GOVERNMENT OF NEPAL

AIRCRAFT ACCIDENT INVESTIGATION COMMISSION

FINAL REPORT

OF

9N-ANC (ATR 72-212A, MSN : 754) AIRCRAFT OPERATED BY YETI AIRLINES PVT. LTD OCCURRED AT

POKHARA (AT THE BANK OF SETI RIVER - GHARIPATAN), KASKI DISTRICT, NEPAL ON 15 JANUARY 2023

SUBMITTED BY:

AIRCRAFT ACCIDENT INVESTIGATION COMMISSION

TO

THE GOVERNMENT OF NEPAL

MINISTRY OF CULTURE, TOURISM AND CIVIL AVIATION

28/12/2023 (2080/09/12 B.S.)

FOREWORD

This final report on the accident of ATR 72-212A version 500, registration 9N-ANC aircraft (flight number NYT691) operated by Yeti Airlines has been prepared by the Aircraft Accident Investigation Commission constituted by the Government of Nepal, on 15 January, 2023 in accordance with the Annex 13 to the Convention on International Civil Aviation and Civil Aviation (Accident Investigation) Regulation, 2071 B.S. to identify the probable cause of the accident and suggest remedial measures to the concerned so as to prevent the recurrence of such accidents in future.

The sole objective of the investigation of this accident is the prevention of accidents of similar nature in future. It is not the purpose of this investigation to apportion blame or liability.

The Commission carried out thorough investigation and extensive analysis of the available information and evidences, statements and interviews with concerned persons, study of reports, records and documents amongst others. The draft final report was sent for comments to concerned states and entities. The comments received has been reviewed and incorporated where deemed necessary. The Commission in its final report has presented safety recommendations to be implemented by the MoCTCA, Civil Aviation Authority of Nepal and Yeti Airlines.

The accident investigation commission acknowledges the support from BEA France, TSIB Singapore, TSB Canada, NTSB United States of America and their advisors.

Composition of Commission:

…………………………………
Mr. Nagendra Prasad Ghimire
Chairman

………………………………………………………
Major General Dr. Dipak Prasad Bastola ,PhD (Retd.)
Member

…………………………………
Sr. Captain Sunil Pradhan
Member

………………………………
Sr. Er. Ekraj Jung Thapa
Member

…………………………………………………….
Joint Secretary Buddhi Sagar Lamichhane
Member Secretary

Abbreviations

AD	Airworthiness Directives
AGL	Above Ground Level
AFM	Aircraft Flight Manual
AIRAC	Aeronautical Information Regulation and Control
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
ATC	Air Traffic Controller
ATPL	Airline Transport Pilot License
ATS	Air Traffic Service
B. S.	Bikram Sambat
C of A	Certificate of Airworthiness
CAAN	Civil Aviation Authority of Nepal
CFIT	Controlled Flight into Terrain
CG	Center of Gravity
CPL	Commercial Pilot License
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DCP	Designated Check Pilot
DD	Deferred Defect
DFDR	Digital Flight Data Recorder
DI	Daily Inspection
EGPWS	Enhanced Ground Proximity Warning Systems
F/O	First Officer
FAA	Federal Aviation Administration
FCOM	Flight Crew Operating Manual
FDR	Flight Data Recorder
FOR	Flight Operation Requirements
FSSD	Flight Safety Standards Department
GPS	Global Positioning System

GPWS	Ground Proximity Warning System
HF	High Frequency
HFACS	Human Factor Analysis and Classification System
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IP	Instructor Pilot
Kg	Kilogram
Kts	Knots
LH	Left Hand
LT	Local Time
MAU	Modular Avionics Unit
MEL	Minimum Equipment List
METAR	Meteorological Report
MFC	Multi-Functional Computer
MOC	Management of Change
MoCTCA	Ministry of Culture, Tourism and Civil Aviation
Mtrs	Meters
N/A	Not Applicable
NTSB	National Transportation Safety Board
OAT	Outside Air Temperature
OM	Operation Manual
Pax	Passengers
PF	Pilot Flying
PHR	Pokhara International Airport
PIC	Pilot in Command
PM	Pilot Monitoring
PPC	Pilot Proficiency Check
RAMP	Region of Aircraft Movement and Parking
RWY	Runway
SAR	Search and Rescue

SB	Service Bulletin
SOP	Standard Operating Procedure
SRM	Safety Risk Management
TAWS	Terrain Awareness and Warning Systems
TCSN	Total Cycle since New
TSB	Transportation Safety Board
TSIB	Transport Safety Investigation Bureau
TTSN	Total Time since New
USA	United States of America
UTC	Universal Co-ordinated Time
VMC	Visual Metrological Conditions
VNPK	Pokhara Domestic Airport
VNPR	Pokhara Regional International Airport
VFR	Visual Flight Rules
VHF	Very High Frequency
WX	Weather

Synopsis

On 15 January 2023, an ATR72-212A version 500 (Registration: 9N-ANC) operated by Yeti Airlines was operating a scheduled flight from Tribhuvan International Airport to Pokhara International Airport. This was the flight crew's third sector of the day and they had been operating shuttle flights between Kathmandu and Pokhara. There were 68 passengers and 4 crew on-board the aircraft. On the final approach to Pokhara International Airport's runway 12, the aircraft sustained a loss of control in flight and impacted with the ground between the old Pokhara Domestic and the new Pokhara International Airport. All persons on board were fatally injured.

The accident was notified by the Ministry of Culture Tourism and Civil Aviation, Nepal to the International Civil Aviation Organization (ICAO), BEA France, NTSB, USA and TSB, Canada as per the standards of ICAO Annex 13.

The Government of Nepal constituted an Aircraft Accident Investigation Commission to find the cause of the accident and propose the recommendations to the concerned agencies to promote the safety of civil aviation as per the provision of the Aircraft Accident Investigation Regulation (2071 B.S.) 2014.

Nine safety recommendations are made for the advancement of flight safety.

In accordance with the provision of the ICAO Annex 13, French, American, Canadian and Singaporean investigators are also involved with this investigation.

The most probable cause of the accident is determined to be the inadvertent movement of both condition levers to the feathered position in flight, which resulted in feathering of both propellers and subsequent loss of thrust, leading to an aerodynamic stall and collision with terrain.

The contributing factors to the accident are:

1 High workload due to operating into a new airport with surrounding terrain and the crew missing the associated flight deck and engine indications that both propellers had been feathered.

2 Human factor issues such as high workload and stress that appears to have resulted in the misidentification and selection of the propellers to the feathered position.

3 The proximity of terrain requiring a tight circuit to land on runway 12. This tight circuit was not the usual visual circuit pattern and contributed to the high workload. This tight pattern also meant that the approach did not meet the stabilised visual approach criteria.

4 Use of visual approach circuit for RWY 12 without any evaluation, validation and resolution of its threats which were highlighted by the SRM team of CAAN and advices proposed in flight procedures design report conducted by the consultant and without the development and approval of the chart by the operator and regulator respectively.

5 Lack of appropriate technical and skill based training (including simulator) to the crew and proper classroom briefings (for that flight) for the safe operation of flight at new airport for visual approach to runway 12.

6 Non-compliance with SOPs, ineffective CRM and lack of sterile cockpit discipline.

Table of Contents

1. FACTUAL INFORMATION

All times used in this report is Nepal Local Time unless otherwise stated. Nepal Local Time is five hours forty-five minutes ahead of Coordinated Universal Time (UTC).

Date of Flight	15 January 2023
Flight Number	NYT691 (Yeti 691)
Aircraft Registration	9N-ANC
Aircraft Type	ATR-72-212A version 500
Type of Operation	Scheduled Passenger Flight
VFR/IFR	VFR (Day)
Departure Airport	VNKT
Time of Departure	1032
Destination Airport	VNPR
Estimated Time of Arrival (ETA)	1058
Time of Accident	1057

1.1 History of the flight

On 15 January 2023, an ATR 72-212A version 500 was operating scheduled flights between Kathmandu (VNKT) and Pokhara International Airport (VNPR). The same flight crew operated two sectors between VNKT to VNPR and VNPR to VNKT earlier in the morning. For first sector, the aircraft landed on runway 30 of VNPR and thereafter departed from VNPR using runway 12. The accident occurred during a visual approach for runway 12 at VNPR.

This was the third flight by the crew members on that day. As per the CVR recordings it was understood that the flight was operated by two Captains, one Captain was in the process of obtaining aerodrome familiarization for operating into VNPR and the other Captain was an instructor pilot. The Captain being familiarized, who was occupying the left-hand seat, was the Pilot Flying (PF) and the instructor pilot, occupying the right-hand seat, was the Pilot Monitoring (PM).

The take-off, climb, cruise and descent to VNPR was normal. The weather was compatible with VMC enroute to the destination airport. During the first contact with VNPR tower, the Air Traffic Controller (ATC) assigned runway 30 for the aircraft to land. But during the later phases of flight the flight crew, without mentioning any reason for changing the allocated runway, requested and received clearance from ATC to change runway 30 to 12 for landing.

At 10:51:36, the aircraft descended from 6,500 feet at fifteen miles away from VNPR and joined the downwind track for Runway 12 to the north of the runway. The aircraft was visually identified by ATC during the approach. At 10:56:12, the pilots extended the flaps to the 15 degrees position and 46 seconds later they selected the landing gears lever to the down position.

At 10:56:27, the PF disengaged the Autopilot System (AP) at an altitude of 721 feet Above Ground Level (AGL). The PF then called for “FLAPS 30” at 10:56:32, and the PM replied, “Flaps 30 and continue descent. The flight data recorder (FDR) data did not record any flap surface movement at that time. Instead, the propeller rotation speed (**Np**) of both engines decreased simultaneously to less than 25%[1] and the torque (Tq) started decreasing to 0%, which

[1] Once the Np of the propeller decreases below 25%, no valid data is recorded in the FDR.

is consistent with both propellers going into the feathered condition[2]. The feather condition is not recorded in the FDR parameters. On the cockpit voice recorder (CVR) area microphone recording, a single Master Caution chime was recorded at 10:56:36. As per CVR readout, the flight crew then carried out the "Before Landing Checklist" without identifying the flaps were not to the 30^0 position, before starting the left turn onto the base leg. During that time, the power lever angle increased from 41% to 44%. At that point, **Np** of both propellers was recorded as Non-Computed Data (NCD) in the FDR and the torque (**Tq**) of both engines was at 0%. When propellers are in feather, they are not producing thrust.

When both propellers were feathered both engines of 9N-ANC were running in flight idle condition during the event flight as per design to prevent overtorque. As per the FDR data, the engine turbo machine were functioning as expected considering the propeller were feathered. At 10:56:50 when the radio altitude callout for five hundred feet[3] was annunciated, another "click" sound was heard[4]. The aircraft turned to the left and reached a maximum bank angle of 30 degrees. The recorded Np and Tq data remained non-computed, in line with propellers being in feather condition. The yaw damper was disconnected four seconds later. The PF consulted the PM on whether to continue the left turn and the PM replied to continue the turn. Subsequently, the PF asked the PM on whether to continue descend and the PM responded it was not necessary and instructed to apply a little power. At 10:56:54, another click was heard, followed by the flaps moving to the 30 degrees position.

When ATC gave the clearance for landing at 10:57:07, the crew did not respond to the tower, the PF mentioned twice that there was no power coming from the engines. The FDR data shows that at 10:57:11, the power levers were advanced first to 62 degrees then to the maximum power position in 2 seconds. It was followed by a "click" sound at 10:57:16. One second after the "click" sound, the aircraft was at the initiation of its last left turn at 368 feet AGL, the high-pressure turbine speed (Nh) of both engines increased from 73% to 77%.

[2] The feathering of a propeller on the ATR72-212A version 500 can be commanded automatically by aircraft systems (with interlocks preventing dual automatic feathering) or manually by the pilot. It is usually performed when an engine is shut down. Propeller feathering reduces drag by aligning the propeller blades chord line with the oncoming airflow.
[3] This refers to five hundred feet about ground surface.
[4] This suggests a crew action inhibiting the master caution light.

It is noted that at 10:57:18, in the very last stage of flight, the PF handed over control of the aircraft to the PM. At 10:57:20, the PM (who was previously the PF) repeated again that there was no power from the engines. At 10:57:24 when the aircraft was at 311 feet AGL, the stick shaker[5] was activated warning the crew that the aircraft Angle of Attack (AoA) increased up to the stick shaker threshold.

