AAIR-076/1
19 Jan, 2020

**Government of Nepal**
**Aircraft Accident Investigation Commission, 2019**

# FINAL REPORT

Summit Air Flight SMA 802D,9N-AMH
Aircraft Industries, LET-410
Lukla, Nepal
14 April 2019

**Aircraft Accident Investigation Commission, 2019**

# FINAL REPORT

Summit Air Flight SMA 802D
Aircraft Industries, LET-410
Lukla, Solukhumbu
14 April 2019

Submitted To:

The Government of Nepal
Ministry of Culture, Tourism and Civil Aviation

19 January, 2020

# FOREWORD

On 14 April 2019, Summit Air's scheduled flight SMA 802D, registration 9N-AMH from Tenzing-Hillary Airport, Lukla to Ramechap Airport, crashed at Tenzing- Hillary airport while the aircraft was on take-off roll.

After the accident, the Government of Nepal constituted four member Aircraft Accident Investigation Commission on 14 April 2019, as per the provision of the Civil Aviation (Accident Investigation) Regulation, 2014 (2071 BS), to determine the probable cause and the circumstances of the accident. This Final Report on the accident has been prepared by the Aircraft Accident Investigation Commission in accordance with Annex 13 to the Convention on International Civil Aviation and Civil Aviation (Accident Investigation) Regulation, 2014 (2071 BS) to identify the probable cause of the accident and suggest remedial measures so as to prevent the recurrence of such accidents in future.

The commission was assisted by Accredited Representative Mr. Stanislav SUCHY for state of Design and Manufacturer and his advisors Mr. Alvaro Neves, Technical advisor from EASA, Ms. Zuzana Sekeresova from GEAC and Mr. Miroslav Pesak from Aircraft Industries, a.s. and BEA, France.

The sole objective of this investigation is the prevention of recurrence of accidents of similar nature in future. It is not the purpose of this investigation to apportion blame or liability. As per the Civil Aviation (Accident Investigation) Regulation, 2014 (2071 BS), clause 20, this report doesn't carry any legal liability.

Chairman
Rajesh Raj Dali

Member
Er. Rajesh Prasad Shrestha

Member
Capt. Rabindra Dangol

Member Secretary
Buddhi Sagar Lamichhane

**Date: … January 2020**

# SYNOPSIS

| | |
|---|---|
| **Operator** | Summit Air Pvt. Ltd. |
| **Aircraft Type and Model** | L410UVP-E20 |
| **Registration** | 9N-AMH |
| **Type of Flight** | Scheduled Commercial |
| **Accident Location** | Tenzing-Hillary Airport, Lukla, Nepal |
| **People on board** | Flight Crew-2, Cabin Crew-1, Passengers-0 |
| **Date and Time of Accident** | 14 April 2019, 0322 (LT 0907) |
| **All times in this report are in UTC.** | **Local Time : UTC+5:45** |

On 14 April 2019, around 0322Hrs, Aircraft Industries' L410UPV-E20, registration 9N-AMH, owned and operated by Summit Air Pvt. Ltd. met with an accident at Tenzing-Hillary Airport, Lukla when it veered right and excursed the runway during take-off roll from runway 24. The aircraft first collided with Manang Air's helicopter, AS350B3e, registration 9N-ALC, with its rotor blade running on idle power and then with Shree Airlines' helicopter, AS350B3e, registration 9N-ALK just outside the inner perimeter fence of the aerodrome into the helipad before coming to a stop. The PIC and Cabin Crew of 9N-AMH survived the accident, whereas the Co-pilot and one security personnel on ground were killed on the spot. One more security personnel succumbed to injury later in hospital during the course of treatment. 9N-AMH and 9N-ALC both were substantially damaged by impact forces. There was no post-crash fire.

The accident was notified to the concerned authorities as provisioned on Chapter 4, Section 4.1 of ICAO Annex 13. The Government of Nepal constituted four membered Aircraft Accident Investigation Commission on 14 April 2019 to determine the cause and the circumstances of the accident as per the provision of the Civil Aviation (Accident Investigation) Regulation 2014 of Nepal.

For flight recorder analysis, the CVR was sent to Air Accidents Investigation Institute (AAII), Czech Republic and BEA, France for downloading/decoding and analysis. AAII, Czech Republic and BEA, France performed the entire technical job in association with two commission members, and the Accredited Representative (ACCREP) from Czech Republic. The FDR was downloaded, decoded and analyzed in AAII, Czech Republic.

The commission issued two interim recommendations to CAA Nepal on 6 May 2019 as follows:

1. PIC should not handover the controls to Co-pilots during take-off and landing in STOL airfields.

2. Recommendation to use available full runway length for take-off and to check and confirm all parameters at take-off power are normal before initiating take-off roll in STOL airfields.

The Aircraft Accident Investigation Commission determines that the probable cause of the accident was aircraft's veering towards right during initial take-off roll. The veer was a result of generation of asymmetric power due to abrupt shifting of right power lever rearwards. The particular reason for abrupt shifting of the power lever couldn’t be identified.

Unless otherwise indicated, recommendations in this report are addressed to the regulatory authorities of the State having responsibility for the matters with which the recommendation is concerned. It is for those authorities to decide what action is taken.

# Table of Contents

# Table of Figures

# Abbreviations

| | |
|---|---|
| AAII | Air Accidents Investigation Institute |
| ACAS | Aircraft Collision Avoidance System |
| ACCREP | Accredited Representative |
| AMHS | Aeronautical Message Handling System |
| AFIS | Aerodrome Flight Information Service |
| AOC | Air Operator Certificate |
| ATC | Air Traffic Controller |
| ATPL | Airline Transport Pilot License |
| BEA | Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile |
| CAAN | Civil Aviation Authority of Nepal |
| CB | Circuit Breaker |
| CG | Centre of Gravity |
| CPL | Commercial Pilot License |
| CVR | Cockpit Voice Recorder |
| DC | Direct Current |
| EASA | European Union Aviation Safety Agency |
| FDR | Flight Data Recorder |
| FOR | Flight Operation Regulation |
| HF | High Frequency |
| IP | Instructor Pilot |
| ITT | Inter Turbine Temperature |
| MPD | Maintenance Planning Document |
| MSL | Mean Sea Level |
| LH | Left Hand |
| OD | Operations Director |
| OEM | Original Equipment Manufacturer |
| OM | Operations Manual |
| PF | Pilot Flying |
| PIC | Pilot-in-command |
| PM | Pilot Monitoring |
| RH | Right Hand |
| RPM | Revolution per minute |
| SMS | Safety Management System |
| SOP | Standard Operating Procedures |
| STOL | Short Take-off and Landing |
| TQ | Torque |
| UTC | Universal Time Coordinated |
| VHF | Very High Frequency |
| VNLK | Tenzing-Hillary Airport |
| WOW | Weight on Wheels |

# Factual Information

## 1.1 History of Flight

On 14 April 2019, around 0322Hrs, Aircraft Industries' L410UPV-E20, registration 9N-AMH, owned and operated by Summit Air Pvt. Ltd. met with an accident at Tenzing-Hillary Airport, Lukla when it veered right and excurred the runway during take-off roll from runway 24. The aircraft first collided with Manang Air's helicopter, AS350B3e, registration 9N-ALC, with its rotor blade running on idle power and then with Shree Airlines' helicopter, AS350B3e, registration 9N-ALK just outside the inner perimeter fence of the aerodrome into the helipad before coming to a stop. The PIC and Cabin Crew of 9N-AMH survived the accident, whereas the Co-pilot and one security personnel on ground were killed on the spot. One more security personnel succumbed to injury later in hospital during the course of treatment. 9N-AMH and 9N-ALC both were substantially damaged by impact forces. There was no post-crash fire.

Prior to the accident the aircraft had completed 3 flights on Ramechhap-Lukla-Ramechhap sector. According to PIC, he was in the left seat as the pilot monitoring (PM) and the co-pilot, in the right seat was the pilot flying (PF). According to CCTV footages, the aircraft arrived at the apron from VNRC to VNLK at 0315Hrs and shut its LH engine. The PIC started the LH engine at about 0318 Hrs after unloading cargo and passengers. At 0322:30 Hrs, the PIC aligned the aircraft with the runway at the runway threshold 24 and then handed over the controls to the co-pilot for the take-off roll.

The take-off roll commenced at 0322:50 Hrs. CCTV footage captured that within 3 seconds the aircraft veered right and made an excursion. The aircraft exited the runway and travelled about 42.8 ft across the grassy part on right side of runway 24, before striking the airport inner perimeter fence. It then continued to skid for about 43 ft, into the upper helipad, crashing into 9N-ALC.


*Source: Google Earth (path track added by AAIC)*

**Figure 1** Flight progression from threshold of runway 24 to its final location


*Source: Google Earth (path track added by AAIC)*

**Figure 2** Flight progression from threshold of runway 24 to its final location

Eye witnesses statements, CCTV footages and initial examination of the wreckage showed that rotor blades of helicopter 9N-ALC were on idle when RH wing of the aircraft swept two security personnel (on ground) before slashing its rotor shaft. The moving rotors cut through the cockpit on the right side slaying the Co-pilot immediately. The helicopter toppled onto the lower helipad 6 ft below. The LH wing of the aircraft broke the skid of helicopter 9N-ALK and came to a halt with toppled 9N-ALC beneath its RH main wheel assembly. Due to 2impact, 9N-ALK shifted about 8 ft laterally and suffered minor damages.

**Figure 3** Final position of aircraft

There was no post-crash fire. The PIC switched off the battery and came out of the aircraft through emergency exit along with the cabin crew. The captain of the helicopter 9N-ALC was rescued immediately.

## 1.2 Injuries to persons

| ***9N-AMH*** | | | | |
|---|---|---|---|---|
| ***Injuries*** | ***Crew*** | ***Passengers*** | ***Persons on the Ground*** | ***Total*** |
| ***Fatal*** | 1 | - | 2 | 3 |
| ***Serious*** | - | - | | - |
| ***Minor*** | 1 | - | | 1 |

| ***9N-ALC*** | | | | |
|---|---|---|---|---|
| ***Injuries*** | ***Crew*** | ***Passengers*** | ***Total in the aircraft*** | ***Others*** |
| ***Fatal*** | - | - | - | - |
| ***Serious*** | 1 | - | 1 | - |
| ***Minor*** | - | - | - | - |

9N-ALC's crew sustained a broken tail-bone whereas 9N-ALK's crew escaped without sustaining major injuries. All three deceased were Nepalese citizens.

## 1.3 Damage to aircraft


**Figure 4** Damage to Aircraft

Aircraft 9N-AMH and helicopter 9N-ALC were substantially damaged while the helicopter 9N-ALK endured partial damages.

## 1.4 Other damages

A portion of the aerodrome's inner perimeter fence of the airport was damaged.



