Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

# Investigation Report

## Identification

| | |
|---|---|
| Kind of Occurrence: | Accident |
| Date: | 10 June 2024 |
| Location: | Nthungwa Forest, Nkhata Bay (Republic of Malawi) |
| Type of Aircraft: | Airplane |
| Manufacturer: | General Atomics AeroTec Systems |
| Type: | Dornier 228-202(K) |
| Injuries to Persons: | 3 crew members and 6 passengers were fatally injured |
| Damage to Aircraft: | Aircraft destroyed |
| Other Damage: | Vegetation damage |
| State File Number: | BFU24-0508-DX |

This investigation was conducted in accordance with the regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FlUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

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# Glossary of Abbreviations

| | | |
|---|---|---|
| AD | Airworthiness Directive | Lufttüchtigkeitsanweisung |
| AFM | Airplane Flight Manual | Flughandbuch |
| AGL | Above Ground Level | über Grund |
| AIP | Aeronautical Information Publication | Luftfahrthandbuch |
| AMSL | Above Mean Sea Level | über dem mittleren Meeresspiegel |
| ANSP | Air Navigation Service Provider | Flugsicherungsorganisation |
| AP | Autopilot | automatische Flugregelungs- und Steueranlage |
| ATC | Air Traffic Control | Flugverkehrskontrolle |
| ATIS | Automatic Terminal Information Service | Automatische Ausstrahlung von Lande- und Startinformationen |
| BFU | German Federal Bureau of Aircraft Accident Investigation | Bundesstelle für Flugunfalluntersuchung |
| CAS | Calibrated Airspeed | Kalibrierte Fluggeschwindigkeit |
| CAVOK | Ceiling And Visibility OK (for VFR flights) | Bewölkung und Sichtweiten in Ordnung (für Flüge nach VFR) |
| COP | Co-Pilot | Copilot |
| CPL | Commercial Pilot Licence | Berufspilotenlizenz |
| CRM | Crew Resource Management | |
| CTR | Control Zone | Kontrollzone |
| CVR | Cockpit Voice Recorder | |
| DFDR | Digital Flight Data Recorder | Digitaler Flugdatenschreiber |
| DME | Distance Measuring Equipment | Entfernungsmessgerät |
| EGPWS | Enhanced GPWS | |
| EGT | Exhaust Gas Temperature | Abgastemperatur |
| ELEV | Elevation | Ortshöhe über dem Meer |
| ETA | Estimated Time of Arrival | Voraussichtliche Ankunftszeit |
| ETD | Estimated Time of Departure | Voraussichtliche Abflugzeit |
| FAF | Final Approach Fix | Endanflugpunkt |
| FDR | Flight Data Recorder | Flugdatenschreiber |
| FI | Flight Instructor | Fluglehrer |

| | | |
|---|---|---|
| FIR | Flight Information Region | Fluginformationsgebiet |
| FIS | Flight Information Service | Fluginformationsdienst |
| FL | Flight Level | Flugfläche |
| FMS | Flight Management System | |
| ft | Feet | Fuß (1 Fuß = 0,3048 m) |
| ft/min | Feet per minute | Fuß pro Minute |
| g | acceleration due to Earth's gravity (9,81 m/s²) | Beschleunigung durch die Erdanziehungskraft (9,81 m/s²) |
| GA | General Aviation | Allgemeine Luftfahrt |
| GND | Ground | Grund |
| GPS | Global Positioning System | |
| GPWS | Ground Proximity Warning System | |
| GS | Ground Speed | Geschwindigkeit über Grund |
| HDG | Heading | Steuerkurs |
| | | |
| IAF | Initial Approach Fix | Anfangsanflugpunkt |
| IAS | Indicated Airspeed | Angezeigte Fluggeschwindigkeit |
| ICAO | International Civil Aviation Organisation | Internationale zivile Luftfahrtorganisation |
| IFR | Instrument Flight Rules | Instrumentenflugregeln |
| ILS | Instrument Landing System | |
| IMC | Instrument Meteorological Conditions | Instrumentenwetterbedingungen |
| IR | Instrument Rating | Instrumentenflugberechtigung |
| KCAS | Knots Calibrated Airspeed | |
| KIAS | Knots Indicated Airspeed | |
| KTAS | Knots True Airspeed | |
| kt | knot(s) | Knoten (1 kt = 1,852 km/h) |
| LDA | Landing Distance Available | Verfügbare Landestrecke |
| LDR | Landing Distance Required | Benötigte Landestrecke |
| LM | Landing Mass | Landemasse |
| LOC (or LLZ) | Localizer | Landekurssender |
| LPC | Licence Proficiency Check | |
| MAF | Malawi Air Force | |
| MAP | Missed Approach Procedure | Fehlanflugverfahren |

| | | |
|---|---|---|
| METAR | Aviation Routine Weather Report | Routine Wettermeldung für die Luftfahrt |
| MCC | Multi Crew Coordination | |
| MDA | Minimum Descent Altitude | Sinkflugmindesthöhe |
| ME | Multi Engine | |
| MLM | Maximum Landing Mass | Maximale Landemasse |
| MN | Magnetic North | Magnetisch Nord |
| MSA | Minimum Sector Altitude | Mindestsektorenhöhe über MSL |
| MSL | Mean Sea Level | Mittlerer Meeresspiegel |
| MTOM | Maximum T/O Mass | Maximale Startmasse |
| NDB | Non-Directional radio Beacon | |
| NM | Nautical Mile(s) | Nautische Meile(n) |
| $N_P$ | Propeller Speed | Propellerdrehzahl |
| $N_1$ | engine fan or LP compressor speed | |
| NOTAM | Notice to Airmen | Ergänzende Informationen zur AIP |
| OAT | Outside Air Temperature | |
| OCA/H | Obstacle Clearance Altitude / Height | Hindernisfreiheit über Meeresspiegel / Flugplatz bzw. Schwelle |
| OFP | Operational Flight Plan | Flugdurchführungsplan |
| OM | Operations Manual | Betriebshandbuch |
| OPC | Operator Proficiency Check | |
| PF | Pilot Flying | Pilot, der das Flugzeug steuert |
| PFD | Primary Flight Display | |
| P/F Check | Preflight Check | Vorflugkontrolle |
| PIC | Pilot in Command | Verantwortlicher Luftfahrzeugführer |
| PL | Power Lever | Leistungshebel |
| PNF | Pilot non Flying | Pilot, der den PF unterstützt |
| POH | Pilot’s Operating Handbook | |
| psi | pounds per square inch | (14,5 psi = 1 bar) |
| QFE | altimeter pressure setting to indicate height above aerodrome | |
| QNH | altimeter pressure setting to indicate altitude AMSL | Luftdruck in Meereshöhe |

| | | |
|---|---|---|
| rpm | revolutions per minute | Umdrehungen pro Minute |
| RWY | Runway | Piste |
| SAR | Search and Rescue | |
| SARPS | Standards and recommended Practices | |
| SB | Service Bulletin | |
| SID | Standard Instrument Departure Route | Standard-Instrumentenabflug |
| SIGMET | Information concerning en-route weather phenomena which may affect the safety of aircraft operations | Informationen bezüglich Wettererscheinungen auf der Flugstrecke, welche die Sicherheit des Flugbetriebs beeinträchtigen können |
| SOP | Standard Operating Procedure | Standard-Betriebsverfahren |
| SSR | Secondary Surveillance Radar | |
| TAS | True Airspeed | Wahre Fluggeschwindigkeit |
| TAT | Total Aircraft Time | Gesamtflugzeit des Luftfahrzeugs |
| TAWS | Terrain Awareness and Warning System | |
| T/D | Touch Down | Aufsetzen, Landung |
| T/O | Take-Off | Start, Abheben |
| TODA | T/O Distance Available | |
| TOM | Take-Off Mass | Startmasse |
| TR | Type Rating | Musterberechtigung |
| TRI | Type Rating Instructor | Ausbilder für Musterberechtigungen |
| TRE | Type Rating Examiner | Prüfer für Musterberechtigungen |
| USG | US gallons | (1 USG = 3,79 l) |
| UTC | Universal Time Coordinated | |
| VASI | Visual Approach Slope Indicator | |
| $V_{APP}$ | Approach Speed | Anfluggeschwindigkeit |
| $V_{CAS}$ | Calibrated Air Speed | |
| $V_{NE}$ | Never exceed Airspeed | |
| $V_R$ | Rotation Speed | Rotationsgeschwindigkeit |
| $V_{REF}$ | Approach Reference Speed | |

| | | |
|---|---|---|
| VS | Vertical Speed | Steig-/Sinkgeschwindigkeit |
| $V_{TGT}$ | Target Speed | Zielgeschwindigkeit im Landeanflug |
| $V_1$ | T/O Decision Speed | |
| $V_2$ | T/O Safety Speed | |
| VFR | Visual Flight Rules | Sichtflugregeln |
| VHF | Very High Frequency | Ultra Kurz Welle |
| VMC | Visual Meteorological Conditions | Sichtflugwetterbedingungen |
| VOR | VHF Omnidirectional radio Range | |

# Synopsis

During a domestic passenger flight of the Dornier 228-202(K) military aircraft from Lilongwe-Kamuzu to Mzuzu (Malawi), the aircraft impacted the slope of a hill in marginal visual meteorological conditions (VMC).

At the request of the Government of the Republic of Malawi to the Federal Republic of Germany, the BFU sent an investigation team to Malawi, assisted by an expert from the aircraft manufacturer. The Republic of Malawi delegated the direction of the investigation, conducted on the basis of ICAO Annex 13, to the BFU and appointed an Accredited Representative and 2 Advisers for the investigation.

The accident occurred because the crew flew into instrument meteorological conditions (IMC) during flight under visual flight rules (VFR) and the aircraft collided with the ascending terrain.

The following contributed to the accident:

- the decision to continue the flight to the destination at low level in marginal weather conditions,
- lack of situational awareness, and
- inadequate flight preparation.

In the course of the investigation, the BFU issued 6 safety recommendations. One safety recommendation was addressed to the Minister of Defence of the Republic of Malawi, one to the Minister of Transport and Public Works, 2 safety recommendations were addressed to the Director General of the Civil Aviation Authority and 2 to the Commander of the Malawi Air Force.

# 1. Factual Information

## 1.1 History of the Flight

According to the Flight Information Officer of Mzuzu Airport, the flight crew arrived at the airport at 0600 hrs[1]. The plan was to fly to Lilongwe-Kamuzu, pick up the Vice-president of the Republic of Malawi and 5 other passengers and bring them to Mzuzu.

The GPS data showed that at 0704 hrs, the airplane took off from runway 35 and one minute later during climb, it turned towards the south (Fig. 1, flight path in purple).

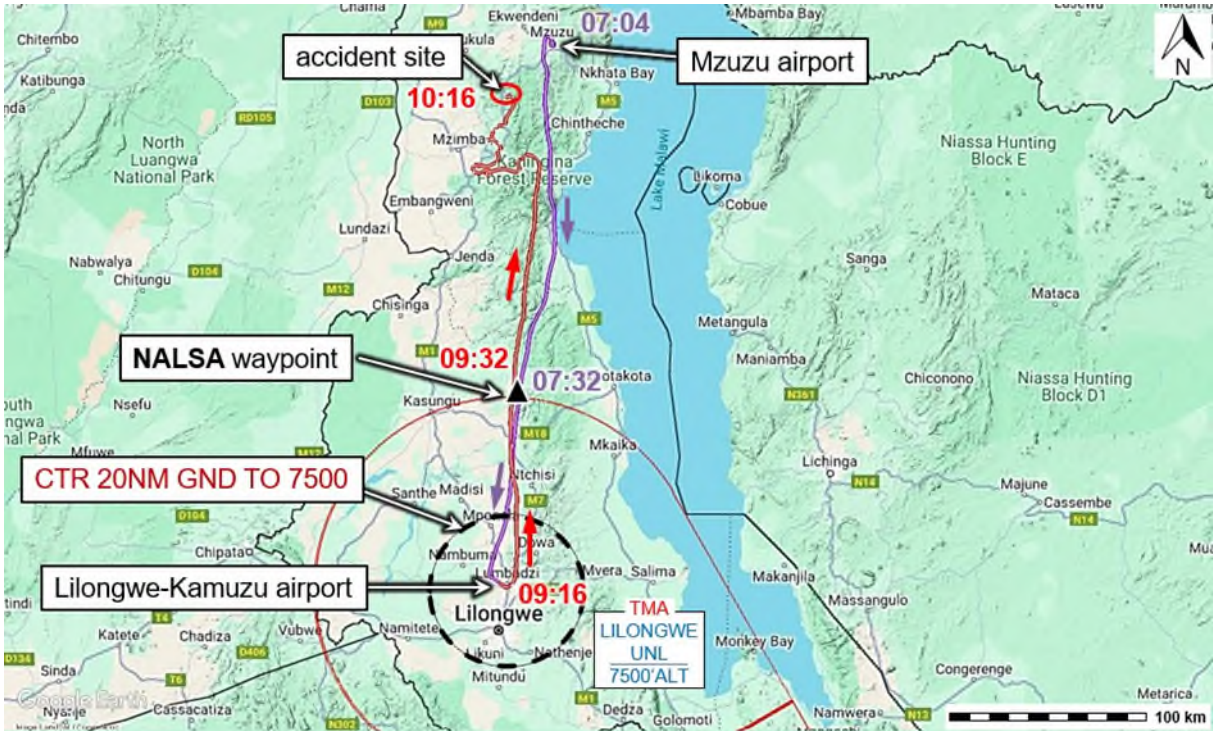



Fig. 1: Flight path of both flights on the day of the accident, according to the GPS recording

Google Earth™, Maps Services, adaptation BFU

According to the controller at Lilongwe-Kamuzu Airport, he received a telephone call from the Flight Information Officer at Mzuzu Airport shortly after take-off that the airplane will probably arrive at waypoint NALSA at 0731 hrs and estimated landing time at Lilongwe-Kamuzu Airport was 0748 hrs. At 0728 hrs, at Flight Level (FL) 100, the flight crew reported on Lilongwe Approach frequency with 3 crew members on board and fuel for a flight time of 02:30 hours, according to the controller's statement. They

[1] All times local, unless otherwise stated (UTC +2h)

transmitted their arrival at waypoint NALSA for 0732 hrs and their estimated landing time at 0748 hrs. The controller issued the clearances for a direct flight to the Non-Directional Beacon (NDB) KG and an ILS approach to runway 14 and communicated the weather information. At 0750 hrs, the airplane turned into the final approach of runway 14, landed 2 minutes later and taxied to parking position 5. The airplane was refuelled for the flight to Mzuzu and the later planned return flight.

