from the student pilot and glided it to maintain 72 knots. Thereafter, he turned the aircraft and aimed for the threshold of Runway 01, as well as changed fuel feed from the left to the right tank. Moreover, he conducted a fault-finding procedure by checking the master, and lane A and B were on; the EFIS indicated low fuel pressure; and both fuel pumps were on. However, the engine still ran rough, and the aircraft was losing altitude. The flight instructor deduced that the aircraft will not make it to Runway 01 and opted to land on an open field close to Runway 01 (at Emoya Lodge). At this point, the engine stopped operating and the flight instructor identified a spot in the open field on which to land the aircraft. He broadcasted his intention to the gliders, thereafter, he selected full flaps on the aircraft and instructed the student pilot to brace himself as he landed the aircraft. After the aircraft came to a stop, he broadcasted to the gliders again to inform them that they had landed, and that they were not injured. The aircraft was not damaged during landing. The flight instructor then switched off all the electronics and evacuated the aircraft with the student pilot. The flight instructor contacted the flying school via his cellphone to report the occurrence. An AME dispatched to the open field (occurrence site) and conducted an inspection on the fuel system; nothing abnormal was found. He started the engine, and it met all the parameters as outlined in the operator's manual. No maintenance or adjustments were conducted to address the engine defects before the engine start and during the engine run.

The investigators released the aircraft to the school after the engine run. The aircraft was then drained of the 93 Octane and refuelled with Avgas. Thereafter, the aircraft was flown to FATP.

Bowser fuel receipt:

According to the fuel slip of the bowser from which ZU-IIL and ZU-IEI were refueled, the fuel purchased was 754.08 litres of 93 Octane on 10 November 2023. Not 95 Octane as the student pilot of ZU-IIL stated above.

Manufacturer's visit:

After two similar occurrences of the same aircraft type from the same flying school were reported to the manufacturer, two representatives from the aircraft manufacturer (The Airplane Factory) dispatched to Bloemfontein to investigate the occurrences on 29 November 2023. After receiving consent from the owner of the aircraft, the aircraft maintenance organisation (AMO) staff at FATP gave the representatives access to the hangar in which both aircraft were parked. They could not get a fuel sample from ZU-IIL as all the fuel was drained, and they were told that the fuel was discarded. ZU-IEI's 93 Octane fuel was drained and replace with Avgas before it was flown back to FATP, therefore, the manufacturer's representatives could not retrieve a fuel sample from ZU-IEI. The representatives noticed that there was a fuel bowser in the hangar which was used to get MOGAS from the filling station to the airfield, which was also empty. The manufacturer's representatives were told that all the fuel from the bowser was discarded too; they then decided to acquire a fuel sample from the filter and pipelines of the bowser to test it. From their visual assessment, the fuel sample was a bright yellow colour which meant that it was a 93 Octane fuel grade or lower. The fuel sample was sent for testing and the report showed that the fuel sample was indeed a 93 Octane grade and had a high percentage of water in it. (See extract from the report below).

Laboratory report

According to the report, the fuel sample appeared clear of water to the naked eye, but the American Society for Testing and Material (ASTM) results showed that the water content in the fuel sample was 625.3mg/kg and the maximum allowable is 350mg/kg, see the test report below.

SAMPLE NUMBER: 11.2023.S11361123

ANALYSIS	SPECIFICATION SANS 1598: 2014	METHOD	SAMPLE ANALYSIS RESULTS
APPEARANCE	CLEAR	VISUAL	Bright with free water droplets
COLOUR		VISUAL	Goldish Yellow
DENSITY kg/l @ 20° c	0.710 to 0.785	ASTM D4052	0.7445
10 % Distillation	65° c	ASTM D86	54
50 % Distillation	77 to 115° c	ASTM D86	100
90 % Distillation	185° c	ASTM D86	157
FBP % Distillation	215° c	ASTM D86	204
VLI	10 RVP + 7 E70	Report	Insufficient Sample
RVP	10 %MAX	ASTM D4953	Insufficient Sample
Free Water	0	VISUAL	POSITIVE
Residue	2%	ASTM D86	1.4
Water Content, mg/kg	Typically, 350 max.	ASTM D6304	625.3
Evaporation @ 70° C		Report	23

Conclusion of the report stated that the fuel sample contained a free water sediment. The fuel absorbed water (mg/kg) was elevated. Elevated absorbed water will negatively affect the fuel combustibility.

Fuel grade recommended for Rotax912IS(Source: Sling aircraft POH, Page 1-7)

Anti-knock: Minimum RON 95

MOGAS: EN 228 Super, EN 228 Super plus, ASTMD4814.

AVGAS: AVGAS 100LL (ASTM D910).

The aircraft was refuelled with 93 Octane instead of 95 Octane or higher as recommended in the Pilot's Operating Handbook (POH) by the manufacturer.