**Figure 5** Tyre mark on the runway and aerodrome inner perimeter fence damage

## 1.5 Personnel Information

### 1.5.1 Pilot-in-command

| | | |
|---|---|---|
| Age: | 48 years | |
| Type of License: | ATPL | |
| Aircraft Rating: | C-208B, L410UVP-E20 | |
| Recent Pilot Proficiency Check: | January 28, 2019 | |
| Operator's Line Check: | February 14, 2019 | |
| Last Medical Check-up | Valid until August 2019. | |
| Flying Experience: | Total: | 15652:03 hrs |
| | On Type: | 3558:02 hrs |
| | Last 90 days (January to March): | 154:36 hrs |
| | (April): | 23.25 hrs |
| | Last 28 days: | 42:38 hrs |
| | Last 7 days: | 12:25 hrs |
| | Last 24 hrs: | 2:20 hrs |
| Previous rest period: | 3 days | |

### 1.5.2 Co-pilot

| | |
|---|---|
| Age: | 33 years |
| Type of License: | CPL |
| Aircraft Rating: | L410UVP-E20 |
| Recent Pilot Proficiency Check: | January 16, 2019 |
| Instrument Rating: | Valid till June 30, 2019 |
| Operator's Line Check: | February 25, 2019 |
| Last Medical Certificate: | Valid until August 2019 |
| Flying Experience: | Total: 865:29 hrs |
| | On Type: 636:04 hrs |
| | Last 90 days (January to March): 93:34 hrs |
| | (April): 21:31 hrs |
| | Last 28 days: 63:20 hrs |
| | Last 7 days: 5:40 hrs |
| | Last 24 hours: 2:20 hrs |
| Previous rest period: | 5 days |

## 1.6 Aircraft Information

### 1.6.1 General Information

| | |
|---|---|
| Manufacturer: | Aircraft Industries, a.s. Czech Republic |
| Model: | L410UVP-E20 |
| Date of manufacture: | April 9, 2014 |
| Manufacturer's Serial Number: | 2914 |
| Aircraft Registration Number: | 9N-AMH |
| Owner of the Aircraft: | Summit Air Pvt. Ltd. |
| Operator of Aircraft: | Summit Air Pvt. Ltd. |
| Total Airframe Time since New: | 4426:43 hrs (as of April 13, 2019) |
| Total Cycle since New: | 5464 (as of April 13, 2019) |

### 1.6.2 Power-plant Information

| | |
|---|---|
| Make: | GE Aviation |
| Model: | GE H80-200 |
| Time between Overhaul: | 3600 hrs or 6600 cyc, whichever comes first. |
| *LH Engine*: | |
| Manufacturer's Serial No.: | 132014 |
| Time since Overhaul: | 446.03 hrs (As of April 12, 2019) |
| *RH Engine*: | |
| Manufacturer's Serial No.: | 151019 |
| Time since Overhaul: | 1840:05 hrs (As of April 12, 2019) |

### 1.6.3 Propeller Information

| | |
|---|---|
| Make: | Avia Propeller |
| Model: | AV-725-1-E-C-F-R (W)/CFR230-433 |
| Time between Overhaul: | 3600 hrs or 72 months, whichever comes first. |

*LH Propeller*:

| | |
|---|---|
| Manufacturer's Serial No.: | 130036 |
| Time since Overhaul: | 3530:23 hrs (As of April 12, 2019) |

*RH Propeller*:

| | |
|---|---|
| Manufacturer's Serial No.: | 130040 |
| Time since Overhaul: | 96:00 hrs (As of April 12, 2019) |

### 1.6.4 Certification of Aircraft

| | |
|---|---|
| Certificate of Registration: | Summit Air Pvt. Ltd., 9N-AMH |
| Certificate of Airworthiness: | Valid until March 4, 2020 |
| Radio Mobile License: | Valid until March 4, 2020 |
| Certificate of Release to Service: | Valid until 4511 hrs or May 6, 2019 |

As per the available evidences and documents, the aircraft was operated by Summit Air Pvt. Ltd. since its induction into Nepal on 14 June 2017. Maintenance of the aircraft was carried out in accordance with Customized Maintenance Schedule; (Issue 3, Revision 4) approved by Civil Aviation Authority of Nepal on 22 January 2019.

The last maintenance carried out on the aircraft was P1 check which was carried out on April 7, 2019. Daily inspection was performed on 13 April 2019 at 1800 hrs (local time) and Pre-flight inspection of the day was carried out on 14 April 2019 (time not specified).

## 1.7 Fuel

**JET A-1** fuel was used on the aircraft. As per the load sheet 480KG fuel was onboard the aircraft before departure.

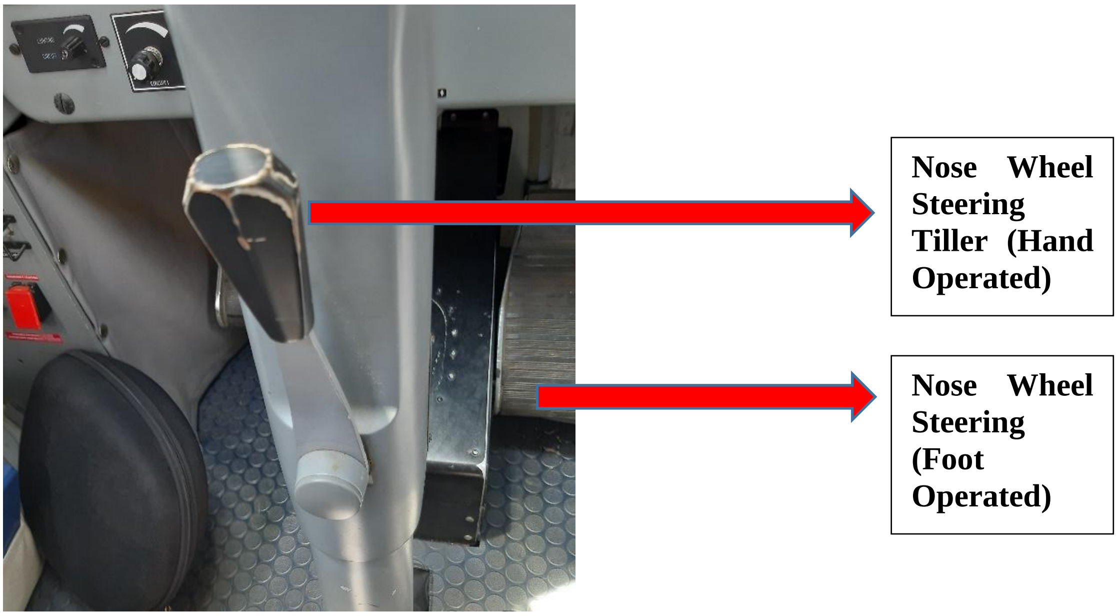
## 1.8 Aircraft and Aircraft system

This aircraft is an all metal, high wing twin turboprop L410 UVP-E20 aircraft which was manufactured by LET, Aircraft Industries, a.s., Czech Republic. It is intended for transport of up to 19 passengers or cargo or for special mission. The aircraft is powered by two GE H80-200 engines and AV – 725 propellers. The aircraft has been certified according to FAR 23 including Amendment 34 airworthiness requirements. Type certificate is issued by EASA and validated by CAAN on 6 October 2013.

Based on the accident scenario, PIC interview, analyzing CCTV videos and airport topography, the commission decided to concentrate its study mainly on the following two systems of the aircraft.

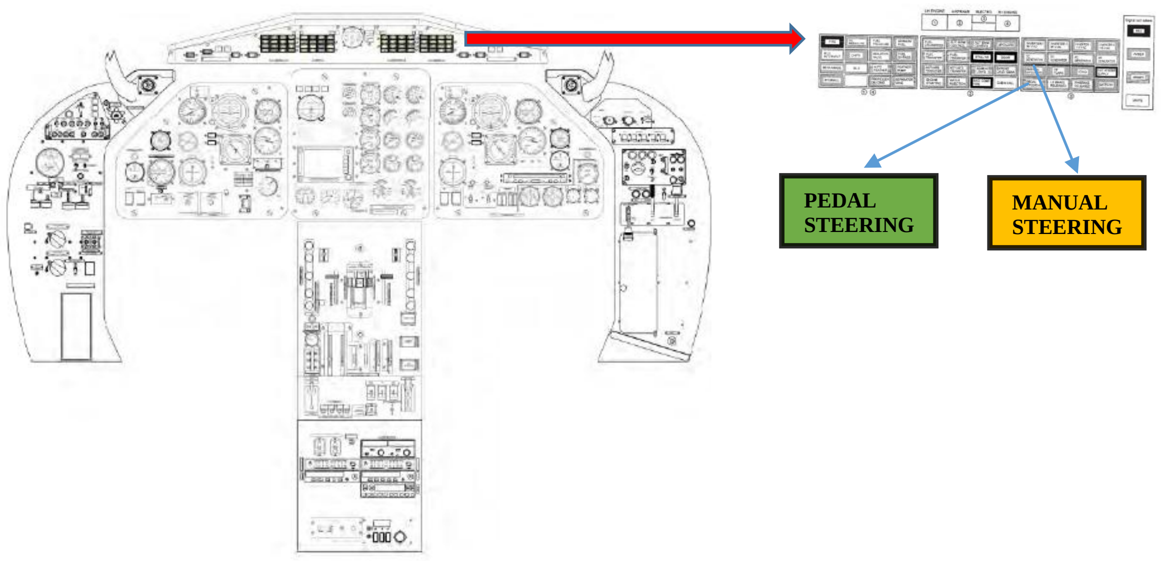
### 1.8.1 Nose Wheel Steering System

In Let410, Nose wheel Steering is an electro-hydraulic-mechanical system and can be hand operated by a lever on the Captain’s steering column or foot-operated by pedals depending on the selection of nose wheel steering to manual or pedal. Manual nose wheel steering enables taxiing of the aircraft. The pedal foot-operated steering controls the nose wheel within small angles and is used for take-off roll and landing roll only. PIC has control over the manual operated steering mechanisms while taxing up to line up in the Runway.




The steering servo has two independent functions in the aircraft.


- When connected into the hydraulic system through the switch located on the central control panel (signaling lamps in the PEDAL STEERING, MANUAL STEERING window in the signaling panel are ON) it works as a steering servo.
- When not connected into the hydraulic system, i.e. the switch on the control panel is OFF (signaling lamps in the PEDAL STEERING, MANUAL STEERING window are OFF) it works as a shimmy damper. The steering servo must be switched OFF when towing the aircraft by a tractor.




Let410: Operation of the nose wheel steering system when hand operated

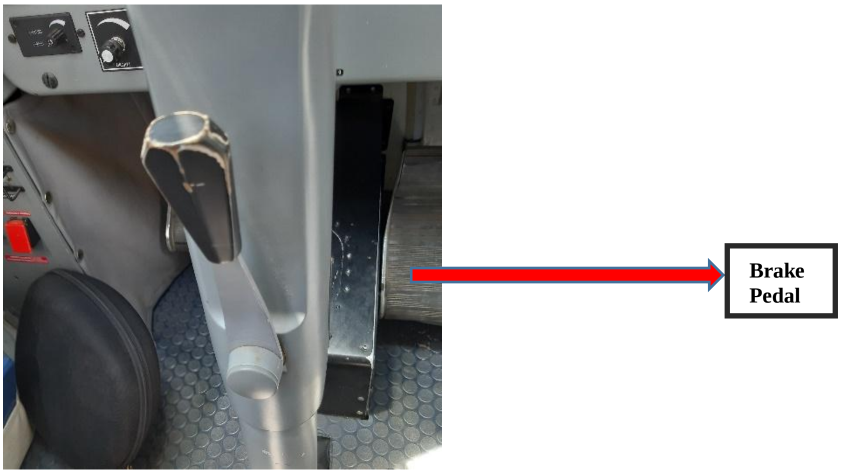
With LANDING GEAR circuit breaker on and NOSE WHEEL STEERING switch in MANUAL position the solenoid valve lets the pressurized hydraulic fluid flow into the nose wheel steering servo circuit. Simultaneously the MANUAL STEERING lamp on signaling panel lights up. The wheel starts turning when Steering Tiller is moved. Manual steering controls the nose wheel within 50° to each side with a tolerance of -5°. The hand operated operation is performed only from PIC’s Steering Tiller when the switch is kept in MANUAL position.

Let410: Operation of the nose wheel steering system when foot operated

With LANDING GEAR circuit breaker on and NOSE WHEEL STEERING switch in PEDAL position and through motion of rudder control pedals the neutral positions of the nose wheel and the rudder become identical. At that moment the terminal switch switches on and closes the electromagnetic clutch. Simultaneously the PEDAL STEERING signaling lamp lights up on the signaling panel. Wheel turning is proportional to the motion of the foot-operated steering pedals. It enables the nose wheel to turn within the range of 4° 30' ± 1 °30' to the right/left. The foot operated steering operation is performed from both foot pedals when the switch is kept in PEDAL position.

### 1.8.2 Braking System

In Let410, the main wheels brakes and parking of the aircraft are controlled with a hydraulic circuit of main wheels braking. The braking circuit is separated from the steady pressure circuit with a non-return valve the separate hydraulic accumulator with which supplies the pressure energy in case of the steady pressure circuit failure from. The hydraulic fluid is supplied through a hand operated valve to four brake valves that generate the pressure for braking. They are controlled by a lever gear from the foot operated steering pedals. The brake valves deliver the hydraulic fluid with smooth reduction from O to 4.4 + 0.3 MPa (0 to 45 + 3 kp/cm2) to the brakes proportionally to intensity of pressing the foot operated steering pedals.




When braking the aircraft by pressing brake pedal, the force is transmitted by a regulation spring to the valve. After releasing the brake pedal, the valve connects the brake circuit with the reverse branch and releases the brake. Higher or lower pressure in brakes can be obtained by changing the intensity of brake pedal pressing. The hydraulic fluid is delivered from the brake valves to shuttle valves.

### 1.8.3 POWER Generation in Turboprop Engines:

Power plant (Engine and Propeller) operation is achieved by three sets of controls for each engine: the Power lever, Propeller lever, and Fuel lever. The power lever serves to control engine power in the range from idle through takeoff power. Forward or aft motion of the power lever increases or decreases gas generator rpm (Ng) and thereby increase or decrease the engine power. The propeller lever is operated conventionally and controls the constant-speed propellers (Np) through the primary governor. The Fuel lever controls the flow of fuel to the engine.

Engine instruments in a turbine engine typically consist of the following basic indicators.

- Torque Indicator
- Inter Turbine Temperature (ITT) indicator
- Propeller (Np) RPM Indicator
- Gas Generator (Ng) RPM Indicator
- Fuel flow (Wf) indicator
- Oil temperature/pressure indicator

The ITT indicator gives an instantaneous reading of engine gas temperature between the compressor turbine and the power turbines. The torque indicator responds to power lever movement and gives an indication in foot-pounds (ft/lb) of the torque being applied to the propeller and can be calibrated in percentage (%). Because in the free turbine engine the propeller is not attached physically to the shaft of the gas turbine engine, two tachometers are justified—one for the propeller Np and one for the gas generator Ng. The propeller tachometer is read directly in revolutions per minute (RPM). The Ng or gas generator is read in percent of rpm.

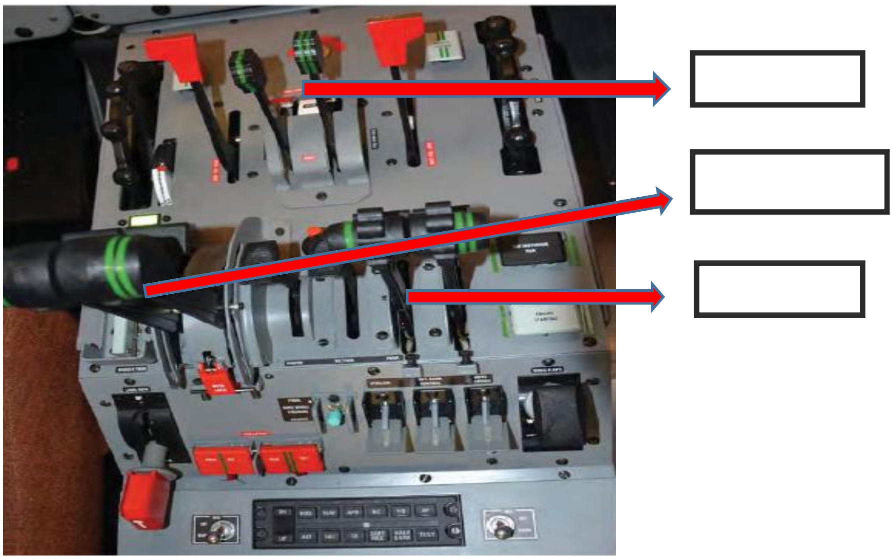
The ITT indicator and torque indicator are used to set takeoff power. Climb and cruise power are established with the torque and propeller speed while observing ITT limits. Gas generator (Ng) operation is monitored by the gas generator tachometer. Proper observation and interpretation of these instruments provide an indication of engine performance and condition.

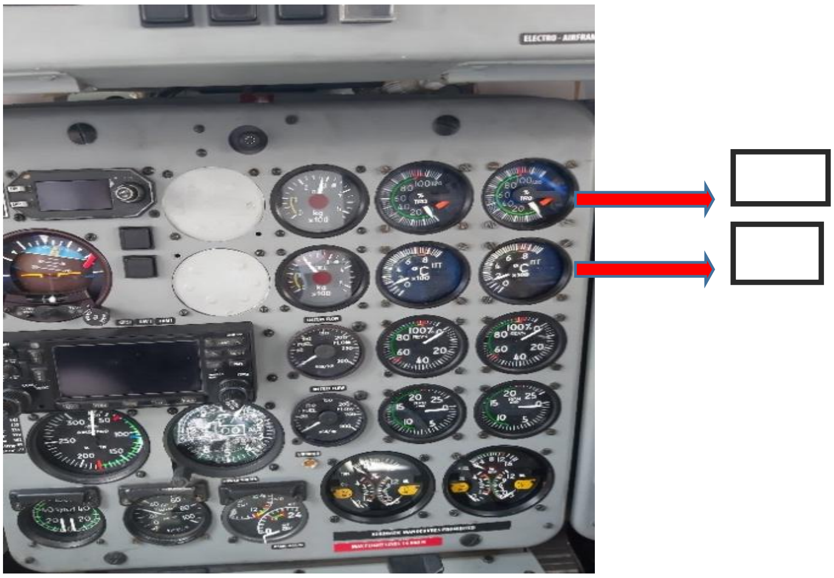
Takeoffs in turboprop airplanes are not made by automatically pushing the power lever full forward to the stops. Depending on conditions, takeoff power may be limited by either torque or by engine temperature.

Power changes are made by increasing fuel flow and propeller blade angle rather than engine speed. An increase in fuel flow causes an increase in temperature and a corresponding increase in energy available to the turbine. The turbine absorbs more energy and transmits it to the propeller in the form of torque. The increased torque forces the propeller blade angle to be increased to maintain the constant speed.

Temperature and altitude play a major role in many flights. Most of the airstrips we frequent are above 8000 ft. Most takeoffs are torque limited but occasionally the altitude and temperature are such that the takeoff becomes temperature limited. Since Lukla airfield is located at high altitude this description is quite relevant.

In cold weather conditions, torque limits can be exceeded while temperature limits are still within acceptable range. While in hot weather conditions, temperature limits may be exceeded without exceeding torque limits. In any weather, the maximum power setting of a turbine engine is usually obtained with the Power levers. The pilot must understand the importance of knowing and observing limits on turbine engines. An over temperature or over torque condition that lasts for more than a few seconds can literally destroy internal engine components





## 1.9 Metrological Information

The weather at the time of accident was fair.

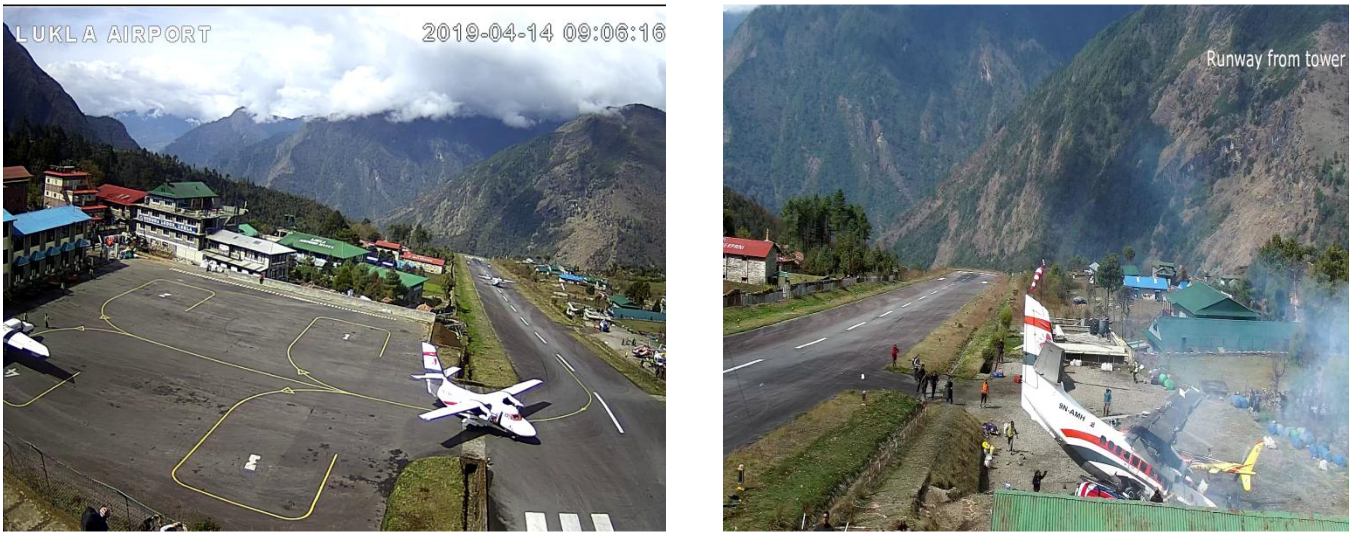



**Figure 6** Weather at the time of accident

## 1.10 Aids to Navigation

Tenzing-Hillary Airport is an AFIS station and not facilitated with any navigation aid.

## 1.11 Communication

Tenzing-Hillary airport is equipped with VHF, HF, and AMHS communication system and landline telephone. No difficulties with communications were known or reported. However, as per the technical report received from the airport, the VHF recorder at the Tower was inoperative from April 13, 2019, 1144 hrs till April 16, 2019. Thus, air traffic services communication recording was unavailable.

## 1.12 Aerodrome Information

| | |
|---|---|
| Name | Tenzing-Hillary Airport |
| Location | Solukhumbu |
| Location Indicator | VNLK |
| Elevation | 2846 m (9337 ft) AMSL |
| Runway Identification | 06/24 |
| Runway Length and slope | 527 x 20 m and 11.7% upslope |
| Runway surface | Bitumen |

Tenzing-Hillary Airport is located 77 NM east of Tribhuvan International Airport. The airport is within a narrow valley. It is a Short Takeoff and Landing (STOL) airfield with one-way approach only, landing from RWY 06 and takeoff from RWY 24.