According to the air navigation service provider, the co-pilot had filed an IFR flight plan for the flight to Mzuzu with the Crew Briefing Office of Lilongwe-Kamuzu Airport. In the flight plan, she had given an estimated flight time to the arrival aerodrome of 00:50 hrs, an endurance of 04:00 hrs and the alternate airports Zomba and Blantyre-Chileka. In response to the Aeronautical Information Officer's question as to why the co-pilot filed 'direct' instead of route W601 (Fig. 5) and wanted to fly at a lower altitude, she replied that they experienced bad weather on the flight to Lilongwe and therefore changed their minds. The report of the Malawi Commission of Inquiry showed that the crew did not obtain weather briefing for the route or the destination aerodrome from the Meteorological Office before departure. The crew had, however, telephoned the FIS officer in Mzuzu to inquire about the weather there. At that time, the visibility there was more than 8 km.[2]

At 0905 hrs the co-pilot reported via radio, requested departure information and 3 min later the engine start-up clearance. The tower controller also informed them about the weather conditions prevailing at the departure airport.

According to the controller, at 0912 hrs, he had given the crew a clearance for a direct flight to Mzuzu in FL90 as well as the departure clearance and the transponder code 2772. The plane took off at 0916 hrs with 3 crew members and 6 passengers on board on runway 14 (Fig. 1 flight path in red). The controller stated that the aircraft's radar target appeared on the monitor when it reached an altitude of about 4,800 ft AMSL. At 0917 hrs, in climb, the aircraft began a left turn, two minutes later the turn was ended in a northerly direction.

According to the controller, the flight crew received the climb clearance to FL90. Later, the flight crew requested to maintain 7,000 ft AMSL. The GPS data showed that at about 0923 hrs, the airplane reached a cruise level of about 7,300 ft (GPS altitude). About one minute later, it passed the border of the airport control zone.

[2] Commission of Inquiry into the Aircraft Accident, Chapter 2.1.5 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

The flight crew informed the controller that they would reach reporting point NALSA at 0932 hrs and the destination at approximately 1005 hrs. The controller passed on this information by phone to the Flight Information Officer at Mzuzu Airport. At 0930 hrs, the controller cleared the flight crew to change to Mzuzu tower frequency 118.1 MHz. According to his statement, due to the low altitude, there was no radar contact at the time.

According to the GPS data, the airplane was flying north and at 0932 hrs, it was 3 NM west of waypoint NALSA at about 7,500 ft. At 0937 hrs, it began to climb and within 3 min it reached about 8,600 ft. At 0944 hrs, the airplane entered descent. At 0950 hrs, at about 1.5 NM north-west of the village Fumbawowa, it began to deviate from the direct course to the destination airport by entering a left-hand turn (Fig. 2 and GPS altitudes in Appendix 1).

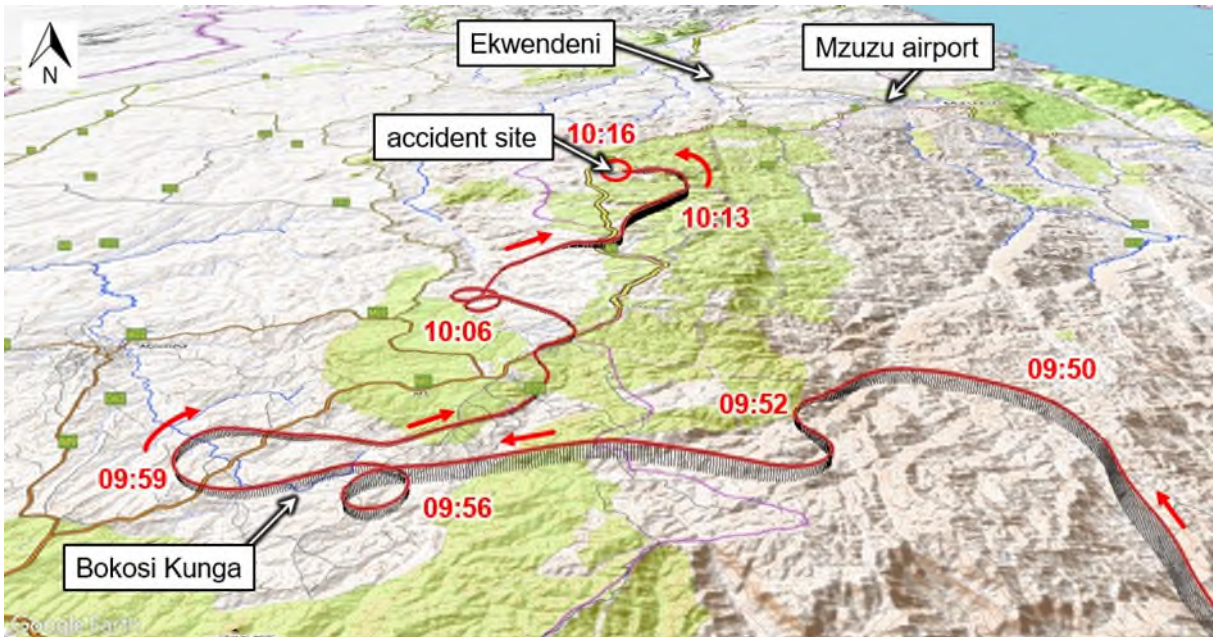



Fig. 2: Flight path according to GPS data between 0950 hrs and 1016 hrs

Source: Google Earth™, Maps Services, adaptation BFU

At 0952 hrs, during the left-hand turn, at about 5,500 ft, the airplane began to climb again. With a track of about 150°, the left-hand turn ended and the airplane turned right in a western direction and at 0955 hrs reached 8,100 ft, then began to descend again. With a track of about 150°, the left-hand turn ended and the airplane turned right in a western direction and at 0955 hrs reached 8,100 ft, then began to descent again. At 0956 hrs, the aircraft flew a full left turn, continued in a south-western direction and at

0958 hrs, it passed the settlement Bokosi Kunga. One minute later, it began to turn right and within one minute reached an eastern heading, then turned to a north-eastern heading. The altitude decreased to about 5,400 ft (about 460 ft AGL). Approximately 2 NM south of a wood industry plant, the airplane turned left in climb to the north. Between 1006 hrs and 1009 hrs, about 3 NM north-west of Chikangawa, the aircraft flew 2 full left turns with a radius of about 600 m in 200 ft to 500 ft AGL.

From 1009 hrs onwards, the airplane continued the flight with various headings in a north-eastern direction, descended to 185 ft AGL and then began to climb again. At 1012 hrs, it was about 25 NM south-west of Mzuzu Airport at about 7,000 ft (about 1,500 ft AGL). Two minutes later, it reached about 2,200 ft AGL. Then, it turned in a northern direction and descended again. At 1015 hrs, the airplane turned left in a north-western direction. Finally, it had a track of about 284° and at 1016 hrs, it impacted the ground in Nthungwa Forest, Nkhata Bay.

All 9 occupants suffered fatal injuries and the airplane was destroyed. After a search of one day, the accident site was found.

The Flight Information Officer at Mzuzu Airport stated that bad weather prevailed at the airport and the conditions continued to deteriorate. Since the flight crew had not contacted Mzuzu until 0950 hrs, he had called them by radio. Five minutes later, he had tried again. Both attempts failed. At 1005 hrs, he had called Lilongwe Area Control Centre to have the estimated arrival time of the airplane confirmed again.

At 1012 hrs, the flight crew had called on the Mzuzu Tower frequency and informed him that they were 20 NM away and intended an approach from the north. The Flight Information Officer transmitted the weather information and that runway 17 was in use. He also informed them about his observation that east, south and west of the airport visibility was about 5 km. The flight crew had wanted to fly towards Ekwendeni to see if the weather conditions were better there. At 1017 hrs, he had contacted the flight crew by radio to find out about their altitude, but as with later attempts he did not receive any answer.

## 1.2 Injuries to Persons

| Injuries | Crew | Passengers | Total on A/C | Others |
|---|---|---|---|---|
| Fatal | 3 | 6 | 9 | |
| Serious | | | | |
| Minor | | | | NN |
| None | | | | NN |
| Total | 3 | 6 | 9 | |

Tab. 1: Injuries to persons Source: BFU

## 1.3 Damage to Aircraft

The aircraft was destroyed.

## 1.4 Other Damage

In the area of the accident, vegetation damage occurred.

## 1.5 Personnel Information

### 1.5.1 Pilot-in-command

The 54-year-old pilot-in-command (PIC) held a commercial pilot license issued by the Civil Aviation Authority of the Republic of South Africa and a license for military pilots of the Malawi Air Force. The pilot was qualified as a PIC and as a flight instructor on the type Do228. He also had a rating for the Xi'an M600. His military license included IFR check flights on the Do228 model in 1996, 1997, 2002, 2004, 2007, 2008, 2013, 2014, 2015, 2017 and latest in 2019. According to the report of the Malawi Commission, he had flown as a copilot on the Do228 between 1996 and the end of May 2008, since end of May 2008 as a PIC.[3]

As of 24 January 2024, an IFR check flight on the Xi'an M600 was documented in his license.

[3] Commission of Inquiry into the Aircraft Accident, Chapter 3.3 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

His total flight experience was 2,367 hrs, of which 2,006 hrs were on type. In the last 90 days, he had flown 24:10 hrs and in the last 24 hours 02:40 hrs.

The BFU had the copy of a medical certificate Class 1 of the pilot issued on 25.11.2020, valid until 25.02.2021. According to the section Limitations, the wearing of reading glasses and proteinuria (protein in the urine) were entered. The BFU had no up-to-date information on the pilot's medical fitness.

### 1.5.2 Co-pilot

The co-pilot was 44 years old and had a license for commercial pilots issued by the Civil Aviation Authority of the Republic of South Africa. According to the Malawi Air Force, she had a license for military pilots of the Malawi Air Force. The BFU did not receive a copy of this military pilot's license. Her military license included IFR check flights on the Do228 model in 2014, 2016 and 2017. The report by the Malawian Commission showed that after a two-year discontinuation - for personal reasons - she had been active again since the beginning of April 2024. Between 02.04.24 and 23.04.2024 she had undergone a recurrency training with the Malawi Air Force.[4] She completed her Recurrency Check Flight on 25.04.2024.

According to the Malawi Air Force, the pilot had a total flight experience of 722 hrs, including 472 hrs on type. In the last 90 days, she had completed 23:50 hrs, of which 02:40 hrs in the last 24 hrs.

The documents available showed that the co-pilot and the pilot-in-command had flown a total of 11:50 hrs together since 16 April 2024.

The BFU did not have an aero-medical certificate of the co-pilot.

In addition to her flying duties in the squadron, she also served as Air Base Safety Officer.

### 1.5.3 Engineer

The 43-year-old aircraft engineer was responsible for supporting the pilots in the technical preparation and post-processing of the flights. He held a diploma in Aircraft Engineering in the field of Aircraft Electrics since 2008. In 2010 he completed a Part 66 CAT B1 Line & Base Maintenance course for the aircraft type Do228.

[4] Commission of Inquiry into the Aircraft Accident, Chapter 3.3 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

# 1.6 Aircraft Information

## 1.6.1 General information

The Do228-202 series of model Do228 was certified in the normal category by the German Federal Aviation Office (LBA) on 6 August 1986. EASA's Type Certificate Data Sheet (TCDS) is based on LBA TCDS No. 2031B/SA (issue 11 dated 08.04.2005). The aircraft is approved for operation with a minimum flight crew of one pilot. It has a seating capacity of 2 pilot seats and 19 passenger seats.

The aircraft Do 228-202(K) (equipped with keel kit) is a twin-engine high-wing airplane in metal construction with a retractable landing gear in nose wheel configuration. It is powered by 2 turboprop engines (Fig. 3).