At 10:57:26, a second sequence of stick shaker warning was activated when the aircraft banked towards the left abruptly. Three seconds later, the radio altitude alert for two hundred feet was annunciated, and the cricket sound and stick shaker ceased. At 10:57:32, sound of impact was heard in the CVR. The FDR and CVR stopped recording at 10:57:33 and 10:57:35 respectively.

Figure 1 Photo captured during last moment of flight

Figure 2 Zoom-in picture of the last moment of the flight

[5] The stick shaker is a system that alerts the flight crew that the aircraft is close to stalling

1.2 Injuries to Persons

Injuries	Crew	Passenger		Total
		Adult	Infant	
Fatal	**04**	**68**	**-**	**72**
Serious	**-**	**-**	**-**	**-**
Minor	**-**	**-**	**-**	**-**
None	**-**	**-**	**-**	**-**
Total	**04**	**68**	**-**	**72**

1.3 Damage to Aircraft

The GPS coordinates of the crash site is as follows:

- Latitude: 28°11’51’’ N
- Longitude: 83°59’6’’E

The aircraft was completely destroyed due to the impact and post impact fire. Most of the fuselage structure, engines and its components were consumed by the fire. The propeller blades were found damaged, detached from the engine at various locations near the point of first impact. The wreckage was located at a gorge on the bank of the Seti Gandaki River and around the bank.

Figure 3 Location of the crash site

Figure 4 Aerial view of the gorge

Figure 5 Aerial view of the crash site area

Figure 6 Wreckage within the gorge

1.4 Other Damages

No damage was caused to private property or persons on ground. There was no noticeable environmental effect caused by the accident.

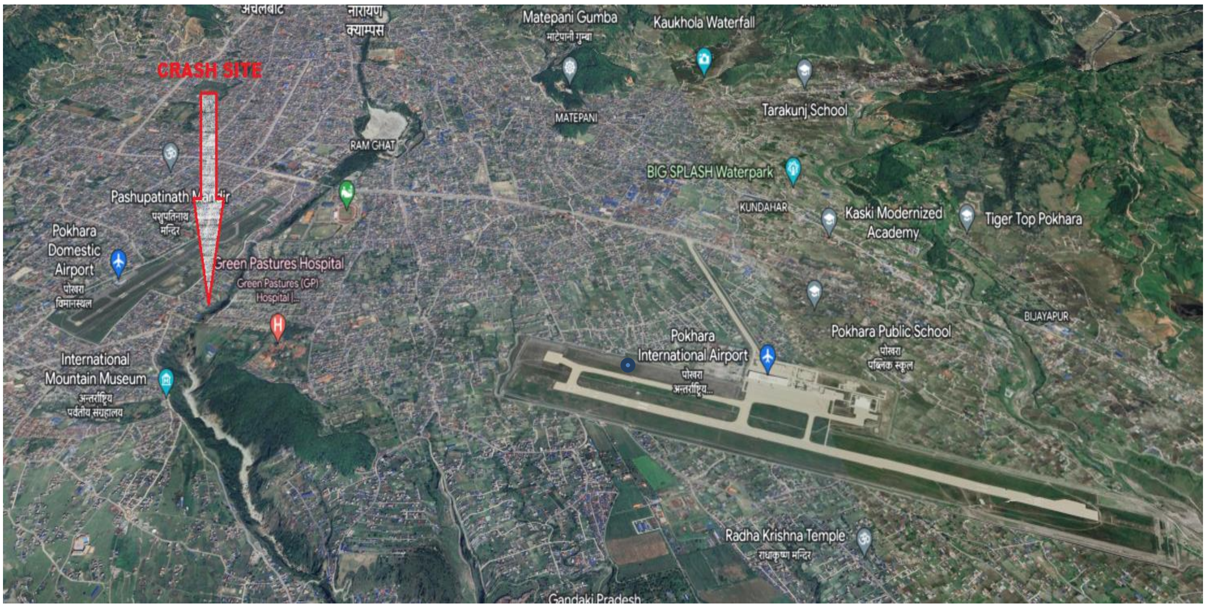


Figure 7 Geographical position of the accident site

1.5 Personnel Information

1.5.1 Pilot Flying

Date of Birth	11 Nov 1978
Gender	Female
License Type	ATPL-333
License Issuing Authority	CAAN
Issued On	27 Nov 2017
License Validity	30 Nov 2027
Aircraft Rating	Valid (ATR 72-212A version 500)
Instructor Ratings	None
Total hours flown	6396:05 Hours

Total hours on ATR type	186:00 Hours
Flight hours in last 12 months	171:05 Hours
Flight hours in last 3 months	121:30 Hours
Flight hours in last 30 days	49:15 Hours
Flight hours in last 7 days	08:50 Hours
Previous rest period	As per CAAN requirements
Medical Certificate Type	Class I
Medical Validity	30 November 2023
Aviation Language Proficiency	Level 4 (Operational)
Language Proficiency validity	10 March 2023
Limitation/ Restriction	JS-41 Aircraft type rating is no longer valid
Marital Status	Married
Previous Accident/ Incident	No Record found

1.5.2 Pilot Monitoring (PM)

Date of Birth	09 Sep 1964
Gender	Male
License Type	ATPL-148
License Issuing Authority	CAAN
Issued On	04 Oct 1999
License Validity	31 Mar 2023
Aircraft Rating	Valid (ATR 72- 212A)
Instructor Ratings	ATR72- 212A
Total hours flown	21901:00 Hours
Total hours on ATR type	3300:00 Hours

Flight hours in last 12 months	821:10 Hours
Flight hours in last 3 months	219:50 Hours
Flight hours in last 30 days	38:55 Hours
Flight hours in last 7 days	19:50 Hours
Previous rest period	As per CAAN requirements
Medical Certificate Type	Class I
Medical Validity	31 March 2023
Aviation Language Proficiency	Level 5
Language Proficiency validity	10 March 2023
Limitation/ Restriction	DHC-6-300 and J-41
Marital Status	Married
Previous Accident/ Incident	No Record found

1.5.3 Medical and Pathological Information

1.5.3.1 Medical History

The PF and PM were examined according to the CAAN medical requirements by designated expert medical practitioners. Both cockpit crews held valid medical certification.

1.5.3.2 Forensic Findings

The forensic test of the deceased crew was done at Nepal Police’s authorized forensic test laboratory. The forensic examination report suggests negative test for common pesticides, common narcotic drugs and phosphate gas.

1.5.4 Flight Duty Time

The flight crews were well within the flight duty time limitations.

1.6 Metrological Information

During the time of the accident, the following weather persisted in Pokhara Valley:

As per PHR control tower visual observation:

VNPR TWR OBS 0420Z: VISIBILITY 7KM FEW 030, VFR NML

METAR PHR as provided by the Meteorological Office, Pokhara:

(a) VNPR METAR 0430Z 17003KT 070V190 6000 FEW025 14/09 Q1016 NOSIG

(b) VNPR METAR 0500Z 12005KT 080V160 6000 FEW025 14/09 Q1015 NOSIG

- The wind speed was light with 3 to 5 knots;
- The prevailing visibility was 6 km;
- The temperature was measured around 14 degrees Celsius;
- The sea level pressure was recorded 1,015 hpa; and,
- The sky was almost clear with only a few clouds (1-2 Octas)

1.7 Aircraft Information

1.7.1 General

Date of Manufacture: 01 August 2007 AD

TTSN: 28731:33 HRS

TCSN: 30104 Cyc

1.7.2 Aircraft

Model	ATR 72-212A version 500
Manufacturer	ATR (French: *Avions de Transport Régional* or Italian: *Aerei da Trasporto Regionale*)
Registration	9N-ANC

MSN	754
Engine Make/Model	P&W CANADA /PW-127 M(LH)/F(RH)
Propeller Make/Model	HAMILTON SUNDSTRAND/568F-1
Certificate of Airworthiness	Valid till 24 Apr 2023
Certificate of Release to Service	Valid till 29 257:43 HRS
Type of Fuel Used	JET A-1

1.7.3 Engine

Manufacturer	-	Pratt & Whitney Canada	
Engine position	-	LH	RH
Type	-	PW127M (LH)	PW127F (RH)
Serial No	-	127079	AV0055
Hours/Cycle since New	-	30636:35hrs/36091	35756:58/54142
Hours/cycle since Last shop visit	-	1558hrs/2628 cyc	1864hrs/3127 cyc

1.7.4 Aircraft Maintenance History

As per the technical records, all scheduled maintenance requirements were complied with. No scheduled maintenance was found pending.

1.7.5 Aircraft Weight and Balance

As per load and trim sheet manifest, the aircraft weight and CG were within prescribed limits.

1.8 Aids to Navigation

Even though Pokhara International Airport is equipped with ILS, the instrument procedure was not in operation at the time of accident. The airport only had functioning Distance Measuring Equipment (DME) transmitting on frequency 112.8 MHz, identification code 'PHR' (CHN 75 X; H24, 281203N 0835905E, Declination 0.0° E, Elevation of transmitting antenna 829m) with voice transmission capability.

1.9 Aerodrome Information

1.9.1 Departure Aerodrome- Kathmandu

Aerodrome Location Indicator	VNKT
Name	Tribhuvan International Airport
ARP Coordinates	274150N - 0852128E
Elevation	4390 ft AMSL
Runway Designation	02/20
Runway Dimension	10000ft/150 ft
Runway Surface	Paved
Refuelling Facility	Available
RFF	Category 9
Type of traffic permitted	IFR/VFR

Navigation Service Surveillance	GNSS, DVOR, DME, NDB, AMSSR
Type of Fleet Permitted	Up to B787, B747 and A330-300

1.9.2 Destination Aerodrome- Pokhara

Aerodrome Location Indicator	VNPR
Name	Pokhara International Airport
ARP Coordinates	28°11′01.69″N 084°00′53.62″E (Center of RWY)
Elevation	803.89 m (2638ft) / 31.4° C (June)
Runway Designation	12/30
Runway Dimension	2500m/45m
Runway Surface	Cement Concrete
Date of first operation start	1 Jan 2023
RFF	Category 8 with MFT, Ambulance
Type of traffic permitted	IFR/VFR
Navigation Service Surveillance	DVOR/DME(117.3MHz/120X) ILS DME- 54X LOCALIZER- 111.7 MHz Glide Path- 333.50 MHz

NOTE: The airport came into operation for VFR flights only from 1 January 2023. AIP with airport data came into effect from 23 February 2023.

1.10 Flight Data Recorder and Cockpit Voice Recorder

The aircraft was fitted with L3 Communications model FA2100-4043-00 FDR, serial number 000592732, and L3 Communications model FA2100-1020-02 CVR, serial number 000494558.

Figure 8 Status of recorders before read-out

The FDR and CVR download and analyses were done at the TSIB Singapore Laboratory under the supervision of the Commission with the participation of the following organizations:

(a) Transport Safety investigation Bureau (TSIB), Singapore

(b) Bureau d'Enquêtes et d'Analyses pour la sécurité de l'Aviation Civile (BEA), France

(c) Transportation Safety Board of Canada (TSB)

(d) ATR, aircraft Manufacturer as adviser of BEA

(e) European Union Aviation Safety Agency (EASA) as adviser of BEA

(f) Pratt & Whitney Canada, Engine Manufacturer as adviser of TSB

From the retrieved FDR data, the investigation team was able to recover the flight path of the event flight and another flight on 12 Jan 23, where another set of crew landed on Runway 12 of VNPR.

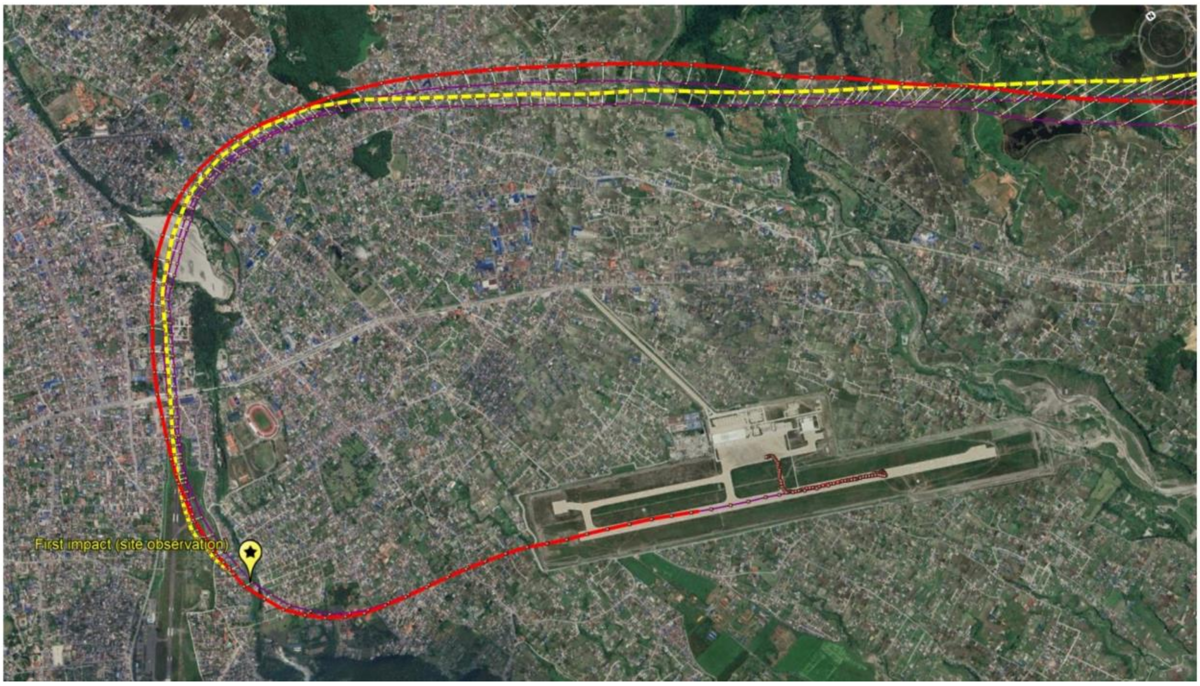


Figure 9 Flight Trajectory of the flight on 15th (Yellow) and 12th (Red) Jan 2023

1.11 Wreckage and Impact Information

The wreckage and Impact Information was collected over multiple visits led and sanctioned by the Commission during the initial phases of the Investigation. Accredited representatives from BEA along with their advisors also accompanied the Commission to collect and analyze the said data and information. It is to be noted that some parts of the wreckage were moved during rescue operations.

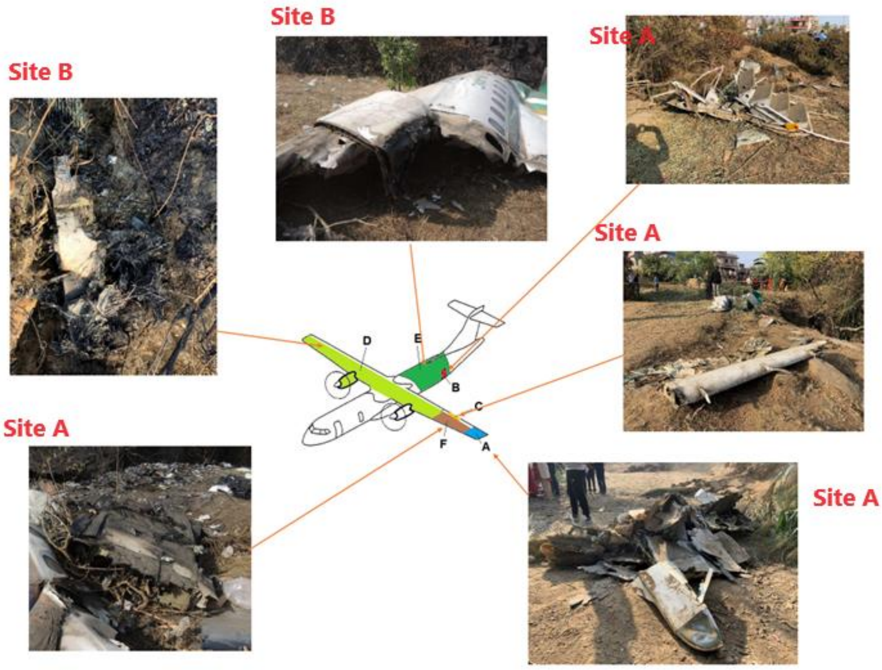
The wreckage was primarily spread across three sites as depicted below as site A, site B and site C.

Figure 10 Aerial view of Sites A, B and C

The aircraft initially impacted the ground with the left-wing tip box resulting in disintegration of LH outer wing box, LH aileron tip and PAX door at site A before it toppled over the gorge. The right wing and right engine section lodged into the adjacent wall at Site B whereas the cockpit, rear fuselage section, the overall tail section, the left engine and some of the rear fuselage dropped down the gorge to site C. Some major parts were transferred from the gorge to site B using a crane during Search and Rescue before the on-site investigation.

1.11.1 Wreckage Distribution

The pictures below depict a global overview of the wreckage as identified on site visit



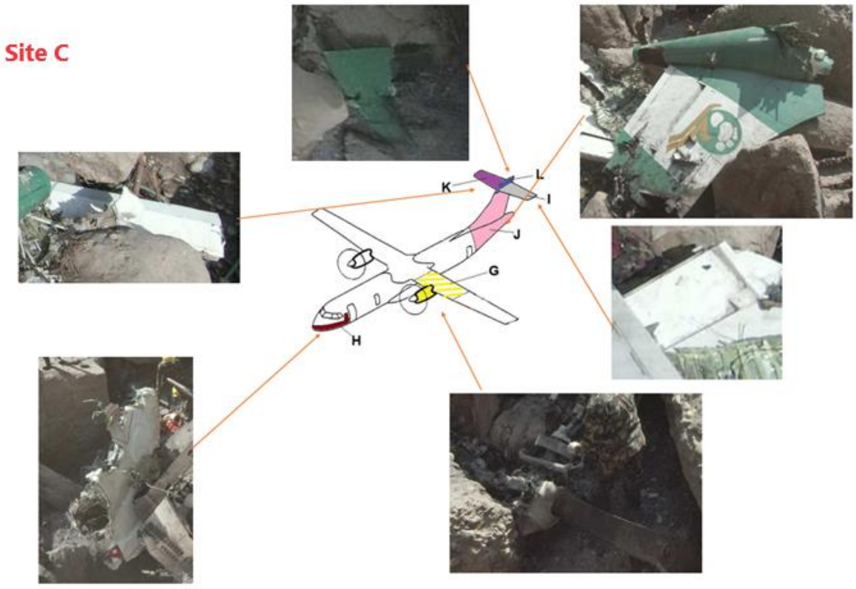


Figure 11 overview of wreckage distribution

Figure 12 Aerial view of Site A

Figure 13 Site A- Identified impact points and parts

Site A: identified aircraft impact points plus aircraft parts such as PAX door and LH outboard flap, miscellaneous belly fairing panels and cabin partition, LH outer wing box, panel segment, leading edge, LH aileron tip and portion of aileron box.

Figure 14 SITE A- Close up of the blue box on the picture above

Site B – identified rear section, RH MLG area, portion of wing (RH side plus LH/center upper area) and RH outer wing box plus miscellaneous cabin/seats items, portion of wing/nacelle/engine (RH side plus LH/center upper area), plus fragment from LH MLG shock absorber.

Figure 15 Aerial view of Site B

Figure 16 Blown up aerial view of components in Site B

Site C – showing identified tail section, vertical and horizontal stabilizers, portion from LH wing/nacelle/engine/propeller plus portion of nose fuselage/cockpit, nose section and cockpit indicators.

Figure 17 Wreckage identified at Site C

The Aircraft structure was completely destroyed and scattered throughout the sites A, B, C and also along the riverbed of the Seti river gorge.

Figure 18 components


Figure 19 Landing gears

Landing gears were detached from the main body. They were moved from their original positions during search and rescue process.

1.12 Fire

The fire was evident mainly at the fuselage area. The on-site investigation and all other available evidence show that the fire was a post-impact event caused by spilled fuel around the vicinity of the crash site.

1.13 Survival Aspect

The accident was fatal. All 72 persons onboard were dead.

1.14 Tests and Research

The following tests and Examinations were carried out as part of the investigation:

1) Tour of the ATR simulator in Singapore
2) Examination of recovered CAP
3) Examination of recovered RH PVM
4) Examination of recovered propeller hubs and blades
5) Examination of recovered MFC card 2B

6) Examination of control pedestal
7) Examination of cockpit indicators

The details of the equipment recovered, sent for test and objectives of such tests are described below:

Group 1: items	Side	Objective	Picture
PVM	RH side	To determine the protection valve and solenoid positions through CT scan and disassembly if required	
Maintenance panel	RH side	To confirm the MFC rotary position. Confirm the MFC bite loaded through comparison with the one recorded in MFC CPU board memory	
Indicators	All	To identify any needle mark upon impact	 
Pedestal cover	N/A	To perform detailed examination to try to identify levers position upon impact	
Pedestal	N/A	To perform detailed examination to identify levers position at impact (CL/PL/Flap)	
MFC CPU	Unknown	Memory to be dumped for any MFC fault code and to identify if auto-feathering command was activated through bite reading	
Prop Assy	LH & RH	To be analysed for blade pitch angle position, transfer tube/actuator axial position and potential mark of balls on hub/blade bearing races	 Prop LH  Prop RH
Prop blade (x9)	Unknown	To be analysed for fracture surface	   
CAP (Crew Alerting Panel)	Center Panel	To idenfiy for any bulb lit upon impact	

1.14.1 Flight simulator

As part of the analysis of the FDR and CVR data, the investigation team visited the ATR-72 full flight simulator facility located at the Seletar Aerospace Hub in Singapore.

The investigation team was able to examine various control inputs and the associated flight deck effects which are of relevance to this investigation.

1.14.2 Propeller Assembly and Blade Examination:

Description of Propeller System

The propeller assembly consists of six composite blades, (each blade consists of):

- A composite spar/shell bonded to a steel tulip for retention
- A nickel sheath on the airfoil leading edge
- An aluminium grid system that permits conductivity from the blade airfoil to the steel tulip for lightning protection
- A counterweight, which is attached to the blade root with a steel counterweight arm. This counterweight applies a twisting moment around the blade pitch change axis to overcome blade loads that would otherwise drive the blade towards fine pitch in case of loss of hydraulic supply.
- Externally bonded de-icers using multiple current pathways to transfer electrical power across the blade
- A bearing fitted on the blade trunnion pin

Retention hardware for each blade includes:

- Two rows of hardened-steel bearing balls with 24 balls in each row trapped in nylon ball separators that permit installation of the balls as an assembly
- A split, plastic blade support ring that prevents the blade from dropping into the hub during periods of low centrifugal load when the propeller is static or in operation at low rotational speeds
- Blade seal components that provide sealing for the propeller lubricating oil

A one-piece, steel hub

- The hub interfaces with the pitch change actuator, the blades retention hardware, and the bulkhead
- The hub mounts on the engine gearbox shaft

A pitch change actuator

- The pitch change piston is sized to develop a blade trunnion load sufficient to overcome the maximum Total Twisting Moment (TTM) of the blade and counterweight
- The yoke assembly changes blade pitch through contact with the blade trunnion bearing. The yoke is kept from turning through an anti-torque arm
- To control blade pitch, the increase and decrease pitch chambers in the actuator use metered pressure supplied by the Propeller Valve Module (PVM) through the transfer tube assembly. The larger increase pitch chamber is forward of the actuator piston, and the smaller decrease pitch chamber is aft of the piston.

A bulkhead

- It supplies the structural support for the spinner
- It has targets to actuate magnetic sensors for speed measurement
- It holds a slip ring assembly that transmits electrical power from a non-rotating brush block to the blade de-icers.

An aluminium spinner

A PVM

A Propeller Valve Module (PVM) is an electro-hydro-mechanical unit that gets electrical, mechanical, and hydraulic inputs from the propeller, gearbox, aircraft, Electronic Propeller Control (EPC), and overspeed governor. It supplies data to the EPC, and supplies pitch change oil to the propeller pitch change actuator via the transfer tube assembly.

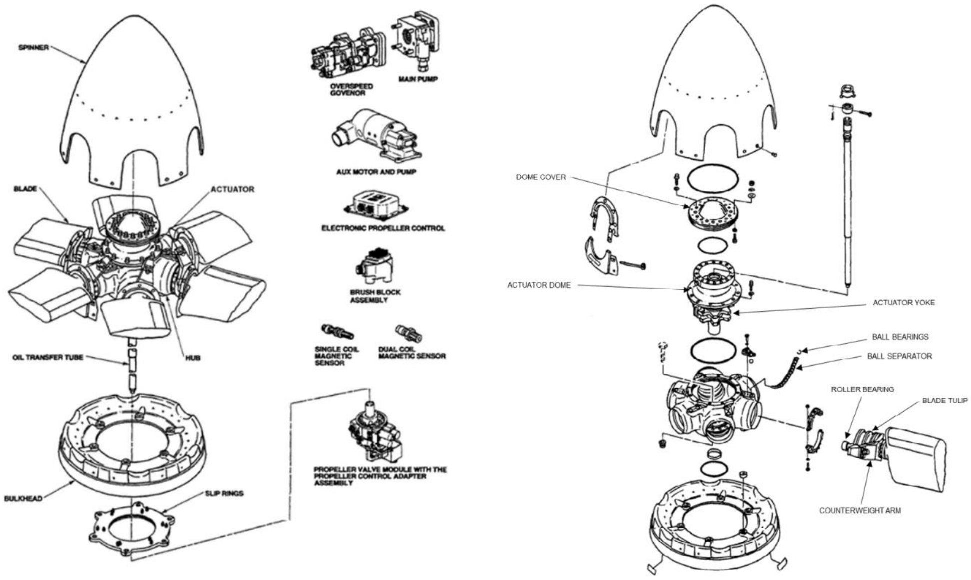


Figure 20 Propeller system and rotating assembly – exploded view

Together with the EPC, the PVM does these functions.

- Basic propeller rotational speed control
- Beta scheduling/control
- Reversing
- Feathering
- Synchrophasing
- Fault detection and annunciation

A main pump supplies high pressure oil to the propeller valve module during normal engine operation. The main pump provides rotational input (proportional to propeller speed) to the over speed governor.

Aux Pump, when activated, supplies high pressure oil for a limited time to the propeller valve module as a redundancy in case the high-pressure oil from the main pump is not available. It is used as an alternative for the main pump supplied oil under some conditions. It is activated whenever the propeller is commanded to feather in flight or selected by the cockpit crew while on the ground.

An Electronic Propeller Control (EPC) is a nacelle-mounted, dual-channel, microprocessor-based unit. The Electronic Propeller Control (EPC) supplies electrical signals to the Propeller Valve Module (PVM). These signals are the increase and decrease pitch commands necessary to achieve the required blade angles for all operating conditions of the propeller system.

A Single-coil and Dual-Coil Magnetic Sensors are coil-wound magnetic sensing devices installed on a bracket that is installed on the engine gearbox. The sensors are actuated by six bulkheads mounted targets.

- The dual-coil magnetic sensors are used to supply propeller speed signals to the EPC for control of speed governing.
- One single-coil sensor is used to supply propeller phase information to the EPC for synchrophasing.
- An additional single-coil sensor is used to supply a signal to the propeller dynamic balancing system. The signal is not supplied to the EPC.

A Propeller Overspeed Governor (OSG) mounts on the main pump. The overspeed governor has a backup speed governor function which increases propeller blade angle when a propeller overspeed occurs.

Figure 21 OEM propeller on Ratier-Figeac assembly line displayed in Feather position

A brush block assembly contains six graphite electrical brushes that transmit the de-icing current from the aircraft to the de-icer via contact with the slip rings. The angle between the blade's counterweight arm and the propeller's plane of rotation (POR) were used to determine the blade's angular position.

Reference station for blade pitch is STA 58" (corresponding to station located at 3/4 of installed blade radius). Blade angle at reference station is named as "beta". When propeller actuator is in feather stop, corresponding beta is between 78 and 79°. During inspections and analysis, relative position between blade CWt arm and Plane of Rotation will be considered. When CWt arm is aligned with POR, corresponding theoretical beta is about 72.5 °.

Examination Results

The two propellers were examined in the facility of Collins Aerospace by the respective experts at Figeac, France under the supervision of representatives from the Commission and BEA.

"Most of the blades on the RH propeller hub were observed to be in feathered position; however, the indices were slightly less obvious on the LH propeller hub. Two blades on the LH hub were in line with the feather setting while the other blades were free around their pitch change axes. The position of the actuator was not at the expected position for feathered propeller, but the actuator could have moved upon impact."

Prop 1 – LH Side:

Of the six propeller blades, two of them (4 and 5) were found stuck in a position where the counterweight arm was close to the plane of rotation, therefore in a position close to that of the flag. Damage to the hub to the right of blade 5 due to the counterweight of this blade was also noted. The repositioning of the counterweight in relation to this damage was also noted. The repositioning of the counterweight in relation to this damage corresponded to a blade close to the flag position. The other blades were partially free to rotate around their axis. The pitch change device piston (located in the centre of the hub) was slightly offset from the position corresponding to that of the flag.

Prop 2 – RH Side:

The blades were all in a position where the counterweight arm was close to the plane of rotation, therefore in a position close to that of the flag. Two blades (1 and 4) were stuck in this position while the other blades were free to rotate. The pitch change device piston (located in the center of the hub) was slightly offset from the position corresponding to that of the flag.

Figure 22 Propeller hub and blades examination at Figeac, France

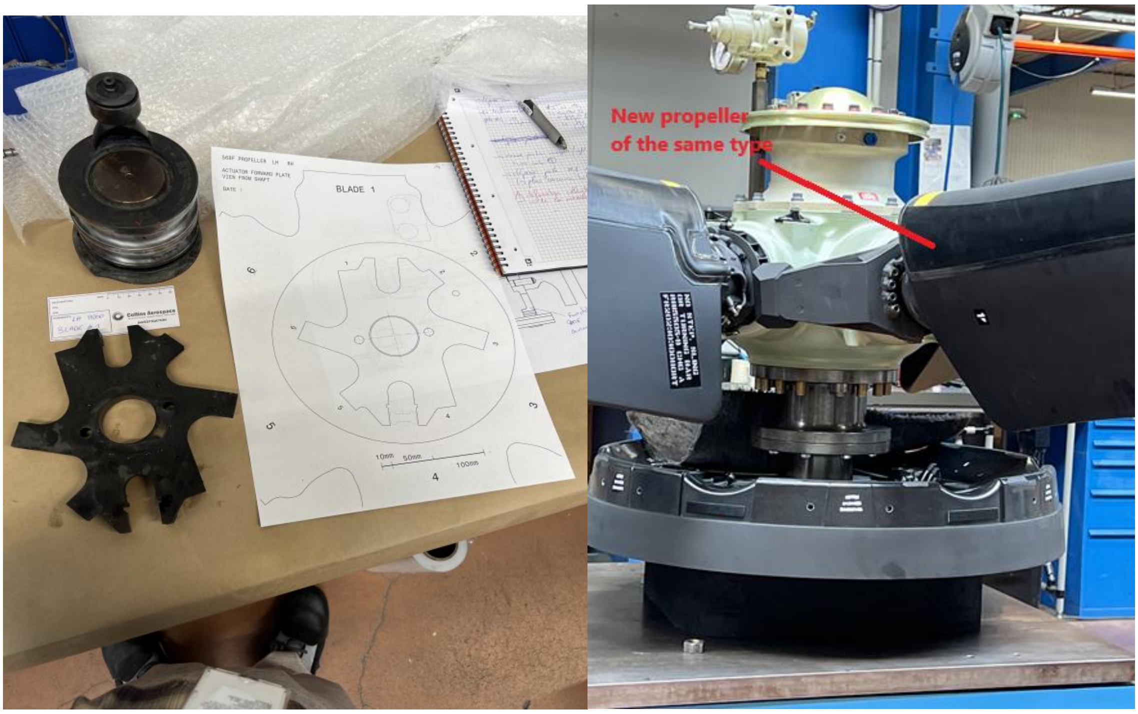


Figure 23 Examination applying different tools and methods

1.14.3 Propeller Valve Module (PVM)

The PVM from the Righthand (RH) Propeller was recovered and sent to BEA for analysis. The BEA was asked to perform a Computed Tomography (CT) scan of the PVM to determine the position of the protection valve and check if it was consistent with commanded feathering. The PVM was scanned at Sematec Metrology, Taverny, France, using a NIKON XTH450 CT-scanner, on April 26th, 2023. It underwent an additional X-ray examination on May 4th, 2023.

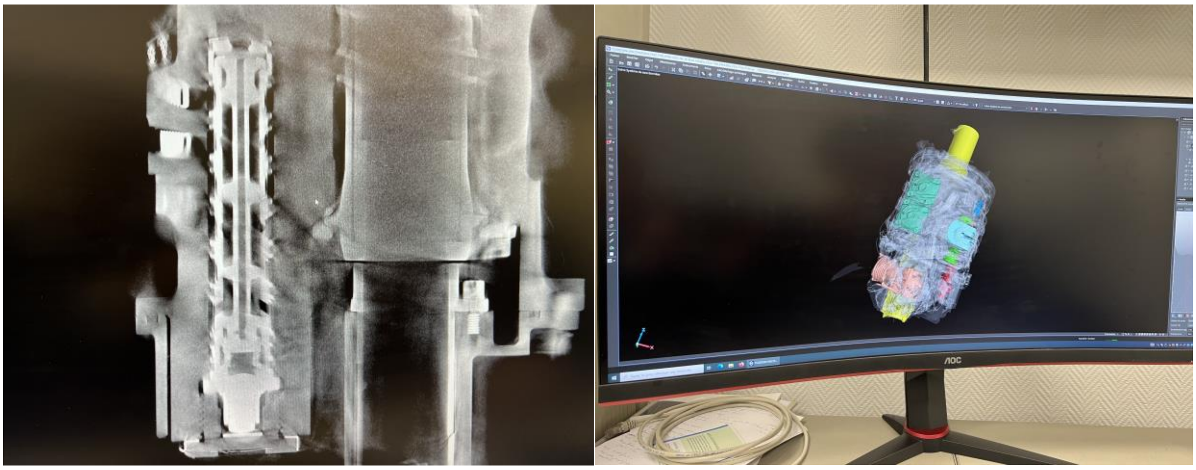


Figure 24 PVM as seen on X-ray during examination

The PVM was examined at BEA's laboratory using Computed Tomography scan and X-ray examination. Upon examination the spool of the protection valve within the PVM appeared to be mobile due to lack of hydraulic in the system. When the PVM was turned upside down, the spool followed the direction of gravity forces. Therefore, the spool position at the time of the event could not be determined rendering the information inconclusive to determine the propeller pitch command at impact.

1.14.4 Multi-Function Computer (MFC)

Two Multi-Function Computers (MFC) are installed on ATR-72-212A version 500 aircraft and are located aft of the cockpit. Each MFC is made up of 2 independent modules, module A and module B. MFC1 (resp. MFC2) includes modules MFC1A and MFC1B (resp. MFC2A and MFC2B). Several aircraft systems are partly or entirely controlled and/or monitored by the MFC computers. The systems functions are performed in module A and/or B of each MFC computer. Each MFC module is interfaced with one Automatic Feathering Unit (AFU) (AFU1 with MFC1A and MFC1B, AFU2 with MFC2A and MFC2B). The MFC integrates 3 distinct functions:

- Crew Alerting Computer function which monitors the aircraft systems and manages the alerts (warning / caution), aural alerting and tactile acknowledgement
- Systems parameters monitoring and several controls management of the systems

- Systems Maintenance functions (BITE)

There are three types of BITE (built in test equipment) information stored in the MFC. Basic BITE, Advanced BITE and Super Advanced BITE. Super Advanced BITE zone records specific information related to Propeller Brake, Feathering and CLA_MAX systems. For each of these systems, the output activation (Propeller brake command, Auto feather command, Condition Lever on Max position) triggers the storage of the activation context in memory.

The AFU command an engine to auto-Feather when certain criteria are met within the programming logic. The AFU function as follows:

- To automatically feather the propeller (to minimize drag) of an engine which has experienced a major loss of power during high power setting close to the ground.

- To simultaneously signal the opposite engine control system to increase the engine power from normal take-off to maximum take-off, to compensate for the loss of engine power.

- To disable the auto feather system of the opposite side to prevent it from auto feathering

When a feather command is given by the AFU, a record is kept in both MFCs Super Advanced BITE record.

The Super Advanced BITE of the read and decoded MFC 2B non-volatile memory from the retrieved CPU card reveals no automatic feathering command activation by the MFC 2B for the accident flight. Both modules of each MFC were interfaced with one Auto Feathering Unit so with one engine, it can be concluded that no automatic feathering activation was commanded by the MFC on the right engine for the accident flight on January 15th 2023.

Fig. 25 Inner electric circuit and the memory chip

1.14.5 Control Pedestal

The Pedestal consists of an aluminium alloy frame which is attached to the floor of the aircraft and seven levers as identified in the photo below (Figure 26 and Figure 27). The upper face of the Pedestal has a cover with slots allowing the movement of each lever. This cover is attached to the frame of the Pedestal.

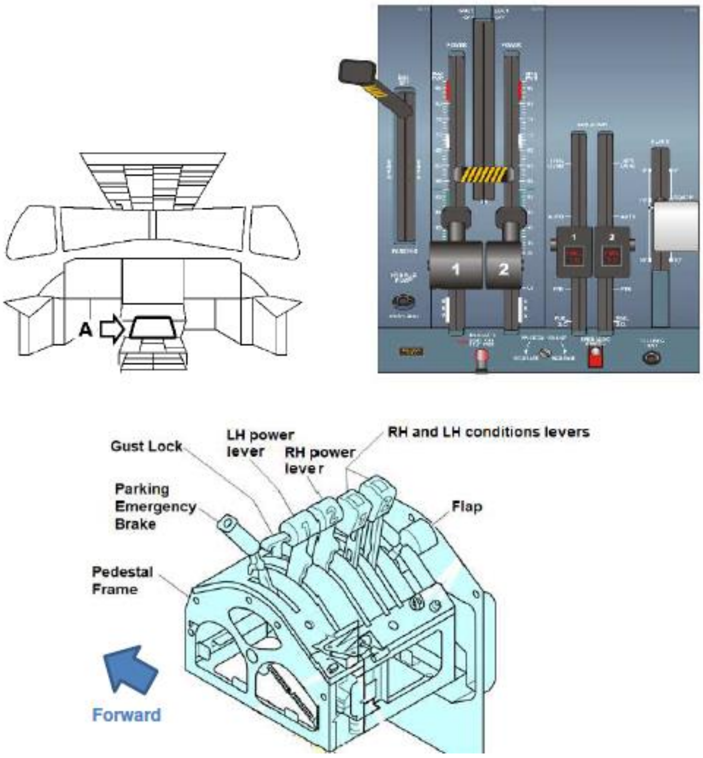


Fig: 26 Pedestal Lever (Source ATR)

The flap lever is associated with two metal rails which have three positions: 0, 15° and 30°. The lever is held in position by the presence of grooves in the rail. To move the lever from one position to another, the knob has to be lifted and released to be locked down in position.

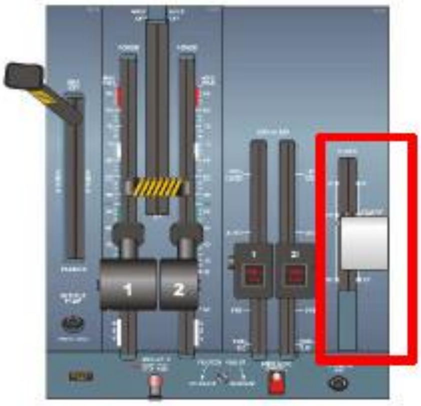


Fig: 27 location of flap lever (Source-ATR)

The two Condition Levers have a marking (1 and 2), they are used to control :

- the HP fuel shut-off on HMU;
- the feathering.

They are located next to each other.

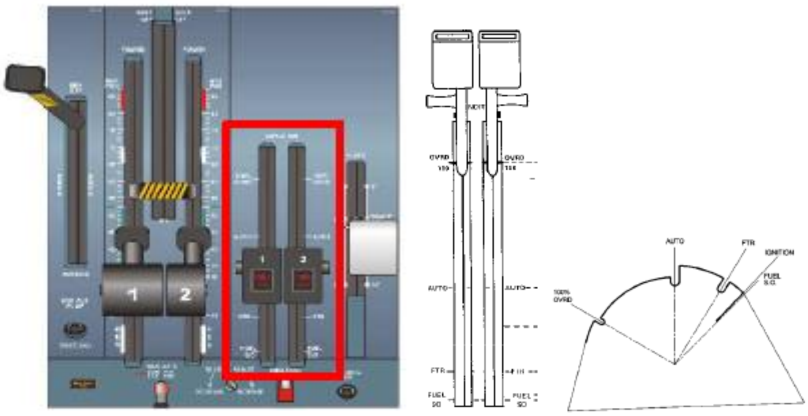


Fig:28 location of condition levers (Source- ATR)

Each lever is associated with a metal rail which is fixed by two screws to the frame of the Pedestal. For lever 1, the rail is located at the left of the lever. For lever 2, the rail is located at the right of the lever.

The two CL are used to control:

- the HP fuel shut-off on HMU
- the feathering
- the out of feather and automatic propeller speed selection
- a 100% Np override that forces the propeller speed to 100%.

The lever is held position by the presence of a spring loaded metal roller. To move from one position to another, the trigger located on the side of each lever must be lifted. This trigger releases the roller and thus allows to move the lever. The system is designed so that, even with trigger lifted, Condition Lever cannot go from AUTO to FSO without making a stop in FTR with trigger being released and lifted again.

The two Power Levers have a marking (1 and 2), they are used to control the engine power for engine 1 and 2. They are located next to each other. Each lever is associated with two metal rails which are fixed to the frame of the Pedestal. Each lever is equipped with two metal rollers which prevent the power lever to be moved below Flight Idle (FI) in flight. To go below FI on ground, a trigger must be lifted.

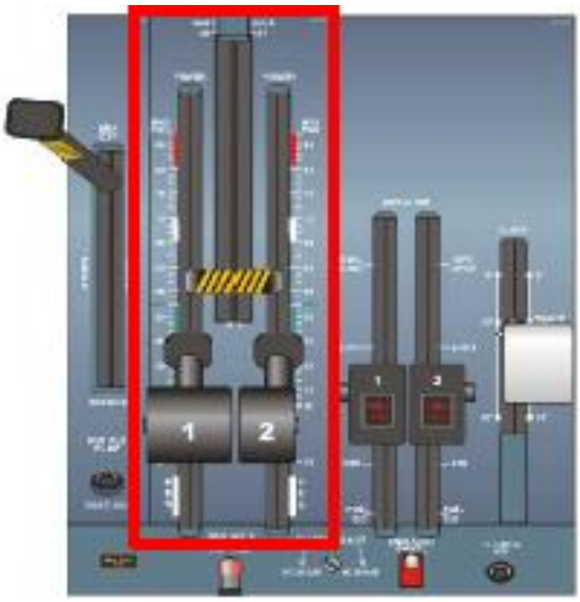


Fig: 29 Location of Power Lever (source-ATR)

The examination of the recovered control pedestal was carried out at BEA, in the presence of representatives from ATR, LEONARDO and OMA companies on May 19, 2023.

Detailed examinations of the pedestal showed:

• The flap lever was locked in the 30° position, with damage to the lever consistent with the application of a high force from the rear during the accident. As a result, the lever was clearly in the 30° position at impact.

• Traces and impact on the Condition Lever 1 rail are consistent with a FEATHER position at impact (no other impact on other position on the rail of Condition lever 1);

• No trace on the Condition Lever 2;

• Traces and damage on Power levers 1 and 2 are consistent with a position forward (zone corresponding to high power).

• the Gust Lock lever was moved rearward upon impact during the accident sequence and deformed. The lever was therefore forward before impact (normal position in flight). (from BEA COMMENT)

1.14.6 Crew Alerting Panel and Cockpit Instruments

The Crew Alerting Panel (CAP) is a panel of indicator lights that is placed in front of both pilots that provides pertinent information to the flight crew when an aircraft system malfunctions or if there are configurations where certain systems are offline or not functioning in its normal operating envelope

The CAP was recovered from the crash site and sent to BEA to determine whether the AC Wild indicator light was illuminated. This would corroborate the findings of the flight recorders.

The Crew Alerting Panel (CAP) lights was examined at the BEA with an X-ray radioscopic unit (Phoenix X-ray Nanomex 180kV), allowing for the visualization of each individual lamp within each alarm, with no need to tear down the CAP assembly (Non Destructive Inspection). The test examines the filaments of each light bulb. Bulbs that are ON have a hot filament and during an aircraft accident, the impact of the aircraft with the ground will induce high deceleration rates. A hot filament is generally ductile giving rise to an increased propensity to stretch under deceleration compared to a cold filament.

A. Crew Alerting Panel (CAP)

- The "Pitch Disconnect" and "FLAPS UNLK" red lights and "ELEC" amber lights were ON, with high confidence
- The 'ENG 1 OIL" red light was probably ON, with medium confidence
- The "HYD" and "ANTI-ICING" amber lights were possibly ON, with low confidence
- All other lights were probably OFF, with high confidence

B. Recovered Cockpit Instruments:

The instrument panel was partially destroyed by fire and impact. They were recovered from the accident site and sent for further inspection to BEA, France.

Each instrument face was visually observed at low and high magnification to look for traces of indentation.

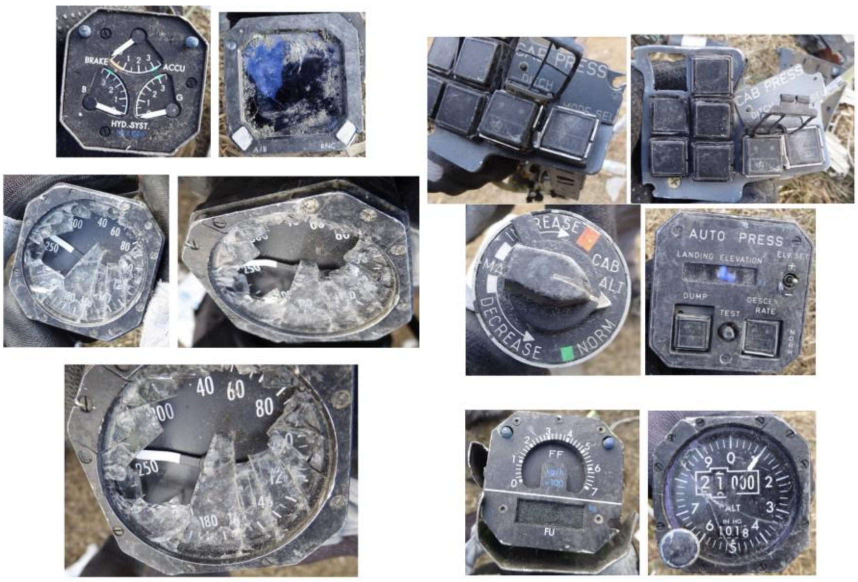


Figure 30 Instruments recovered from Site C

Fuel Flow Indicator: The needle was missing; no indication observed.

Flap Position Indicator: The needle was missing. The blue "EXT" indication was visible.

Hydraulic Triple Pressure Indicator: All three needles were present and were free to move. No needle marks observed on the face.

Interstage Turbine Temperature (ITT) Indicator: The needle was missing and no indication on the face.

Airspeed Indicator: The needle was free to move above 255 knots. Marks consistent with needle impact traces were observed pointing towards 260 knots.

RH Propeller Torque Indicator: The two needles were hard to move, but no evidence of needle trace was observed.

1.15 Organization and Management Information

1.15.1 Yeti Airlines Pvt. Ltd.

Yeti Airlines Pvt. Ltd. started its first commercial flight in September 1998 to STOL airfields with DHC6-300 Twin Otter aircraft. They later expanded their operation to non-STOL domestic sectors with JS-41. They further expanded their fleet to ATR 72- 212A version 500 in 2017 and discontinued JS-41 operations in 2021.

1.15.2 Civil Aviation Authority of Nepal (CAAN)

Civil Aviation Authority of Nepal (CAAN) was established as an autonomous regulatory body on 31st December 1998 under Civil Aviation Authority Act, 1996. Currently, CAAN acts as the regulator and also as a service provider in terms of airport operations and air navigation services amongst others. The authority may issue Requirements, Directives, Manual, order and circular for implementation of the rule, annex, manual and standards prescribed by the international organizations in relation to air service operation.

1.15.3 Ministry of Culture, Tourism and Civil Aviation (MoCTCA)

The ministry of culture, tourism and civil aviation is responsible for discharging state level duties and responsibilities on issues related to Civil Aviation. It is also responsible for accident/incident investigations. There is no permanent body for accident/incident investigations in Nepal as of now. All the accidents/incidents are investigated by a separate Accident/incident Investigation Commission or committee constituted by the state as per Rule 9 of the Civil Aviation (Accident Investigation) Rules, 2014 AD (2071 BS) and the Ministry's Aviation Safety and Accident Investigation Section acts as the secretariat for the commissions.

1.16 Commercial Operation of Pokhara International Airport (PHR)

On 7 August 2022, CAAN's Board of Directors decided to bring Pokhara International Airport in scheduled Operation from January 1, 2023.

On 15 November 2022, all domestic operators were informed to plan for operations from PHR.