## 1.13 Flight Recorders

The aircraft was equipped with Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR). CVR and FDR were recovered in good condition. The recorders were sent to Air Accident Investigation Institute (AAII), Czech Republic for downloading, decoding and analysis. The analysis was completed in the facility of Aircraft Manufacturer in the presence of Commission members and ACCREP from AAII, Czech Republic, Technical experts from EASA, Engine manufacturer and aircraft manufacturer.

### 1.13.1 Cockpit Voice Recorder

The aircraft was fitted with a CVR of 120 minutes recording capacity. No mechanical and significant thermal damage was found during its recovery from the crash site. However, no data was retrieved after multiple attempts of downloading and decoding at Aircraft Industries, Czech Republic and BEA, France.

The details of installed CVR on 9N-AMH aircraft is as follows:

Manufacturer: L3 Communications
Model: 2100-1020-02
Serial Number: 000846533

### 1.13.2 Flight Data Recorder

The aircraft was equipped with a FDR of at least 25 hrs recording capacity. The unit was retrieved in good condition. No mechanical and significant thermal damage was found during its recovery from the crash site.

The details of installed FDR on 9N-AMH aircraft is as follows:

Manufacturer: L3 Communications
Model: 2202-2600-00
Serial Number: 000886349

## 1.14 CCTV at Tenzing-Hillary Airport

CCTV video recordings of the particular moments of the aircraft movement was collected and reviewed in depth in order to verify the witness information and supplement the FDR findings regarding the aircraft movement and position. The CCTV video covered all of the final events including rescue operations.


**Figure 7** CCTV snapshots of final moments

## 1.15 Wreckage and impact information

The take-off roll commenced at 0322:50. CCTV footage captured that within 3 seconds the aircraft 9N- AMH veered right and covered a distance of around 272 ft from the runway threshold, exited the runway and travelled about 42.8 ft across the grassy part on right side of runway 24, before striking the airport inner perimeter fence. It then continued to skid for about 43 ft, into the upper helipad, striking into 9N-ALC and in the lower helipad touching 9N-ALK by left wing of the aircraft, before coming to a stop.

Engines, wings and landing gears were still attached to the aircraft. Some portions of the right propeller were fragmented due to impact with 9N-ALC and the left wing was bent due to impact on ground.

9N-ALC was completely damaged. The main rotor assembly and tail rotor assembly were detached from the helicopter. The fuselage lay below the aircraft's right main wheel assembly.

9N-ALK suffered partial damages.

## 1.16 Medical and pathological information

Post-accident drug and alcohol testing for the PIC indicated negative results.

## 1.17 Fire

CCTV footage showed white fumes arising from the collision. The fire service vehicle reached the location within 50 seconds. On crash-site visit and evaluation, there was no evidence of fire in flight or after the impact.

## 1.18 Survival Aspects

### 1.18.1 Rescue and Fire Fighting Response

CCTV footages show that security personnel and airlines'/airport's staff members attempted 9N-ALC's pilot's rescue within 33 seconds of impact. Tenzing-Hillary Airport is equipped with a small fire tender. The fire tender reached the crash-site within 50 seconds and hosed down the aircrafts to prevent any possible post-crash fire.

### 1.18.2 Evacuation

As per the pilot, the moving rotor blades of helicopter 9N-ALC cut through the cockpit and slashed the co-pilot. In a post-accident interview, the pilot stated that after a few seconds of impact, he recollected himself and evacuated the aircraft and proceeded to rescue the cabin crew through the emergency exit door located above the left side main wheel assembly.  Both the captain and the cabin crew sustained no significant injury. However both were sent for the medical observation.

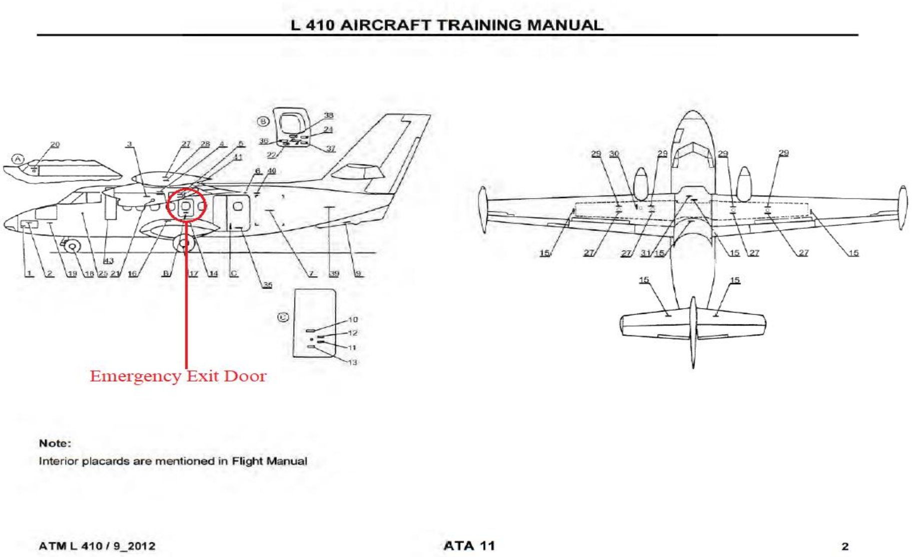




**Figure 8** Cabin crew of 9N-AMH after evacuation

### 1.18.3 Ground Casualties

The aircraft's RH wing swiped two security personnel who were standing on a walkway outside of the runway fence. They were walking towards tower from the helipad after welcoming high level official who arrived on helicopter 9N-ALC. One security personnel died immediately and another died while on the way to hospital airlifting by helicopter.


**Figure 9** Ground Casualties

## 1.19 Test and research

The CVR and FDR were sent to Aircraft Industries, Czech Republic facilities for downloading, decoding and analysis. CVR download and decompression of data resulted in retrieval of no-sound recording. Upon discussion and consultation with the EASA expert, the Commission decided to send the unit to BEA, France for attempts of retrieval. The following methods were used to retrieve usable CVR recordings:

1 Direct download of the CVR.
2 AIK (Accident Investigator Kit) data recovery process.

Both data recovery method provided the same no-sound data. Special Frame (SP) file and CVR's fault log analysis were carried out to investigate the CVR erasure scenarios by BEA, France and Aircraft Industries, Czech Republic. The commission carried out detailed study and analysis incorporating BEA, France's report and L3 communications' (OEM) correspondence.

The FDR data was downloaded using the L-410 aircraft interface at the Aircraft Industries factory in Kunovice, Czech Republic. The data file was recovered, translated via "Rose" software and stored in an Excel file. The calibration matrix of the aircraft configuration at the time of the accident was not available; therefore Aircraft Industries used the factory calibration matrix for data translation. Consequently, several key parameters (such as throttle positions or engine torque values) were only qualitative and the absolute values couldn't be derived.

## 1.20 Organizational and management information

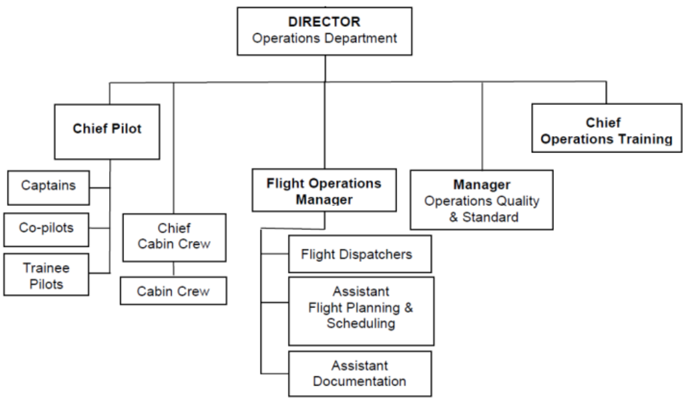
Summit Air Pvt. Ltd (previously Goma Air Pvt. Ltd.) started its operation with two "Cessna Grand Caravan 208 B" from February 24, 2011. Schedule operation from Kathmandu base started after induction of LET410 UVPE-20 STOL aircraft on October 2014. The Air Operator's Certificate (AOC), valid on the date of the accident, was first issued by Civil Aviation Authority of Nepal on October 11, 2010. As of the date of the accident, Summit Air was operating scheduled and charter flights with 4 LET 410UVPE-20 aircrafts (including the accident aircraft).

The company has different departments responsible for particular functions such as: Flight Operations, Corporate safety, flight data monitoring, engineering, continued airworthiness monitoring, quality assurance and sales. Company's Safety Management System (SMS) Manual, prepared by the 'Flight Safety Division' of the company was in place to ensure required safety performance of the company's flight operations by applying the best practice and moving beyond mere compliance with regulatory requirements. Part of the risk awareness processes was achieved through the information/occurrences collected as far as possible by means of hazard and occurrences reporting system, safety reviews, safety audits, safety surveys and accident/incident investigation.

### 1.20.1 Flight Operation Control - Operation Department

Operations Manual (OM) Part A, chapter 2, showed that all captains, co-pilots and trainee pilots require to report directly to the chief pilot. The chief pilot reports directly to the operations director (OD), who, along with Director of Safety report to the Accountable Manager. By policy, pilots had a 10 hour Flight Duty Period on domestic STOL operations out of which they were permitted no more than 8 hours of Flight Time.

According to OM Part A, the OD's duties included, in part, operational control, crew scheduling and rostering and flight watch. The OD was jointly responsible with the PIC for the initiation, continuation, diversion and termination of flight in compliance with regulations and Operational specifications.




### 1.20.2 Company operation Procedure

According to the Operation Manual Part A, the Chief Pilot's duties included training for route and STOL field clearance of pilots, as required. Summit Air's CAAN approved Operations Manual (OM), Chapter 6, para 6.3.5 and Standard Operating Procedure (SOP), Chapter 10 has underlined these qualifications and clearance requirements for STOL airfields.

OM Part A, para 6.3.5.1 states the following:

*" Pilots shall be cleared to the following airfields with copilots categorically through Categories A, B and C; however, where, an operator does not operate any fields in Category A, his pilots may commence clearing Category B airfields after having completed the preliminary requirements of Category B. Similarly where an operator does not operate to any category B airfields, his pilots may, after having cleared Category A airfields, commence clearance of Category C airfields. However, if a pilot has cleared Category C airfields but has not cleared an airfield of Category B, he/she may be cleared of this Category by an Instructor Pilot after the pilot completes at least two missions with an Instructor pilot."*

Extract from SOP Chapter 10 states the following:

*"For STOL operations and STOL field clearance SUMMIT AIR shall follow the regulation set in FOR*
*Fifth Edition, Appendix 9."*

The provision of the Operation Manual part A, para 6.3.2(c) is relevant to depict here to make more clarification this issue:

***6.3.2.c) Second-in-Command (SIC/P2)***
*(a) Company shall not use a pilot to act as co-pilot of Company aircraft unless that person:*
*i) holds a valid CPL license with appropriate class and type rating; and*
*ii) holds an instrument rating endorsed by CAAN, valid for the category, class and type of aircraft.*
*(b) Trainee Pilot*
*Upon joining the company as a co-pilot just after obtaining P2 licence from CAAN, a pilot shall fly minimum 50 hours with Instructor Pilot, after which he/she shall be eligible to fly with other Line Captains.*
*(c) Under supervision flying for co-pilot*
*i) Under supervision flying for co-pilots for upgrading to a pilot license of a higher category shall be conducted only with the prior authorization from the chief-pilot.*
*ii) Such flight as mentioned in clause (i) above may be initiated only after a co-pilot has accumulated not less than 1500 flying hours in aircraft in Nepal.*
*iii) Prior to initiation of such Under-supervision flights for copilots, the operator shall inform in writing to the CAAN of such a program.*
*iv) Flight time experienced under supervision as specified above that is credited towards an Airline Transport Pilot License shall not exceed 500 hours.*

### 1.20.3 CAAN Regulation

The fifth edition of Flight Operations Regulation (FOR) dated January 12, 2011, issued by CAAN, was applicable during the accident. The provision in Chapter 1, of FOR is as follows:

*" Category A STOL Airfield: Those STOL airfields located below 5500 feet AMSL and where missed approach is possible.*
*Category B STOL Airfield: Those STOL airfields which are below 7000 feet above mean sea level and where missed approach is critical.*
*Category C STOL Airfield: Those STOL airfields which are at or above 7000feet above mean sea level, approach is difficult due to local weather conditions and where missed approach is not advisable or possible after a certain point during the approach and landing phase. "*

Pilots shall be cleared to the following airfields with copilots step by step through Categories A, B and C; however, where an operator does not operate to any airfields in Category A, his pilots may commence clearance flight to Category B airfields after having completed the preliminary requirements of Category B. Similarly where an operator does not operate to any Category B airfields, his pilots may, after having cleared at Category A airfields, may further commence clearance flight at Category C airfields.

Similarly in the APPENDIX-9 para 1.3 (SMS AND SOP) of FOR the following provision is in force:

> *While operators now are required to have a Safety Management System in place, particular attention must be paid by operators using STOL fields in their systems focusing particularly on this issue. The SOP too must have a section devoted entirely to the standard procedures to be followed by a flight crew for every STOL field to which it operates.*

# Analysis

## 2.1Introduction

This accident occurred when the LET 410 UPVE-20 aircraft with registration number 9N-AMH excurred the runway during take-off roll. After excursion from the runway, the aircraft struck the airport inner perimeter fence and first collided with Manang Air's helicopter (registration 9N-ALC) which was parked at upper level helipad (with main rotor in idle rotation) and then trickled down to the lower level helipad along with the helicopter where Shree Airlines' helicopter (registration 9N-ALK) was parked before coming to a final stop. The co-pilot, who was the Pilot Flying for the flight, died instantly while the PIC and the cabin crew both were safe and evacuated themselves from the aircraft with minimal injuries.

Due to topography of Tenzing-Hillary Airport, during take-off the11.75% runway downslope generates fast acceleration.  This contributes multiplier effect on the aircraft speed and difficult to control aircraft with normal effort.

Each and every STOL field in Nepal is unique and has its own peculiar characteristics. A STOL pilot should be well acquainted with these characteristics before being released for solo or flights with copilots. STOL fields in Nepal range from the shortest field length of 1400 feet (Doti) to the longest at 2200 feet (Jumla, Jomsom and Phaplu). They range from the lowest elevation at 1,555 feet MSL (Ramechhap) to the highest at 12,297 feet MSL (Syangboche). They range from flat airfields to the steepest at 11.75% (Tenzing Hillary Airport, Lukla). Rapidly changing weather and wind conditions in mountainous regions are both highly critical influential factors in the safe operations in these airfields. Narrow and busy routes through a particular mountain pass during peak travel season to some of these airfields provide further hazards to pilots operating to and from these airfields particularly if their aircraft are not equipped with ACAS equipment or flying solo.

Based on the nature of the accident the following issues were analyzed and evaluated:

- Flight Crew Qualifications and Performance
- Engineering and Aircraft System Analysis
- Flight Recorders Analysis
- Operational Analysis from taxi to take-off
- Aircraft Performance
- Aircraft Maintenance Practices
- Human Factor Analysis

## 2.2 Flight Crew’s Qualifications and Performance

The PIC and the co-pilot were certified, current and qualified in accordance with Nepalese Civil Aviation Requirements. The PIC and co-pilot held valid and current CAAN medical certificates. No reported controversies were found on the qualification and performance of the cockpit crew.

In the accident flight, the co-pilot was given command for take-off roll by the IP/PIC. However, FOR and company's OM state that only P1 endorsed license holders, after completion of requirements, can be cleared for command in STOL fields. Although, it lacks the provisions for the co-pilot clearance to STOL airfields.

The existing regulation does not address the issues regarding where and in what condition the PIC could handover the controls of aircraft to the co-pilot for take-off in STOL airfield like Lukla. Considering Nepal's topography there should be some review in the provisions of FOR in this regard.

## 2.3 Engineering and Aircraft System Analysis

Both the main landing gears and wheel assembly were found normal. No evidence of hydraulic leakage was observed. Both the main tyres were found in inflated condition. Nose oleo was found collapsed due to impact but the tyre was still inflated.

**Figure 10** Condition of Nose wheel, LH wheel and RH wheel assemblies

### 2.3.1 Nose Wheel Steering

**Observation 1: Nose Wheel Steering Switch – Position**

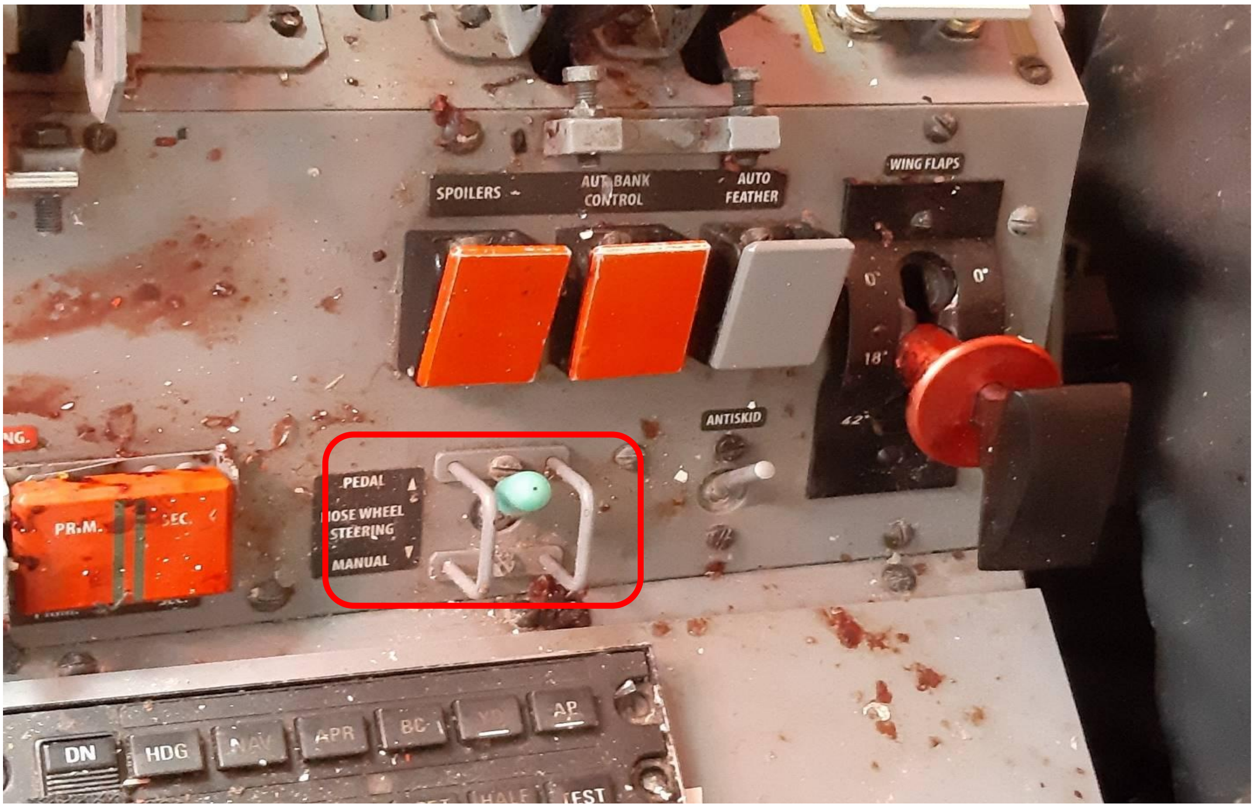



**Figure 11** Nose wheel steering switch position of accident aircraft

**Explanation to Observation 1:**
As explained in the brief description of aircraft systems 1.6.6.1: Operation of the nose wheel steering system when foot-operated can be analyzed that:

The Position of the Nose wheel steering switch during Take-Off should be in "PEDAL" position, which during the crash site investigation visit was found in the correct position. Thus, possibility of the aircraft veering to the right due to Steering mechanism malfunction as a result of incorrect switch selection was ruled out by the commission.

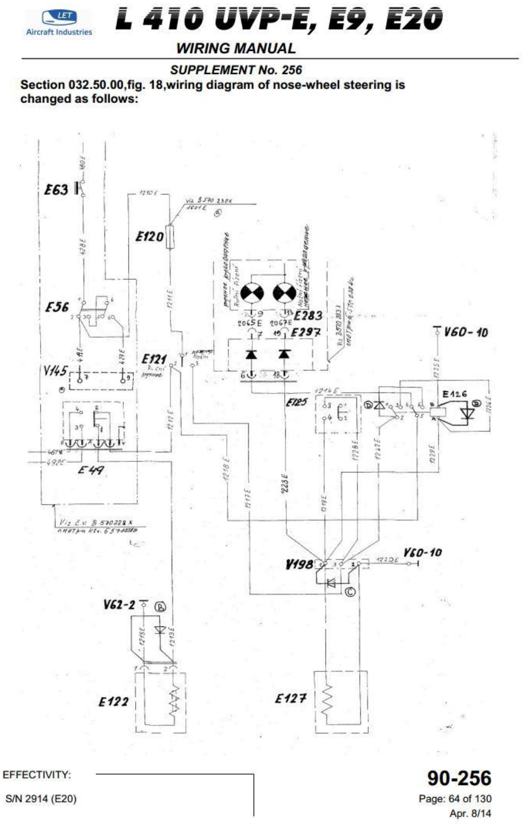
**Observation 2: Nose wheel Steering CB was found Popped Out**


**Figure 12** Nose wheel Steering CB was found Popped Out

**Explanation to Observation 2 :**
The veering to the right due to the failure of Steering mechanism as a result of incorrect switch selection was ruled out in observation 1. The observation that pop out of CB Nose Wheel Steering might have led to the malfunction in the Steering mechanism resulting the aircraft to veer to the right was evaluated. However, if the CB had popped out after Line Up when the Nose wheel Steering Switch is positioned to "PEDAL", this would have not triggered annunciation green light 'PEDAL STEERING" in CWD and the PIC would have aborted the initiation of take-off. Moreover, during post-accident interview with PIC, he stated that there were neither abnormalities on the Steering mechanism annunciation nor any reported defects earlier. Thus, the commission ruled out the possibility of Nose wheel steering CB pop out before take-off.

**Observation 3: How did the CB pop out?**
The Steering Wiring Diagram explains the possibilities of CB pop out function and probable causes. Wiring Diagram for Wheel Steering for A/C S/N 2914 is depicted below.
Nose (Manual & Pedal) wheel steering circuit is powered by 28VDC from DC distribution system through Landing Gear CB, Gear Selector (Gear Down position), Nose Wheel Steering CB (CB panel) and Manual / Pedal steering selector (central control panel). Nose Wheel Steering CB performs Nose Wheel steering short circuit protection. If this CB was popped out, there could be short circuit either in Manual or Pedal part of this circuit. Based on it, it is

very hard to determine probable causes, because every component (Weight on Wheels - WOW switch, clutch, valve, relay, protection diodes) of this circuit represents potential short circuit risk. Hence, the commission narrowed down the likelihood of CB pop out is due to short circuit in the WOW micro switch circuit (common component for Manual & Pedal Part of Nose Wheel Steering circuit) as a result of nose oleo collapse after impact.



Aircraft Industries

**L 410 UVP-E, E9, E20**

**WIRING MANUAL**

**SUPPLEMENT No. 256**

**Section 032.50.00,fig. 18,wiring diagram of nose-wheel steering is changed as follows:**



EFFECTIVITY:

S/N 2914 (E20)

**90-256**

Page: 64 of 130

Apr. 8/14

LET Aircraft Industries **L 410 UVP-E, E9, E20**

**WIRING MANUAL**

**SUPPLEMENT No. 256**

**Legend to fig.18, wiring diagram of NOSE-WHEEL STEERING**

| Designation | Name | Type | Location |
|---|---|---|---|
| E 120 | Fuse | 4ČSN 354733F/1500 | Fuse panel |
| E 121 | Switch | PPNG – 15K | Central control panel |
| E 122 | Selenoid valve | GA 184 | Ceiling of nose wheel bay |
| E 125 | Terminal switch | D 701 | Under the floor of copilot |
| E 127 | Electromagnetic clutch | LUN 2550.02 | Under the floor of copilot |
| E 126 | Relay | TKE 52 PODG | Under the floor of copilot |
| E 49 | Terminal switch | LUN 3159.01-7 | Nose landing - gear |
| E 56 | Change over switch | 2 PPG – 15K | Control panel |
| E 63 | Circuit breaker | AZRGK - 5 | Overhead panel |
| | Diodes | 1 N 4007 | |

EFFECTIVITY:
S/N 2914 (E20)

**90-256**
Page: 65 of 130
Apr. 8/14

## 2.4 Flight Recorders Analysis

### 2.4.1 CVR Analysis

CVR data was downloaded using two data recovery method (direct download and the AIK dedicated investigation techniques), duration of each wav files (*9N-AMH_directReadout_Hxx.wav*) was 2 h 04 min 14 s. However, the decoded data contained no recordings.

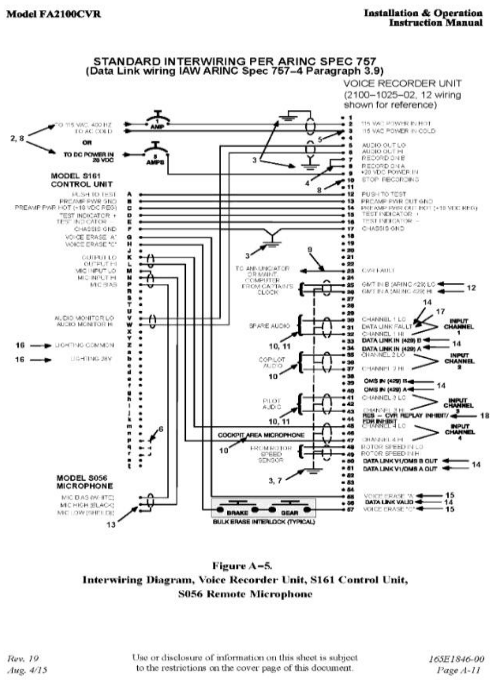
#### 2.4.1.1 Serviceability of the installed CVR Equipment:

The recording test was performed at Let 410 factory. The recording session was followed by 9 min 06 s of audio recording. This audio content corresponded to operations on ground done during a test (Czech speeches were recorded all along this session of 9 min 06 s). It was then proved that the CVR was serviceable. There is no technical defect on the CVR which could restrict the recording.

#### 2.4.1.2 Possibility of CVR Data erasure:

In case the CVR would have been intentionally erased shortly after the accident the first direct download performed in the scope of the investigation would have delivered a very short audio file (few seconds) starting by a power-on tone. The SP file would have contained only one recording session number. The factual analysis confirmed that it was not the case. The technical analysis shows that the data was not erased.

This aircraft was produced without interconnection between CVR control unit (S161 – pin H) and CVR unit (FA2100 – pin 57) as is shown in CVR producer's Inter wiring Diagram. The ERASE function is deactivated in the aircraft, so, the CVR could not be erased intentionally.




The commission concluded that there had been installed no means at aircraft level, namely parking brake & gear switch, that perform CVR bulk erase.

#### 2.4.1.3 Possibility of CVR recording overwrite:

On-board accidental over-write of data after the accident: In that case the essential BUS power supply or battery would have continued to power the CVR after the accident and would have continued to electrically supply the CVR unit for more than 1 h 55 min. As per PIC's statement during post-accident interview, the power was shut down and secured. Thus, the possibility of CVR data overwrite is not likely.

#### 2.4.1.4 Possibility of Incorrect CVR Installation

The presence and quality of audio is checked live at the aircraft with the 17TES0043 Portable Interface/1 handheld tool. Also, there should be periodic downloads of stored CVR data, that is sent off, or analyzed in-house, as part of a CVR Intelligibility Check. Summit Air has a procedure of CVR functionality checks which is intelligibility checks for this aircraft. If there was an audio presence problem, it would have shown up during a scheduled intelligibility check task.

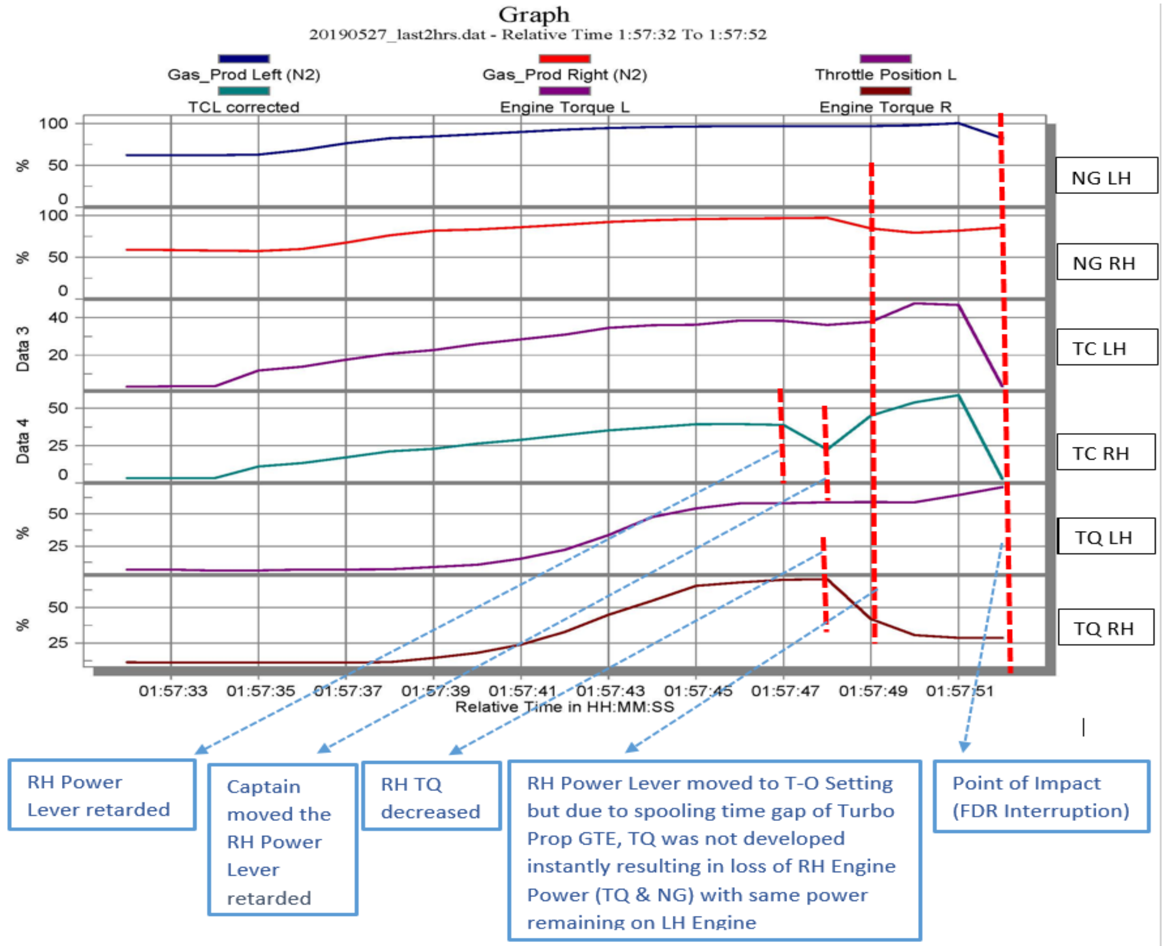
In aid to support the assumption that the CVR is incorrectly installed on the aircraft, Commission communicated with the CVR Manufacturer L3 Communication. Based on analysis of reports and correspondence from AAII, BEA and L3 Communications, the commission could not reach to a conclusive answer.

Considering the probabilities presented on the outcome of the analysis of why no-recording of any voice data happened, incorrect installation of the equipment on the aircraft is likely.

### 2.4.2 FDR Analysis

Based on the nature of crash and to support probable cause of accident, Among the 107 parameters that were recorded in the FDR only the following FDR parameters were analyzed critically:

(1) Altitude
(2) NG RPM LH
(3) NG RPM RH
(4) Air/Gnd
(5) DC Elec LH
(6) DC Elec RH
(7) TCL LH
(8) TCL RH
(9) TQ LH
(10) TQ RH
(11) NP RPM LH
(12) NP RPM RH
(13) Mag Heading
(14) Pitch Attitude
(15) Roll Attitude
(16) Brake Pr LH
(17) Brake Pr RH
(18) HYD Pr Emergency
(19) Long_Acceleration (NX)
(20) Lat_Acceleration (NZ)
(21) Vert_Acceleration (NY)
(22) EngL_Oil Pressure LOW LH
(23) EngL_Oil Pressure LOW RH
(24) Engine_BETA Range LH
(25) Engine_BETA Range RH
(26) XMIT KEYING1
(27) XMIT KEYING2




To explain the Graphical FDR analysis, the data sheet of relevant parameters is shown below:

| Relative | ALT | NG RPM | NG RPM | Air/ Gnd | DC Elec | DC Elec | TCL | TCL | TC Corr | TQ | TQ | NP RPM | NP RPM | Mag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | | Left (N2) | Right (N2) | Ground | Left | Right | Left | Right | Right | Left | Right | Left | Right | Heading |
| HH:MM:SS | Feet | % | % | | | | | | | % | % | RPM | RPM | Deg |
| 1:57:35 | 8932 | 62.8 | 57.5 | Ground | ON | ON | 12 | -43.4 | 11 | 6.26 | 11.26 | 1025 | 937 | 244.5 |
| 1:57:36 | 8932 | 68.5 | 59.9 | Ground | ON | ON | 14 | -39.7 | 13.3 | 6.91 | 11.26 | 1074 | 1007 | 244.5 |
| 1:57:37 | 8933 | 76.4 | 67.4 | Ground | ON | ON | 18 | -34 | 17.1 | 6.91 | 11.26 | 1208 | 1168 | 244.5 |
| 1:57:38 | 8933 | 82.5 | 76.2 | Ground | ON | ON | 21 | -28 | 21.2 | 7.1 | 11.56 | 1434 | 1402 | 244.5 |
| 1:57:39 | 8934 | 84.6 | 81.9 | Ground | ON | ON | 23 | -25.6 | 22.9 | 8.86 | 14.57 | 1633 | 1575 | 244.5 |
| 1:57:40 | 8934 | 87.2 | 83.3 | Ground | ON | ON | 26 | -20.7 | 26.3 | 10.65 | 18.05 | 1767 | 1678 | 244.5 |
| 1:57:41 | 8934 | 89.9 | 86.1 | Ground | ON | ON | 28 | -17 | 29 | 15.31 | 23.93 | 1940 | 1839 | 244.5 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1:57:42 | 8934 | 92.7 | 88.9 | Ground | ON | ON | 31 | -12.8 | 32.1 | 22.17 | 32.85 | 2086 | 2008 | 244.5 |
| 1:57:43 | 8935 | 94.6 | 92.1 | Ground | ON | ON | 35 | -8.7 | 35.2 | 33.52 | 44.8 | 2094 | 2127 | 244.5 |
| 1:57:44 | 8935 | 95.9 | 94.2 | Ground | ON | ON | 36 | -6.1 | 37.2 | 47.59 | 54.71 | 2066 | 2079 | 244.5 |
| 1:57:45 | 8935 | 96.5 | 95.7 | Ground | ON | ON | 36 | -3.5 | 39.3 | 54.22 | 65.22 | 2072 | 2063 | 244.5 |
| 1:57:46 | 8935 | 97 | 96.4 | Ground | ON | ON | 38 | -3.3 | 39.4 | 58.12 | 67.72 | 2064 | 2084 | 244.5 |
| 1:57:47 | 8935 | 97 | 96.7 | Ground | ON | ON | 38 | -4.1 | 38.8 | 58.23 | 69.46 | 2071 | 2072 | 244.8 |
| 1:57:48 | 8936 | 96.8 | 97.1 | Ground | ON | ON | 36 | -26.2 | 22.4 | 59.02 | 70.04 | 2060 | 1898 | 243.2 |
| 1:57:49 | 8935 | 97 | 84.4 | Ground | ON | ON | 38 | 3.6 | 45.1 | 59.09 | 41.95 | 2062 | 1658 | 241.6 |
| 1:57:50 | 8932 | 97.9 | 79.3 | Ground | ON | ON | 48 | 13.9 | 54 | 58.99 | 30.59 | 2075 | 1639 | 248.8 |
| 1:57:51 | 8928 | 100.4 | 81.8 | Ground | ON | ON | 47 | 19.1 | 58.8 | 64.57 | 28.68 | 2109 | 1728 | 258 |
| 1:57:52 | 8923 | 82.4 | 85.5 | Ground | ON | ON | 3 | -56.8 | 2.7 | 70.71 | 28.71 | 1735 | 1647 | 268.1 |
| 1:57:52 | FDR Interruption | | | | | | | | | | | | | |
| 1:58:02 | 3040 | 0 | 0 | In Air | ON | ON | 186 | 169.2 | 362.4 | -0.09 | 1.2 | 0 | 0 | 184.2 |

**FDR Interruption**

**Aircraft Lined Up**

**RH POWER Started to decrease**

## FDR Analysis:

20190527_last Impact.dat 28-05-19 14:08

| Relative | ALT | NG RPM | NG RPM | Air/ Gnd | TCL | TCL | TC Corr | TQ | TQ | NP RPM | NP RPM | Mag | Brake Pr | Brake Pr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | | Left (N2) | Right (N2) | Ground | Left | Right | Right | Left | Right | Left | Right | Heading | Left | Right |
| HH:MM:SS | Feet | % | % | | | | | % | % | RPM | RPM | Deg | | |
| 1:57:43 | 8935 | 94.6 | 92.1 | Ground | 35 | -8.7 | 35.2 | 33.52 | 44.8 | 2094 | 2127 | 244.5 | 37.5 | 43.3 |
| 1:57:44 | 8935 | 95.9 | 94.2 | Ground | 36 | -6.1 | 37.2 | 47.59 | 54.71 | 2066 | 2079 | 244.5 | 37.5 | 42.7 |
| 1:57:45 | 8935 | 96.5 | 95.7 | Ground | 36 | -3.5 | 39.3 | 54.22 | 65.22 | 2072 | 2063 | 244.5 | 32.3 | 32.5 |
| 1:57:46 | 8935 | 97 | 96.4 | Ground | 38 | -3.3 | 39.4 | 58.12 | 67.72 | 2064 | 2084 | 244.5 | 4.3 | 5.5 |
| 1:57:47 | 8935 | 97 | 96.7 | Ground | 38 | -4.1 | 38.8 | 58.23 | 69.46 | 2071 | 2072 | 244.8 | 3.7 | 0.2 |
| 1:57:48 | 8936 | 96.8 | 97.1 | Ground | 36 | -26.2 | 22.4 | 59.02 | 70.04 | 2060 | 1898 | 243.2 | 1 | 1.6 |
| 1:57:49 | 8935 | 97 | 84.4 | Ground | 38 | 3.6 | 45.1 | 59.09 | 41.95 | 2062 | 1658 | 241.6 | 0.8 | 0.1 |
| 1:57:50 | 8932 | 97.9 | 79.3 | Ground | 48 | 13.9 | 54 | 58.99 | 30.59 | 2075 | 1639 | 248.8 | 0.7 | 0.1 |
| 1:57:51 | 8928 | 100.4 | 81.8 | Ground | 47 | 19.1 | 58.8 | 64.57 | 28.68 | 2109 | 1728 | 258 | 9.9 | 40.3 |
| 1:57:52 | 8923 | 82.4 | 85.5 | Ground | 3 | -56.8 | 2.7 | 70.71 | 28.71 | 1735 | 1647 | 268.1 | 21.1 | 47.6 |
| 1:57:52 | FDR Interruption | | | | | | | | | | | | | |
| 1:58:02 | 3040 | 0 | 0 | In Air | 186 | 169.2 | 362.4 | -0.09 | 1.2 | 0 | 0 | 184.2 | 0.4 | 0.2 |

**(1) TIME 1:57:43** Aircraft lined up and ready to ROLL as evident on **full BRAKES pressure**.
NG LH = 94.6.5% and NG RH = 92.1%
TQ LH = 33.52% and TQ RH = 44.8%
NP RPM LH 2094 and NP RPM RH = 2127
HDG = 244.5 Deg

**(2) TIME 1:57:46** Aircraft Take-Off Power and initiated ROLL as evident by **BRAKES release**
NG LH = 97% and NG RH = 96.4%
TQ LH = 58.12% and TQ RH = 67.72%
NP RPM LH 2064 and NP RPM RH = 2084
HDG = 244.5 Deg

**(3) TIME 1:57:48** The RH Power Lever began to retard as evident by **dropping TCL RH (Corrected) and NP RH Dropping**
NG LH = 96.8% and NG RH = 97.1%
TQ LH = 59% and TQ RH = 70.04%
NP RPM LH 2060 and NP RPM RH = 1898
HDG = 243.2 Deg

**(4)** **TIME 1:57:49** The RH Power began to decrease as evident by **dropping in RH Engine NG, TQ, NP RPM and so the aircraft started to veer towards right**
NG LH = 97% and NG RH = 84.4%
TQ LH = 59.1% and TQ RH = 41.95%
NP RPM LH 2062 and NP RPM RH = 1658
HDG = 241.6 Deg

(5) **TIME 1:57:52** The point of impact (FDR Interruption)

**Scene 1 (Normal)**

**Scene 2 (9N-AMH veered to the right of RWY 24 after 4 secs T/O Roll is initiated)**

**Scene 3 (9N-AMH first hit Manang Air 9N-ALC helicopter)**

**Scene 4 (9N-AMH and 9N-ALC both crushed to ground)**

**(Source: youtube.com)**

**Scene 5 (Both 9N-AMH and 9N-ALC then collided with Shree Air's 9N-ALK helicopter which was parked)**

**Scene 6 (After the accident)**

## 2.5 Operational analysis from taxi to take off

As CVR voice recording was unavailable and tower conversation recording system was also unserviceable since last 2 days, this operational analysis is based on different sources like surveillance camera (CCTV) footage, post-accident conversation with PIC of the flight, interviews with ATC at Lukla tower, FDR analysis report and eye witnesses statement at the time of accident and documentary evidences.

This was the 4th scheduled flight of that day in that sector. The aircraft completed normal landing and made a quick turnaround as aircraft was empty on return sector from Lukla to Ramechhap.

Aircraft carried out a normal taxi and hold short of runway waiting for lineup runway 24 because another aircraft (Tara Air's DO228) was on lineup position for takeoff. As per PIC, crew finished take-off checks during taxi.

Immediately after Tara air's DO228 aircraft took off, aircraft entered the runway for take-off and lined up at the threshold of the runway 24.

At line up position, PIC took the decision to handover controls for take-off to copilot (who was less experienced) from Lukla under his discretion as Instructor Pilot. As per PIC, the ill-fated aircraft had some technical issues regarding friction lock and power lever in the past and normal practice was to keep hand on power lever by Captain on takeoff roll.

On line up position, PF advanced power and confirmed the engine parameters were indicating normal. On each STOL take-off roll both engine torque, ITT, RPM (Ng & Np), fuel flow, engine oil temperature and pressure should be checked and confirmed. Pilot needs tower clearance as runway clear prior to initiating take-off roll. This needs two way communications between pilot and ATC before departure.

PF (copilot) initiated takeoff roll after around 15 seconds. PF advanced the power levers, and released the brakes for takeoff roll. Upon take off roll, PF removed his hand from power lever to hold the control column with both hands. As per PIC, he used to keep his hands at power lever to make sure that power lever didn't not shift rearward, while flying as a PM, but somehow he failed to do so on that particular flight. From FDR analysis, post-accident interview of PIC and CCTV footage, the commission found that after two seconds of initiation of take-off roll, right power lever shifted rearwards and immediately after, aircraft started to swing towards right.

Time taken from line up position to takeoff roll by the crew was not enough for handing over controls from PIC to co-pilot for takeoff preparation.

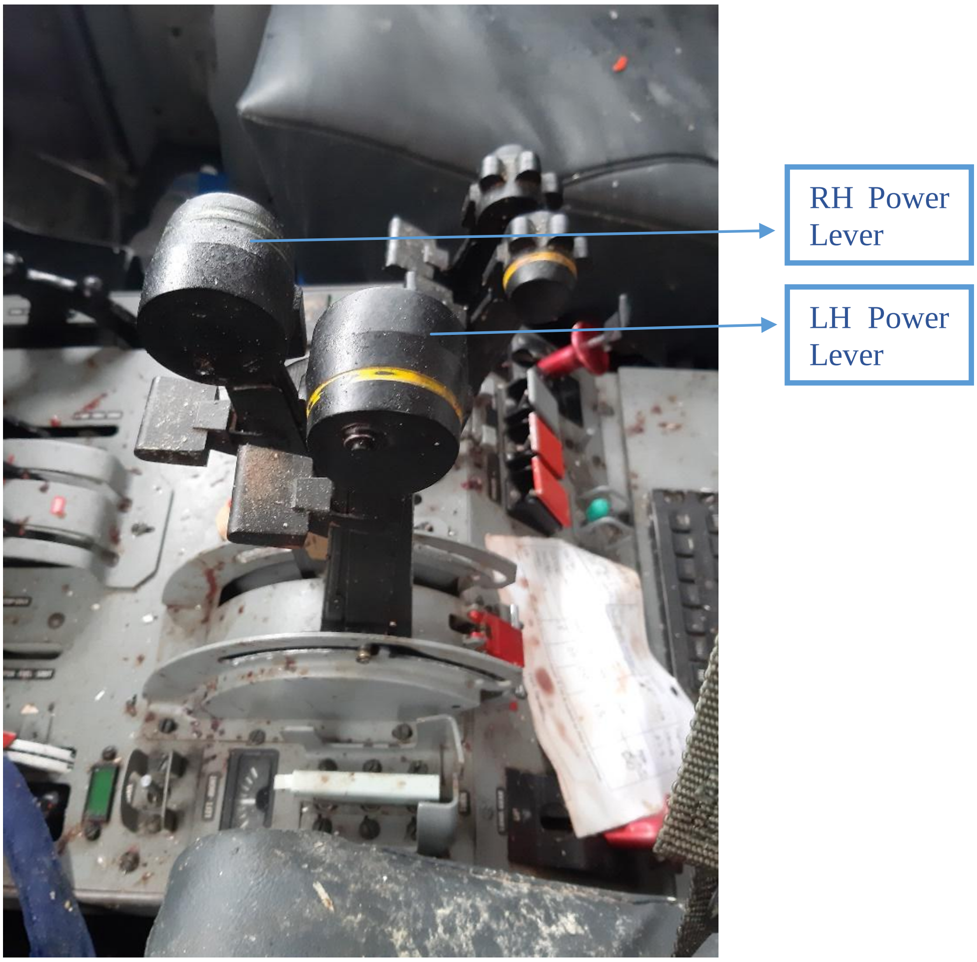
Before take-off, crew has to receive takeoff clearance, check engine parameter like torque, ITT, RPM, fuel flow, engine oil pressure/temperature and takeoff callouts.

As per FDR data analysis, takeoff set torque was not same on both engines. Right engine torque was giving 33.52% torque and left engine torque was giving 44.8 % torque.

Aircraft began to veer at the beginning of steep slope of runway 24, 28 meter from the threshold. As per PIC, when he realized that the aircraft was veering towards right, he took over the aircraft controls from the copilot. Once PIC realized that the right power lever was shifting backwards, he advanced the power lever forward as a correction. PIC applied foot

brakes to control the aircraft veer and to stop the aircraft. Due to the rudder position, right brake was more effective when both foot brakes were applied.
The right foot brake tyre marks were found 72 meter from threshold at the right edge of the runway. There were no tyre marks found of left brake use. This action contributed the aircraft to veer more towards the right.
5 seconds after initiation of take-off, aircraft hit the runway fence close to the edge of the runway and swiped two security personnel who were standing on a walkway outside of the runway fence. They were walking towards tower from the helipad after welcoming high level official who arrived on helicopter 9N-ALC. One security personnel died immediately and another died while on the way to hospital airlifting by helicopter.

Aircraft hit Manang Air's helicopter 9N-ALC, 13 meter away from fence at upper helipad with engine running on idle power at the time of impact. Helicopter was toppled to the lower helipad 6 ft below. 9N-ALC's helicopter pilot was severely injured as he was trapped underneath and later rescued. The running rotor blades of 9N-ALC helicopter chopped right forward section of 9N-AMH aircraft and hit co-pilot's head, he died instantly at the time of accident. The LH wing of the aircraft broke the skid of helicopter 9N-ALK and came to a stop with toppled 9N-ALC beneath its RH main wheel assembly. Due to impact, 9N-ALK shifted about 8 ft laterally and suffered minor damages (few dents on the fuselage due to scattering of metal pieces during collision impact).



According to PIC, his decision to advance power and to apply uneven braking in the attempts for correction at slow speed was inappropriate. PIC should have aborted the takeoff using reverse thrust and foot brakes
It took 10 seconds from aircraft roll to accident till aircraft came to still position. Without the CVR and tower conversation recording the action taken by crew during entire accident period could not be verified. Captain shut down the engine before exiting the aircraft.

In this accident, it was observed that the take-off was initiated based on setting Prop RPM instead of TORQUE, the substantial evidence is depicted below in FDR analysis data.

| Relative | ALT | NG RPM | NG RPM | Air/ Gnd | DC Elec | DC Elec | TCL | TCL | TC Corr | TQ | TQ | NP RPM | NP RPM | Mag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | | Left (N2) | Right (N2) | Ground | Left | Right | Left | Right | Right | Left | Right | Left | Right | Head ing |
| HH:MM: SS | Feet | % | % | | | | | | | % | % | RPM | RPM | Deg |
| 1:57:43 | 8935 | 94.6 | 92.1 | Ground | ON | ON | 35 | -8.7 | 35.2 | 33.52 | 44.8 | 2094 | 2127 | 244.5 |

## 2.6 Human Factors Analysis.

Normally wind starts increasing after 10 am local time at Tenzing-Hillary airport. Weather at the airport is unpredictable and it's always a rush to finish all flights before weather becomes unsuitable for operation. Besides, there is a constant pressure to the crew to complete all flights scheduled for the day within stipulated time frame.

The aircraft was scheduled for five flights from Ramechhap to Lukla on that day. These flights are approximately 20 minutes and in short intervals. The accident took place on mid-April, which is a high tourist season at Lukla, which adds additional pressure to marketing as well as operations to cater the needs of passengers. For departure, the aircraft started its LH engine at 0318, commenced taxi at 0321.13 aligned with the runway at 0322.35 Hrs. and commenced take off roll at 0322.50 Hrs. and crashed at 0322.59 Hrs.

Repetitive short flights on the same sector with same crew induce complacency. Crew with this state of mind often tends to overlook the severity associated with operation in critical airports. This eventually made the PIC complacent on that particular flight as it was fourth flight, was an empty aircraft and weather was fair.

Moreover, the accident occurred on the day of Nepalese New Year. The commission analyzed the fact of crew having a celebration on New Year's Eve and to assess whether it caused sleep deprivation among the crew or not and whether they had alcohol consumption. However, commission found out that crew had enough sleep and were fit for the flight and they had no alcohol consumption the day before the flight. This was further supported by toxicology report of the PIC.

According to the PIC, the co-pilot acting as PF for the flight set the power by moving the power levers forward and removed his hands from the power lever to the control column. PIC himself used to keep his hands at power lever to ensure that the power lever wouldn’t revert, but somehow he failed to do so, on that particular flight. From FDR analysis, post-accident interview of PIC and CCTV footage, the commission found that after two seconds of initiation of take-off roll, right power lever shifted rearwards and aircraft started to veer towards right.

When the PIC realized veering of aircraft, he took over the aircraft control from the copilot. However, he was unable to abort the takeoff and stop the aircraft.

This relates to the relaxed state of the PIC as well as over consciousness of the co-pilot to control the aircraft with both his hands, without realizing the shift of right power lever rearwards.

It has been observed in Nepalese aviation industry that the desire of copilots to master difficult airports before even being authorized or ready to do so is a major challenge. During discussions, it was found that co-pilots have a tendency to request for such opportunities in order to be recognized among their coworkers so as to be considered the first choice as a FO for all senior captains. Further, IPs' rarely object to such requests by co-pilots when favorable conditions exist like empty aircraft and fair weather.

This sense of early achievement, which actually is dangerous, triggers a sense of satisfaction and feeling of confidence in co-pilots. Commission analyzed this fact and found relevance in this accident.

Different attitudes of PIC and co-pilot, repeated operation of same crew, same aircraft and same short sector created complacency which contributed to the accident.

# Conclusion

## 3.1 Findings

1. The PIC was qualified and certified in accordance with the rules and the regulations of CAAN for STOL field.
2. Rest period and duty time of the PIC was within the prescribed limits.
3. No evidence was found to indicate any pre-existing medical condition that might have adversely affected the pilot's performance during that flight.
4. The PIC in the left seat was PM and the co-pilot, seated in the right seat was PF.
5. The aircraft exited the runway and travelled about 42.8 ft across the grassy part on right side of runway 24, before striking the airport inner perimeter fence. It then continued to skid for about 43 ft, into the helipad, crashing into 9N-ALC first, and then hitting 9N-ALK before coming to a stop.
6. RH wing of the aircraft swept two police officials (outside inner perimeter fence) before slashing the rotor shaft of 9N-ALC. The moving rotors cut through the cockpit on the right side slaying the first officer immediately.
7. Co-pilot flight handling procedure as PF was not found in FOR and Airline SOP for STOL field.
8. The aircraft was empty and CG was within the limit.
9. The weather was fair at the time of the accident.
10. Immediately after initiation of takeoff roll, aircraft veered to the right. The crew were neither able to maintain runway center line nor abort the takeoff.
11. There was no post-crash fire.
12. Human factor analysis showed complacency in cockpit crew.
13. The aircraft was maintained properly as per approved maintenance schedule. No maintenance work was found overdue.
14. The FDR Data was downloaded and analyzed successfully in Aircraft industries laboratory but the CVR voice data could not be retrieved at the facility. So the commission members in consultation with Accredited Representative and EASA experts sent the CVR to BEA France facility. However, the CVR recordings couldn’t be retrieved.
15. There was no ITT input to the FDR model installed in the aircraft.
16. The tower ATC-Pilot VHF communication recorder was also unserviceable since 13th April 2019, 1144 Hrs.
17. Nose wheel steering CB was found popped out.

18. Simultaneous heavy mixed operations of fixed and rotor wing aircrafts in a close distance added to the damages caused by runway excursion as the rotors of the helicopter were still running on idle.

## 3.2 Probable Cause

The commission concluded that the probable cause of the accident was aircraft's veering towards right during initial take-off roll as a result of asymmetric power due to abrupt shifting of right power lever rearwards and failure to abort the takeoff by crew. There were not enough evidences to determine the exact reason for abrupt shifting of the power lever.

## 3.3 Contributing Factors

1. Failure of the PF(being a less experienced co-pilot) to immediately assess and act upon the abrupt shifting of the right power lever resulted in aircraft veering to the right causing certain time lapse for PIC to take controls in order to initiate correction.
2. PIC's attempted corrections of adding power could not correct the veering. Subsequently, application of brakes resulted in asymmetric braking due to the position of the pedals, and further contributed veering towards right.

# Recommendations

The Commission has forwarded the following safety recommendation for the enhancement of flight safety and prevents reoccurrence of such accident in future:

## 4.1 Summit Air Pvt. Ltd.

1. The operator should train crew for rejected takeoff procedures in simulator for unforeseen situation at STOL fields.

2. The Operator should consider FA2200 FDR model with SB modification as an OPTION to enable Fuel Flow & ITT parameter inputs. It can primarily be used as a tool for Engine Health Monitoring and Engine Overrun and over-temperature limits in cases of incidents or accidents.

## 4.2 Civil Aviation Authority of Nepal (CAAN)

1. Considering the typical nature of Nepalese airfields a clear provision regarding the restriction of handing over of flight control by PIC to co-pilot and categorical up gradation of co-pilot to pilot in the STOL airfields should be included in FOR.

2. CAAN should ensure the continuous recordings of the pilot –ATC recording in all airports.

3. CAAN should study the possibilities of shifting the existing helipad at Lukla.

4. The interim recommendation issued by the commission should be followed accordingly.

## 4.3 Aircraft Industries, a.s., Czech Republic

1. As no conclusions could be drawn as to why there was no CVR recording in this accident, the commission advises manufacturer to review MPD (Maintenance Planning Document) in a more robust way to ensure availability of CVR recording.