Water in aviation fuel (Source: Federal Aviation Administration Advisory Circular 20-125)

3. Source of water in aviation fuel

a. Water can enter an airport fuel system through leaks in underground tanks, leaks in the seals of such items as dome covers, floating roofs, and hatches during rain or snowstorms, when equipment is being washed, by marine or surface transport equipment delivering fuel to the airport, and by condensation and precipitation of dissolved water in fuel.

b. Water can enter an aircraft fuel system through leaks in the vents, seals, or poorly fitting fuel caps on filler openings during rain or snowstorms or when the aircraft is washed, from refuelling system equipment, by condensation and precipitation (especially when an aircraft has partially filled tanks), and when refuelling during rain or snowstorms.

4. WATER.

Water occurs in aviation fuels in two forms: Dissolved and free.

a. Dissolved Water. All aviation fuels dissolve water in varying amounts depending upon the fuel composition and temperature. Dissolved water in fuel is similar to humidity in air.

(1) Lowering fuel temperatures will cause dissolved water to come out of solution as free water somewhat like fog comes out of air. The creation of free water occurs at a rate of about one part per million per degree Fahrenheit (1 ppm/deg. F).

(2) Dissolved water is not a problem for aircraft operation as long as it remains in solution. Dissolved water cannot be removed by filtration but can become free water with temperature change. Once free, it can cause operating problems.

b. Free Water. Any water in excess of that which will dissolve is called free water. Free water can appear either as water slugs (in bulk quantities) or as entrained water.

(1) Water slugs are, as the name implies, a relatively large amount of water appearing .in one body or layer. A water slug may be a pint or less or may be measured in gallons depending on the capacity of a fuel tank.

(2) Entrained water is suspended in tiny droplets in the fuel. Individual droplets may or may not be visible to the naked eye, but they can give the fuel a cloudy or hazy appearance depending upon their size and quantity.

(3) When a water slug and fuel are violently agitated (for instance when passing through a pump), entrained water results. Entrained water will settle out in time depending upon the droplet size, specific gravity and viscosity of the fuel and currents within the tank. For this reason, a water haze may be seen in turbine fuel but the haze is seldom seen in aviation gasoline. Entrained water may also be formed by the lowering of the temperature of a fuel saturated with dissolved water. Furthermore, entrained water droplets can join together to form large drops or slugs of free water.

(4) Aircraft engines will tolerate a small amount of free water (30 ppm. is usually considered to be the maximum) if it is in a fine, uniformly dispersed state. The best way to minimize the amount of water entering a - system is through inspection and maintenance of equipment and by making certain that only clean and dry fuel is received into storage and delivered into an aircraft.

What happens when fuel mixes with water? (Source:https://www.boldmethod.com/learn-to-fly/systems/fuel-sump-contamination-causes-engine-failure-contamination/)
The engine may not fail right away when running on contaminated fuel. The first indications will likely be sputtering and a generally rough-running engine. Once enough water is mixed with fuel, combustion is no longer possible. Water is the most common contaminant in aviation fuel. Because water is denser than fuel, you will find water settling to the lowest part of the tank.

Conclusion

The engine manufacturer recommended 95 Octane or higher in the POH as it is purer than 93 Octane. When the aircraft is flying, fuel moves; it is possible that at some point the fuel that was combined with water had a high percentage of water, which made combustion impossible. This, in turn, caused the engine to flame out. After landing, fuel settles; when started again, there might be a higher percentage of fuel for combustion, and the engine can start, run and meet all parameters.

Findings (ZU-IIL)

1. The student pilot was initially issued a Student Pilot Licence (SPL) on 10 July 2022. The licence was reissued on 2 October 2023 with an expiry date of 29 September 2024. The student pilot's Class 2 medical certificate was issued on 21 September 2023 with an expiry date of 30 September 2024, and with a medical restriction.

2. The last annual inspection on the aircraft was certified on 16 November 2023 at 2 661.4 total airframe hours. The aircraft had accumulated 2 675.9 hours at the time of the accident, which meant that it was flown a further 14.5 hours after the annual inspection.

3. The Authority to Fly (ATF) was initially issued on 24 August 2016. The last ATF renewal was issued on 19 June 2023 with an expiry date of 31 August 2024.

4. The Certificate of Registration (C of R) was issued to the present owner on 31 January 2020.

5. The aircraft manufacturer representatives took a fuel sample from the bowser pipelines to be tested; it was found that the fuel was of the incorrect grade, and it was contaminated.

6. The aircraft was refuelled with 93 Octane instead of 95 Octane or higher, as recommended by the manufacturer in the POH.

7. The aircraft had adequate fuel for the flight, however, the fuel had absorbed water sediments which resulted in a lack of combustibility and, thus, the subsequent in-flight engine stoppage. This was followed by an unsuccessful forced landing on a field and the substantial damage to the aircraft.

Probable Cause(s)

In-flight engine stoppage due to lack of fuel combustion which was likely caused by incorrect fuel grade used and water sediments; this led to an unsuccessful forced landing on an open field as well as substantial damage to the aircraft.

Contributing Factor(s)

Aircraft was refuelled with 93 Octane that also contained water sediments.

Safety Action(s)

None.

Safety Recommendation/Message
None
About this Report
The decision to conduct a limited investigation is based on factors inluding 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 possible 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.
Disclaimer
This report is produced without prejudice to the rights of the AIID, which are reserved.

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa