PRELIMINARY ACCIDENT REPORT

Accident and Incident Investigations Division

Accident
- Preliminary Report -
AIID Ref No: CA18/2/3/10080

Figure 1: File picture of ZS-IGG aircraft. (Source: https://www.jetphotos.com)

Description:

On Friday, 26 November 2021, a pilot accompanied by two passengers on-board a Cessna 421B Golden Eagle aircraft with registration ZS-IGG took off on a private flight from Hoedspruit Eastgate Aerodrome (FAHS) in Limpopo province to Rand Aerodrome (FAGM), Gauteng province. The pilot conducted a pre-flight inspection and the aircraft had about 482 litres (127 US gallons) of Avgas LL 100 fuel in the tanks. According to FAHS control tower, the aircraft took off from Runway 09 at 1100Z and climbed to Flight Level 014 (FL014) / 14 000ft. After approximately 45 minutes while cruising above Witbank in Mpumalanga province, the pilot broadcasted on Johannesburg (JHB) area control 126.7-Megahertz (MHz) frequency informing them that the engines were running rough. During this time, it was drizzling; the pilot noted nothing faulty on the aircraft instruments or gauges. The area control then cleared the pilot to descend to a lower altitude and directed him to fly to Middleburg Aerodrome (FAMB), which was in his proximity. During the final approach for Runway 14, both engines stopped, and the aircraft was unable to reach Runway 14; the pilot landed on an open field, approximately 0.81 nautical miles (NM) north of FAMB. The aircraft was substantially damaged and the pilot sustained minor injuries. The two passengers were not injured. A preliminary finding revealed that the rough-running engines were caused by the induction (air intake) icing.

INTRODUCTION

Reference Number	**:** CA18/2/3/10080
Name of Owner/Operator	**:** George Chettle
Manufacturer	**:** Cessna Aircraft Cooperation
Model	**:** Cessna 421B Golden Eagle
Nationality	**:** South African
Registration Marks	**:** ZS-IGG
Place	**:** On an open field, north of Middleburg Aerodrome (FAMB)
Date	**:** 26 November 2021
Time	**:** 1150Z

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, 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****.*

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.

Any person who has information concerning this accident should contact the Accident and Investigations Division (AIID) on AIIDinbox@caa.co.za

Investigation Process:

On Friday 26 November 2021, the Accident and Incident Investigations Division (AIID) was notified of an accident involving a Cessna 421B Golden Eagle aircraft with registration ZS-IGG which occurred on an open field, north of Middleburg Aerodrome (FAMB).

The AIID has appointed an investigator-in-charge (IIC) and a co-investigator. Notifications were sent to the State of Registry, State of Operator, and the State of Manufacture and Design. No accredited representatives were appointed. The AIID will lead the investigation and issue the final report. The information contained in this Preliminary Report is derived from the initial information gathered by the investigating team during the on-site investigation.

The AIID reports are made available to the public at:

http://www.caa.co.za/Pages/Accidents%20and%20Incidents/Aircraft-accident-reports.aspx

Notes:

1. Whenever the following words are mentioned in this report, they shall mean the following:

- Accident – this investigated accident
- Aircraft – the Cessna 421B Golden Eagle involved in this accident
- Investigation – the investigation into the circumstances of this accident
- Pilot – the pilot involved in this accident
- Report – this accident report

2. Photos and figures used in this report were obtained from different sources and may be adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report are limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or the addition of text boxes, arrows or lines.

ABBREVIATION	DESCRIPTION
AD	Airworthiness Directive
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AMM	Aircraft Maintenance Manual
AMO	Aircraft Maintenance Organization
AMSL	Above Mean Sea Level
ARCC	Aeronautical Rescue and Coordination Centre
ARCC	Aeronautical Rescue and Coordination Centre
ATPL	Airline transport Pilot Licence
CAR	Civil Aviation Regulations
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
CVR	Cockpit Voice Recorder
ELT	Emergency Locator Transmitter
EMS	Emergency Medical Services
FAA	Federal Aviation Administration
FAGM	Rand Aerodrome
FAHS	Hoedspruit Eastgate Aerodrome
FALA	Lanseria Airport
FAMB	Middleburg Aerodrome
FDR	Flight Data Recorder
FL	Flight Level
Ft	Feet
GPS	Global Positioning System
Hp	Horsepower
IAW	In Accordance With
IFR	Instruments Flight Rules
IIC	Investigator in Charge
L	Litres
MHz	Megahertz
NM	Nautical Miles
POH	Pilot Operating Handbook
RPM	Revolution per Minute
SACAA	South African Civil Aviation Authority
SAPS	South African Police services
SB	Service Bulletin
USA	United States of America

1. FACTUAL INFORMATION

1.1. History of Flight:

1.1.1 The pilot reported that on Wednesday, 24 November 2021, he was accompanied by two passengers (family members) on-board a Cessna 412B Golden Eagle twin-engine aircraft with registration ZS-IGG on a private flight from Rand Aerodrome (FAGM) to Eastgate Hoedspruit Aerodrome (FAHS) in Limpopo province. Their intention was to return to Rand Aerodrome (FAGM) in Germiston, Gauteng province on 26 November 2021 (two days later). Visual Meteorological Conditions (VMC) by day prevailed and the flight plan was filed with Johannesburg (JHB) briefing office. The flight folio page serial number 30 indicated that 310 litres of Avgas LL100 fuel was uplifted; the main (tip) tanks and auxiliary tanks were filled to capacity, totalling 662 litres (174 US gallons). Before departing FAGM, the pilot reported that he conducted a pre-flight inspection on the aircraft, and all was normal with no defects recorded in the flight folio. The flight to FAHS was uneventful and lasted about 1.2 hours.

1.1.2 On Friday, 26 November 2021, the pilot and the same two passengers drove to FAHS where the pilot conducted a pre-flight inspection on the aircraft with no abnormalities noted. The aircraft had about 482 litres (127 US gallons) of fuel remaining. Visual Meteorological Conditions (VMC) by day prevailed, and the aircraft was operated under the Instrument Flight Rules (IFR); the flight plan was filed with JHB briefing office. Visibility at departure aerodrome (FAHS) was good with broken cloud base at 4 000 feet (ft) above ground level (AGL). The engines start-up was uneventful, and the pilot waited until all the engine indications were within the green arch with normal fuel flow on both engines. According to FAHS control tower, the ZS-IGG aircraft took off from Runway 09 at 1100Z. The pilot reported that the aircraft climbed to Flight Level 014 (FL014) / 14 000ft with the engines set at 31 inches of manifold pressure (MP) and 1800 revolutions per minute (RPM). After approximately 45 minutes while cruising above Witbank in Mpumalanga province at 14 000ft, the pilot broadcasted on JHB area control 126.7-Megahertz (MHz) frequency, notifying them that the engines were running rough.

1.1.3 During this time, it was drizzling; the pilot noted nothing faulty on the aircraft instruments or gauges. However, the aircraft could not maintain altitude due to loss of power. The pilot enquired with JHB area controller if there were high grounds around Witbank area. The weather condition was reported by the pilot as overcast with cloud base at 4 000ft, and tops at 10 000ft AGL. The controller then cleared the pilot to descend to a lower altitude and directed him to fly to Middleburg Aerodrome (FAMB), which was in his proximity; he caught sight of FAMB after breaking the clouds. The pilot reported that during a descent, he switched the tanks from the mains (tip) tanks to auxiliary tanks, assuming that the rough-running engines were possibly due to fuel starvation, and selected the auxiliary pumps to HIGH mode. But there was no change to the rough-running engines. During the final approach for Runway 14, both engines stopped, and the pilot landed on an open field, approximately 0.81 nautical miles (nm) north of FAMB.

1.1.4 The aircraft was substantially damaged while the pilot sustained minor injuries. The two passengers sustained no injuries. The South African Police Services (SAPS) and the Emergency Medical Services (EMS) were notified of the accident; they swiftly responded to the accident site. Paramedics administered first aid to the pilot and the passengers were transported to Midmed Hospital for medical check-up. All three occupants were released the same day. The flight was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.5 The accident occurred on an open field, north of FAMB at Global Positioning System (GPS) co-ordinates determined to be S25° 41 08´.40" E029° 26 25´.90" at an elevation of approximately 4 886ft.

Figure 2: The accident site north of FAMB Runway 14. (Source: Google Earth Map)

1.2. Injuries to Persons

Injuries	Pilot	Cabin crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	1	-	-	1	-
None	2	-	2	2	-
Total	**3**	**-**	**2**	**3**	**-**

1.3. Damage to Aircraft

1.3.1 The aircraft sustained substantial damages during the accident sequence.

Figure 3: A view of the aircraft at the accident side.

1.4. Other Damage

1.4.1 None.

1.5. Personnel Information

Nationality	British	Gender	Male	Age	37
Licence Number	0272271990	Licence Type	Commercial Pilot Licence (CPL)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instruments Rating				
Medical Issue Date	17 November 2021				
Medical Expiry Date	30 November 2022				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	394.8
Total Past 24 Hours	0
Total Past 7 Days	1.2
Total Past 90 Days	20
Total on Type Past 90 Days	20
Total on Type	6

*NOTE: The pilot was a British citizen. He had a valid United Kingdom Civil Aviation Authority (UKCAA) issued Airline Transport Pilot Licence (ATPL) and a Class 1 aviation medical certificate, issued on 13 April 2018 with an expiry date of 30 April 2019 and with no restrictions. On 19 January 2019, the pilot wrote an email to the South African Civil Aviation Authority (SACAA) seeking assistance in converting his UKCAA issued pilot licence. The SACAA form number CA61.01.13b dated 21 January 2019 indicated that there was consensus between the SACAA and the pilot that the pilot's ATPL be frozen, and that it be converted to a Commercial Pilot Licence (CPL). The SACAA form number CA61-11.4 dated 25 July 2019 indicated that the pilot was then revalidated to a CPL at Lanseria International Airport (FALA). The SACAA statement of examination results dated 6 August 2019 indicated that the pilot had passed the air law, meteorology, flight performance and planning procedures on 18 July 2019. Another statement of examination results dated 6 August 2019 indicated that the pilot completed the instruments rating on 24 July 2019. The pilot's skills test was completed on 30 November 2020 with an expiry date of 30 November 2021.

1.6 Aircraft Information

1.6.1 Aircraft description

Source: Pilot's Operating Handbook POH:

The Cessna 421B Golden Eagle aircraft is a 7 seat, all-metal, low wing pressurised aircraft manufactured by Cessna Aircraft Cooperation in the United States of America (USA). The cabin is accessed from a door on the left-hand side behind the wing. The aircraft was certified by the Federal Aviation Administration (FAA) to operate into known icing conditions (FIKI) and it is equipped with the surface anti-ice, heated propellers, heated windshield, heated static source, and the engine inlets alternate air source. The aircraft is powered by two Teledyne Continental GTSIO-520-H turbocharged, six-cylinder reciprocating, horizontally opposed, fuel injected engines rated at 375-horsepower (hp) at 2,235 revolution per minute (RPM) and 39,0 inches manifold pressure. The engines were each fitted with a McCauley three bladed, full feathering, constant speed propeller. The aircraft had a tricycle retractable electrically operated landing gear using air-over oil shock struts and electrically operated split flaps with settings of 0, 15, 30 and 45 degrees.

1.6.2 Cessna 421B fuel system description:

Fuel was contained in six individual wing tanks. The main tanks (tip) are located on each wing tip and the auxiliary tanks are in the main wing structure outboard of each engine. The useable fuel 193 litres (51 US gallons) in each main tank and 138 litres (36.5 US gallons) in each auxiliary tank. The 26.6 US gallons capacity wing locker tanks were not filled; thus, the total useable capacity of fuel was 662 litres (174 US gallons). The fuel selector handles of each side (left or right) are situated between the seats on the floor, and they provide

selection of: OFF, AUXILLIARY, MAIN and CROSSFEED. The auxiliary fuel pumps system on the C421B model was modified in accordance with (IAW) the Service Bulletin (SB) MEB88-3. The switches are labelled AUX PUMP, L (left engine) and R (right engine) and switch positions are LOW, OFF and HIGH. The LOW position operates the auxiliary pumps at low speed and are used, when required, to supplement fuel pressure for all normal operations. The HIGH position is reserved for emergency operation and operates the pumps at high speed. The HIGH position supplies sufficient fuel flow to sustain partial engine power in the event of an engine-driven fuel pump failure. Cessna owner's manual recommends that the aircraft be operated via the main (tip) tanks fuel supply during take-off, landing, and all normal operations. A caution is highlighted in the owner's manual alerting operators that should the auxiliary fuel pump switches be placed in the HIGH position with the engine-driven fuel pump (s) operating normally, total loss of engine power may occur. The aircraft POH identified Avgas LL100 as the primary fuel. The engine cockpit instrumentation included fuel pressure gauges, the fuel flow indicators, and the manifold pressure gauges. The cockpit annunciator panel provided visual indications for the fuel related system.

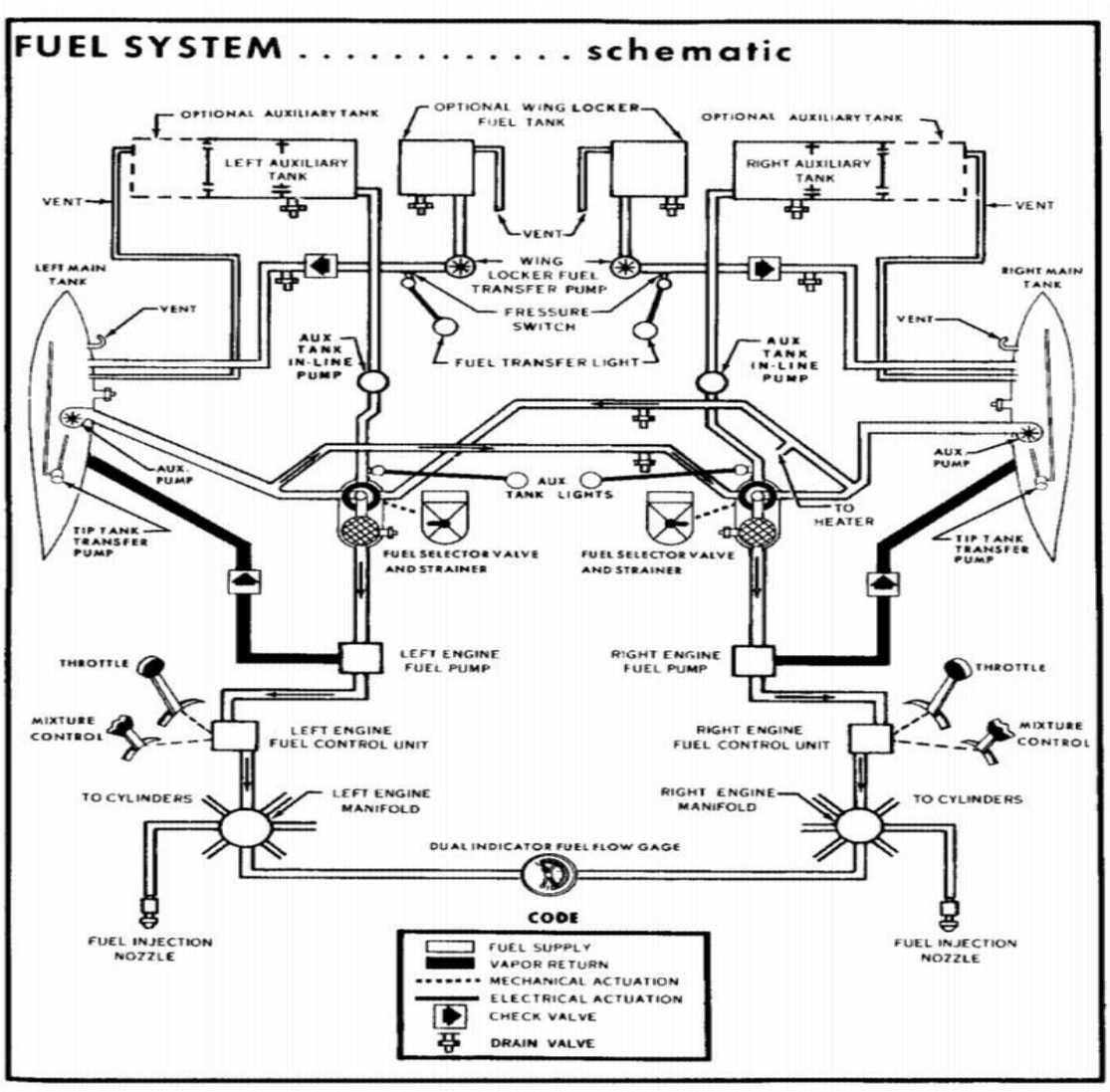

Figure 4: Cessna 421B fuel sytem schematic.

1.6.3 Sudden engine roughness in-flight procedure

Source – Aircraft Flight Manual (AFM)

a) Power – REDUCE IMMEDIATELY (Both engines)

1) Manifold Pressure. -32.5 inches. Hg MAXIMUM

2) RPM – 1950 MAXIMUM (1800 recommended)

b) Engine – Determine affected engine

c) Problem – ANALYSE

d) Engine – SECURE (If roughness cannot be cleared)

e) Operating Engine – ADJUST

f) Trim Tabs – ADJUST (5° bank towards good engine)

g) As soon as practical – LAND

Airframe:

Type	Cessna 421B	
Serial number	421B-0221	
Manufacturer	Cessna Aircraft Company	
Year of manufacture	1972	
Total airframe hours at the time of accident	7117.1	
Last Mandatory Periodic Inspection (Hours & Date)	7092.10	17 February 2021
Hours Since Last Mandatory Periodic Inspection	25	
Certificate of Airworthiness (Issue Date)	20 December 2017	
Certificate of airworthiness (Expiry Date)	31 March 2022	
C of R (Issue Date) (Present owner)	12 December 2016	
Maximum take-off weight	3379.3 kg	
Type of fuel recommended	Avgas LL 100	
Fuel used	Avgas LL 100	
Operating categories	Part 91	

*NOTE: The aircraft flight folio page serial number 29 showed that a 200-hour Mandatory Periodic Inspection (MPI) was carried out on 17 February 2021 at 7092.10 total airframe hours. The aircraft was maintained by a Regulator-approved aircraft maintenance organisation (AMO). The AMO approval certificate was issued by the Regulator on 6 March

2021 with an expiry date of 28 February 2022. The Certificate of Release to Service (CRS) was issued by the AMO on 17 February 2021 with an expiry date of 16 February 2022 or at 7192.10 airframe hours, whichever comes first. Examination of the aircraft technical records indicated that the aircraft was properly certified and maintained in accordance with (IAW) the SACAA regulations and approved procedures. All applicable Airworthiness Directives (ADs) and mandatory Service Bulletins (SBs) on the aircraft were complied with as on the date of accident. Scrutiny of the aircraft flight folio revealed that there were no snags pending on the aircraft prior to the accident flight.

Engine 1 (Left):

Type	Continental GTSIO-520-H
Serial Number	817510R
Hours Since New	7089.4
Hours Since Overhaul	1558,4

Propeller 1:

Type	McCauley 3AF34C92-P
Serial Number	799834
Blade Serial Numbers	i. K117366YS ii. K117383YS iii. K117403YS
Hours Since New	7089.4
Hours Since Overhaul	101.4

Engine 2 (Right):

Type	Continental GTSIO-520-H
Serial Number	2190494-72D
Hours Since New	7152.8
Hours Since Overhaul	339.4

Propeller 2:

Type	McCauley 3AF34C92-P
Serial Number	7810566
	i. K97841YS ii. K101202YS iii. K101203YS
Hours Since New	7089.4
Hours Since Overhaul	101.4

1.7 Meteorological Information

1.7.1 An official weather report was obtained from the South African Weather Service (SAWS) for Middleburg for 26 November 2021.

i. Significant weather charts:

The significant weather charts showed scattered stratocumulus and cumulus clouds forecasted over the accident site with the base ranging between 7 000ft to 8 000ft AGL and the top expected at 12 000ft AGL at 1200Z. A review of the weather report specified the icing (in-flight freezing) conditions between 8 000 to 12 000ft around the time of the accident as well as the intended route of flight.

Wind direction	070°	Wind speed	02kts	Visibility	N/a
Temperature	-8°C	Cloud cover	N/a	Cloud base	N/a
Dew point	-4°C	QNH	N/a		

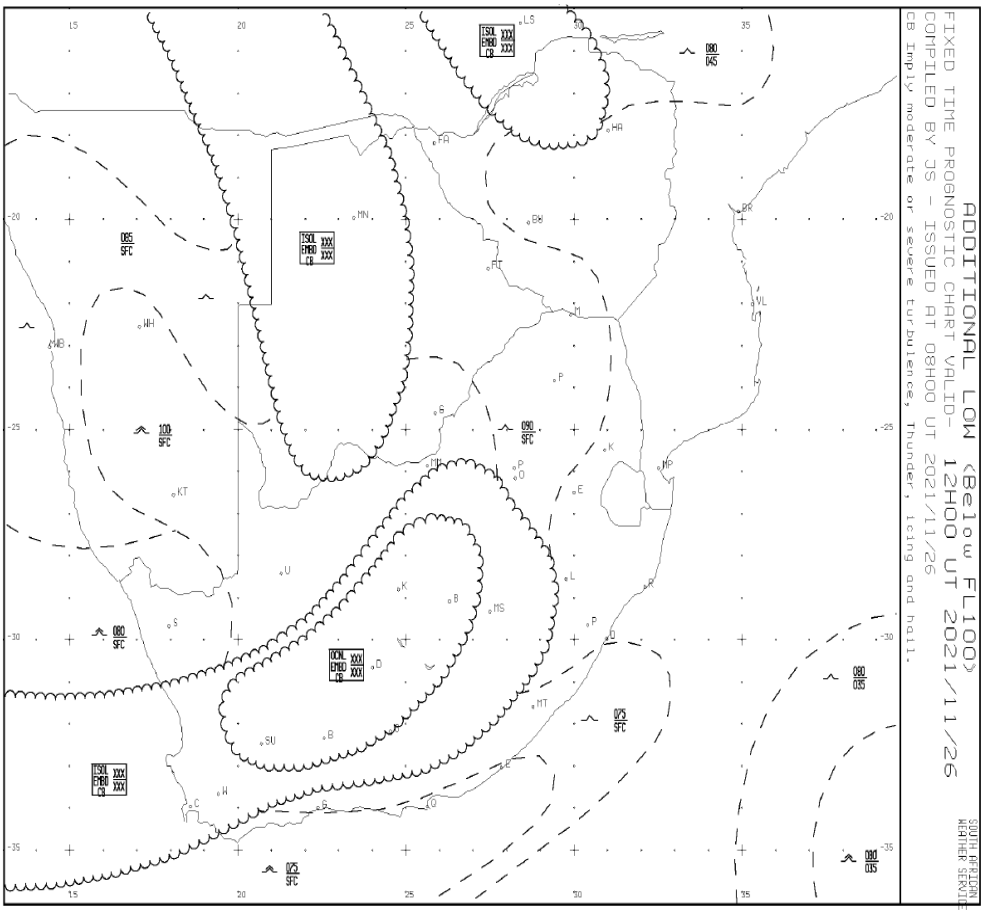

Figure 5: A satellite image showing icing conditions at the time of flight.

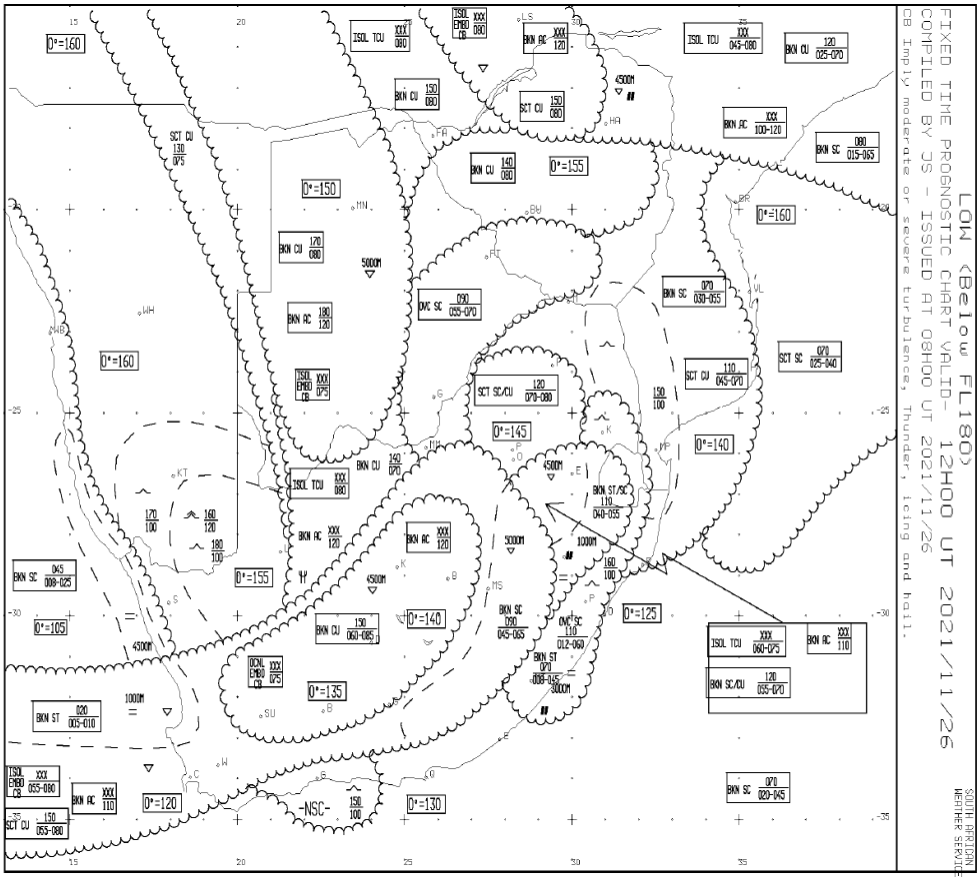

Figure 6: A satellite image showing the icing conditions at the time of flight.

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA) for the aircraft type. There was no record indicating that the navigation was unserviceable prior to or during the flight.

I. Magnetic compass

II. Garmin GTX 330

III. Garmin GNS 430

IV. Bendix King KT-76A

V. Rockwell Collins WXR-220

VI. Bendix King KX155

VII. Bendix King KN-62A

1.9 Communication

1.9.1 The aircraft was equipped with standard communication equipment as approved by the Regulator for the aircraft type. There were no recorded defects with the communication equipment prior to the flight.

1.9.2 The pilot broadcasted on JHB area control on very high frequency (VHF) 126.7 MHz before descending to FAMB. The aircraft was fitted with the Emergency Locater Transmitter (ELT). After impact, the ELT transmitted signals to Johannesburg Information, further alerting the relevant authorities.

1.10 Aerodrome Information

1.10.1 The aircraft was expected to land at FAGM at approximately 1255Z, but never made it to the aerodrome. It was later reported that the aircraft had crash-landed on an open field, north of FAMB, approximately 0.81 nautical miles (NM) at GPS co-ordinates determined to be S25° 41 08´.40" E029° 26 25´.90" at an elevation of approximately 4 886ft.

Aerodrome Location	Middleburg Aerodrome (FAMB)	
Aerodrome Co-ordinates	S25° 41 08´.40" E029° 26 25´.90"	
Aerodrome Elevation	4 886ft	
Runway Designations and Dimensions	14/32	1800m × 25m
Runway Designations and Dimensions	02/20	1345 × 25m
Runway Used	None	
Runway Surface	Gravel and Asphalt	
Aerodrome Status	Licensed	
Approach Facilities	Runway Lighting	

1.11 Flight Recorders

1.11.1 The aircraft was neither equipped with a cockpit voice recorder (CVR) or a flight data recorder (FDR), nor was it required by regulation to be fitted to this aircraft type.

1.12 Wreckage and Impact Information

1.12.1 Examination of the accident site indicated that the aircraft landed hard on an open field. The main landing gear doors separated from their respective struts and all three landing gears broke off at the struts during landing. The aircraft then skidded on the belly with flaps extended to 45° setting and stopped approximately 65 metres from the first point of impact. The pitot probe/tube mounted underneath the nose section broke off. The bottom fuselage skin and the antennas were damaged. The nose gear strut/wheel assembly was found approximately 12m from the first point of impact, followed by the left main gear strut/wheel assembly on the left approximately 16m, and the right main gear strut/wheel assembly, which was further away approximately 22m from the first point of impact. All three landing gear struts oleos and the tyres contained pressure. The fuselage nose-section collapsed in compression and separated on the right-side nose-cargo compartment area. The right-side main (tip) tank suffered overload failure at its attachment area, however, the fuel pipe feeding the engine was still intact. The wing structure, including the auxiliary fuel tanks and the locker tanks, was intact.

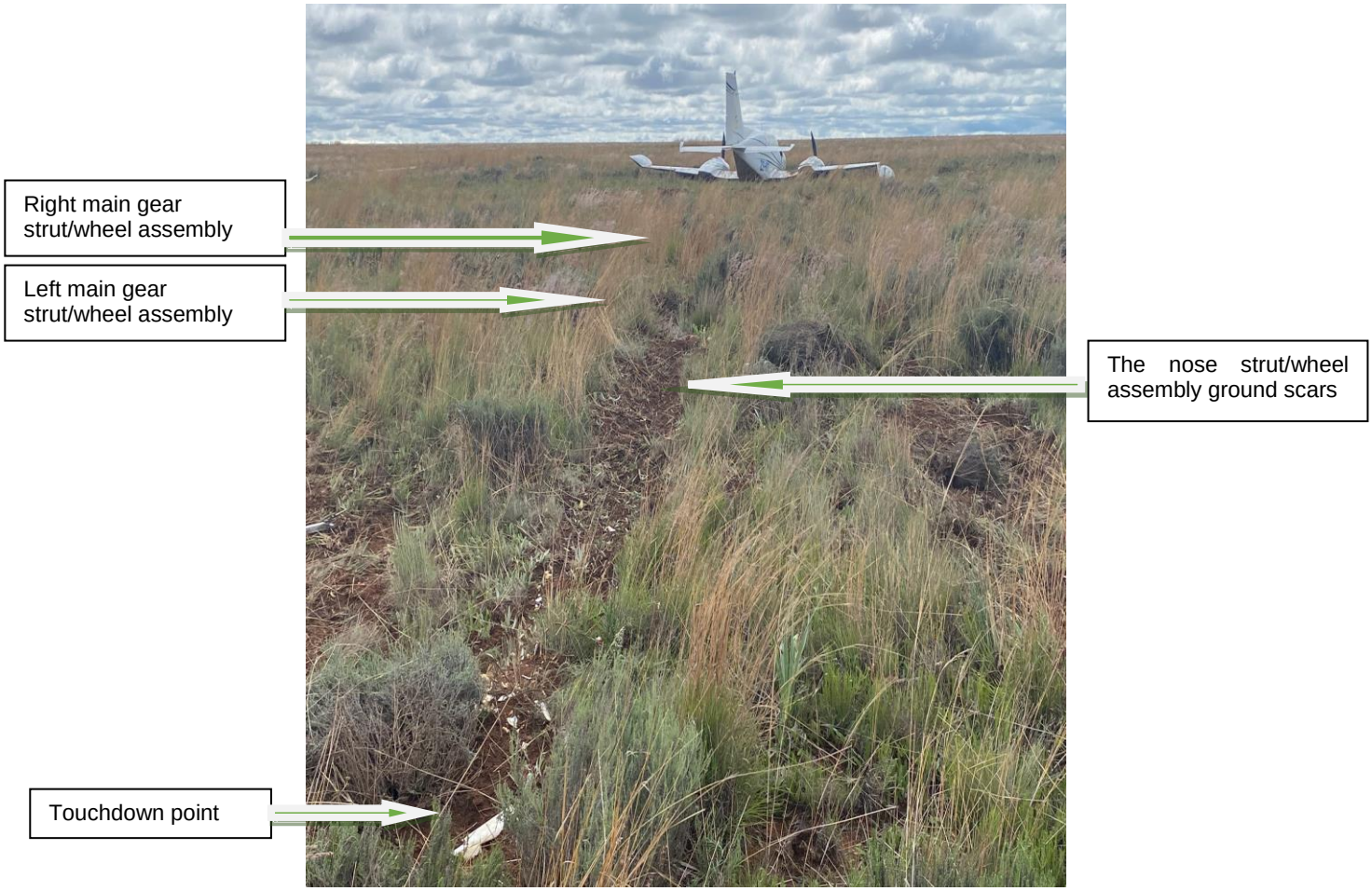

Figure 7: First point of impact and the final position of the aircraft.

Figure 8: View of the broken main landing gear struts with the wheel assemblies still attached.

1.12.2 Examination of the cockpit area showed both throttle levers in a closed position. The mixture levers were both in the idle cut-off position. All instruments, radios and switches were intact. The landing gear handle in the cockpit was found in an extended position. None of the circuit breakers were pulled. *The manually operated T-handles on the left pilot side below the control column that operates the alternate air source were found in a closed position and the auxiliary pump switches on the left pilot side-panel were selected to HIGH mode.*

Figure 9: View of the aircraft console showing the landing gear lever selected in an extended position and the flap lever at 45° setting.

Figure10: The left and right ALTERNATE AIR levers in a pressed position.

Figures 11/12: View of the auxiliary pumps in a HIGH mode setting. There is a placard (yellow window above) installed on the left pilot side panel indicating AUX PUMP HIGH FOR ENGINE DRIVEN PUMP FAILURE (VERY LOW OR NO FUEL PRESSURE).

1.12.3 The engines were found still attached to their respective mountings and the propellers secured to their engine flanges. Examination of the aircraft's propellers showed that the engines were not operational during landing. Neither of the propellers was feathered.

Figures 13/14: Pictures showing neither of the propellers feathered.

1.12.4 Examination of the engines did not reveal any pre-impact mechanical malfunctions or anomalies that would have precluded normal operations. All major components of the aircraft were accounted for at the accident site. Flight control continuity was established from the cockpit control columns to each respective control surface.

1.13 Medical and Pathological Information

1.13.1 To be discussed in the final report.

1.14 Fire

1.14.1 There was no evidence of pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The accident was considered survivable as the occupants were properly restrained with the aircraft-equipped safety harnesses during the flight, as well as the low impact force associated with the accident. Work-order 13131 dated 5 March 2021 showed that a Kannad 406 AF ELT part number S1821502-02, serial number 40131-0019 was installed on the tail section and on the left-side of the aircraft in accordance with (IAW) the maintenance manual (MM) 25-63-05, Revision 4, dated 20 January 2019. The ELT activated and was detected by the Aeronautical Rescue and Coordination Centre (ARCC) in JHB. The ELT was switched off by the investigators during the on-site investigation.

Figure 15: The ELT as installed on the aircraft's tail-section.

1.16 Tests and Research

1.16.1 A preliminary finding revealed that the rough-running engines were caused by the induction icing (intake icing). The air filter's primary function on the engines is to remove dust and other foreign objects from the induction air. However, if they become obstructed or blocked by ice, the engines are starved for air, and would ultimately draw air from their respective engine intake manifolds with rapidly decreasing induction air pressure. There is no gauge in the cockpit to indicate induction icing except for the development of rough-running engines as the obstruction chokes the air flow. The alternate air (ALT AIR) T-handles on the left pilot side must be pulled out IAW the AFM to bypass the engine air filters, thus, allowing the unfiltered alternate air to be taken from inside of each engine nacelle into the combustion.

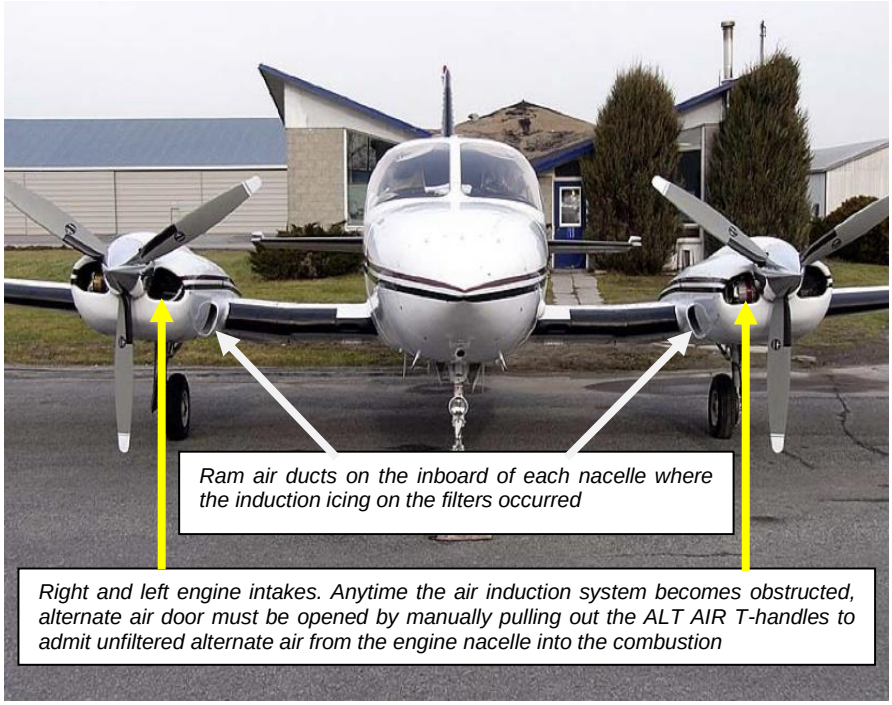

Figure 16: File picture of the Cessna 421B model aircraft (not ZS-IGG) — (Source: https://www.jetphotos.com). The picture shows the ram air ducts on the in-board of each nacelle and the alternate air entry point through the nacelles into the combustion.

1.16 Organisational and Management Information

1.17.1 The flight was conducted IAW the provisions of Part 91 of the South African Civil Aviation Regulations 2011 as amended.

1.17.2 A 200-hour MPI was carried out on 17 February 2021 at 7092.10 total airframe hours. The Certificate of Release to Service (CRS) was issued by the AMO on 17 February 2021 with an expiry date of 16 February 2022 or at 7192.10 airframe hours, whichever comes first.

1.18 Additional Information

1.18.1 Induction icing (Source – Federal Aviation Administration [FAA] Advisory Circular No: 91-74B dated 10 August 2015)

1) *Ice in the induction system can reduce the amount of air available for combustion. The most common example of reciprocating engine induction icing is carburetor ice. Most pilots are familiar with this phenomenon, which occurs when moist air passes through a carburetor venturi and is cooled. As a result of this process, ice may form on the venturi walls and throttle plate, restricting airflow to the engine. This may occur at temperatures between 20 °F (-7 °C) and 70 °F (21 °C). The problem is remedied by applying carburetor heat, which uses the engine's own exhaust as a heat source to melt the ice or prevent its formation. Fuel-injected aircraft engines usually are less vulnerable to icing, but still can be affected if the engine's air source becomes blocked with ice. Manufacturers provide an alternate air source that may be selected in case the normal system malfunctions.*

2) *In turbine-engine-powered aircraft, air that is drawn into the engines creates an area of reduced pressure at the inlet, which lowers the temperature below that of the surrounding air. In marginal icing conditions (i.e., conditions where icing is possible), this reduction in temperature may be sufficient to cause ice to form on the engine inlet, disrupting the airflow into the engine. Another hazard occurs when ice breaks off and is ingested into a running engine, which can cause damage to fan blades, engine compressor stall, or combustor flameout. When anti-icing systems are used, runback water also can refreeze on unprotected surfaces of the inlet and, if excessive, reduce airflow into the engine or distort the airflow pattern in such a manner as to cause compressor or fan blades to vibrate, possibly damaging the engine. Another problem in turbine engines is ice, particularly snow and ice crystals accumulating on the engine probes used to set power levels (e.g., engine inlet temperature or Engine Pressure Ratio (EPR) probes), which can lead to erroneous readings of engine instrumentation (e.g., Air Florida B-737 accident National Transportation Safety Board (NTSB) accident report NTSB/AAR-82-08).*

3) *Ice also may accumulate on both the engine inlet section and on the first or second stage of the engine's low-pressure compressor stages. This normally is not a concern with pitot-style engine airflow inlets (i.e., straight-line-of-sight inlet design).*

However, on turboprop engines that include an inlet section with sharp turns, ice can accumulate in the aerodynamic stagnation points at the bends in the inlet duct. If ice does accumulate in these areas, it can shed into the engine, possibly resulting in engine operational difficulties or total power loss. Therefore, with these types of engine configurations, the use of anti-icing or de-icing systems per the Aircraft Flight Manual (AFM) is very important. Supercooled water drops tend to form ice on the turbine engine inlet, fan, and first few stages of the compressor. Ice crystals, when present in high concentrations, tend to form ice deeper in the turbine engine's compressor section. Ice accretions can ultimately shed and damage the compressor or cause engine surge or flameout. These conditions are analyzed and tested during original engine airworthiness approvals. These tests are conducted to demonstrate the turbine engine's tolerance to these conditions.

1.18.2 Icing and cloud types:

Basically, all clouds at subfreezing temperatures have icing potential. However, drop size, drop distribution, and aerodynamic effects of the aircraft influence ice formation. Ice may not form even though the potential exists. The condition most favourable for very hazardous icing is the presence of many large, supercooled water drops. Conversely, an equal or lesser number of smaller droplets favours a slower rate of icing. Small water droplets occur most often in fog and low-level clouds. Drizzle or very light rain is evidence of the presence of small drops in such clouds; but in many cases there is no precipitation at all. The most common type of icing found in lower-level stratus clouds is rime. On the other hand, thick extensive stratified clouds that produce continuous rain such as altostratus and nimbostratus usually have an abundance of liquid water because of the relatively larger drop size and number. Such cloud systems in winter may cover thousands of square miles and present very serious icing conditions for protracted flights. Particularly in thick stratified clouds, concentrations of liquid water normally are greater with warmer temperatures. Thus, heaviest icing usually will be found at or slightly above the freezing level where temperature is never more than a few degrees below freezing.

In layer type clouds, continuous icing conditions are rarely found to be more than 5,000 feet above the freezing level, and usually are two or three thousand feet thick. The upward currents in cumuliform clouds are favourable for the formation and support of many large water drops. The size of raindrops and rainfall intensity normally experienced from showers and thunderstorms confirm this. When an aircraft enters the heavy water, concentrations found in cumuliform clouds, the large drops break and spread rapidly over the leading edge of the air foil forming a film of water. If temperatures are freezing or colder, the water freezes quickly to form a solid sheet of clear ice. Pilots usually avoid cumuliform clouds when possible. Consequently, icing reports from such clouds are rare and do not indicate the frequency with which it can occur. The updrafts in cumuliform clouds carry large amounts of liquid water far above the freezing level. On rare occasions icing has been encountered in thunderstorm clouds at altitudes of 30,000 to 40,000 feet where the free air temperature was colder than minus 40° C. While an upper limit of critical icing potential

cannot be specified in cumuliform clouds, the cellular distribution of such clouds usually limits the horizontal extent of icing conditions. An exception, of course, may be found in a protracted fight through a broad zone of thunderstorms or heavy showers.

1.18.3 Air induction system: (Source – Engine Service Manual).

Induction air enters the sytem through a ram air duct located on the inboard duct of each nacelle and is directed through a filter mounted to the turbo-charger compressor air inlet. A magnetically controlled alternate air door incoperated in the airfilter permits compresor suction to open the door and admits alternate air if the air induction system becomes obstructed. A manually controlled alternate air door within the nacelle permits the pilot to open it to admit alternate (heated engine compartment air) if the air induction system should become obstructed. An exhaust driven turbocharger is automatically controlled by controllers to maintain a manifild pressure at 39.5 inches Hg, from sea level to acritical altitude (16.000ft) regardless of temperature. The turbocahrger is completely automatic requiring no pilot action to critical altitudes.