ICAO Manual on Certification of Aerodromes (Doc 9774) states:

*....."1.1.1 ……………… **Responsibility of ensuring safety, regularity and efficiency of aircraft operations at aerodromes under their jurisdictions rests with individual states**. …"*

*1.2.5 -- "….**However, since air traffic services are an integral part of an aerodrome's operation, their regulation should be coordinated with that of aerodromes and considered within the certification process…."***

1.16.1 Safety Risk Management (SRM)

CAAN conducted Safety Risk Management (SRM) assessment for PHR prior to commencing commercial operations. During this assessment, it was noted that the validations of standard simulations and proper assessments were not carried out for normal approach, go-around, departure and engine failure contingencies. The SRM team identified the proximity of terrain as an *Unsafe event/top event* that could potentially lead to an accident. To mitigate this risk, the SRM team proposed the following control measures:

a. The operators should develop SOP for PHR.

b. A Validation Flight should be conducted by each operator.

It was recommended that these control measures be put into place by FSSD before commencement of operations to PHR.

1.16.2 Validation flight by operators

Prior to initiating commercial operations into PHR, airlines were required to perform obligatory demonstration flights overseen by CAAN. A few airlines noted that the approach and landing on RWY 12 were difficult and not advisable. Nevertheless, Yeti airlines utilized RWY 30 for landing and RWY 12 for departure during their demonstration flight. However, following CAAN's approval for both runways, despite a lack of visual circuit procedure for RWY12, the airline commenced their commercial operations from both runways.

1.16.3 Publication of Airport data in Aeronautical Information Publication (AIP)

General aerodrome information for PHR was published on 29 Dec 2022. However, the detailed flight procedures for PHR (VNPR AD 2.22) was uploaded in AIP and came into effect only from 23 February 2023 based on ICAO AIRAC Cycle; permitting IFR flights thereafter.

1.17 Additional Information

1.17.1 Stabilization Policy

Yeti Airlines' SOP Issue 3 Rev 00 dated 24-05-2022 (3.25):

"…Stabilized means

1. *The aircraft is in the correct landing configuration;*
2. *Flight Path and Speed appropriate (V_{APP} -0 kts, V_{APP} + 20kts) (Give a precaution call)*
3. *Only minor changes in heading and pitch are required to maintain correct flight path;*
4. *Rate of descent is not greater than 1,000 fpm or required by approach procedure;*
5. *Power setting is appropriate for the aircraft configuration as defined in the relevant aircraft document FCOM/ AFM;*
6. *All briefings and checklist complete…"*

1.17.2 Eye witness statement

The video of final moments before the crash was recorded by a nearby resident from his terrace. According to the footage and his accounts, the aircraft banked sharply towards left simultaneously sinking rapidly. The video surfaced on social media and the stills are portrayed in Figure 1.

An engineer stationed at VNPK parking area remembered witnessing the aircraft manoeuvre as it banked to align with RWY 12 for PHR. While a colleague (Helicopter pilot) standing beside him remarked on the aircraft's unusually low altitude during that moment. Initially he noticed rotation of one of the propellers, and then, almost simultaneously the second propeller which suspected him to believe engine failure as it is less common to spot propeller's rotation mid-air when the engines are operating above idle. He also recollects a sudden upper movement of the aircraft nose followed by a rapid descent.

1.17.3 Management of Change (MOC)

The CAAN State Safety Programme (2019), ICAO Manual on Human Performance (HP) for Regulator (DOC 10151, 2021) and ICAO Assembly Resolution A40-4; all call for the State/Regulator to evaluate and manage the impact of change in the aviation system of the State so that no operation takes place in a changed system or operational context until all the safety risks are evaluated and controlled prior to implementing significant changes.

1.18 Search and Rescue (SAR) Operations

The Ministry, airport authorities and local authorities coordinated for SAR operation. The first responders reached the accident site within minutes of the accident. The SAR operation lasted for several days due to geographical adversity of the accident site. Seventy out of seventy two bodies were recovered and sent for post mortem examinations.

2. ANALYSIS

The investigation was specially focused on:

(a) The actual position of the blades at impact.

(b) The circumstances under which both propellers went into the feathered condition

(c) Human Factors

(d) Visual approach procedures into RWY 12 at Pokhara International Airport

The analysis of the event was performed with reference to technical examination reports of different components and equipment, ICAO documents, existing rules and regulations of Nepal, international best practices, interviews with concerned etc.

2.1 Technical Analysis

2.1.1 Propeller Hub and recovered blades

The propeller rotating parts' examinations were performed on April 25 & 26, 2023 at Collins Ratier - Figeac facility (France) in the presence and under the supervision of the investigation Commission. Purpose of the examination was to retrieve blade pitch angles at the time of aircraft's impact.

Inspection findings and analysis results are compatible, on both propellers, with a pitch at impact close to feather position (about 12^0 max below feather).

2.1.1.1 Propeller in feathered condition:

During the course of the investigation, in particular, the analysis of the flight recorder data, the recorded parameters indicated that the propellers were most likely moved to the feathered condition when the PF requested for Flaps 30 during the approach. The condition levers and flap lever are located next to each other on the pedestal and closer to the co-pilot seat.

The FDR only recorded 187 parameters of which the position of the condition levers were not recorded. It was through the detailed examination of aircraft components from the wreckage that provided corroborating evidence for the flight recorder data as follows:

• The witness marking from the propeller hub indicated that the propeller were close to the feathered angle.

• The right hand MFC super advance BITE records did not indicate any auto feather command from the RH AFU.

The witness marks from the pedestal indicates that the left condition lever was in the feathered position. Although the right hand condition lever did not have witness marks it is probable that the lever was also in the feathered position based on the FDR data and MFC examination corroboration.

All evidence gathered from the detailed examinations appear to indicate that the propellers were manually selected to the feathered position.

Figure 25 Prop #1 hub assembly

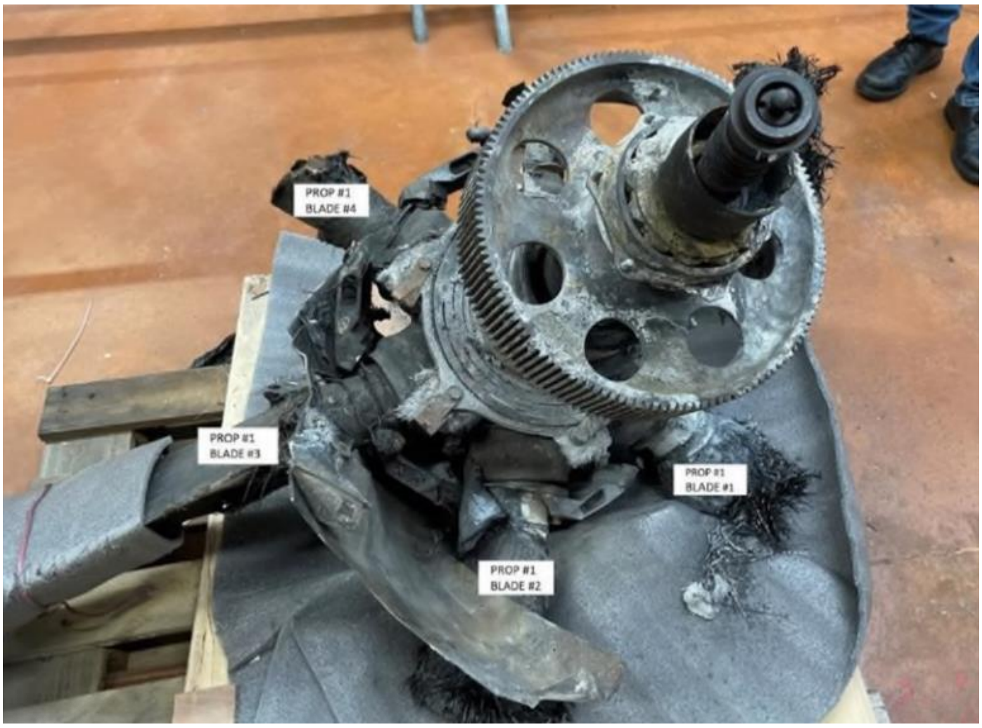


Figure 32 Prop #2 hub assemblies

2.1.2 MFC

The active “Super Advanced BITE" zone of the read and decoded MFC non-volatile memory from the retrieved CPU card reveals no automatic feathering command activation by the MFC. The CPU board history of the retrieved CPU card SN 00004800585 reveals that it was installed in February 2016 on MFC PN LA4E20606HM0100 SN 4E2002308. This CPU board has been identified as being installed in module B, as CPU boards are specific in between module A and module B. These pieces of information, together with the maintenance logbook (from BEA source) which states that MFC unit SN 4E2002308 was installed in MFC2 position, allows to conclude that the retrieved CPU card was installed in MFC 2B module.

The Super Advanced BITE of the read and decoded MFC 2B non-volatile memory from the retrieved CPU card reveals no automatic feathering command activation by the MFC 2B for the accident flight.

2.1.3 Systems Analysis

There was no evidence of engine failure in FDR data analysis until the impact of the aircraft. Both the engines were running at idle condition till the time of impact. Hence the possibility of engine failure is ruled out. There was no evidence of any systems failure either. Hence, the failure of the aircraft systems e.g. hydraulic, flight control and other major components can, too, be ruled out. The probability that the power-plants, systems, or structural failures or any other mechanical malfunction contributing to the accident can be ruled out. The Commission examined the maintenance history of the aircraft and found that all the airworthiness directives and service bulletins had been complied with as per the maintenance requirements within the prescribed time frame. The technical logs and log books show that the maintenance works, major inspection works and modifications were carried out as per the approved maintenance program and bulletins. No technical defect was found in the technical logbook prior to the flight. On the basis of available evidences, any technical or mechanical reason has been discounted.

2.1.4 Control Pedestal

The examinations were carried out at the BEA. These reviews were conducted in the presence of representatives from ATR, LEONARDO and OMA companies on May 19, 2023

The objective of the exams was to try to determine the position of the levers during the initial impact of the aircraft with the ground by looking for impact markings left by the various levers with the pedestal frame and other areas.

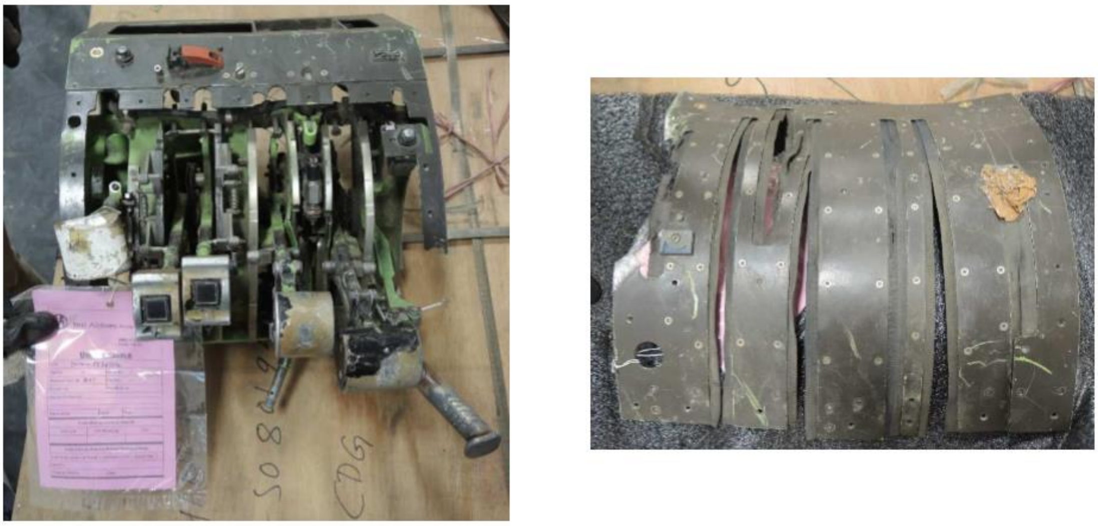


Figure 26 Control Pedestal of 9N-ANC

Detailed examinations of the pedestal showed:

• The flap lever was locked in the 30° position, with damage to the lever consistent with the application of a high force from the rear during the accident. As a result, the lever was clearly in the 30° position at impact.

• Traces and impact on the Condition Lever 1 rail are consistent with a FEATHER position at impact (no other impact on other position on the rail of Condition lever 1);

• No trace on the Condition Lever 2;

• Traces and damage on Power levers 1 and 2 are consistent with a position forward (zone corresponding to high power).

• The Gust Lock lever was moved rearward upon impact during the accident sequence and deformed. The lever was therefore forward before impact (normal position in flight).

2.1.5 GPWS

In this GPWS, different mode is responsible for different functions. Mode 1 is for Excessive Rate of Descent – alerting domain envelope, Mode 2A for Excessive Terrain Closure Rate - alerting domain envelope, Mode 2B for Excessive Terrain Closure Rate “desensitized” - alerting domain envelope and Mode 3 for providing alerts for excessive altitude loss after take-off or during a missed approach. Last, Mode 4 provides alerts for insufficient terrain clearance with respect to flight phase and speed in three sub-modes: Mode 4A is active during cruise and approach with landing gear up. Mode 4B is active during cruise and approach with landing gear down. Mode 4C is active during take-off phase with gear and flaps not in landing configuration. Note that, in modes 4A and 4B, the "Too Low Terrain" warning area upper limit may be reduced to 500 feet radio altitude when EGPWS has all GPS altitude, pressure altitude and radio altitude data available to compute a reliable consolidated altitude.

In this case, GPWS warning system was serviceable came twice during this last sector (Kathmandu - Pokhara Flight). For Honeywell EGPWS MK8 based TAWS architecture, the following table summarizes cockpit effects in terms of aural alerting and visual alerting for each GPWS and Enhanced functions.

TAWS function	Aural alerting (speakers)	Visual alerting (lights and
GPWS mode 1	"SINKRATE" + "PULL UP"	GPWS on 3WZ and 4WZ
GPWS mode 2	"TERRAIN TERRAIN" + "PULL	GPWS on 3WZ and 4WZ
GPWS mode 3	"DON'T SINK"	GPWS on 3WZ and 4WZ
GPWS mode 4 terrain	"TOO LOW TERRAIN"	GPWS on 3WZ and 4WZ
GPWS mode 4 gear	"TOO LOW GEAR"	GPWS on 3WZ and 4WZ
GPWS mode 4 flaps	"TOO LOW FLAPS"	GPWS on 3WZ and 4WZ
GPWS mode 5 soft	"GLIDESLOPE" (–6dB)	G/S on 3WZ and 4WZ
GPWS mode 5 hard	"GLIDESLOPE" (0dB)	G/S on 3WZ and 4WZ
GPWS mode 6 callout	"FIVE HUNDRED"	--
GPWS mode 6 callout	"MINIMUMS MINIMUMS"	--
GPWS mode 6 bank	"BANK ANGLE BANK ANGLE"	--
TAD terrain caution	"TERRAIN AHEAD, TERRAIN AHEAD"	GPWS on 3WZ and 4WZ + solid yellow area on EFIS
TAD terrain warning	"TERRAIN AHEAD, PULL UP"	GPWS on 3WZ and 4WZ + solid red area on EFIS /
TAD obstacle caution	"OBSTACLE AHEAD, OBSTACLE AHEAD"	GPWS on 3WZ and 4WZ + solid yellow area on EFIS
TAD obstacle warning	"OBSTACLE AHEAD, PULL UP"	GPWS on 3WZ and 4WZ + solid red area on EFIS /
TCF / RFCF	"TOO LOW TERRAIN"	GPWS on 3WZ and 4WZ

Figure 27 GPWS and enhanced function

2.2 Operational (Flight) Analysis

The departure from KTM was normal.

Before reaching MANKA, the PM expressed intentions to familiarize PF on RWY 12 if traffic permits and briefed on the visual approach procedure for RWY 12 emphasizing the need of a sharp turn during final approach. The intent for runway change was to clear PF from RWY12 under IP supervision. However, this familiarization from RWY12 was not planned by the operator's operations department.

When the aircraft was at 15 miles to PHR, 6500ft, the PM requested and received clearance for landing on RWY 12. After receiving approval for RWY12, the PM briefed the PF on manoeuvring techniques, the circuit, heading and radial to be followed as well as the altitude to be maintained. After joining downwind, RWY12, the crew announced flap 15. The PM continued briefings on visual landmarks, obstacle, runway orientation etc. The crew then announced flap 30. However, it was found the checklist in all phases of flight was not carried out appropriately as per SOP.

PF voiced concerns about ELEC lights but CVR records do not show any response from PM. The PF then asked if they should continue the turn to which the PM responded "positive". Subsequently, PM advised on increasing the power, but PF reported that there was no power. and PF once again repeated that there was no power, no torque. The FDR records show the power levers were moved from flight idle position to RAMP position.

The PM who was occupying right hand seat had made 2 landings at RWY 12; one from left hand seat and the other from right hand seat. The flight was first for PF who was occupying left hand seat. Previous experience, type of flight and seating position, etc. might have affected the situational awareness in the critical phase of the flight.

From the retrieved FDR data, flight path of the event flight as well as another flight on 12th Jan, 2023 where other set of crews landed on RWY 12 were recovered.

The flight trajectories show that the flight path gradients were not as per ATR 72-212A version 500's flight manual. Due to the tight circuit and shortened final leg of RWY 12, the stabilization criteria for visual approach couldn't be maintained at the height of 500 ft. AGL. Sequence of events of the accident flight resembled previous flights of the day to Pokhara, except for when flap 30 was called (yet not acknowledged by the other crew) on the accident flight, the flaps were not deployed; rather both propellers went to feather resulting in loss of torque in both engines. However, when the flaps 30 were finally deployed, there were no recorded callout from either cockpit crew.

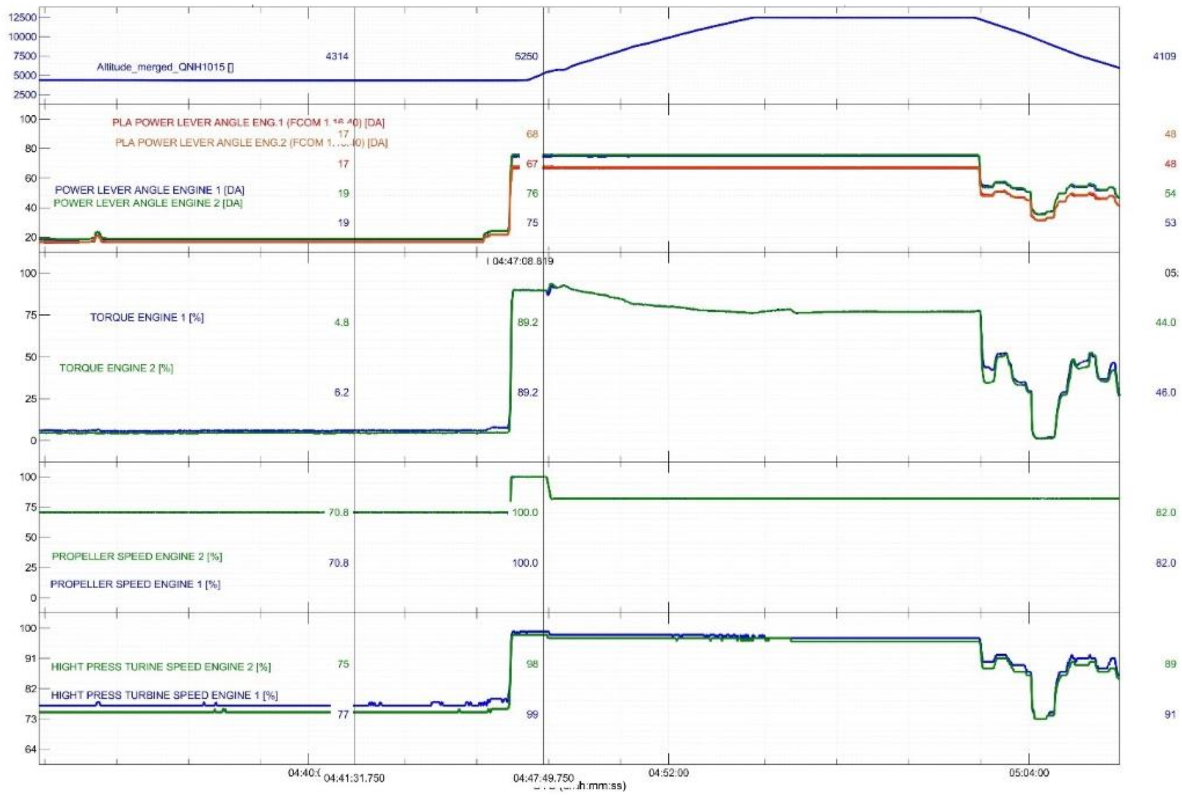


Figure 35 Engine and propeller parameters as per FDR

2.3 Commencement of PHR's commercial operation

The Commission analyzed the process to be followed before the commencement of new airport into comercial operation and derived the following observation.

2.3.1 Regulatory oversight

As per the available documents, it is found that the regulator conducted the Safety Risk Management of the PHR airport to identify possible hazards, unsafe events, consequences and recommended measures of mitigation before bringing PHR into scheduled commercial operation.

The hazard identified by SRM team regarding proximity of terrain which could potentially lead to a devastating accident was of a serious concern.

As per recommendations, the domestic scheduled operators conducted validation flights under CAAN supervision. The approval of validation flights as well as development of SOP was a prerequisite for commencement of scheduled flight operations to PHR. However, there is no evidence of CAAN approving the SOP before authorizing validation flights with regards to Yeti Airlines. Similarly, the commission observed a lack of analysis and examination of human performance considerations, from the regulator, before deciding to start flight operations in PHR. Air Traffic Services regulation was neither coordinated with that of aerodromes nor considered within the aerodrome certification process. CAAN neither developed the visual circuit procedure on its own nor did it ensure development of it by the airlines concerned. However, CAAN approved operations from both the runways.

It is the responsibility of safety regulator to assess the service provider’s plan for change before providing operating authorization in changing environment to mitigate the risk and to increase the confidence of public in air travel.

2.3.2 Validation Flight

During validation flight conducted by Yeti Airlines, they used runway 30 for landing and runway 12 for departure, under the supervision of CAAN inspector. Validation flight report was submitted by the inspector to CAAN. The flight was operated under day IFR principle. Since the airport was going to be operated only for VFR flight, the validation flight was supposed to be conducted under full VFR condition using both runways and both right hand and left hand visual circuits of RWY 12 for landings. So the recommendation for the suitability of both runways for arrival and departure without enough exercise and test seems not satisfactory.

2.4 Human Factors Analysis

To assess the human factors contribution to the accident, the commission carried out an in-depth analysis.

The investigation commission was assisted by the services of a group of experts in the field of human factors from the FAA to analyze human factor issues in this accident. The SHELL model was used for the human factors analysis.

In aviation, the SHELL model is one of many methods and models that may be used to understand the relationship between the human and the environment with respect to an incident or accident and to analyze the interaction of multiple systems. The SHELL model may be helpful in the analysis of crew actions of Yeti 691.

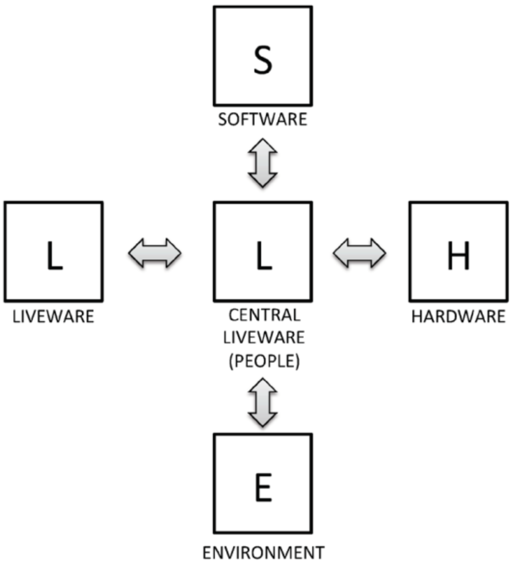


Figure 36 Engine and propeller parameters as per FDR

Liveware

A 72-hour history of both crewmembers indicated that fatigue and their health issues were not a factor prior to the accident. Both pilots were reported to have eaten routine foods, went to bed, and rose at routine hours.

The PF owned a noise-cancelling headset and this type of device has been known to decrease the sensitivity of acoustical sensory cues in flight and may have contributed to the crew not perceiving the accidental feathering of both engines. The PM did not own noise-cancelling headset.

The CVR transcript captured a flight deck environment rich with discussion on the appropriate way to fly a visual approach into the new Pokhara Airport. Both pilots were experiencing high workload, distractions to the external environment, and may have impacted on effective CRM within the cockpit. This may have lead them to not follow the checklist properly in critical phases of flight. The crew were most probably distracted due to excessive conversation in cockpit because the flight was first for the PF and the PM was occupied with providing instructions and was not focused on the PM duties.

Environment

Although weather conditions and time of day were optimal, challenges provided by the opening of the new Pokhara Airport certainly played a role in crew distraction. The new airport had opened only two weeks prior to the accident flight. With both crewmembers having extensive experience flying in Nepal, and experience flying to/from the old Pokhara Airport, because the old Pokhara Airport was very close to the new Pokhara Airport, it can be assumed that both were very familiar with the terrain around Pokhara.

The crew requested to land on runway 12, necessitating flying a downwind, base and final leg, instead of a straight in approach that they were initially cleared for. This may have been part of the instructor pilot’s decision to ensure proficiency at approaching the airport from both directions.

Manoeuvring and configuring the aircraft for a visual approach to a new airport could have certainly increased the workload and stress on both crewmembers. A visual approach requires attention outside of the aircraft by the PF and adequate support from the PM to ensure all checklist items and aircraft configuration settings are done correctly. In this case it is likely that both crewmembers were focused outside the aircraft which could result in distractions in carrying out the PM functions.

Hardware

The centre pedestal design of the ATR 72-212A version 500 does not directly preclude inadvertent movement of the propeller condition levers in lieu of the flap handle (or vice versa), but some design considerations mitigate this risk.

In order to move a propeller condition lever, the pilot must first activate a trigger below the lever to disengage the lever from a detent. Similarly, the flap handle also has detents, but there is no trigger. The entire flap handle is raised to lift the lever out of the detent.

Additionally, the shape of each lever is such that they would feel different when touched. There are different number of levers (two for condition levers and one for flap), the colours are different and their locations on pedestal also differ. The flap handle is shaped like an airfoil, the propeller condition levers have ridged knobs, the thrust levers are smooth and cylindrical, and the landing gear handle is shaped like a wheel. These are all industry standard design considerations.

Consideration has been given by the investigation to the alignment of the flap handles in the 15 degree position which is geometrically close to the condition lever AUTO position. Given the previous design features therefore, one has to consider other inputs such as workload, confirmation bias and the operational context that contributed to the pilot monitoring actions.

The CVR transcript indicated that there was likely a chime that followed the feathering of both propellers. Considering ATR 72 systems failures resulting from Np drop due to feathering in flight, this was likely an electrical, anti-icing or hydraulic system caution.

The CVR transcript also highlighted that the crew was making configuration changes prior to landing well below 1,000’ AGL which could contribute to increase the crew workload.

Software

The configuration of the aircraft for the visual approach to Pokhara may have been carried out at an altitude lower than desirable as stated in the operator’s SOPs. The operator’s SOP for Task Sharing indicates “In all situations, BOTH CMs must be aware of all important selections or switching and maintain situational awareness throughout the flight. Cross monitoring of Speed Bug / Altimeter settings / changes in frequencies / changes in aircraft configuration (Gear / Flaps) is mandatory.”

Because both crewmembers should be aware of configuration changes as indicated above, it would be reasonable to expect Yeti to have a crosscheck or confirmation by both crewmembers to ensure appropriate changes are carried out. However, because of the increased workload and stress, it appears as though this procedure to crosscheck and confirm switch selections was not followed.

The available recorded data, coupled with witness video and the teardown report of the centre pedestal, point to one likely scenario: The most probable sequence of events of the accident is a selection of both Condition Levers to Feather position, which resulted in feathering of both propellers and subsequent loss of thrust. Without change of the aircraft flight path, the loss of speed resulted in a loss of control in flight. Contributing to this accident was the high workload associated with unfamiliar airport operations and subsequent loss of recognition of undesired aircraft state.

2.5 Visual Approach Procedure

At the time of the accident Pokhara had two operational airports, Pokhara airport and Pokhara International airport (VNPR). Pokhara airport was used for domestic flights whereas VNPR was used for international flights. VNPR was newly opened on 1 January 2023. At the time of the accident, VNPR had not yet published their instrument approach procedures and was operating as a Visual Flight Rules (VFR) only airport.

However, procedures to allow for such visual approaches had not been developed. The operator had developed a visual circuit pattern internally into VNPR and attempted for the aircraft to remain clear of surrounding terrain and Pokhara domestic airport. This resulted in an approach that required tight turns during the descent and would result in the aircraft being at a lower altitude once aligned to RWY 12. This did not meet the requirements for a stabilised visual approach. This would result in a challenging approach, increase the flight crew's workload and decrease the safety margin.

The operator had carried out demonstration flights to VNPR prior to it opening; however the demonstration flights were for VFR landings on RWY 30 and departure on RWY 12. The operator had also developed a visual circuit for landings on RWY 12 but did not carry out any demonstration flights for this visual approach.

CAAN has a process for operators to develop and propose approaches into airports. The approval process also allows operators to conduct validation flight with the approval of CAAN to demonstrate the viability of the design approach.

3. CONCLUSION

3.1 Findings

1. The aircraft possessed a valid certificate of airworthiness and registration at the time of the occurrence. The aircraft departed TIA with no known defects.

2. The cockpit crew were qualified and certified in accordance with the rules and the regulations of the CAAN.

3. Both the flight crew members had adequate rest and the duty time was within the prescribed limit prior to the flight.

4. The aircraft was operating within the performance limitations as per its Flight Manual. The weight and CG were within the prescribed limits.

5. The aircraft was maintained as per the requirements. No maintenance work was found to be overdue. And all maintenance records had been maintained properly.

6. There was no evidence of aircraft control systems, structural, or power-plant failures before the ground contact. All damages to the aircraft occurred after the impact.

7. VMC prevailed at Kathmandu and within the Pokhara valley at the time of the aircraft's approach at PHR. The whole flight was conducted under VFR.

8. The visual approach circuit pattern followed by the flight for RWY12 did not meet the criteria for a stabilized visual approach. No visual trajectory was published for RWY 12.

9. Aerodrome obstacle data and information on facilities available at PHR Airport were published in AIP Nepal and became effective on December 29, 2022, while the ATS IFR procedures and holdings becoming effective on February 23, 2023.

10. Air Traffic Services Regulation was not coordinated with that of Aerodromes and not considered within the certification process.

11. The MOC carried out by the operator and approved by the regulator was inadequate.

12. The MOC carried out by one of the domestic airline planning to operate at PHR identified "Lack of published data of Pokhara International airport in AIP" as a *Hazard*

of *High risk category*, creating the unsafe event "Crew confusion and disorientation" and ultimately the possible outcome as CFIT.

13. The approach on RWY12 was first attempt for the PF and third for the PM since the start of operations at PHR.
14. Company trainings prior to clearance to PHR were found insufficient for the crew. Skill based training for new airport was not given to the crew.
15. The checklists were not performed by the crew in compliance with the SOP.
16. Following the un-intentional feathering of both engine propellers, the flight crew failed to identify the problem and take corrective actions despite the CAP cautions. The PF owned a noise-cancelling headset whereas PM did not.
17. It is likely that the PM had misidentified and moved both condition levers to FEATHER when the PF called for flaps 30 without appropriate crosscheck loop as per CRM training.
18. The PF did not visually crosscheck the position of Flaps 30 and confirmed it.

3.2 Probable cause

The most probable cause of the accident is determined to be the inadvertent movement of both condition levers to the feathered position in flight, which resulted in feathering of both propellers and subsequent loss of thrust, leading to an aerodynamic stall and collision with terrain.

3.3 Contributing Factors

The contributing factors to the accident are:

7 High workload due to operating into a new airport with surrounding terrain and the crew missing the associated flight deck and engine indications that both propellers had been feathered.

8 Human factor issues such as high workload and stress that appears to have resulted in the misidentification and selection of the propellers to the feathered position.

9 The proximity of terrain requiring a tight circuit to land on runway 12. This tight circuit was not the usual visual circuit pattern and contributed to the high workload. This tight pattern also meant that the approach did not meet the stabilised visual approach criteria.

10 Use of visual approach circuit for RWY 12 without any evaluation, validation and resolution of its threats which were highlighted by the SRM team of CAAN and advices proposed in flight procedures design report conducted by the consultant and without the development and approval of the chart by the operator and regulator respectively.

11 Lack of appropriate technical and skill based training (including simulator) to the crew and proper classroom briefings (for that flight) for the safe operation of flight at new airport for visual approach to runway 12.

12 Non-compliance with SOPs, ineffective CRM and lack of sterile cockpit discipline.

4. SAFETY RECOMMENDATIONS

The Accident Investigation Commission has determined that the following safety recommendations should be implemented for the advancement of flight safety:

4.1 Recommendation to the Operator

1. The operator should take into consideration the stabilization criteria when designing or proposing approaches for approval by CAAN.
2. The operator should ensure the sufficient skill-based training for the crew before operation at new airport.
3. Safety department should act effectively to monitor and take prompt corrective actions against the violations related to CRM discipline and not following the checklist during flight.
4. The operator should conduct an in-depth MOC study with considerations to human factors and other probable safety issues before establishing criteria for aircraft clearance and approval of crew in a new operating environment.
5. The operator should ensure the sufficient technical ground class to the crew.

4.2 Recommendation to CAA Nepal (Safety Regulator)

1. While conducting the aerodrome certification process the Aerodrome Safety Standard Department should consider all the safety critical parameters including the ATS procedures, visual circuits and stabilization criteria for the particular aircraft in conformance with the aircraft design criteria and local operational environment to ensure the safety of flight operation.
2. CAAN should ensure that the appropriate visual flight path is approved which allows the criteria for a stabilized visual approach to be met by the operator or ANS service provider prior to the start of commercial operation in any new airport or before introducing any new fleet in the existing airport.
3. CAAN should evaluate and manage the impact of change in the aviation system so that no operation takes place in a changed system or operational context until all the safety risks are evaluated and controlled prior to implementing the significant changes.

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

Government of Nepal should establish a permanent investigation entity with sufficient financial, human and technical resources to meet the international obligation as per Annex 13 of the Chicago Convention.

5. SAFETY ACTIONS

The commission was informed by the regulator and the operator that the following safety actions were initiated:

5.1 By CAAN

1. CAAN prohibited visual approach landings on VNPR runway 12 after the accident.
2. CAAN issued a circular on 1 February, 2023 requiring all airplanes while conducting flight to stabilize not below 500 feet AGL in STOL airfields and not below 1000 feet AGL in rest of the airfields.
3. A Letter of Agreement between VNPR (PIA) tower and VNPK (FEWA) tower was developed for better coordination between the two airports quite before the operation of airport.
4. On 26 March 23, the CAAN setup a 5-member committee to study various operational safety issues including stabilized approach criteria at airports for IFR and VFR operations. The following recommendations where proposed by the committee:
    - Flight Safety Foundation’s recommended stabilization criteria of 1000 ft for IFR flights, 500 ft for VFR flights and 300 ft for circle to land to be implemented and supersede previous approvals.
    - Airlines to study and develop SOPs together with risk mitigation measures for airport when the stabilisation criteria cannot be met.
    - VFR operations for arrivals onto runway 12 at VNPR can be allowed with ceiling minima above 2500 ft.
    - CAAN shall install and develop further surveillance infrastructure to integrate the existing radar facility to increase en-route surveillance capability.
    - Install surveillance facility at VNBW and VNPR.
    - CAAN establish a common approach control unit for VNBW, VNPR and VNBP with sufficient CNS coverage.

- Sectorisation of the Area Control Centre into Area East and area West for effective communication, surveillance and air traffic control service.

1. Based on the recommendations of the study committee CAAN issued another circular on 19 May, 2023 allowing runway 12 for approach and landing during VFR condition with ceiling minima requirement above 2500 feet.

5.2 By the Operator

1. Training of the operator's Instructor/Examiner pilots from the experts in Toulouse completed after the accident, at the request of CAAN.
2. Rehabilitated Management of Operations and Engineering Department Key Post holders.
3. Started monitoring of each flight crew in-flight performance evaluation & line check as a continuous process.
4 Conducted the IATA 5 day's full course of SMS to all Safety Action Group Members.
5. Company has been conducting de-icing boot repair training to line Maintenance Engineer at MAB Engineering Services Malaysia.
6. Conducted the 2 days ground class and 2 days REC + PPC as a part of flight crew performance assessment for all our company's Captains and Co-pilots with ATR manufacturer Instructors/ Examiners at ATR training centre in Toulouse France.
7. The operations director has been and will continuously monitor the safe operational activities as per duties and responsibility mention in OM - A as approved by CAAN.
8. In addition, the operations meetings are being regularly conducted with company IPs, pilots and other safety concern and will be continued.