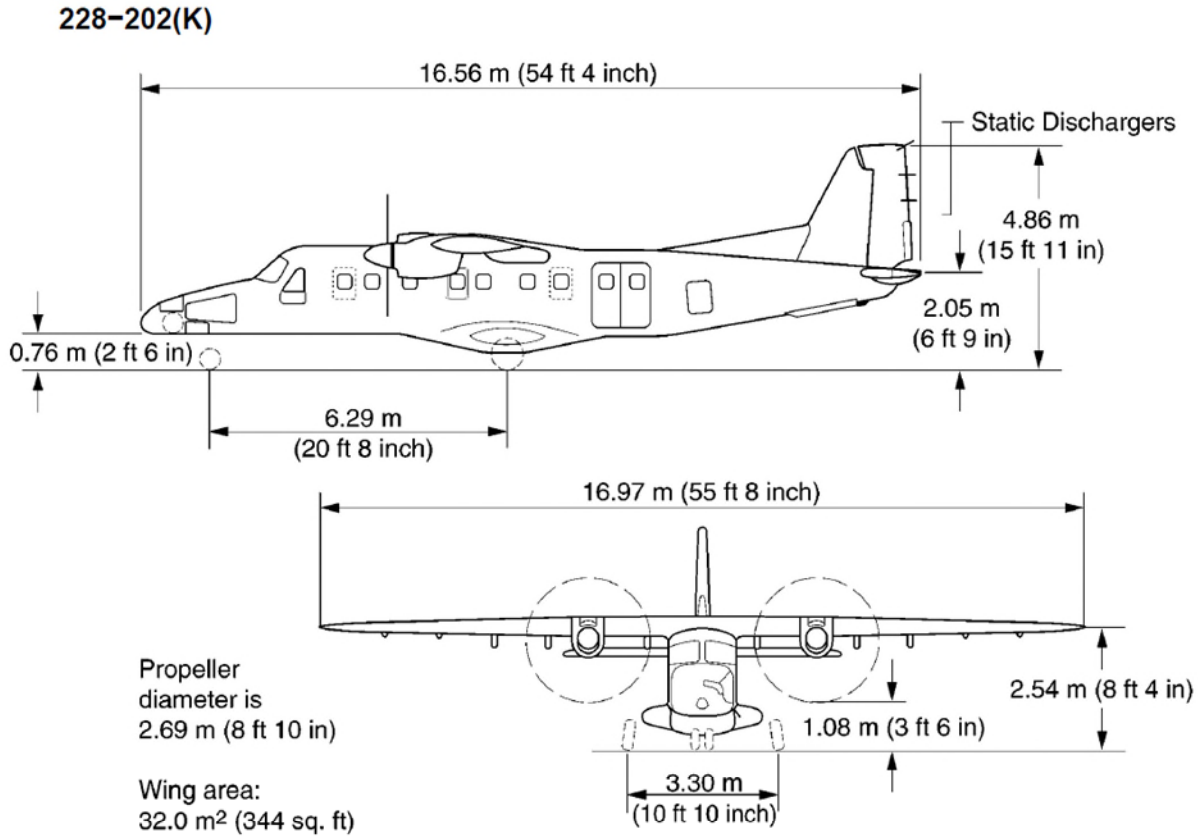



Fig. 3: Two-way view Do 228-202(K) Source: Manufacturer

Manufacturer: General Atomics AeroTec Systems

Sample: Do 228-202(K)

| | |
|---|---|
| Manufacturer's Serial Number: | 8148 |
| Year of manufacture: | 1987 |
| MTOM: | 6,200 kg |
| Engines: | Honeywell TPE 331-5 (s/n P-39183 and P-39171) |
| Propellers: | Hartzell HC-B4TN-5ML (s/n CDA4793 and CDA4794) |
| Total operating time: | 3,492:56 hours |

The aircraft was registered as a military aircraft by the Republic of Malawi and was operated by the Malawi Air Force.

The aircraft had a classic instrumentation in the cockpit and was equipped for IFR-flights. In addition, a 7" screen Garmin Aera 760 navigation system with serial number 6HD001128 was installed on 06.09.2022.

According to the testimonies of pilots and engineers of the squadron and the documentation of the maintenance actions, the aircraft was ready for use and had no technical complaints.

The provided fuel receipt showed that the airplane was refuelled with 483 l Jet A1 fuel at Lilongwe-Kamuzu Airport prior to departure to Mzuzu Airport.

### 1.6.2 Information in the Pilot's Operating Handbook

Airspeed limitations

The Pilot's Operating Handbook (POH), Section 2 Limitations, contained the following information, among others (Fig. 4):

| SPEED | KCAS | KIAS | REMARKS |
|---|---|---|---|
| Maximum Maneuvering Speed ($V_A$) | 146 | 147 | Do not make full or abrupt control movements above this speed. |
| Maximum Flaps Extended/Operating Speed ($V_{FE}/V_{FO}$) | | | Do not exceed this speed while operating the flaps or with flaps extended. |
| Flaps 1 | 149 | 150 | The Flaps DN position is only selectable in conjunction with the optionally installed trim coupling system. |
| Flaps 2 and DN | 129 | 130 | |
| Maximum Landing Gear Extended/Operating Speed ($V_{LE}/V_{LO}$) | 158 | 160 | Do not exceed this speed while operating the landing gear or with the landing gear extended. |

Fig. 4: Excerpt from the Pilot Operating Handbook, Section 2 Limitations Source: Manufacturer

According to POH, Section 4 Normal Procedures, the Best Rate of Climb Speed (Vy) was 120 KIAS and the Approach Speed (Vref) (Flaps 1) was 100 KIAS.

Annunciator system

The aircraft had an annunciator system consisting, among other things, of the Caution & Warning Panel mounted in the middle of the instrument panel and a Warning Horn (1,000 Hz sound).

According to the BEFORE STARTING ENGINE checklist, the function of the lamps of the Caution & Warning Panel and the warning tone had to be checked by pushing the LAMP TEST button on the Pedestal Panel between the pilot seats before each flight.

## 1.7 Meteorological Information

### 1.7.1 Weather conditions at the departure aerodrome

At 0900 hrs, the weather service at Lilongwe Kamuzu International Airport detected the following weather conditions:

| | |
|---|---|
| Wind: | 180°/ 15 kt |
| Visibility: | more than 10 km |
| Clouds: | 5-7 octas at 2,200 ft AGL, 5-7 octas at 9,000 ft AGL |
| Temperature: | 15 °C |
| Dewpoint: | 11 °C |

| | |
|---|---|
| QNH: | 1,029 hPa |

### 1.7.2 Weather conditions at the destination aerodrome

According to the written records of the weather service at Mzuzu Airport, the following weather conditions prevailed at 1000 hrs:

| | |
|---|---|
| Wind: | 150°/ 6 kt |
| Visibility: | Less than 8 km |
| Clouds: | 3-4 octas at 600 ft, 5-7 octas at 1,500 ft and 8 octas at 7,000 ft AGL |
| Precipitation: | drizzle, in the vicinity of the airport fog |
| Temperature: | 15 °C |
| Dewpoint: | 15 °C |
| QNH: | 1,026 hPa |

Sunrise in Mzuzu on the day of the accident was at 0559 hrs.

### 1.7.3 Weather conditions in the area of the accident site

According to the CAA of Malawi, the Rules of the Air and Air Traffic Control, 1970, Regulation 20 and 21 stipulated that a pilot-in-command had to familiarize with the weather reports for the departure aerodrome, the route and the destination aerodrome.

As part of the investigation, the BFU asked for information on the weather forecasts and documented weather conditions on the route produced by the Malawi Meteorological Service for the relevant period. Malawi's Civil Aviation Authority stated that the Department of Meteorological Services did not provide meteorological data for the en-route phase, as only information from aerodrome meteorological stations would be used. Therefore, crews in the Meteorological Briefing Office would only receive weather information about the departure and destination aerodromes.

Information in the report of the Malawi Commission of Inquiry

According to the investigation report of the Malawi Commission of Inquiry Chapter 2.1.5, several witnesses travelling by car from Lilongwe to Mzuzu stated that on the day of the accident there was ‘very bad weather and low visibility’ between Mzimba and Mzuzu. Witnesses from the radio communication mast about 500 m west of the

accident site and from a watchtower of the Department of Forestry reported very poor visibility, strong winds and rain.[5]

Official meteorological information of the German Meteorological Service

The BFU asked the German Meteorological Service (DWD) for official meteorological information on the weather conditions prevailing on the route and especially in the area of the accident site.

> *The German Meteorological Service (DWD) has ground weather reports for Malawi in its archives of 10.06.2024, exclusively for the time 0600 UTC as well as the hourly METAR reports of the Lilongwe-Kamuzu Airport (FWKI), from which information on visibility, cloudiness and ground wind emerge. In addition, there are high-resolution satellite images of the visible channel with a temporal resolution of 15 minutes, which allow conclusions to be drawn about the cloud cover.[6] Finally, it was checked whether there were flash messages from the global Vaisala measuring network about Malawi. In the morning of 10.06.2024 no lightning was detected over Malawi.*
>
> *Due to this limited data, the DWD is not in a position to make more precise statements about the meteorological conditions in the area of the accident site.*
>
> *The BFU has provided the German Weather Service with the recording of the flight path [...] from the day of the accident. For better illustration, the flight history, the state borders and Lake Malawi were displayed in the meteorological maps. In addition, the BFU already has METAR data from FWKI and FWUU, which it has provided to the DWD.*

## 1.8 Aids to Navigation

The Department of Civil Aviation Malawi provided the BFU with the Aeronautical Information Publication (AIP) of the Republic of Malawi, issue 21 July 2017, for the investigation. According to the Department of Civil Aviation, this was the AIP issue valid at the time of the accident.

The AIP Part 1 General (GEN), Chapter 1.7 Differences from ICAO Standards, recommended Practices and Procedures listed the deviations from ICAO rules applicable in

[5] Commission of Inquiry into the Aircraft Accident, Chapter 2.1.5 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025
[6] Appendices 3 and 4 to the investigation report

Malawi. Deviating from the standards and recommended practices of ICAO Annex 4 Aeronautical Charts, neither Visual Approach Charts-ICAO nor the Aeronautical Chart ICAO 1:500 000 were published for Malawi.

### 1.8.1 Airspace structure in Malawi

According to the Ministry for Transport and Public Works, the Republic of Malawi had 2 major international airports: Lilongwe-Kamuzu International Airport and Blantyre-Chileka International Airport. Four more airfields were equipped with a paved runway. These airfields also included the one in Mzuzu. In addition, there were 26 airfields with unpaved runways in Malawi.

The Flight Information Region (FIR) Lilongwe was structured as follows: The two international airports were each surrounded by a control zone (CTR) with a radius of 20 NM. These control zones extended from the ground up to 7,500 ft AMSL. Above the CTR, the Terminal Manoeuvring Areas (TMA) Lilongwe and Chileka, respectively, extended. The Control Area (CTA) Lilongwe was between FL145 and unlimited altitudes. Mzuzu Airport was located north of the CTA Lilongwe border (Fig. 5). Radar coverage by air traffic control existed in both CTR, in both TMA and in the upper airspace.

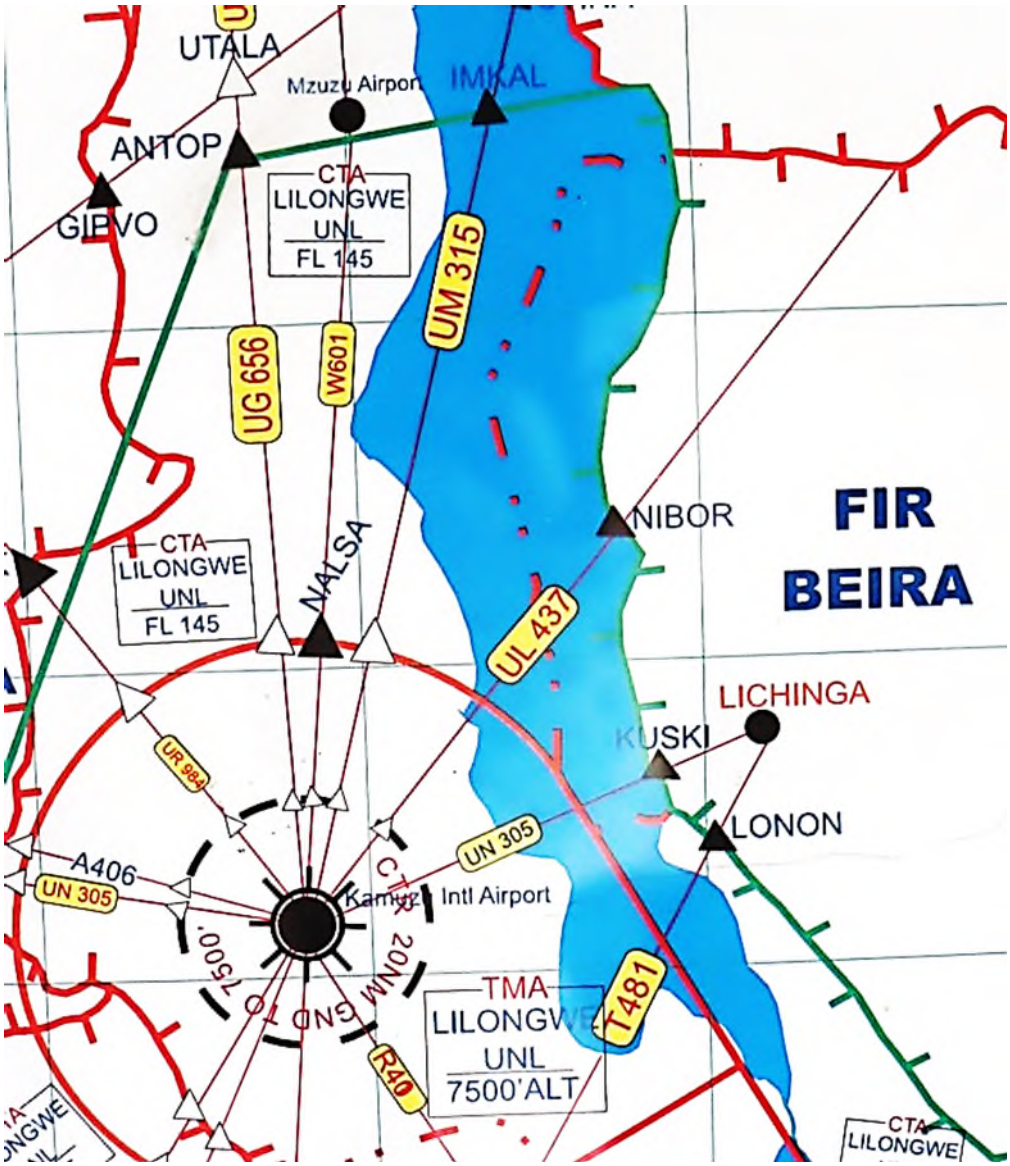



Fig. 5: Excerpt Malawi airspace with the airport of departure and destination Source: DCA Malawi

In Chapter 1.2 Visual Flight Rules of the AIP Part 2 Enroute (ENR), the weather minima for VFR flights were specified.

For VFR flights in Class G airspace the following was stipulated:

> *[...]*
>
> *"...above 3,000 ft AMSL or above 1,000 ft above terrain whichever is the higher: Clear of clouds and in sight of the surface, flight visibility 5 km. When so prescribed by the appropriate ATS authority:*

*a) lower flight visibilities to 1,500 m may be allowed for flights operating:*

*1. At speeds that, in the prevailing visibility, will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision; or*

*2. in circumstances in which the probability of encounters with other traffic would normally be low, e.g. in areas of low volume traffic and for aerial work at low levels.*

*b) HELICOPTERS may be permitted to operate in less than 1,500 m flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision.*

*[...]*

The Chapter „ENR 4 Radio Navigation Aids/Systems" Sub-chapter "ENR 4.1" of the AIP Part 2 Enroute (ENR) listed radio navigation means including their coordinates, frequencies, range etc. In this chapter, the VOR/DME VMZ north-west of Mzuzu Airport with a range of 100 NM and the NDB UU (range 50 NM) were listed, among others. According to the Flight Information Officer at Mzuzu Airport, the VOR/DME and the NDB have not existed for at least 15 years. However, the NDB KG located 3.9 NM north-west of Lilongwe Airport was missing in this list.

### 1.8.2 Information in the visual flight map of the Malawi Air Force

In a VFR flight map available to the Malawi Air Force, the highest terrain elevation/obstacle (Maximum Elevation Figure) in the area around the accident site (11°-12° S, 33°-34° E) was displayed with a value of 6,800 ft AMSL and in the area of Mzuzu airport with 7,100 ft AMSL (Fig. 6).


Fig. 6: Excerpt from the VFR flight map with the maximum elevation figure Source: Malawi Air Force

## 1.8.3 Use of the satellite navigation system

General Settings

The volume of the device was set to 70%. There were no saved Bluetooth connections, e. g. to headsets.

The device stored a number of flight plans between aerodromes in Malawi as well as to some aerodromes outside the country. Regarding the approach of runway 17 of the destination airport Mzuzu, a waypoint called Final 17, another waypoint FAF17 UU and a waypoint MAP17 UU were stored, among other things.

Terrain Proximity Function

According to the Area 760 Pilot's Guide, the Terrain Proximity function is the standard function in which the terrain or obstacle heights with reference to the current flight altitude are displayed in different colours on the moving map. To have a full-screen display, the pilot must have selected the "map" or "terrain" display on the device. If none of them are selected, Caution and Warning Alerts are displayed in a pop-up window at the lower left part of the screen. The terrain is shown in red if it is above or within 100 ft below the aircraft and in yellow if it is between a user-defined caution elevation and 100 ft below the aircraft (Fig. 7). In the present case, the Caution Elevation was set at 1,000 ft.

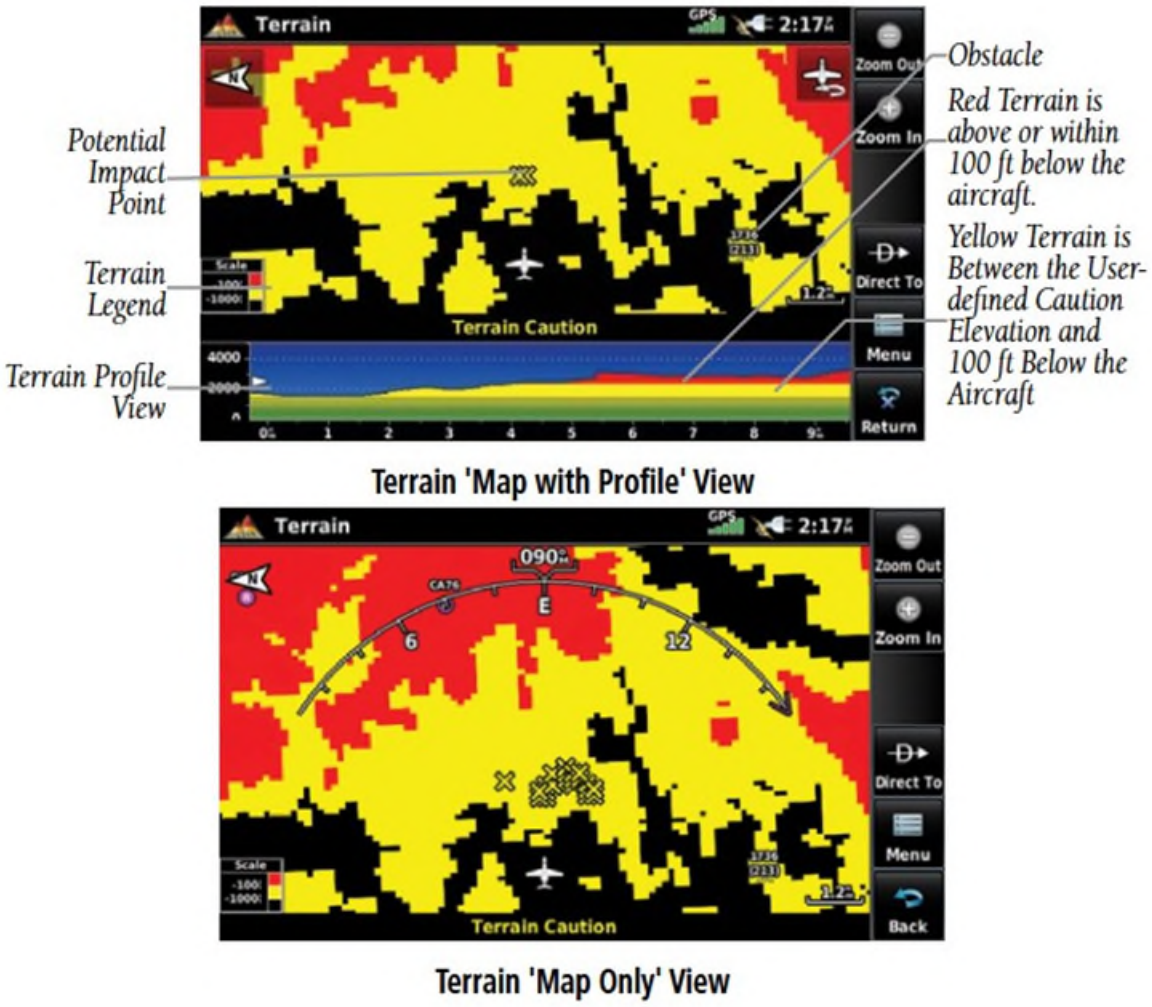



Fig. 7: Variants of the terrain map display Source: Garmin Area 760 Pilot's Guide

In addition to the visual warning, the device had a number of acoustic caution and warning alerts (Fig. 8).

| Alert Severity | Terrain | Obstacle | Descent Rate |
|---|---|---|---|
| Caution | "caution, terrain"<br>"caution, terrain ahead" | "caution, obstacle"<br>"caution, obstacle ahead" | "caution, sink rate" |
| Warning | "terrain ahead! pull up!"<br>"terrain! terrain! pull up! pull up!" | "obstacle ahead! pull up!"<br>"obstacle! obstacle! pull up! pull up!" | "sink rate, pull up!"<br>"pull up!" |

Aural Alerts Summary

Fig. 8: Acoustic Caution and Warning Alerts Source: Garmin Area 760 Pilot's Guide

The navigation system's obstacle data was up-to-date.

## 1.9 Radio Communications

The radio communications between the flight crew and the air traffic control units at Lilongwe were not recorded. Radio communications between the flight crew and the Flight Information Service (FIS) in Mzuzu were also not recorded.

## 1.10 Aerodrome Information

### 1.10.1 Lilongwe-Kamuzu Airport

According to the Malawi AIP, Lilongwe-Kamuzu Airport (FWKI) is located 11 NM north of the capital Lilongwe at 4,029 ft AMSL.

It was equipped with a 3,540 m long and 45 m wide asphalt runway with the direction 133°/313°. At the time of departure, runway 14 was in use.

### 1.10.2 Mzuzu Airport

According to the Malawi AIP, Mzuzu Airport (FWUU) is located 1 NM north-west of the city of Mzuzu at 4,117 ft AMSL.

It was equipped with a 1,300 m long and 18 m wide asphalt runway with the direction 165°/345°. At the time of the accident, runway 17 was in use.

## 1.11 Flight Recorders

The air navigation service provider in Lilongwe had no recorded radar data of the two flights on the day of the accident.

The airplane was not equipped with a Cockpit Voice Recorder or a Flight Data Recorder. These recording devices were not required by relevant aviation regulations.

The navigation system Garmin Aera 760 had recorded position data (GPS position and altitude above time). The BFU read out the data. In addition to the data of the accident flight, position data of flights from 7 March 2024 onwards could be saved and analysed.

The software “Garmin Basecamp” was used to access the internal memory of the navigation system. It had stored all user-saved “waypoints” and “flight plans”.

The Diagnostics Page was also analysed. It was determined that the navigation system had switched off automatically about 2:45 hrs after the aircraft’s impact (time of the accident), due to low battery.

The recording of the accident flight began at 0846:48 hrs on the apron of the departure airport and ended at 1016:14 hrs in the immediate vicinity of the accident site (Fig. 1). Appendix 1 to the report shows the course of the GPS altitude during the entire accident flight. For preparation and better visualization, intermediate points in flight (cubic interpolation) and on the ground (linear interpolation) were created. In addition, the ground speed, vertical speed, ground elevation (based on Google Maps), GPS altitude, track and the bank angle were calculated from the position data.

The analysis of the GPS data of the accident flight revealed that the aircraft flew several times temporarily at low height. Between 0952:58 hrs and 0953:21 hrs, the aircraft was at an altitude of less than 1,000 ft AGL. Seven minutes later, between 1000:24 hrs and 1011:42 hrs, the aircraft was again in the altitude band of less than 1,000 ft AGL. The lowest altitude was 185 ft AGL. After the aircraft had briefly climbed to about 2,000 ft AGL, it again went into a descent. From 1015:22 hrs until the impact, the aircraft was again in the altitude band of less than 1,000 ft AGL. Between 1000 hrs and 1016 hrs, the average ground speed was 128 kt (Appendix 2). As a result of the wind from south to southeast, the indicated speed may have been even lower.

## 1.12 Wreckage and Impact Information

### 1.12.1 Accident Site

The day after the accident, search and rescue personnel recovered the occupants' bodies from the wreckage and the accident site. In doing so, wreckage parts were moved from their original positions. Then, the accident site was cordoned off and secured until the investigation team arrived.

The accident site was located about 34 km (18 NM) south-west of the destination airport in the Nthungwa Forest, Nkhata Bay District which is part of the Malawi Northern Region. The airplane impacted the south-eastern slope of a hill, which is about 1,940 m (6,365 ft) high, about 2 km east of highway M1 and about 700 m south of a settlement. At the top of the hill was a about 30 m high telecommunication cell tower (Nthungwa Tower). The accident site was about 500 m east of it at a height of about 1,870 m In the area of the accident, the slope had a gradient of 25-30°. During impact, the airplane had a heading of about 283°.

First, the aircraft's outer part of the right wing collided with a tree trunk at a height of about 4.5 m above ground. Part of the honeycomb structure of the wing stuck in the tree trunk (Fig. 9). Based on the traces on the tree trunk and the right wing, it was determined that the aircraft did not have any recognisable bank angle at the time of the collision.

Fig. 9: Traces of collision with a tree (marked in red), close-up on the right Source: BFU

At a distance of about 12 m north-west of the tree, the airplane's lower fuselage surface had impacted the ground.

The right-hand wing tip and the right aileron lay north-west of the impact site of the fuselage. Parts of the interior and some cockpit instruments were scattered over an area of about 60 m x 25 m.

The main wreckage had come to rest on the slope about 80 m from the tree it had collided with (Fig. 10). The fuselage had come apart and the engines were torn off the wings. The cowling of both engines had fractured abreast of the first compressor stage. The propellers of both engines were torn off the shafts.


Fig. 10: Overview over the accident site Source: BFU

The flaps were in position 1. The flap control lever was deformed. The landing gear was extended, the landing gear lever in the position “DOWN”. The switch on the overhead panel for the windscreen wipers was set to ”ON”.

The Horizontal Situation Indicator (HSI) and the Radio Magnetic Indicator (RMI) on the co-pilot’s side showed a heading of 284°. The barometric altimeter on the left side of

the instrument panel showed a reference pressure of 1,029 hPa and the one on the right of 1,026 hPa. The position trim indicator was torn out of the pedestal panel. The pointer for indicating the horizontal stabilizer trim position was missing.

The horizontal stabilizer was massively damaged and deformed on the right side. On the left, it indicated a position close to ‘neutral’.

The Emergency Locator Transmitter (ELT) was found in the wreckage. The switch in the cockpit was in position ‘ARM’, the switch on the device itself was in position ‘OFF’ (Fig. 11). The device was secured by the BFU.


Fig. 11: Switch on the ELT in position ‘OFF’ (left), switch in the cockpit in position ‘ARM’ Source: BFU

The navigation system Garmin Aera 760 was secured at the accident site by the BFU and later read out in the BFU laboratory (Fig. 12).


Fig. 12: Recovery of the navigation system at the accident site Source: BFU

## 1.12.2 Examination of the Warning and Caution Panel

The Warning and Caution Panel on the instrument panel was removed and examined in more detail in the BFU laboratory.

The device was documented, cleaned and disassembled before the examination.

The Warning and Caution Panel had 6 warning indicators (red). These were the oil warning left and right, the BATT TEMP warning left and right, the $V_{MO}$ warning and the DOORS warning. There were also 24 Caution indications (amber). Of the 35 possible display fields of the Warning and Caution Panel, 30 were occupied (Fig. 13). When disassembling the device, there were 46 light bulbs in the respective slots, while 10 light bulbs were found loose in the device. The 5 unoccupied display fields had light bulbs in the respective slots, 4 of these had 2 light bulbs and one of the unoccupied displays had one light bulb installed (Fig. 14). Thus, of the total of 70 probably installed light bulbs, 14 were missing.

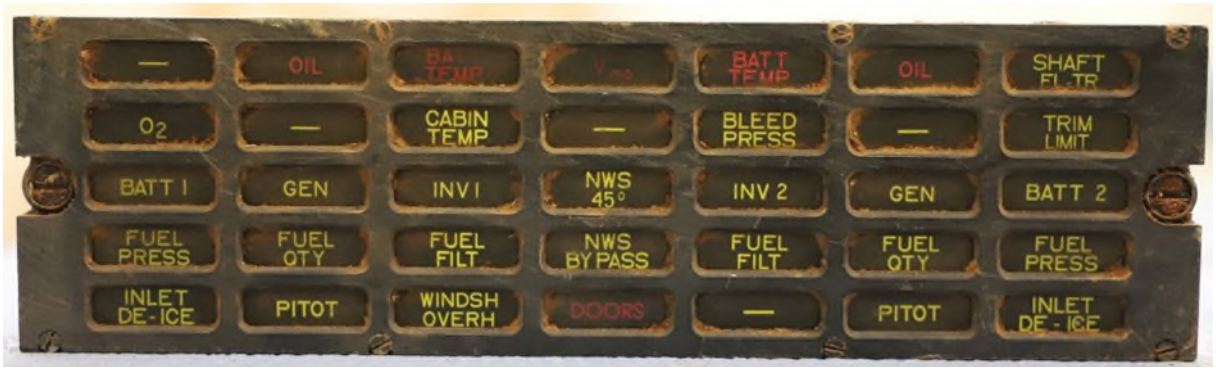



Fig. 13 Warning and Caution Panel Source: BFU

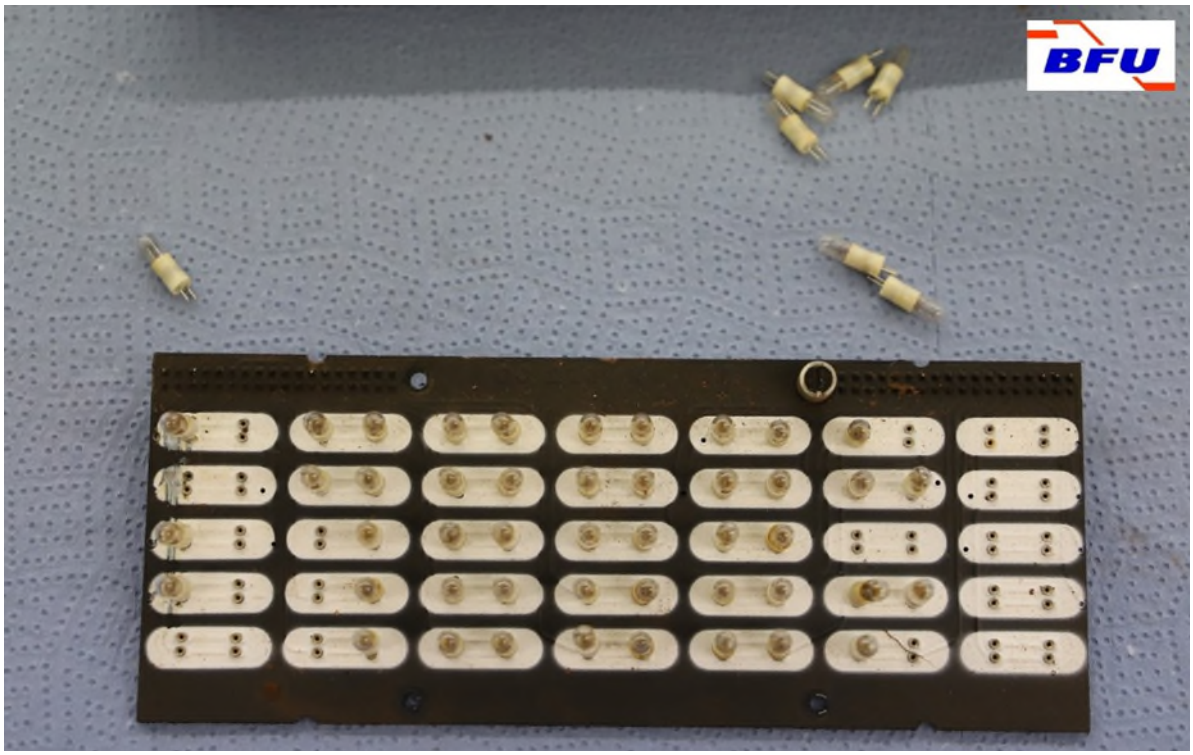


Fig. 14 Warning and Caution Panel lamps Source: BFU

All 56 light bulbs were examined under the microscope. None of them showed an elongation of the filament. Six of the light bulbs had a broken filament. As a result of the investigation, it can be concluded that none of the 56 light bulbs examined was illuminated at the time of the impact of the aircraft.

At 8 display fields, only one light bulb was found in its slot. One of these fields was not occupied. The 7 other display fields were BATT 1, FUEL PRESS left, GEN left, FUEL QTY left, PITOT left, OIL right, and PITOT right.

In a total of 8 of the fields, neither of the 2 light bulbs was in their slot. All 8 fields were Caution fields. Specifically, these were INLET DE-ICE left, $O_2$, GEN right, SHAFT FL-TR, TRIM LIMIT, BATT 2, FUEL PRESS right and INLET DE-ICE right.

According to the manufacturer, the Caution indication INLET DE-ICE left, $O_2$, GEN right, BATT 2, FUEL PRESS right and INLET DE-ICE right could not have had any influence relevant to this specific accident. Only the Caution indication SHAFT FL-TR and TRIM LIMIT - if they had been lit - could have had certain effects on the aircraft or its pilots.

In POH Chapter 3 Emergency and Abnormal Procedures, the following was described:

> ***TRIM COUPLING (if installed)***
>
> ***SHAFT FL-TR Caution Light On***
>
> *When the amber SHAFT FL-TR caution light illuminates, the trim coupling flexible shaft is defective and the FLAPS DN position must not be selected. When the flaps are extended or retracted, the respective nose up or nose down moments will increase. Stick forces can be reduced by operating the flaps in steps and trimming at each position.*
>
> ***TRIM LIMIT Caution Light On***
>
> *The amber TRIM LIMIT caution light illuminates if the actuator limit switches are defective when the stabilizer trim actuator is driven to the maximum NOSE UP or NOSE DN position. Stabilizer trim should be used with caution, paying particular attention to the trim indicator and taking care not to exceed 1.5° NOSE DN or 5.0° NOSE UP. Flaps position DN must not be used.*

## 1.13 Medical and Pathological Information

Eight of the nine occupants were subject to a post-mortem examination. The BFU had these post-mortem reports available for investigation purposes.

According to the post-mortem reports, the occupants suffered fatal multiple injuries in the form of high-impact trauma on impact. Leading were severe injuries of head and thorax, followed by multiple fractures of the arms, legs and pelvis.

In the autopsy reports on the pilots, no information was found with regard to possible pre-existing illnesses or possible health impairments. Toxicological tests had not been carried out.

## 1.14 Fire

There was no evidence of a fire in flight or after impact.

## 1.15 Survival Aspects

According to the Flight Information Officer at Mzuzu Airport, he had called Lilongwe-Kamuzu Tower at 1042 hrs after he had lost radio contact. The Tower controller had informed him that they also had no radio contact with the flight crew. The controller called the flight crew on the Tower frequency, but could not establish contact. The flight crews of two other aircraft flying at high altitudes were asked to attempt radio contact with the missing airplane. All attempts remained unsuccessful.

At 1131 hrs at Lilongwe-Kamuzu Airport, the Rescue Coordination Centre (RCC) was activated. Surrounding national and international airports were contacted by phone to enquire whether the airplane had landed there. At about 1430 hrs, search and rescue personnel from Mzuzu Airport and others arrived at the region around Ekwendeni to search for the airplane. Later, witnesses came forward whose information suggested that a crash had occurred in the area of the cell tower Raiply. Subsequently, the search and rescue personnel were sent there. According to the report of the RCC, the search was impaired by low visibility. Employees of the Malawi RCC asked the Aeronautical Rescue Coordination Centre (ARCC) at Johannesburg (South Africa) for support in finding the airplane's ELT signal.

The following day, helicopters from Zambia, one US American military aircraft and some unmanned aerial vehicles (UAV) assisted in the search. At about 1000 hrs, search and rescue personnel located the accident site and the wreckage.

## 1.16 Tests and Research

Not applicable.

## 1.17 Organizational and Management Information

### 1.17.1 Approaches of the Malawi Air Force into Mzuzu

Pilots of the Malawi Air Force had told the Malawi Commission that for approaches into Mzuzu under visual flight rules, they would try to find cloud gaps in the vicinity of the aerodrome to gain ground visibility and then make the landing approach. For the flight

to Mzuzu, low-cloud areas in the area around Ekwendeni or above Lake Malawi are often used for descent. This is the procedure that the Malawi Air Force normally uses when flying from Lilongwe to Mzuzu when weather conditions are poor. It is often the case in Mzuzu that the weather conditions change within a few minutes.[7]

### 1.17.2 Procedure for using the Navigation System

The BFU asked the Malawi Air Force for detailed information on the procedures for using the navigation system in the flight operations of the squadron, for training the flying personnel in general on this device and the two pilots in particular who were injured.

According to the squadron, the use of the navigation system was not obligatory, but optional, i.e. a decision of the pilots. There were no standard procedures for this in the squadron. In order to familiarize themselves with the navigation system, the “Pilot’s Guide” document was available to the pilots. Also with regard to the handling of the terrain proximity function of the navigation system, there was no standard procedure in the squadron. According to the squadron, all pilots had completed the training in September 2022 and were familiar with the navigation system.

### 1.17.3 Weather service for civil aviation in Malawi

In Malawi's AIP, chapter GEN 3.5 Meteorological Services described that these services were provided by the Department of Climate Change and Meteorological Services.

It was stipulated that at the stations Lilongwe-Kamuzu and Blantyre-Chieleka weather observation will be carried out around the clock (H24) and METAR, SPECI and TREND messages will be issued. At Mzuzu station, these tasks were carried out during the operating period (0400-1600 UTC).

A personal weather consultation was offered at Lilongwe-Kamuzu, Blantyre-Chieleka and Mzuzu stations, according to AIP. For this purpose, the following was stipulated:

> ***5 Notification required from operators***
>
> *Notification from operators in respect of briefing consultation, flight documentation and other meteorological information needed for international flights is*

[7] Commission of Inquiry into the Aircraft Accident, Chapter 2.2.10 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

*normally required at least four hours before the estimated time of departure; and for internal flights at least two hours before estimated time of departure.*

## 1.18 Additional Information

### 1.18.1 Events on the day before the accident

On 9 June 2024, the day before the accident, the flight crew of the airplane went on duty at the Airbase Zomba at around midday. Instructions were issued to fly the mortal remains of a person having died two days previously and some of his family members from Blantyre-Chileka to Mzuzu. The funeral of the deceased was planned for the next day. At 1253 hrs, the flight crew took off with the aircraft later involved in the accident from Zomba's runway 27, flew a traffic circuit and then conducted the positioning flight to Blantyre-Chileka. At 1313 hrs the landing occurred on runway 28. At 1605 hrs, the airplane took off from runway 10 for the flight from Blantyre-Chileka to Mzuzu. On board were the deceased and some family members. The flight led according to GPS data in a northerly direction, over Lake Malawi and east of the settlement Chintheche over the land until the aircraft curved about 11 NM northeast of Mzuzu first in a south-westerly direction and then about 2.5 NM north of Mzuzu into the final approach of runway 17. At 1732 hrs, the airplane landed on runway 17 of Mzuzu Airport.

The Commission's report showed that the weather service in Mzuzu had informed the FIS officer about the current weather conditions on 09.06.2024 at 17:00. Accordingly, the following weather conditions prevailed at that time: Wind 160° at 0.3 kt, cloudy SCT at 600 ft AAL, visibility less than 20 km, temperature 18 °C, dew point 18 °C. At the time after landing, testimonies described the weather as foggy with spray rain. The Commission's report also stated that the crew in Blantyre-Chileka had not obtained weather information from the Meteorological Office in Blantyre-Chileka prior to the start of the flight.[8]

The three crew members spent the night at a hotel in Mzuzu. According to the Malawi Air Force, in the evening, the flight crew received the order to pick up the Vice-President of the Republic of Malawi and his entourage the following day in Lilongwe-Kamuzu and fly them to Mzuzu and after the funeral, which began at 1000 hrs, back to Lilongwe, because the Vice-President was scheduled to meet the President in the afternoon

[8] Commission of Inquiry into the Aircraft Accident, Chapter 2.1.2 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

before his departure for a trip abroad. Afterwards, the crew should have flown to Mzuzu again to bring the family members of the deceased back to Blantyre-Chileka.

### 1.18.2 Evaluation of mobile data

Position determination

Because of the missing radar coverage of the lower airspace north of the border of the TMA Lilongwe, the BFU asked the telephone company for the mobile radio data of the airplane's occupants' mobile devices. This request was made at the beginning of the investigation. The intention of the BFU was to secure trajectory data (approximate position and time). The data was provided. It showed that four mobile devices of the three occupants had been switched on and logged into different radio cells during the accident flight.

Due to the fact that the GPS could be ensured at the accident site and the data stored therein could be evaluated in the laboratory of the BFU, a detailed analysis of the mobile phone data was no longer necessary for the documentation of the flight path.

Further findings

According to the Commission's report, at 1010 hrs, a communication via messenger service had taken place between one of the passengers and another person in which the passenger had texted: 'too much turbulence'.[9]

### 1.18.3 Satellite-based search for ELT signals

The Emergency Locator Transmitter Narco Avionics ELT10 was mounted in the cabin on the left fuselage side next to the door. It was an ELT which transmits signals on the frequencies 121.5 MHz and 243 MHz. The ELT was examined. It was determined that it was not functioning because its battery had expired in 2004. According to the Malawi Air Force, for such devices there were no spare parts and no budget for new 406 MHz ELT.

Until the end of January 2009, COSPAS-SARSAT satellites had monitored the frequencies 121.5 MHz and 243 MHz. Since 1 February 2009, the satellites only monitored the internationally agreed emergency frequency 406 MHz.

[9] Commission of Inquiry into the Aircraft Accident, Chapter 2.1.2 (https://www.malawi.gov.mw/index.php/resources/publications/reports), last accessed 19.02.2025

In the flight plan filed by the co-pilot in the Aeronautical Information Office for the flight to Mzuzu, the field ‘UHF’ was ticked under Emergency Radio, but not the field ‘ELT’.

### 1.18.4 Radio communications and radar data

With regard to the recording of radio and radar data by air navigation service providers, the following provisions were laid down in ICAO Annex 11:

> *6.1 Aeronautical mobile service (air-ground communications)*
>
> *6.1.1 General*
>
> *[...]*
>
> *6.1.1.3 When direct pilot controller two-way radiotelephony or data link communications are used for the provision of air traffic control service, recording facilities shall be provided on all such air-ground communication channels.*
>
> *Note. — Requirements for retention of all automatic recordings of communications in ATC are specified in Annex 10, Volume II, 3.5.1.5.*
>
> *6.1.1.4 Recordings of communications channels as required in paragraph 6.1.1.3 shall be retained for a period of at least thirty days.*
>
> *[...]*
>
> *6.4.1 Automatic recording of surveillance data*
>
> *6.4.1.1 Surveillance data from primary and secondary radar equipment or other systems (e.g. ADS-B, ADS-C), used as an aid to air traffic services, shall be automatically recorded for use in accident and incident investigations, search and rescue, air traffic control and surveillance systems evaluation and training.*
>
> *6.4.1.2 Automatic recordings shall be retained for a period of at least thirty days. When the recordings are pertinent to accident and incident investigations, they shall be retained for longer periods until it is evident that they will no longer be required.*

### 1.18.5 Requirements for meteorological Service

With regard to meteorological services, ICAO Annex 3 included the following provisions, among others:

*9.2 Briefing, consultation and display*

*[…]*

*9.2.1 Briefing and/or consultation shall be provided, on request, to flight crew members and/or other flight operations personnel. Its purpose shall be to supply the latest available information on existing and expected meteorological conditions along the route to be flown, at the aerodrome of intended landing, alternate aerodromes and other aerodromes as relevant, either to explain and amplify the information contained in the flight documentation, or as agreed between the meteorological authority and the operator concerned, in lieu of flight documentation.*

*9.2.2 Meteorological information used for briefing, consultation and display shall include any or all of the information listed in 9.1.3.*

*9.2.3 If the aerodrome meteorological office expresses an opinion on the development of the meteorological conditions at an aerodrome which differs appreciably from the aerodrome forecast included in the flight documentation, the attention of flight crew members shall be drawn to the divergence. The portion of the briefing dealing with the divergence shall be recorded at the time of briefing and this record shall be made available to the operator.*

*9.2.4 The required briefing, consultation, display and/or flight documentation shall normally be provided by the aerodrome meteorological office associated with the aerodrome of departure. At an aerodrome where these services are not available, arrangements to meet the requirements of flight crew members shall be as agreed between the meteorological authority and the operator concerned. In exceptional circumstances, such as an undue delay, the aerodrome meteorological office associated with the aerodrome shall provide or, if that is not practicable, arrange for the provision of a new briefing, consultation and/or flight documentation as necessary.*

*9.2.5 Recommendation.— The flight crew member and/or other flight operations personnel for whom briefing, consultation and/or flight documentation has been requested should visit the aerodrome meteorological office at the time agreed*

*between the aerodrome meteorological office and the operator concerned. Where local circumstances at an aerodrome make personal briefing or consultation impracticable, the aerodrome meteorological office should provide those services by telephone or other suitable telecommunications facilities.*

### 1.18.6 Controlled Flight into or towards Terrain

Controlled Flight into or towards Terrain

ICAO's Global Aviation Safety Plan (CFSP) listed 5 Global high-risk Categories of Occurrences.[10] These included:

- Controlled Flight Into or towards Terrain (CFIT)
- Loss of Control In-flight (LOC-I)
- Mid-air Collision (MAC)
- Runway Excursion (RE) and
- Runway Incursion (RI)

Concerning CFIT, ICAO stated:

*3.4.2.1 Controlled flight into terrain*

*CFIT is an in-flight collision with terrain, water or obstacle without indication of loss of control. Accidents categorized as CFIT involve all instances where an aircraft is flown into terrain in a controlled manner, regardless of the crew's situational awareness. CFIT accidents involve many contributing factors, including: procedure design and documentation; pilot disorientation; and adverse weather. Requirements for aircraft to be equipped with ground proximity warning systems have significantly reduced the number of CFIT accidents. Despite the absence of CFIT accidents involving transport category aircraft over the past few years, CFIT accidents often have catastrophic results when they occur, with very few, if any, survivors. Therefore, there is a high fatality risk associated with these events.*[11]

[10] https://www.icao.int/safety/CFSP/Documents/10004_en.pdf, Chapter 3.4.2 ff last accessed 08.04.2025
[11] https://www.icao.int/safety/CFSP/Documents/10004_en.pdf, Chapter 3.4.2 ff last accessed 08.04.2025

Scud Running

The term Scud Running is understood to mean the intention of pilots to fly at low altitude, below the clouds, to avoid entering into instrument flight conditions.

The U.S. Federal Aviation Administration describes Scud Running as:

*“Pushing the capabilities of the pilot and the aircraft to the limits by trying to maintain visual contact with the terrain while trying to avoid physical contact with it.”*[12]

## 1.19 Useful or Effective Investigation Techniques

Not applicable.

[12] FAA Advisory Circular No 60-22, Aeronautical Decision Making

# 2. Analysis

## 2.1 General/Accident history

### 2.1.1. Traces at the accident site

The traces found at the accident site, the distribution of the debris and the damage to the aircraft indicate that the aircraft flew into the ascending terrain at relatively low sink rate and high forward speeds. This resulted in a clearly visible mark of the first impact of the aircraft fuselage on the ground and a subsequent disintegration of the aircraft with a “fan-shaped” wreckage distribution. This corresponds to the typical characteristics of a Controlled Flight Into or towards Terrain (CFIT).

### 2.1.2 Technical aspects

Examination of the light bulbs of the Warning and Caution Panel retrieved from the cockpit revealed no evidence of any technical malfunction. The fact that 14 light bulbs were missing in the panel which was damaged during impact of the aircraft, opens a few theoretical scenarios.

No light bulbs were found in 8 display fields after the accident. The theoretical possibility that one or more of those 8 display fields had no light bulbs (out of the 2 it can hold) before the accident is very unlikely. On the one hand, the function of the indicator lights had to be checked on every flight before starting the engines. The pilots, as well as the engineer flying with them, would have noticed if the indicator lights were missing or inoperative. On the other hand, according to the maintenance staff and the flying staff of the squadron, the aircraft was in good technical condition. In addition, no technical defects were described at any time before or after the flights on the day of the accident or the day before in the telephone conversations with air base personnel.

The second theoretical possibility is that for some or all of the 8 display fields, the light bulbs may have been illuminated. All these 8 display fields were Caution indications. An illuminated caution indication means that it would require the flight crews’ attention but no immediate action. According to the manufacturer, of these 8 display fields, only the two amber caution lights SHAFT FL-TR and TRIM LIMIT could have had an impact on the aircraft or its pilots in this particular case. However, a defect indicated by the SHAFT FL-TR indicator would only have resulted in the flaps could not be fully extended. In addition, the greater elevator control forces that would have been generated when extending or retracting the flaps would have had to be trimmed manually. From

the BFU's point of view, it is very unlikely that the pilots would have maneuvered in low altitude over a long period of time with an illuminated caution light TRIM LIMIT.

## 2.2 Individual Actions

### 2.2.1 Actions of the Flight Crew

Meteorological flight preparation

Both on the day of the accident and on previous flights, the crew refrained from obtaining information about forecasts and weather data from the Meteorological Office. According to the CAA, however, the crew could not have expected any weather information for the planned flight route at a briefing in the Meteorological Office anyway. This may have been the reason why they - contrary to the air regulations - did not make use of this service. It was not possible to clarify whether the pilots used other sources of weather data for their flight preparation e.g. via their mobile phones. On the other hand, the crew's phone call to the FIS officer in Mzuzu prior to departure shows that they at least dealt with the prevailing weather there before departure.

Conduct of the Flight

It is clear from the statements made by the controller in Lilongwe and the FIS officer in Mzuzu that the co-pilot conducted the radio communications. This indicates that she performed the function of pilot monitoring (PM) and therefore the pilot-in-command was pilot flying (PF). Given the prominence of the passengers, the flight profile, the weather conditions and the different flight experience of the two pilots, this division of tasks is understandable.

From the beginning of the flight until 0944 hrs, i. e. 28 min after take-off, the flight was inconspicuous. After that, the aircraft left the cruising altitude and began to descend, deviating from the direct course to the destination airport.

The available meteorological satellite images from 0945 hrs to 1015 hrs and the respective position of the aircraft show that the crew steered the aircraft to areas with a lower degree of cloud coverage (Appendix 3 and 4). The flight crew chose a low flight altitude above ground. This clearly indicates that it was the intention of the pilots to gain or maintain visual contact with the ground. The recorded flight path indicates that the pilots did not use the autopilot at this stage, but flew manually instead.

According to the statements of pilots of the Malawi Air Force, going low level in marginal weather conditions corresponded to their usual procedures. This corresponds to

the definition of the term ‘scud running’ as described by the FAA. During this low-level flight, the flight crew went below the minimum safety altitude several times and over a longer period of time.

The recorded data of the accident flight as well as the previous flights did not clearly show how exactly this crew used the navigation system. In any case, the waypoints stored in the navigation system for an approach to Mzuzu were not actively used.

According to the FIS officer, he had radio contact with the crew at 1012 hrs. The fact that the co-pilot had set her altimeter to the QNH of Mzuzu airfield (1,026 hPa) confirms the radio contact.

The aircraft impacted the ground approximately 70 m below the top of the hill and a further 30 m below the top of a mobile phone mast standing on the summit. The BFU is convinced that the pilots were unaware that the aircraft was just about to collide with the ascending terrain. This can be explained by the fact that, in the last seconds of the flight, they went into instrument meteorological conditions.

It was not possible to determine exactly when the crew extended the flaps in position 1 (5°) and the landing gear. A possible explanation could be that flying in low visibility with flaps 1 (5°) allowed them to fly slightly slower, therefore giving more time to react and foremost, have a better visibility of the terrain ahead (Appendix 2). For what reasons the crew extended the landing gear, could not be determined.

### 2.2.2 Actions of Air Traffic Service Personnel

Coordination of flights between the various air traffic control units took place via telephone contacts. This was even more important under the given conditions of limited radar coverage in large parts of Malawi's airspace. For example, take-off messages, estimated time of arrival or overflight times as well as the fuel endurance were communicated this way. Based on this information the FIS officer began calling the crew by radio at 0950 hrs.

After several unsuccessful attempts due to the distance and the low altitude of the aircraft, the radio contact was finally established at 1012 hrs.

Due to the fact that this radio communication was not recorded, the analysis is based solely on the information provided by the FIS officer. According to the written statement of the FIS officer in Mzuzu, the co-pilot had reported on the radio at 1012 hrs and informed that the aircraft was 20 NM away and the crew intended to approach from the north. In later interviews, it had been said that the co-pilot had indicated the position

with 20 NM north of the airfield. It was not clear whether the incorrect position was actually given by the co-pilot or whether the reported position was not correctly understood. In any case, search and rescue forces were initially sent in the wrong direction for this reason.

## 2.3 Specific Conditions

### 2.3.1 Weather Situation

For an analysis of the weather conditions, the DWD had only limited data available. For example, there were only ground weather reports from 08:00 (06:00 UTC) for the day of the accident in Malawi. However, the meteorological satellite images were very helpful in understanding the reasons for the flight trajectory chosen by the crew.

The available testimonies provided a meaningful description of the weather conditions along the flight route. Witnesses driving in cars along Highway M1 from Mzimba to Mzuzu reported ‘very bad weather and low visibility’. Other witnesses from the telecommunication cell tower about 500 meters west of the accident site, as well as from a watchtower of the Department of Forestry, said that there was very poor visibility, strong wind and rain. The text message sent on board the aircraft six minutes before the accident ‘too much turbulence’ supplemented the description of the weather.

### 2.3.2 Flight Crew decision-making

Due to the fact that the aircraft was not equipped with a CVR or FDR, the scope of the investigation was limited. Therefore, the motivation or decision-making, but also the cooperation of the two pilots, cannot be understood in detail.

The planning for the event on the day of the accident with the start of the funeral ceremony at 1000 a.m. resulted in a narrow time window for the two flights. It could not be clarified whether passengers put pressure on the PIC during the flight to continue the flight to the destination at low altitude under the weather conditions encountered. The PIC may also have imposed this pressure on himself.

### 2.3.3 Health Condition of the two Pilots

During the autopsy of the bodies of the two pilots, no examinations regarding possible health impairments were carried out. No toxicological tests have been carried out. Therefore, even if health impairments cannot be completely ruled out, the flight trajectory clearly shows that the aircraft was manually controlled during the low-flight phase, which lasted about 25 minutes. For the BFU, it is therefore unlikely that there has been a relevant health impairment of one of the pilots.

## 2.4 Defences

In the scope of this investigation, the term defences mean technical systems, actions, procedures, and organisations which shall minimise the effects of technical or human error in regard to flight safety.

### 2.4.1 Crew resource management

Good crew resource management (CRM) is such a defence. One of the prerequisites for CRM is the ability of a PIC to motivate a crew member to good teamwork. For this purpose, there should be an atmosphere of mutual appreciation between the pilots, which, for example, encourages the co-pilot to share his observations and express any concerns. Good teamwork in the cockpit also includes involving the other in decision-making, a meaningful division of tasks, mutual support and verification, e.g. in the form of monitoring or a cross check. In addition to the specific choice of route, a decision to cancel the flight with climb and return to the airport of departure or to the alternate could also have been made. To which extent the experienced PIC involved the less experienced co-pilot in the decision making is unknown.

### 2.4.2 Terrain Proximity Function of the Navigation System

The aircraft had a navigation system with terrain proximity function with valid obstacle data. Although this system is not comparable to an Enhanced Ground Proximity Warning System (EGPWS), it could in principle have contributed to increasing the ground-related situational awareness of the flight crew via acoustic and visual warnings.

The vertical flight profile recorded by the navigation system shows that the crew steered the aircraft three times into the altitude band of less than 1,000 ft AGL (Caution Alert). In these phases, the navigation system showed yellow terrain. One of these low-level phases lasted more than 11 minutes. Whether the pilots perceived the visual Caution Alert could not be clarified with sufficient certainty. The navigation device was

mounted at the Center Pedestal and was therefore not in the central field of view of the pilots.

Due to the noise level in the cockpit in conjunction with the headsets worn by the pilots and the volume set on the navigation system, it is unlikely that the pilots have perceived the acoustic caution alerts.

On the other hand, the pilots deliberately chose the very low altitude. During this low flight, the attention of the PIC and probably the co-pilot was directed to the outside and not to the displays of the instruments.

### 2.4.3 Emergency Locator Transmitter

The ELT built into the aircraft had been technically obsolete and out of function for many years and therefore could not support the search and rescue operation. The process of organizing the SAR operation shows that this information was not available at the Rescue Coordination Centre, whose employees had therefore in vain asked the Aeronautical Rescue Coordination Centre (ARCC) in Johannesburg (South Africa) for assistance in finding the ELT signal of the aircraft.

## 2.5 Organizational framework conditions

This accident belongs to the event category Controlled Flight into or towards Terrain (CFIT), which is one of the global high-risk categories described by ICAO in the Global Aviation Safety Plan (CFSP). As noted by ICAO, in the event of accidents of this category, there is a high probability of a fatal outcome for the occupants of an aircraft.

### 2.5.1 Flight Operations of Malawi Air Force

Many challenges play a role in the daily flight operations of the Malawi Air Force. These include, but are not limited to, short-term flight operations at the request of the government, coupled with short-term changes to plans, the infrastructure in Malawi, which allows air operations under VFR at a larger number of aerodromes but not under IFR. In addition, there is the orography of the country and sometimes challenging meteorological conditions.

The equipment of the aircraft plays a role due to the limited financial means as well as the low number of flight hours. Thus, the crashed aircraft had completed on average a little less than 100 operating hours per year. The respective overall flight experience

of the two pilots resulted in an average of 60-70 flight hours per year. In order to ensure safe flight operations under these conditions, the Malawi Air Force should have appropriate standards and procedures in place. In doing so, the various expected orders to the squadron should be taken into account and risk mitigation measures should be developed and applied.

The results of the analysis of the data of the navigation system suggest that the pilots of the of the squadron used the system very different. On the one hand, some of the users had entered a larger number of flight plans to the various aerodromes of the region, as well as a number of waypoints, also for the approach of the airfield Mzuzu, were stored. On the other hand, the two pilots did not use the potential of the navigation system during the flights on the day of the accident and the day before. The BFU is of the opinion that the squadron should develop standard operating procedures that include the use of the navigation system. These standard operating procedures should also include the terrain proximity function of the navigation system in order to improve the situational awareness of pilots.

The Malawi Air Force did not have up-to-date information regarding up-to-date aeromedical certificates of the two crashed pilots. In the opinion of the BFU, this shows a deficit with regard to the supervision of flight crew. The data on both pilots show that IFR check flights were only documented at irregular intervals.

The fact that the copilot did not tick “ELT” in the flight plan indicates that the pilots and engineers of the squadron were aware that the installed ELT was without function. The flight plan was filed in the AIS office and was available to air traffic control. However, this did not result in the Rescue Coordination Centre being informed about the missing ELT.

### 2.5.2 Compliance with ICAO Standards in Malawi

The investigation of the accident revealed that, contrary to standards, flight data (radar and radio) were not recorded in Malawi. This was not in line with ICAO Annex 11 standards. As a result, some valuable information was missing for this investigation. In order to be able to access such data in future investigations, appropriate measures should be taken.

Contrary to ICAO Annex 3 standards, the Meteorological Authority did not provide meteorological information on the planned route. This was also contrary to the national aviation regulations, according to which crews were obliged to familiarize themselves with weather information for the flight route before the flight.

Improving meteorological data would assist crews in their flight preparation or SAR forces in their search and rescue activities. This would therefore be an important contribution to improve aviation safety.

# 3. Conclusions

## 3.1 Findings

### 3.1.1 Crew

- The investigation was unable to find aero-medical certificates for either pilot valid at the time of the accident.
- During the course of the investigation, no indications of possible health impairments of the pilots were found.
- The pilot-in-command was experienced both in terms of his overall flying experience and on type.

### 3.1.2 Aircraft

- The aircraft was equipped for flights under instrument flight rules and also had a navigation system with a terrain proximity function.
- No indications of accident-related technical defects were found on the aircraft.
- The plane had enough fuel on board for the flight to Mzuzu and back to Lilongwe.
- There was no evidence of a fire in flight or after the impact.
- The investigation of the Warning and Caution Panel revealed no indications of accident-relevant system failures.

### 3.1.3 Weather conditions

- Contrary to ICAO Annex 3 standards, the Meteorological Service did not provide meteorological information on the planned route.
- Testimonies provided evidence that poor weather conditions and partly instrument flight conditions prevailed on the route.
- The crew decided to fly the aircraft into marginal weather conditions close to the ground in order to reach the destination free of or below the clouds by sight. This tactic corresponded to the procedures used in the squadron.
- With this decision, the crew set themselves consciously at an increased risk of a CFIT event. Whether this decision was influenced, for example, by self-

imposed pressure or pressure exerted by passengers could not be determined with certainty.

- The aircraft was for a long time at low altitude above ground in hilly terrain.
- The crew eventually flew into instrument meteorological conditions and the plane collided with the ascending terrain.

### 3.1.4 Survival aspects

- The ELT built into the aircraft was no longer functional for 20 years. This was known in the squadron and the copilot accordingly made no entry in the field ELT on the flight plan.
- The technical standard of the ELT was outdated and has not been supported for years. The Rescue Coordination Centre was not aware of this when coordinating the SAR operation for the aircraft.
- The lack of an effective emergency transmitter, as well as misleading information about the last position of the aircraft made the search for the accident site more difficult.
- Due to the severity of the injuries sustained during the impact, the accident was not survivable for the aircraft occupants.

### 3.1.5 Organizational aspects

- The planned as well as the actual course of events on the day of the accident resulted in deadline pressure for the execution of the flight and a punctual landing in Mzuzu.
- The Malawi Air Force did not have up-to-date data on the validity aeromedical certificates of its flight crew.
- Contrary to ICAO Annex 11 standards and recommendations, radar and radio were not recorded in Lilongwe.

## 3.2 Causes

The accident occurred because the crew flew into instrument meteorological conditions during flight under visual flight rules and the aircraft collided with the ascending terrain.

The following contributed to the accident:

- the decision to continue the flight to the destination at low altitude in marginal weather conditions,
- lack of situational awareness, and
- inadequate pre-flight preparation.

# 4. Safety Recommendations

The BFU issued 2 safety recommendations in August 2024, the date of publication of the interim report:

09/2024

The Minister of Defence of the Republic of Malawi should ensure that aircraft of the Malawi Air Force transporting persons are equipped with a functional Emergency Locator Transmitter (ELT).

10/2024

The Minister of Transport and Public Works of the Republic of Malawi should ensure that up-to-date information concerning radio navigation aids in Malawi is available to aircraft crews at all times.

The Department of Civil Aviation should check the proper function of the radio navigation aids and update the respective information in the Malawi Aeronautical Information Publication (AIP).

As a result of the investigation, the BFU released in addition the following 4 safety recommendations:

05/2025

The Director General of the Civil Aviation Authority of the Republic of Malawi should ensure that air navigation service providers or airport operators record radar data and radio traffic at least at the country's major airports and keep it stored for a period of at least 30 days.

06/2025

The Director General of the Civil Aviation Authority of the Republic of Malawi should ensure that crews in preparation of their flight can obtain the best possible information about the meteorological conditions occurring during the flight.
For this purpose, the Department of Meteorological Services should provide meteorological data for the en-route phase as well as for planned alternate aerodromes.

07/2025

The Commander of the Malawi Air Force should ensure that aero-medical data of its individual flight crew members are up-to-date and copies of the latest certificates are stored in their respective military units at all times.

08/2025

The Commander of the Malawi Air Force should ensure that a high level of aviation safety is ensured in the operations of the transport aircraft squadron.

To this end, the various possible orders to the squadron should be analyzed in terms of their specific risks and risk mitigation measures should be established where necessary. Appropriate standard procedures should be developed or clarified.

Braunschweig, 30 May 2025

Bundesstelle für Flugunfalluntersuchung
(Federal Bureau of Aircraft Accident Investigation)

| | |
|---|---|
| Investigator in charge: | Jens Friedemann |
| Field Investigation: | Dr Susann Winkler, Jens Friedemann |
| Assistance: | Dr Susann Winkler, Dr Thomas Harendza, Ekkehart Schubert, Martin Beckert, Uwe Berndt |

# 5. Appendices

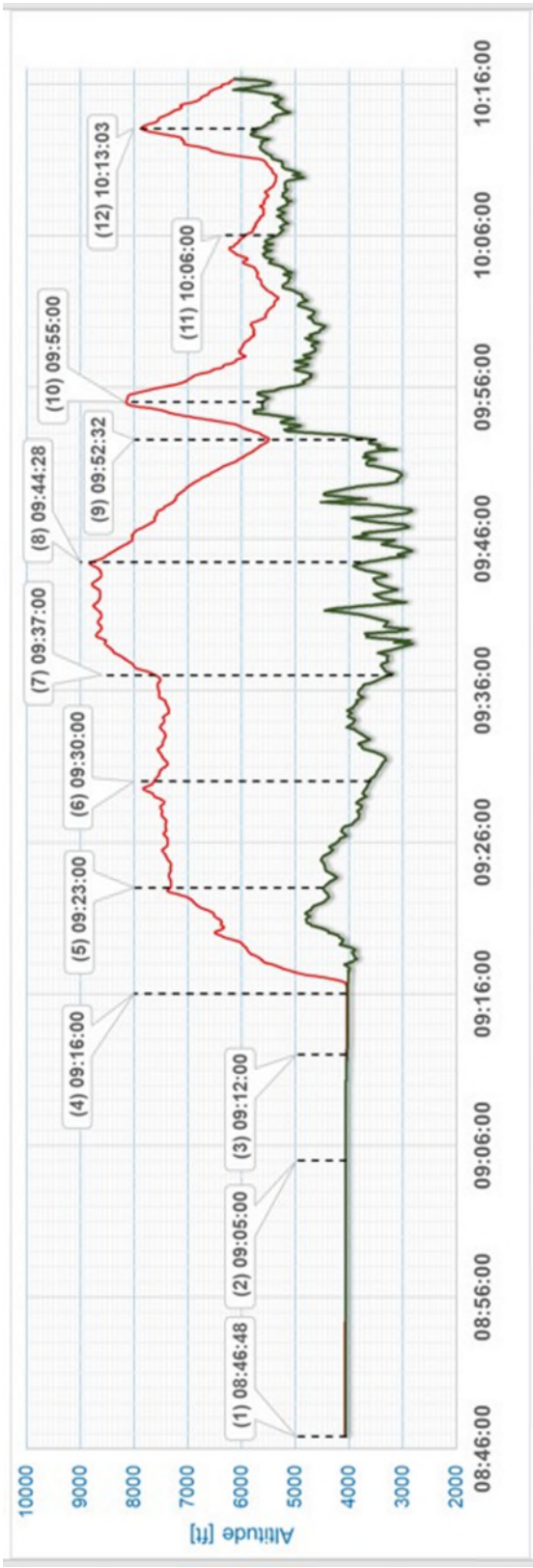
Appendix 1: Altitude and elevation during the accident flight over time

Appendix 2: Detail of altitude and elevation combined with height and ground speed

Appendix 3: Satellite images of the cloud coverage at 09:15 and 09:45 hrs with the respective position of the aircraft

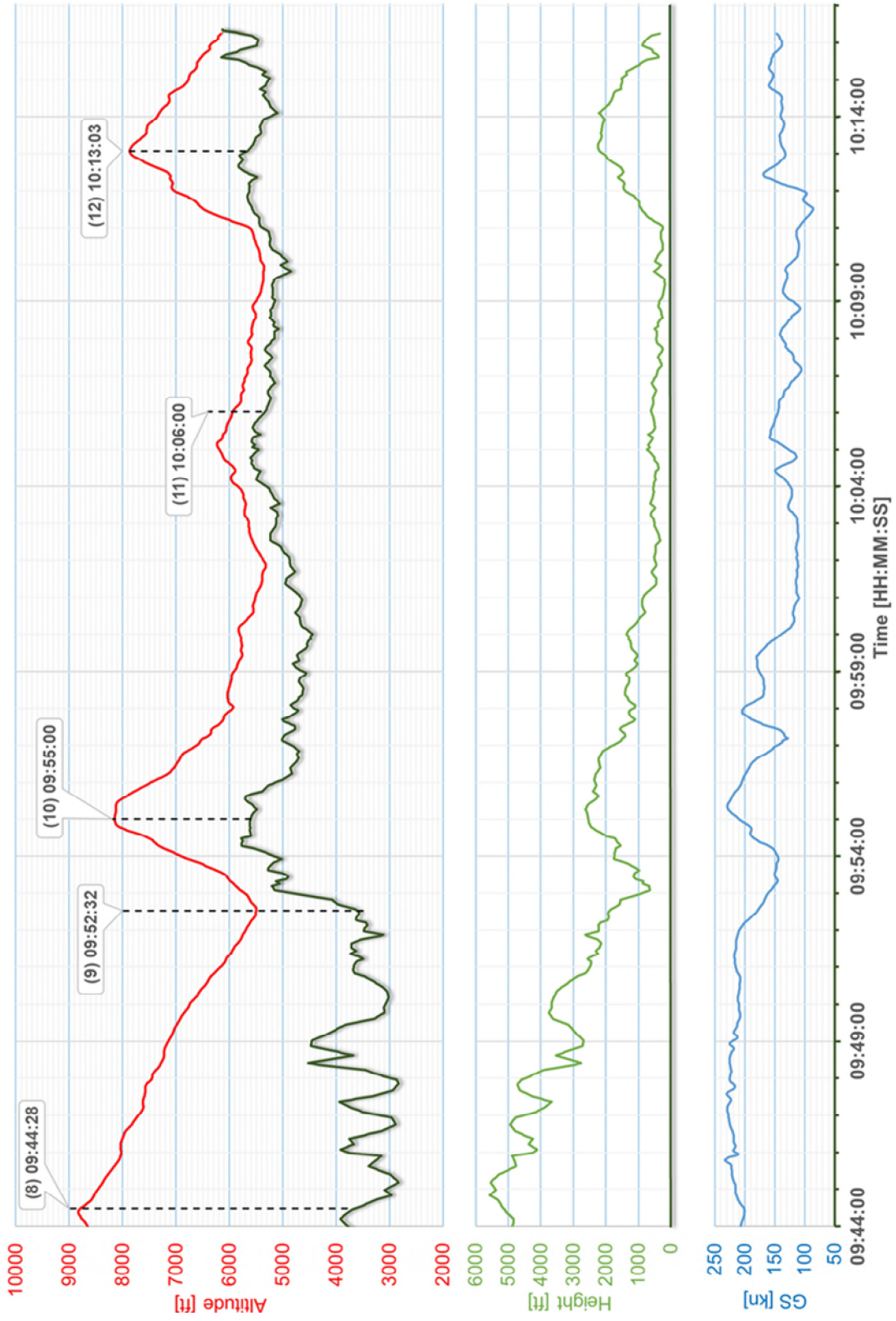
Appendix 4: Satellite images of the cloud coverage at 10:00 and 10:15 hrs with the respective position of the aircraft

Appendix 1 Altitude and elevation during the accident flight over time

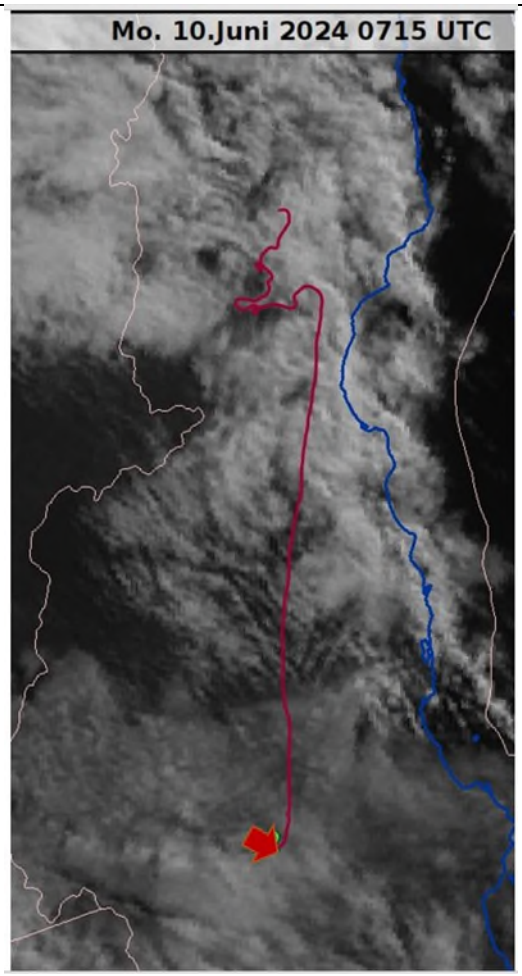
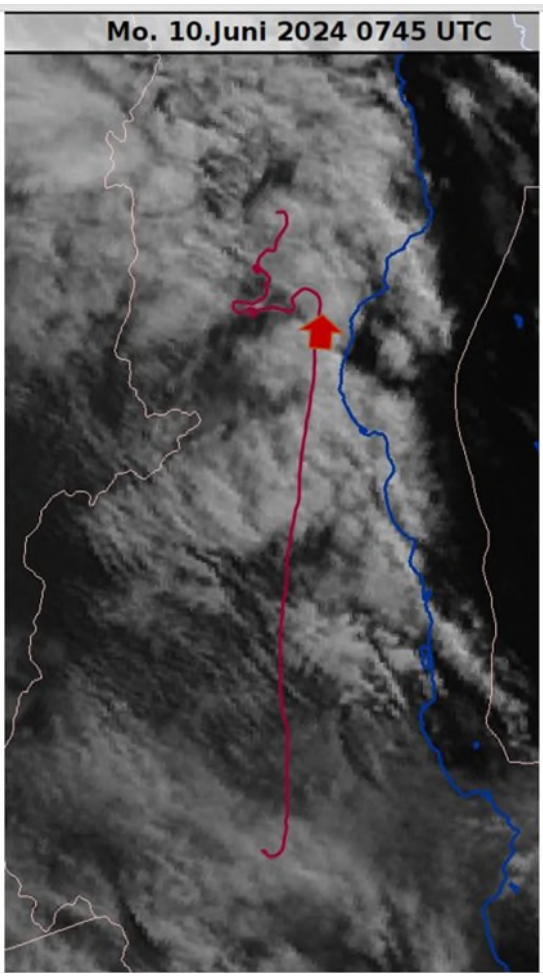



| | |
|---|---|
| (1) GPS was switched on | (7) airplane started climb to 8,600 ft |
| (2) co-pilot asked for departure information | (8) airplane entered descent |
| (3) controller gave routing clearance | (9) airplane began to climb again from 5,500 ft |
| (4) airplane took off from runway 14 | (10) airplane reached approximately 8,100 ft and began to descend again |
| (5) airplane reached cruising altitude 7,300 ft | (11) airplane flew two full circles to the left |
| (6) controller cleared to change freq. to 118.1 MHz | (12) airplane reached approximately 7,000 ft and shortly afterwards began to descend again |

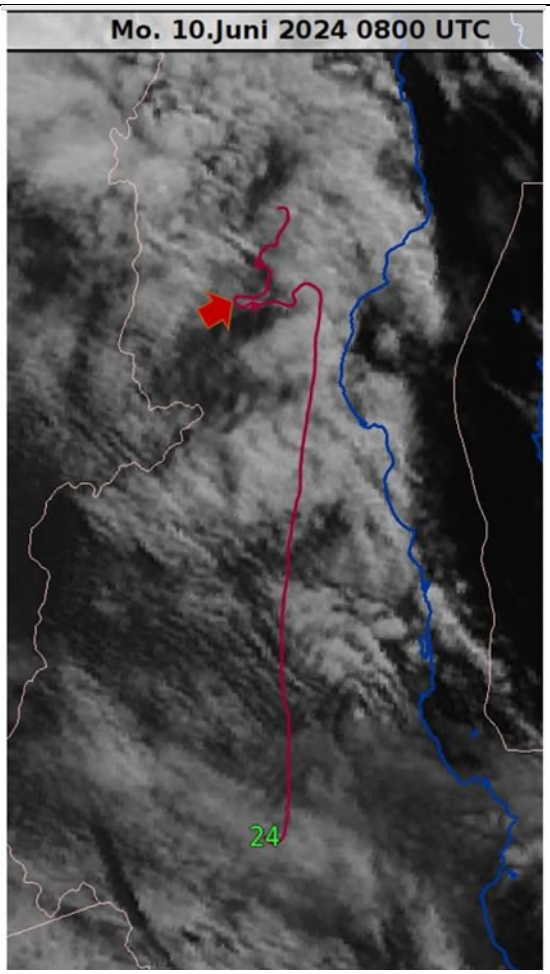
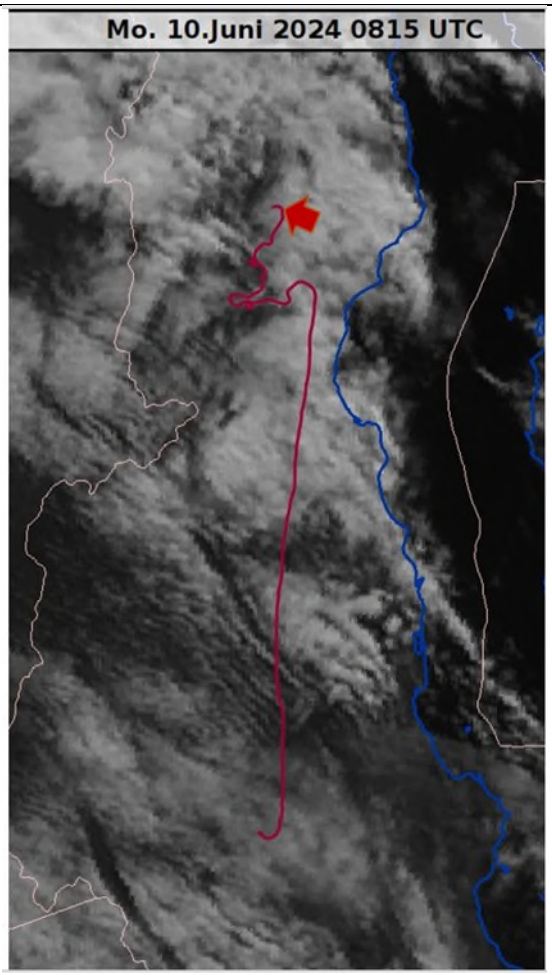
Appendix 2 Detail of altitude and elevation combined with height and ground speed



Appendix 3 Satellite images of the cloud coverage at 09:15 and 09:45 hrs with the respective position of the aircraft

| | |
|---|---|
|  |  |
| Plane before departure | Before the start of the price deviation |

Appendix 4 Satellite images of the cloud coverage at 10:00 and 10:15 hrs with the respective position of the aircraft

| | |
|---|---|
|  |  |
| Meandering at low altitude | Position 1 min before the accident |