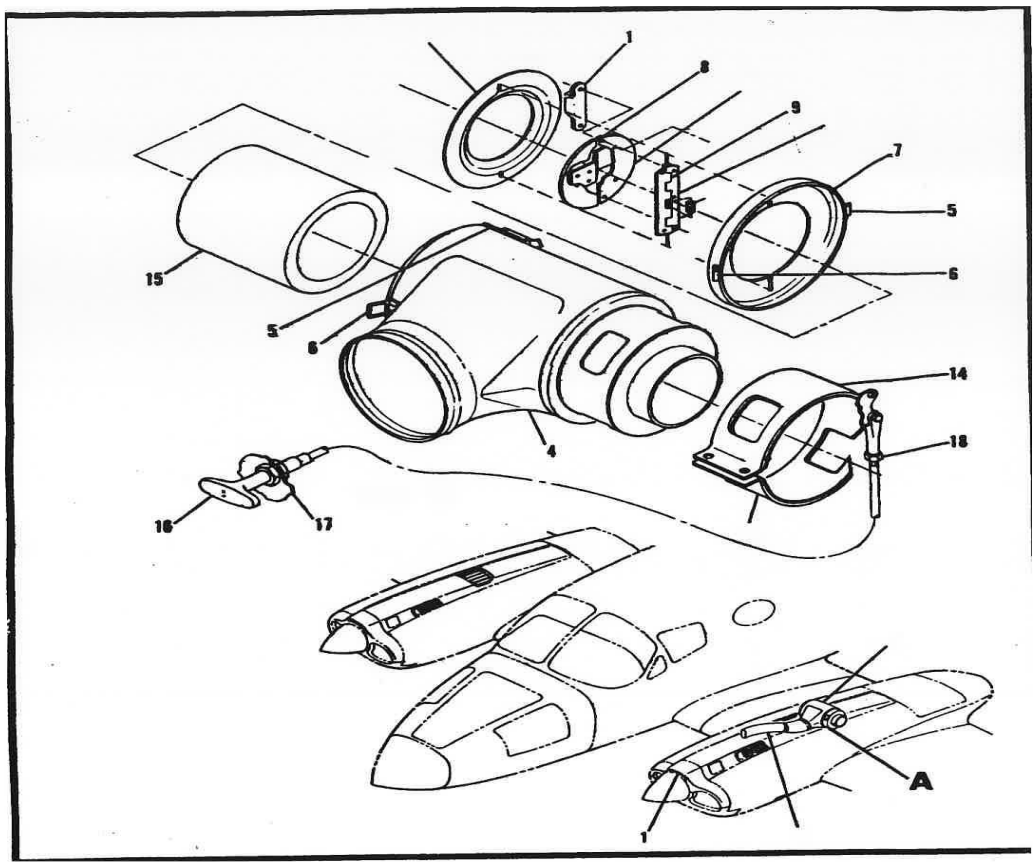

Figure 17: Turbocharger induction air components. (Source: Engine Service Manual).

1.18.3 Air inlet (induction) or filter and cold (external) alternate air inlet icing: Source – AFM

1. *Alternate Air Controls – PULL OUT*
2. *Propellers – INCREASE (Avoid continuos operation in the yellow arch)*
3. *Mixture – LEAN as required*
4. *"Pressurised Air" Control – PULL TO DUMP (LH and/ or RH as appropriate)*
    a) *Above 10000ft. with both air sources dumped*
        1) *If supplemenray oxygen is not available – EMERGENCY DESCENT to 10000ft*
        2) *If supplementay oxygen is available:*
            (a) *Oxygen Knob – PULL on*
            (b) *Assure each passenger is using oxygen*
            (c) *Descent as soon as practical to 10 000ft*

1.19 Useful or Effective Investigation Techniques

1.19.1 To be discussed in the final report.

2. Findings

2.1 General:

From the available evidence, the following preliminary findings were made with respect to this accident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions heading:

- **Findings —** are statements of all significant conditions, events or circumstances in this accident. The findings are significant steps in this accident sequence, but they are not always causal or indicate deficiencies.

2.1.1 The flight was conducted IAW the provisions of Part 91 of the South African Civil Aviation Regulations 2011 as amended.

2.1.2 The aircraft had about 482 litres (127 US gallons) of fuel remaining; therefore, was sufficient for the flight to FAGM.

2.1.3 The aircraft was issued a Certificate of Airworthines on 20 December 2017 with an expiry date of 31 March 2022.

2.1.4 The aircraft was issued a Certificate of Registration on 12 December 2016.

2.1.5 A review of the weather report specified icing conditions between 8 000 to 12 000ft around the time of the accident as well as the intended route of flight. The weather had a bearing to the accident.

2.1.6 The pilot was a British citizen with a valid UKCAA issued ATPL and a Class 1 aviation medical certificate issued on 13 April 2018 with an expiry date of 30 April 2019. The pilot's latest aviation medical certificate was issued by the SACAA on 17 November 2021 with an expiry date of 30 November 2022 and with no restrictions.

2.1.7 The SACAA form number CA61.01.13b dated 21 January 2019 indicated that there was consensus between the SACAA and the pilot that the pilot's ATPL be frozen, and that it be converted to a Commercial Pilot Licence (CPL).

2.1.8 The SACAA form number CA61-11.4 dated 25 July 2019 indicated that the pilot was then revalidated to a CPL at FALA.

2.1.9 The SACAA statement of examination results dated 6 August 2019 indicated that the pilot had passed the air law, meteorology, flight performance and planning procedures on 18 July 2019. Another statement of examination results dated 6 August 2019 indicated that the pilot completed the instruments rating on 24 July 2019. The pilot had an endorsement of single and multi-engines aircraft on his licence, including a Cessna 421C model aircraft.

2.1.10 Examination of the aircraft's technical records indicated that the aircraft was properly certified and maintained IAW the SACAA regulations and approved procedures. There were no open or differed maintenance items listed in the aircraft flight folio before the accident flight.

2.1.11 The last 200-hour MPI on the aircraft was completed on 17 February 2021 at 7092.10 airframe hours. The aircraft was maintained by a Regulator-approved AMO. The AMO approval certificate was issued by the Regulator on 6 March 2021 with an expiry date of 28 February 2022.

2.1.12 Neither of the propellers was feathered.

2.2 On-going Investigation

2.2.1 The investigation is on-going and the investigators will look into other aspects of this occurrence which may or may not have safety implications.

This Report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa