FINAL REPORT

on

ACCIDENT INVESTIGATION

of

9N-AME (CRJ 200LR, MSN 7772) Aircraft

Operated

by

Saurya Airlines Pvt. Ltd.

on

July 24, 2024

Submitted By:

Aircraft Accident Investigation Commission

Submitted To:

Government of Nepal
Ministry of Culture, Tourism and Civil Aviation

July 14, 2025

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Preface

This Aircraft Accident Investigation Commission (AAIC) was formed on July 24, 2024, by the Government of Nepal to investigate the accident of 9N-AME aircraft, operated by Saurya Airlines Pvt. Ltd. The aircraft was departing for base maintenance from Tribhuvan International Airport, Kathmandu.

The sole objective of AAIC's Air Accident Investigation is the prevention of similar accidents in the future. This investigation does not seek to apportion blame or liability. Accordingly, this report should not be used to assign blame or determine civil or criminal liability.

Foreword

This report on the accident of 9N-AME, CRJ 200LR aircraft (flight number SAU-FER) aircraft operated by Saurya Airlines Pvt. Ltd. is based on the investigation carried out by the Accident Investigation Commission (AAIC) duly constituted by the Government of Nepal on July 24, 2024 as per the provisions of the Civil Aviation (Investigation of Accident) Regulation 2014 (2071 B.S.) and following the guidelines of Procedure Manual of Aircraft Accident/Incident Investigation 2022, Nepal.

The sole objective of the investigation is to identify the cause of the accident and suggest recommendations to prevent the recurrence of such kinds of accident in the future. It is not the purpose of this investigation to apportion blame or determine civil or criminal liability. The Commission acknowledges the support provided by the safety regulator CAAN, operator Saurya Airlines, Nepal Army, Nepal Police, the Central Police Forensic Laboratory, TSIB Singapore, TSB Canada, FAA USA, Shree Airlines, and Department of Aerospace and Mechanical Engineering, IOE Pulchowk campus, among others.

Note:

a) *This report contains the facts which have been determined up to the date of publication.*

b) *The extracts may be published without specific permission provided that the source is duly acknowledged, the material is reproduced accurately, and it is not used in a derogatory manner or in a misleading context.*

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

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Abbreviations and Definitions

AD	Airworthiness Directive
ADC	Air Data Computer
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AHRS	Attitude and Heading Reference System
AIP	Aeronautical Information Publications
AMSL	Above Mean Sea Level
AOA	Angle of Attack
AOCR	Air Operator Certificate Requirement
ASDA	Accelerated-Stop Distance Available
ATPL	Airline Transport Pilot License
B.S.	Bikram Sambat
C of A	Certificate of Airworthiness
CAAN	Civil Aviation Authority of Nepal
CG	Center of Gravity
CPL	Commercial Pilot License
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DG	Dangerous Good
DME	Distance Measuring Equipment
EGPWS	Enhanced Ground Proximity Warning Systems
ELT	Emergency Locator Transmitter

FDR	Flight Data Recorder
F/O	First Officer
FOR	Flight Operation Requirements
FSSD	Flight Safety Standards Department
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HF	High Frequency
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
KTM	Kathmandu
LDA	Landing Distance Available
LDR	Lightweight Data Recorder
LH	Left Hand
LMC	Last Minute Change
LW	Landing Weight
METAR	Meteorological Report
MHz	Mega Hertz
MLG	Main Landing Gear
MoCTCA	Ministry of Culture, Tourism and Civil Aviation
MTOW	Maximum Take Off Weight
NCAR	Nepalese Civil Airworthiness Requirements
OM	Operations Manual
P1	Pilot in Command (PIC)
P2	Co-Pilot or Second in Command

Pax	Passengers
PELR	Personnel Licensing Requirements
PF	Pilot Flying
PM	Pilot Monitoring
P/N	Part Number
PIC	Pilot in Command
PKR	Pokhara
PPC	Pilot Proficiency Check
QRH	Quick Reference Handbook
RH	Right Hand
RMI	Radio Magnetic Indicator
R/W	Runway
SB	Service Bulletin
S/N	Serial Number
SOP	Standard Operating Procedure
SRA	Safety Risk Assessment
STOL	Short Take Off and Landing
TCAS	Traffic Collision Avoidance System
TODA	Take-Off Distance Available
TORA	Take-off Run Available
TOW	Take Off Weight
TSIB	Transportation Safety Board, Singapore
TWR	Tower
UTC	Universal Co-ordinated Time

VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Metrological Conditions
VNKT	Kathmandu Aerodrome
Z	Zulu time [UTC]
ZFW	Zero Fuel Weight

Synopsis

On July 24, 2024, the CRJ 200LR aircraft (Registration: 9N-AME, MSN:7772) operated by Saurya Airlines was scheduled for ferry flight (Flight Number: SAU-FER) from Tribhuvan International Airport (VNKT), Kathmandu to Pokhara International Airport (VNPR), Pokhara. The flight was approved as ferry flight, by Air Transport Division of the Civil Aviation Authority of Nepal on July 23, 2024, with an extension period of 72 hours. The purpose of the ferry flight was to conduct base maintenance (C-check) of the aircraft, at Pokhara International Airport's hanger. The aircraft had been grounded for 34 days prior to the event flight.

The aircraft met an accident during take-off at around 05:26 UTC (11:11 am local time), crashing within the premises of Tribhuvan International Airport. All occupants except the Pilot in Command lost their lives. The accident was notified by the Ministry of Culture Tourism and Civil Aviation, Nepal to the International Civil Aviation Organization, State of Manufacture, TSB Canada and NTSB, USA which is state of manufacture for engines, as per the provisions of ICAO Annex 13.

The Government of Nepal constituted a 5-member, Aircraft Accident Investigation Commission to find the most probable cause of the accident and suggest recommendations as to prevent the recurrence of similar accidents as per the provision of the Aircraft Accident Investigation Regulation, 2014 (2071 B.S.). The commission carried out thorough investigation and extensive analysis, along with accident site visits and examinations, interviews with concerned personnels, study of different reports, records and documents and flight data analysis. In accordance with the provision of the ICAO Annex 13, American, Canadian and Singaporean investigation agencies also provided support in this investigation.

The most probable cause of the accident was a deep stall during take-off because of an abnormally rapid pitch rate commanded at a lower than optimal rotation speed.

The contributory factors to the accident are:

1. Incorrect speeds calculated based on erroneous speedcard. The interpolated speedcard of the operator for 18,500 kg TOW mentions incorrect V-speeds for take-off. This error in the speedcard went unnoticed since its development. There was no acceptance/approval of the speedcard booklet.
2. Failure to identify and address multiple previous events of high pitch rate during take-off by the operator.
3. The operator showed gross negligence in complying with the prevailing practices of ferry flight planning, preparation and execution. There is a lack of consistent definition of ferry flights.
4. Gross negligence and non-compliances by the operator during the entire process of cargo and baggage handling (weighing, loading, distribution and latching), while violating the provisions of operational manual and ground handling manual. The load was not adequately secured with straps, tie-downs, or nets, while the flight preparation was rushed.

The commission issued three interim safety recommendations as immediate remedial measures. In this report, 41 safety recommendations are made for the advancement of safety.

1. Factual Information

1.1 History of Flight

On July 24, 2024, the CRJ 200LR aircraft (Registration: 9N-AME, MSN:7772) operated by Saurya Airlines was scheduled for ferry flight (Flight Number: SAU-FER) from Tribhuvan International Airport (VNKT), Kathmandu to Pokhara International Airport (VNPR), Pokhara. The flight was approved by Air Transport Division of the Civil Aviation Authority of Nepal (CAAN) on July 23, 2024, with an extension period of 72 hours. The purpose of the ferry flight was to conduct base maintenance (C-Check) of the aircraft, at Pokhara International Airport's hanger. Table 1 provides the details of the flight.

Table 1: Flight information

Date of Flight	July 24, 2024
Flight Number	SAU-FER
Aircraft Registration	9N-AME
Aircraft Type	CRJ 200LR
Purpose of flight	Ferry flight
Permit Number	CAAN-FP554/2024
VFR/IFR	VFR
Departure	Tribhuvan International Airport, Kathmandu (VNKT)
Destination	Pokhara International Airport, Pokhara (VNPR)
Time of Accident	05:26 UTC

The aircraft had been grounded for 34 days before the event flight. The preservation of aircraft and return to service maintenance checks were carried out as per aircraft maintenance manual.

On the event day, the aircraft lined up on runway 02 at VNKT at around 05:25:35 UTC and prepared for the commencement of take-off roll. The provided V-speeds were V_1 = 114 knots, V_R = 118 knots and V_2 = 125 knots. At 05:25:55 UTC, the aircraft commenced rotation for takeoff.

The flight data recorder stopped recording at 05:26:08 UTC. The first impact of the right wing on the ground was a few seconds later. Directly after rotation, the aircraft was unable to gain sufficient altitude and rolled to the right with the right wingtip impacting the ground. The geographical coordinates of the location of first impact are 27°42’3’’ North and 85°21’42’’ East, located at the entrance/exit point of taxiway Juliet of VNKT. The aircraft crashed on the east side of runway 02 at VNKT. The aircraft was destroyed in the post-impact disintegration and fire.

1.1.1 Sequence of the Event Flight

The analysis of Flight Data Recorder (FDR) data was performed in combination with the investigation of CCTV footages and Cockpit Voice Recorder (CVR) records.

Figure 1: Flight path and event markers

The reconstructed path of the aircraft is shown in Figure 1. The figure includes the marking on the flight path significant to the comparative observation of the aircraft based on FDR data, CCTV footages, significant CVR audio information, and terrain references. Figure 2 shows the markers C and F as seen in the CCTV footage, while Figure 3 shows the unusual attitudes of the aircraft after take-off leading to the accident. The aircraft underwent a right, left and right bank before the right wing impacted on the ground at ‘1’.

Figure 2: CCTV footage view of the events marked **C** and **F** in Figure 1

Figure 3: Event sequence with unusual attitudes leading to the accident, captured by a CCTV camera

After rotation for takeoff at 05:25:55 UTC, the aircraft attained a height of 50 ft above ground level (AGL) within around 5 seconds. Based on the height computed from inertial data, the aircraft attained a height of slightly above 100 ft AGL by 05:26:03 UTC (marked 'G' in Figure 1). At 'G', the aircraft was at 94.6° roll angle with a heading of 24.7°, veering right of Runway 02.

1.1.2 Event Details

The overall sequence of events can be sub-divided into five segments.

Flight Preparation

The CVR recordings show the sequence of events leading up to the engine start sequence. The First Officer (F/O) was the first crew to enter the cockpit of the occurrence aircraft to prepare for flight. Saurya Airlines personnel including the store incharge and ground staff loaded the cargo section of the aircraft. The ground personnel described the situation of the cargo section as being *completely full*, after which the Saurya Airlines personnel preparing for the event flight also proceeded to load the baggage and equipment on the aircraft cabin.

From UTC 04:23 (time stamps based on CVR), around 1 hour before the event flight, the F/O was heard in the CVR recording performing pre-start checks. Between 04:40 and 04:55, the flight dispatcher provided tentative details of the aircraft weight and balance, which the F/O used for calculating V-speeds. The Pilot in Command (PIC) entered the cockpit at UTC 04:55, around 30 minutes before take-off. The PIC inquired with the F/O about the checks that had been performed and proceeded to provide further supervisory instructions. Until 05:15, the crew (including S/N crew) had conversations with other persons onboard about the C-check planned in Pokhara, about the destination airport, and other casual topics unrelated to the flight.

At 05:15, the crew was informed that more personnel were expected to arrive, and were instructed to wait. About a minute later, the PIC explained that they would need to cancel engine start-up if they didn't start taxi then. At around 05:16:20, the ATC inquired with the crew whether taxi for 9N-AME should be delayed, to which the crew requested that it may take 30 more minutes. However, shortly afterwards, at 05:17, the final personnel seem to have arrived and the cabin door was closed. The crew then went for both engine start-up. The left engine did not start on first try, due to *no fuel flow* as remarked by the crew. The engine then restarted normally on the next try.

The first data point on the FDR was observed at 05:13:21 where the aircraft was positioned on the domestic apron which is situated on the northern end of the airport (see marker 'A' in Figure 1).

Pre-Takeoff

The control surface check for the elevators and ailerons was performed during the taxi at approximately 05:20:21. The flaps were then raised to 20 degrees. The aircraft taxied the full length of taxiway Foxtrot reaching taxiway Echo at approximately 05:23:22. The aircraft entered the runway at 05:24:21 to perform a backtrack to the threshold of runway 02. At 05:25:01, the aircraft reached runway 02 threshold and made a radio call. At 05:25:25, the crew made a second radio call and applied power for takeoff with both engines N1 power achieving 92% within 13 seconds. At 05:25:35, the aircraft started accelerating with an airspeed of around 30 knots near marker 'D' in Figure 1. A complete checklist before take-off was not performed, including rudder check.

Rotation

At 05:25:55, the aircraft rotated near 120 knots computed airspeed. It attained a pitch up of 13 degrees within 4 seconds (15 degrees in 6 seconds) at a maximum calculated pitch rate of 8.6 degrees/second, and the aircraft rolled 26 degrees right at a maximum calculated roll rate of 15.5 degrees/second. The maximum pitch rate was obtained over a 0.25 s window, while sampling at 4 Hz. During this 3 second period, the aircraft reached 131 knots computed airspeed and 11 feet radio height (18 feet change in pressure altitude). At this time, the stick shaker activated on both sides for a duration of 4 seconds, which coincided with an unidentified GPWS audio message. The fuselage angle of attack recorded 6.9 degrees during the activation.

Take-off

During the subsequent 4 seconds from 05:26:01 to 05:26:05, the aircraft rolled left up to 55 degrees at a recorded roll rate of 36.6 degrees/second. The aircraft remained approximately 15 degrees nose up and groundspeed remained steady around 147 knots. The radio height increased to 77 feet (95 feet change in pressure altitude). The N1 engine power remained constant at 92%. The stick shaker deactivated for 1 second, followed by another activation for 2 seconds correlating with another GPWS audio message. The stick pusher was also activated on both sides during the second stick shaker activation, which was immediately followed by a pitch down and a GPWS Pull Up message.

At approximately 05:26:05, the aircraft rolled right reaching 94.6 degrees at the maximum capable recorded roll rate of 56.1 degrees/second. The aircraft pitched up to 19 degrees, followed by a reduction to 2 degrees pitch (recorded rate of -8.1 degrees/second) during the maximum roll angle.

During the entire take-off, the heading changed by 12 degrees. The vertical acceleration ranged from 0.40G to 1.69G and the lateral acceleration peaked at 1.54G during the maximum roll rate.

Impact into Terrain

The final recorded value of the radio height was at 63 feet during a roll of 30 degrees right with pitch ranging between -3 degrees and 1 degree. The speed was 142 computed airspeed with the fuselage angle of attack reaching between 8 and 12 degrees. The last recorded location is approximately 6100 feet from the threshold of runway 02, just prior to taxiway Juliet. The aircraft impacted the terrain East of the runway at 27°42'3'' North and 85°21'42'' East. The right wing made first impact on the ground. There onwards, the impact trail extended by around 1000 ft towards the east of the runway.

1.2 Injuries to Persons

A total of 19 people were on board the aircraft. The Pilot in Command (PIC) sustained serious injury while 18 other people lost their lives. Details on injuries to persons is shown in Table 2.

Table 2: Injuries to persons

Injuries	**Crew**	**Persons on Board**		**Total**
		Adult	**Child**	
Fatal	2*	15	1	18
Serious	1	-	-	1
Minor	-	-	-	-
None	-	-	-	-
Total	3	15	1	19

* *Including one Supernumerary (S/N) Crew*

1.3 Damage to Aircraft

The aircraft was destroyed due to high velocity impact, and post impact fire as seen in Figure 4. The aircraft also collided with the container and shed of Air Dynasty Heli Services Pvt. Ltd. The cockpit portion was stuck on the Air Dynasty container on the eastern side of the airport. Most of the fuselage structure and its components were damaged due to fire.

The impact of the right wing on the ground marked the start of the disintegration of the right wing and the subsequent accident.

1.4 Other Damage

The collision of 9N-AME with the container and shed of the Air Dynasty Heli Services Pvt. Ltd. led to damage of Air Dynasty properties. Mainly, a container of Air Dynasty was dragged from its initial installation site on the eastern side of the airport. It was partly destroyed during the impact and further taken apart during the rescue efforts from the 9N-AME cockpit. A shed at the Air Dynasty site was also damaged. The airport ground infrastructure along the aircraft's distraction track was also damaged during the impact of the right wing and subsequent fire. Images of this damage are shown in Figure 5.

Figure 4: Top: scene at the main wreckage site, bottom: burnt fuselage and empennage sections, and the detached left engine. Images were taken on July 24 and 25, 2024.

The components of the 9N-AME aircraft cockpit and other systems and avionics were scattered in the vicinity of the Air Dynasty container site. These areas had a mixed wreckage from the 9N-AME aircraft and components of an Air Dynasty helicopter. These components can also be seen in Figure 5.

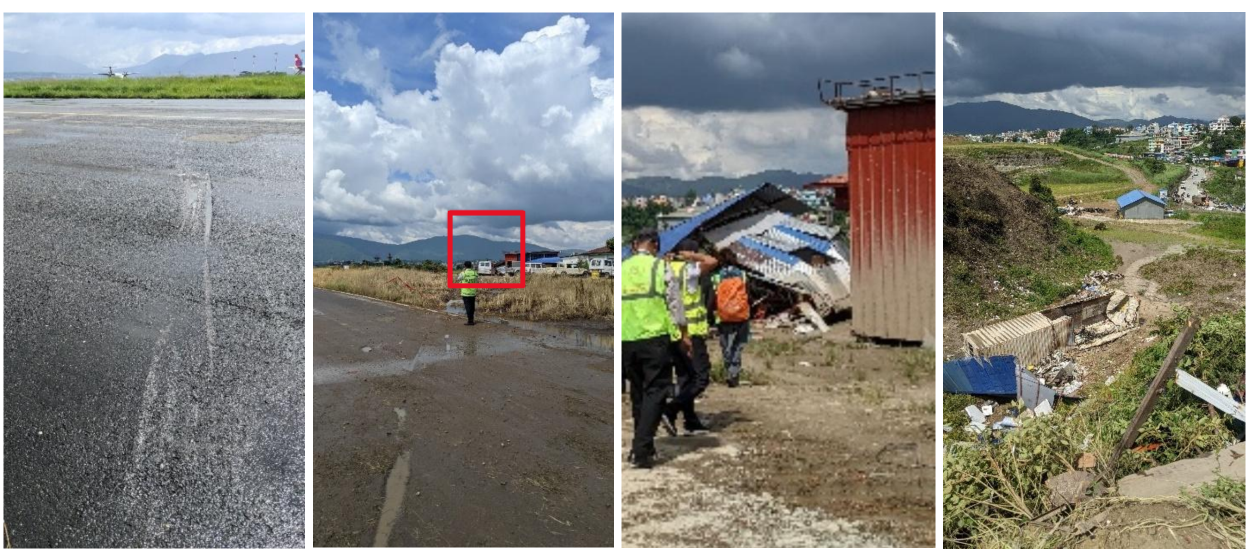


Figure 5: Accident site photos, taken on July 25, 2024, tracing the damage that occurred during the accident. [***Top-left:*** location of first impact by the right-wing east of runway-02 top-left; ***top-center-left:*** trail left by the right-wing as the aircraft plummeted towards the Air Dynasty shed area seen in the background; ***top-center-right:*** destroyed shed of Air Dynasty, beside the red container; ***top-right:*** crash site looking downhill of the location of the Air Dynasty shed area; ***bottom-left:*** Air dynasty container dragged down-hill by the aircraft upon impact; ***bottom-right:*** the container where the 9N-AME cockpit was stuck, showing the wreckage remaining after RFF team had taken apart the cockpit during rescue.]

The components in the mixed wreckage were found to be damaged during the accident; however, the assessment of third-party damage was not within the scope of this investigation.

1.5 Personnel Information

1.5.1 Pilot in Command

Table 3: Pilot in Command's profile

Date of Birth	February 17, 1989
Gender	Male
License type and Number	ATPL 324 (A)
Initial issue	August 2011, As Copilot, Beech 1900 D
Issuing authority	CAAN
License issued on CRJ –200	March 11, 2015
Date of PIC endorsement	July 31, 2017

Current Aircraft Rating	CL65 ** (CRJ-200)
Instructor Ratings	Nil
Current PPC	February 2024
Last PPC	August 2023
License validity date	July 31, 2028, unless otherwise other requirements fulfill
Medical certificate type	Class I
Medical validity	July 2025
Limitation/Restriction	Shall wear correcting lens and carry a spare set of spectacles while exercising the privilege of license. (+ 0.50 right eye and 0.75 left eye)
Total hours on type	4922:45
Total hours flown	6185:10
Flight hours in last 12 months	574:20 Hrs.
Flight hours in last 3 months	148:20
Flight hours in last 30 days	47:00
Flight hours in last 7 days	04:40
Previous rest period	5 nights and 4 days
Aviation language proficiency	Level 6
Limitation/restriction	Beech 1900 C type rating is no more valid
Marital status	Married
Previously reported accident/ incident	None
Enforcement (If Any)	None

** CL-65 is a type rating on pilot certificates for the MHI CRJ200, and covers the CRJ700, CRJ705 and CRJ900 models, but not the CRJ10001.

1.5.1.1 In-service training/courses:

Table 4: Pilot in Command's training status

Training	Current	Previous
Simulator Training	Feb 2024	August 2023
DG Training	June 2024	June 2022
Emergency Evacuation	March 2024	March 2023
Ground Recurrent on type	August 2023	July 2022
Route Check	March 2024	March 2023
Flight recurrent training:	February 2024	August 2023
CRM	June 2024	June 2023
SMS	June 2024	June 2023
Human Factors	June 2024	June 2023

1.5.1.2 Background of PIC

The PIC obtained his Commercial Pilot License (CPL) from Aviatour Flying School, located at Mactan International Airport in Cebu, Philippines, in 2009. Subsequently, he successfully passed the Nepal CPL(A) examination on December 25, 2009. According to records maintained by CAAN, his initial CPL endorsement was granted on a Beechcraft 1900D aircraft on August 10, 2011, followed by an endorsement as a co-pilot (P2) on a Beechcraft 1900C aircraft on July 28, 2012. He then commenced his career with Guna Airlines. During this tenure, he logged a total of 1,030 hours and 10 minutes on the Beechcraft 1900 before joining Saurya Airlines as a co-pilot in 2015.

Upon joining Saurya Airlines, he was selected for CRJ 200 type rating training at the CAE Aviation Academy in Madrid, Spain. His CPL endorsement for the CL-65 (CRJ 200) aircraft as a co-pilot was finalized on May 11, 2015. Furthermore, he passed the FAA Airline Transport Pilot License (ATPL) examination in February 2016 and the CAAN ATPL examination in December 2016.

Having met all eligibility criteria outlined in Flight Operations Requirements (FOR) Chapter 9, Clause 9.13(b), and the Company Operation Manual Part (A), Chapter 6, Clause 6.4(c) for P1 (PIC) upgrade training, Saurya Airlines upgraded his status from P2 to P1 on the CRJ 200. He completed ground training at the Baltic Aviation Academy in Vilnius, Lithuania, and simulator training for the P1 role at Lufthansa Aviation Training Operations GmbH in Germany. Following successful completion, his ATPL license as PIC was issued on July 31, 2017.

The PIC had also been working as the Operation Director of the company.

1.5.2 First Officer

Table 5: First officer's profile

Date of Birth	March 15, 1998
Gender	Male
License type and number	CPL 607
Initial issue	April 23, 2021
Issuing authority	CAAN
License issued on CRJ -200	April 23, 2021
Current aircraft rating	CL65 (CRJ-200)
Instructor ratings	Nil
Total hours on type	1602:40
Total hours flown	1824:16
Total IFR hours	277:15
Current PPC on	March 10, 2024
Last PPC on	March 03, 2024
License validity date	November 30, 2025
Medical certificate type	Class I
Medical validity	November 2024
Flight hours in last 12 months	435:45
Flight hours in last 3 months	140:40
Flight hours in last 30 days	65:30
Flight hours in last 7 days	13:00
Previous rest period	1 Night and 1 day

Aviation language proficiency	Level 4 (operational)
Instrument rating	April 23, 2021
Limitation/restriction	None
Marital status	Single (not married)
Previously reported accident/incident	None
Enforcement (If Any):	None

1.5.2.1 In-service training/courses:

Table 6: First Officer's training status

Training	Current	Previous
Simulator training	March 2024	October 2023
DG training	June 2024	June 2022
Emergency evacuation	March 2024	March 2023
Ground recurrent on type	August 2023	July 2022
Route check	March 2024	March 2023
Flight recurrent training:	February 2024	February 2023
CRM	June 2024	June 2023
SMS	June 2024	June 2023
Human Factors	June 2024	June 2023

1.5.2.2 Background of F/O

The F/O of the event aircraft obtained his CPL from Flight Training Services at Grand Central Airport, Midrand, South Africa, in 2019. He subsequently passed the Nepal CPL(A) examination on December 2, 2019. His initial ground training for the CRJ 200 type rating was conducted at the Baltic Aviation Academy (BAA) in Vilnius, Lithuania. Following this, he attended simulator training at Lufthansa Aviation Training Operations GmbH in Germany. However, he was unable to pass the simulator test on his first attempt and was advised to undergo additional theoretical sessions before retaking the test.

According to CAAN records, the F/O's initial issue of CPL(A), with license number 607, was granted on April 21, 2021, for the CRJ 200. He subsequently joined Saurya Airlines as his first employer. At the time of the accident, his total flight time was recorded at 1,602 hours and 40 minutes. Additionally, the F/O experienced a period of layoff with the airline but was later reinstated based on flight hours. Due to the company's low flight activity, his duty and flight hours were significantly reduced, leading to lower compensation.

1.5.3. S/N Crew

Table 7: S/N Crew's profile

Date of Birth	June 21, 1990
Gender	Male
Basic License Exam Passed on	November 24, 2020
Initial Type Training on CRJ 200	November 10, 2017
AMT License Number	CAAN.66.351
Initial Issue Date	November 07, 2019
Issuing Authority	CAAN
License Endorsed on CRJ -200	November 24, 2020
Current Aircraft Rating/Type	B.1/ Bombardier CL-600-2B19 (GE CF34)
Certificate of Authorization Issued on	January 19, 2021
Medical Certificate Type	Not Required
Medical validity	Not Required
Previous rest period	N/A
Limitation/ Restriction	None
Marital Status	Married

1.6 Aircraft Information

Table 8 summarizes the aircraft information.

Table 8: Aircraft information

Aircraft Type	CRJ 200LR
Aircraft Type Certificate	A276/Issue No. 4
Manufacturer	Bombardier Inc (Now owned by MHI RJ Aviation ULC)
Date of Manufacture	March 2003

Manufacturer's Designation of aircraft	CL-600-2B19 (CRJ 200LR)
TTSN	28893:29
TCSN	29788
Certificate of Release to Service	November 24, 2023 (28520:20)
ARC	April 17, 2025
Registration	9N-AME
MSN	7772
Engine Make/Model	GE Aerospace / CF34-3B1
Engine (LH) hours/cycles	9896:29/8656
Engine (RH) hours/cycles	9119:59/7152
LH/RH Engine Serial Number	872111/872134
Certificate of Airworthiness	Valid till April 17, 2026
Certificate of Registration	Issued on April 9, 2017
Mobile Radio Station License	Valid till April 17, 2026
Type of Fuel Used	JET A-1
Maximum Takeoff Weight (MTOW)	24,040 kg

1.6.1 Aircraft History

The aircraft was manufactured in March 2003 with serial number 7772. The aircraft was first registered as N695BR with Atlantic Coast Airlines in May 2003. Before being procured by Saurya Airlines, the aircraft was still registered as N695BR under the ownership of Bank of Utah. The aircraft was delivered to Saurya Airlines in March 2017, and was subsequently registered as 9N-AME in Nepal.

1.6.2 ADs/SBs Status

All applicable Airworthiness Directives (AD) had been complied with and the repetitive inspections required as per the applicable AD were being carried out at the interval specified in the respective AD. All applicable Mandatory Service Bulletin had been complied with. Up on the review of Continuing Airworthiness Records, no dues were found for accomplishment of applicable Airworthiness Directives and Mandatory Service Bulletin.

1.6.3 Equipment Detail

Following flight and navigation equipment was installed on the aircraft.

Table 9: Equipment detail

S/N	Mandatory Equipment	Make	Model	Part Number	Serial number
1.	HF	N/A	N/A	N/A	N/A
2.	VHF	Rockwell Collins	VHF 422A	622-7292-101	10XMX 4103
3.	Encoding Altimeter	Rockwell Collins	ADC-850A	822-0372-415	1KPRF 3245
4.	Magnetic Compass	Precision Aviation	PA1700	PA1700-WT52LB	73870
5.	ADF	Rockwell Collins	ADF-462	622-7382	130LT 13OLK
6.	Marker Beacon	N/A	N/A	N/A	N/A
7.	RMI(AHRS)	Rockwell Collins	AHC-85E	622-9336-400	51WC 1L81C
8.	HIS(ISI)	Thales Avionics	501-1557-10	-	-
9.	VSI	-	-	-	-
10.	Weather Radar	Rockwell Collins	RTA-844	622-9302-004	13CWB
11.	GPS	Rockwell Collins	GPS-4000	822-0931-003	23CB
12	ELT	ARTEX	2406-2	453-5000	15551
13.	ATC Transponder	Rockwell Collins	TDR-94D	622-9210-004	133WK 137WJ
14.	ADS-B	-	-	-	-
15.	EGPWS	Honeywell	MK V	965-0976-003-212-212	4046
16.	FDR	L-3 Communication	FA2100	2100-4043-00	563140

17	TCAS	Rockwell Collins	TTR920	622-8971-022	5900
18	CVR	L-3 Communication	FA2100CVR	2100-1020-00	051792
19.	VOR	Rockwell Collins	VIR-432	622-7194-201	1354D
					1354F
20.	DME	Rockwell Collins	DME-442	622-7309-101	13CVW
					2068
21	FMS	Rockwell Collins	FMC4200	822-0783-011	1G5F
22.	EFIS	Rockwell Collins	EFD-4076	622-9810-016	2614
					137HY
23.	Tracking Device	-	-	-	-
24.	SATCOM	-	-	-	-

1.6.4 Review of Maintenance Documents

Review of the maintenance records of the aircraft revealed the following information:

1. Survey inspection for renewal of Certificate of Airworthiness (C of A) and Airworthiness Review Certificate (ARC) was carried out on March 13, 2024, with MLG TBO due on April 17, 2024.

2. The aircraft received an extension for both MLG TBO on April 20, 2024, valid until June 19, 2024.

3. On April 26, 2024, the flight release certificate was issued based on CAAN permit to fly number 9N-AME/01/2024. On the same day, a test flight was conducted after receiving a permit to fly for renewal of expired C of A.

4. After the expiry of the extension, the aircraft was grounded and sent for short-term storage.

5. Initial preparation for short term storage was performed on June 21, 2024.

   i. Short term storage for 7 days was carried out on June 28, 2024.
   ii. Short term storage for 14 days was carried out on July 05, 2024.
   iii. Short term storage for 21 days was carried out on July 12, 2024.
   iv. Short term storage for 28 days was carried out on July 19, 2024.

v. Removal and installation of the left and right main landing gear dressed assembly were carried out due restoration on July 22, 2024.

6. Return to service check was carried out on July 24, 2024, in the morning of the day of the event flight.

After review of available maintenance records, no significant discrepancy was found on the maintenance of 9N-AME.

1.6.5 Examination of Systems

According to CVR and FDR information, no malfunctions of aircraft systems were recorded.

1.6.6 Examination of Engines Performance

According to CVR and FDR information, the following sequence of events/data relevant to the engine performance was obtained:

- The right engine started at 05:14:49 reaching 27% N1 within 55 seconds.
- The left engine started at 05:17:17 however, the N1 engine power only achieved 6% before reducing back to 0%. The left engine was immediately restarted and was able to reach 26% N1. The entire process to perform left engine ignition took 1 minute and 57 seconds from the initial start.
- The vibration levels of each engine averaged around 0.20 mils with brief increases up to 0.63 mils in the left engine during turns in taxi. At 05:25:25 the crew applied takeoff power and within 13 seconds the N1 achieved 92% on both engines.
- After rotation, N1 engine power remained constant at 92%. However, there was an observed peak in the left engine N1 vibration of 1.0 mils followed 3 seconds later by a peak of 1.2 mils in the right engine N1 vibration. No malfunctions were recorded in either of the engines during the aircraft movement on the ground and during the subsequent events upon rotation for takeoff.

1.6.7 Weight and Balance Information

The last aircraft weighing was carried out on August 17, 2021, as certified in the aircraft weighing report in Appendix 1. The weighing results are provided in Table 10.

Table 10: Aircraft empty weight detail

Aircraft Basic Empty Weight	13981.5 kg
Aircraft CG (X-Arm)	13.46 m
Aircraft CG (%MAC)	36.38

Empty weight is the total weight of an aircraft excluding the crew, payload (including passengers and baggage), usable fuel and drainable oil.

Upon review of the Load and Trim Sheet of the event flight submitted by Saurya Airlines, the following data were noted. The sheet is provided in Appendix 2.

Table 11: Load and Trim Sheet information

Weight parameters	Weight (kg)	Remarks
Dry Operating weight	14,407	
Operating weight	16,257	
Passenger weight	1,280	Calculated as per CAAN Flight Operations Directive-08 Ammendment#2, Issued by CAAN on November 26, 2015
Zero fuel weight	16,287	
Take-off fuel	1,850	
Take-off weight	18,137**	As stated in the load and trim sheet of the event flight.

*** The weight of 18,137 kg listed in the load sheet included a ballpark estimate of baggage weight of 600 kg. The discussion between crew, maintenance, and ground personnel, regarding the ballpark estimate was heard in the CVR recording.*

*** This value is listed with minor correction from the 18,132 kg weight stated in Section 1.6.2 of the preliminary report.*

The number of persons on board was 16, with 3 crew members (1 as an S/N crew). Non-airline personnel and non-required crew were present onboard. As per the Load and Trim Sheet, the fuel on board was 2000 kg. The location of the center of gravity at TOW was at 20% MAC, and the stabilizer trim setting was at 6 as per cockpit setting and indication (corresponding to a value of -4.6 as per Aircraft Maintenance Manual).

The baggage weight was measured at the crash site by the Commission, in the presence of Saurya Airlines and TIA security personnel. The weight including bags, tools, equipment, manuals, and other cargo materials recovered and measured in situ at the crash site was 402.5 kg.

The baggage loaded onboard the aircraft was not limited to the cargo section. Interviews with Saurya Airlines personnel, rescue personnel, as well as the on-site investigations conducted by the Commission revealed that a large amount of baggage was distributed throughout the cabin (henceforth meaning the passenger cabin). This included, but not limited to, flammable items such as lubricants and contact cleaners, wheel chocks, toolboxes, and food items, which were haphazardly placed on seats and isles without any securing measures. The PIC and flight dispatcher stated that they were aware of the items being placed in the cabin but did not raise any concern.

Numerous passenger baggage was also found at Saurya Airlines corporate office, which totaled 98.6 kg. It is noted here that the transport of the passengers' baggage from the crash site to Saurya Airlines corporate office, at Sinamangal, Kathmandu, on the day of the crash, is a severe case failure of all entities involved during the rescue and recovery efforts on the event day. Not only were the baggage removed without due process from the crash site, but they were also carried away and managed to pass out of the security screenings of the airport, ultimately making their way to the Saurya Airlines corporate office. Baggage items recovered by the Commission, and those found at the Saurya Airlines office are shown in Appendix 7.

1.6.8 Maintenance Management

Saurya Airlines is an NCAR Part M, Subpart G approved organization (CAAN.M.017) holding CAAN Air Operators Certificate No. 083/2014. Its aircraft are maintained by its own NCAR Part 145 AMO under the approval on CAAN.145.013. The other maintenance support is outsourced to appropriately approved Maintenance organizations in accordance with the procedures described in the Continuing Airworthiness Management Exposition.

The CAMO and AMO of Saurya Airlines is structured under the management of the same Accountable Manager and Quality Manager. Similarly, the CAMO and AMO are also under one Safety Manager.

1.7 Meteorological Information

Between 05:00 UTC and 05:30 UTC, the weather was fair with 8 km visibility and the wind was calm. The reported METAR of VNKT were as follows:

- 240500Z 00000KT 8000 FEW010 SCT030 BKN100 26/22 Q1006 NOSIG=
- 240530Z 29003KT 8000 FEW010 SCT030 BKN100 26/22 Q1006 NOSIG=

The METAR data indicates that the wind at 05:00 UTC was 0 knots, while at 05:30 UTC it was 3 knots from westerly direction. There were a few clouds at 1,000 feet AGL, scattered clouds at 3,000 feet AGL, followed by another cloud layer at 10,000 feet AGL. Outside air temperature was 26 °C and QNH pressure was 100.6 kPa. No significant weather was reported.

1.8 Aids to Navigation

Tribhuvan International Airport is equipped with navigation aids like VOR/DME, NDB and surveillance aid like RADAR. The KTM VOR is located at 27°40'25''N, 085°20'55''E at an elevation of 1330 m. The operating frequency of the KTM VOR is 113.2 MHz and Kathmandu NDB, VOR/DME and RADAR are certified for operation.

There are two approaches available at Kathmandu airport; VHF omnidirectional range along with distance measuring equipment (VOR/DME) and Required Area Navigation (RNAV/RNP). The RNP AR approaches were designed for runways 02/20, to enhance the overall safety of aircraft operations.

1.9 Communications

Fully equipped, ATS communication facilities are available at VNKT. All the communication recordings were collected and analyzed by the commission as necessary. The communication equipment at Kathmandu tower were operating normal at the time of accident.

Table 12: VNKT communication systems

Service	**Call sign**	**Frequency**
TWR	Kathmandu Tower	118.1 MHZ
SMC	Kathmandu Ground	121.9 MHZ
APP	Kathmandu Approach	120.6MHZ /125.1 MHZ
ACC	Kathmandu Control	126.5 MHZ/124.7 MHZ
TIS	Kathmandu Terminal	127.0 MHZ

1.10 Aerodrome Information

Table 13 provides the details on aerodrome information.

Table 13: Aerodrome information

Item	**Information**				
Name	Tribhuvan International Airport				
Location	Kathmandu				
Aerodrome Location Indicator	VNKT (ICAO), KTM (IATA)				
Aerodrome Elevation	Elevation 1339.5 m (4395ft) AMSL				
Aerodrome Reference Temperature	29.81°C				
Runway Designation	02/20				
Runway Dimension	3074 m x 45 m				
Runway Strip Dimension	3194 m x 280 m				
Declared Distances	**RWY**	**TORA**	**TODA**	**ASDA**	**LDA**
	02	3074	3374	3074	2774
	20	3074	3374	3074	3074

Clearway Dimension	300 m x 150 m 300 m x 150 m
RESA Dimension	240 x 90 at both end of RWY
Stop way Dimension	Nil
Slope of Runway	0.807% (average)
Runway Surface and Strength	Asphalt 76 F/C/W/T
AD Category for fire fighting	Category 9
RWY and TWY markings and LGT	RWY: RWY 02/20, THR, TDZ, Centerline, RWY Edge marked and RWY end THR, RWY Centerline, RWY Edge have lights. TWY: Centerline, holding positions at all TWY/RWY intersections marked and edge with blue lights.
Approach Lights	High intensity Cat-I Precision LED Approach Light System at RWY 02
RWY Light System	High intensity bi-directional white-yellow, Red Yellow LED elevated edge lights of variable brilliance and High intensity bi-directional white-red LED inset centerline lights of variable brilliance
PAPI	RWY 20 / 02: High Intensity of variable brilliance (Angle 3.000)
Runway Markings	RWY 02/20, Threshold (THR), Touchdown Zone (TDZ), Centerline, RWY Edge marked and RWY End, Threshold, RWY edge lights
Taxiway Markings	Centre line, holding positions at all TWY/RWY intersections marked and TWY edge with blue lights

During the accident site visit, the commission carried out a visit of airside at VNKT airport to assess the runway and taxiway strip (safety area), airport emergency plan and status of compliances on airport physical conditions. The following observations were made regarding the current situation of airport physical conditions:

- The existing perimeter road at many locations are not at sufficient clearance distance from the centerline of the runway as per ICAO Annex-14 SARPs.
- There are low-lying areas at the east side (north to south throughout the runway length) including the accident location of the Saurya Airlines aircraft (see Figure 1) and at the west side of the runway (towards south from taxiway-E) which do not comply with the ICAO Annex-14 SARPs for Runway Strips. These areas are also not easily accessible during emergency conditions.

As per ICAO Annex-14, Paragraph 3.4.3 (and 3.4.4), the width of runway strips for a precision approach runway shall, wherever practicable, extend laterally to a distance of at least 140 m on each side of the centerline of the runway and its extended centerline throughout the length of the strip where the code number is 3 or 4.

Annex-14, Volume-1, Chapter 3, 3.4.8, recommends that the portion of a strip of an instrument runway within at least 75 m from the centre line should be graded where the code number is 3 or 4. For a precision approach runway, it may be desirable to adopt a greater width where the code number is 3 or 4. Figure 6 shows the shape and dimensions of a wider strip that may be considered for such a runway. This strip has been designed using information on aircraft running off runways. The portion to be graded extends to a distance of 105 m from the centreline, except that the distance is gradually reduced to 75 m from the centreline at both ends of the strip for a length of 150 m from the runway end.

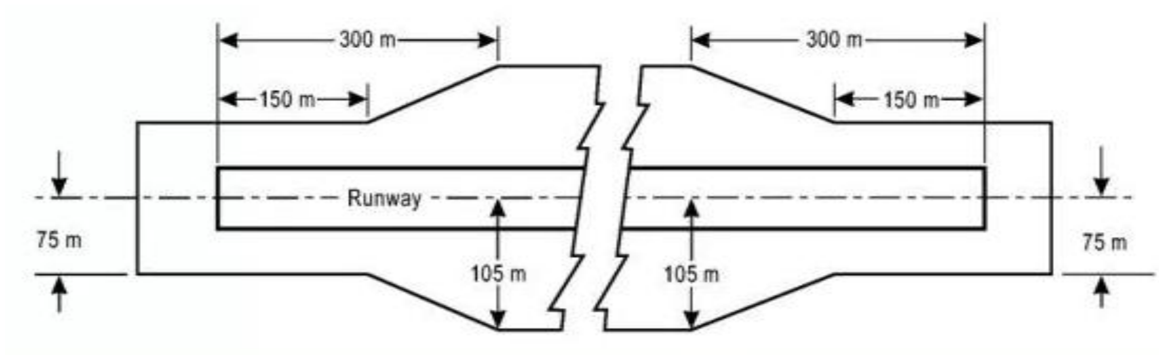


Figure 6: Graded portion of a strip including a precision approach runway where the code number is 3 or 4. [Source: ATCEP, CAAN]

In the AIP Nepal published by CAAN on November 3, 2022 (AMDT 08/2022), the runway strip is mentioned to be 280 m, which is as per the ICAO Annex 14 Volume-1 standard. However, at the site the runway strip the width was observed be only around 150 m, which is not sufficient.

1.11 Flight Recorder

The aircraft was fitted with FDR and CVR. The extraction and recoveries of data from both recorders were performed in the facilities of the Transport Safety Investigation Bureau (TSIB), Singapore, under the supervision of AAIC. Accredited representatives from Transportation Safety Board of Canada (TSB) and National Transportation Safety Board (NTSB), USA, were present to witness the data recovery FDR and CVR and participated in preliminary analysis of the data. Advisors of accredited representatives from Federal Aviation Administration (FAA), USA and GE Aerospace also participated in the briefings. The details of both recorders are presented in Table 14. In addition, Figure 7 depicts the condition of recorders.

Table 14: FDR and CVR Information

SN	Recorder	Model	Part No.	Serial Number
1	Flight Data Recorder (FDR)	FA2100	2100-4043-00	000563140

2	Cockpit Voice Recorder (CVR)	FA2100	2100-1020-00	000651792

Figure 7: Condition of recorders as received by AAIC (left), and after being transported to TSIB, Singapore (right)

1.12 Wreckage and Impact Information

The wreckage of the aircraft was spread over an area covering the length from the vicinity of the runway 02 and the eastern fence of TIA.

The sequence of the crash marking the wreckage distribution is shown in Figure 8. The right wing first impacted on the ground at ‘1’ (at around 05:26:10 UTC), marking the start of the disintegration of the right wing and the subsequent crash. In addition, the following markers represent the location of the wreckage components:

- The fuselage of the aircraft lay in two distinct parts, at ‘4’ (cockpit) and ‘5’.
- The left wing was attached to the fuselage at ‘5’.
- The right engine was attached to the fuselage at ‘5’.
- The left engine was found detached at ‘2’.

At the main wreckage location, marked ‘5’, the left wing and empennage lay seemingly attached to the fuselage. The portion above the cabin floor was completely burnt-off due to fire. The cargo compartment was destroyed and the baggage in the compartment had largely fallen off to the left of the aircraft. The fuselage of the aircraft rested on a slightly right bank position, with the elevator deflected up and rudder deflected left.

The layout of the wreckage distribution as identified on site visit is depicted in Figure 9. It is to be noted that some parts of the wreckage may have been moved during the rescue operations.

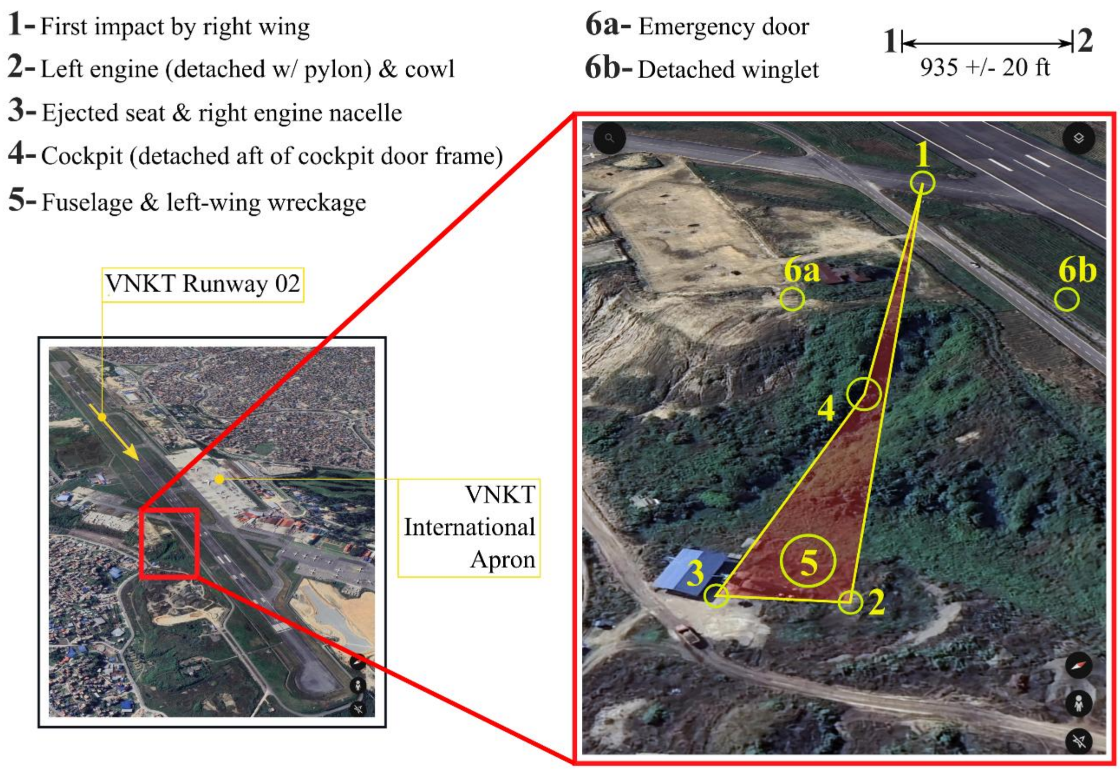


Figure 8: Site corners showing the initial impact and distribution of the crashed aircraft

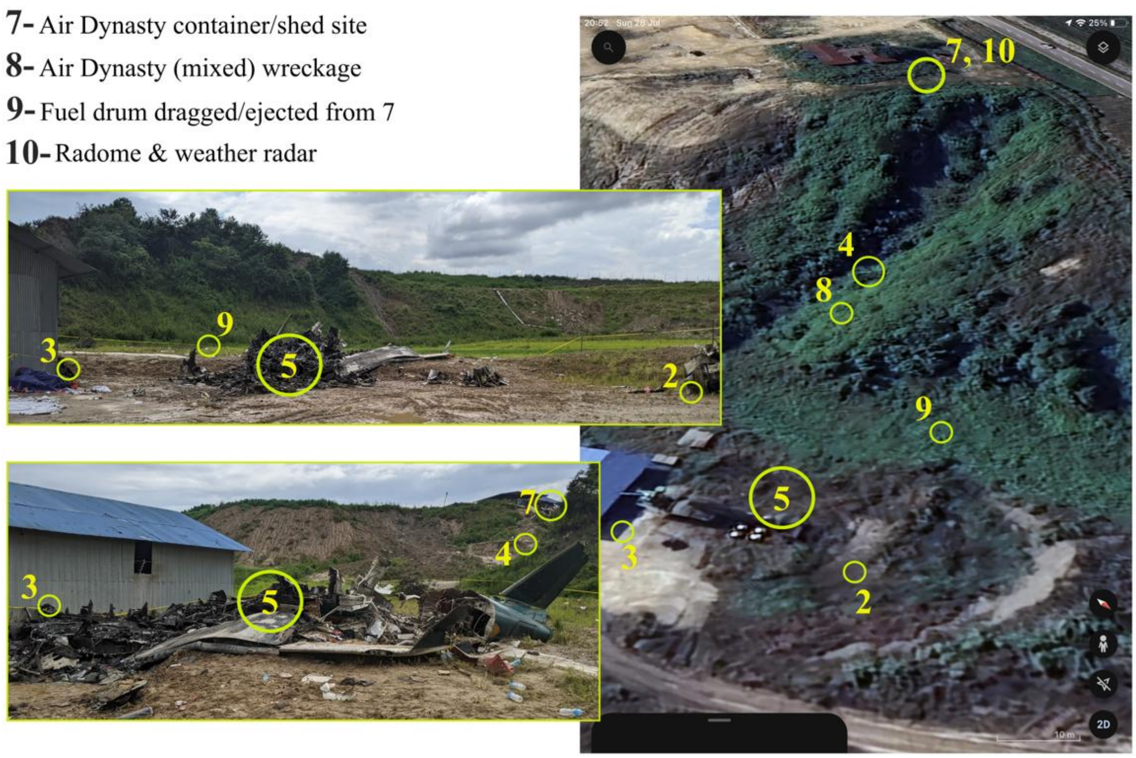


Figure 9: Overall distribution of the wreckage (see Figure 8 for markers ‘1’ to ‘5’)

The left engine detached from the empennage when the aircraft impacted at ‘5’ and lay at ‘2’. The engine had ingested rubble, and the fan blades showed damage from impact with pebbles and other materials in the rubble. The left engine had broken off at the root of the pylon. The right engine could not be distinctly spotted among the wreckage. However, parts of nacelle and inlet cowl were located at ‘3’, ‘8’ and on the right of the empennage at ‘5’.

Notably, flammable fluids and other dangerous goods were also found among the wreckage. These included lubricants, hydraulic fluid, engine oil, contact cleaner, etc. Figure 10 shows the items found at the wreckage site. The LPS contact cleaner was identified as a dangerous good (UN1950; hazard class: 2.1; aerosols; flammable).

Figure 10: Hydraulic fluid and some flammable items found at the wreckage site

Figure 11: Wreckage site at marker ‘5’, with recovered containers of fluidic items

Saurya Airlines did not have a dangerous good permit and was not authorized to carry dangerous goods onboard. Given the nature of haphazard loading of the aircraft, the possibility that the items were not present in the cabin during the event flight cannot be ruled out. The Commission recovered many of such items' containers from the cabin section of the wreckage. It should be noted, however, that these items may have been either ejected or moved during the rescue operations. The Commission also spotted hydraulic fluid spread on the floor of the burnt-down cabin of the aircraft at the wreckage site. Figure 11 shows the wreckage at marker '5' and some of the fluid containers recovered from the cabin and cargo section.

A particular scenario observed at the wreckage at '5' was the nature of destruction of the entire front fuselage section. Aft until the empennage, the fuselage was burnt down to the cabin floor, as shown in Figure 12. Few parts from the fuselage outer structure were found at the wreckage site, for e.g., the skin panel seen near the center upper-half of Figure 11. This indicates the possibility of several simultaneous factors:

1. The front part of the cabin was fully exposed to fire entrainment, particularly originating from the fuel spilled from the port-side tanks. This would have led to difficulty in reaching the persons onboard in the cabin from the front of the aircraft during rescue efforts.
2. The fuel spilled from the left wing contributed mainly to the fire in the cabin. The wreckage was banked in a position that allowed the spilled fuel to flow directly towards the cabin.
3. The RFF effort was not swift enough to control the fire from engulfing the cabin wreckage at '5'. While some of the fuselage structure was taken apart during the rescue efforts, the wreckage shows fire damage of an extensive nature, indicating that the fire in the cabin had been burning long enough to cause the extensive damage seen in Figure 12.
4. The presence of flammable items onboard exacerbated the fire situation in the cabin.

Figure 12: Fuselage wreckage at marker '5' as seen from the front of the cabin

1.13 Medical and Pathological Information

1.13.1 Medical Information

A. The Pilot in Command (PIC)

The PIC's latest medical examinations took place on July 2, 2024, and submitted to CAAN on July 4, 2024. It was found satisfactory according to CAAN's approved Civil Aviation Medical Requirements. The PIC's medical report is provided in Appendix 3.

As per the medical record, the following information was found:

- The PIC was found medically fit for flight.
- The only relevant medical finding is that the PIC shall wear correcting lens and carry a spare set of spectacles while exercising the privilege of license.
- Hearing was normal.
- No health defect existed prior to or to the time of the accident.
- Previous medical history and findings of examinations, as well as interviews with family members and acquaintances, give no indications of abuse of alcohol, medicines or drugs.

B. The Co-Pilot (F/O)

The F/O was medically found fit for flight. The F/O's medical report is provided in Appendix 4.

- No significant health defects existed prior to or to the time of the accident.
- Hearing was normal.
- Previous medical history and findings of examinations, as well as interviews with acquaintances, give no indications of abuse of alcohol, medicines or drugs.

1.13.2 Pathological (Forensic) Report

The pathological (forensic) report was prepared by Nepal Police Forensic Laboratory. As a result of the very high energy impact, all occupants of the aircraft suffered serious injuries to vital organs. The primary cause of the death as reported by the forensic reports was due to multiple blunt force trauma at chest and head of the persons on board. As the cabin of the aircraft was fully burnt down to the cabin floor, the persons on board the cabin also suffered from burn trauma. The deceased crew stuck in the cockpit detached at marker '4' also suffered from burn trauma.

The result of pathological examination showed negative test for common pesticides, common narcotic drugs, and common phosphine for the crew. The report is provided in Appendix 5.

1.14 Fire

After the ground impact of the right wing at marker ‘1’, the fuel in the right-wing tank ignited that created a trail of fire from ‘1’ through markers ‘4’ and ‘5’. Fire also erupted, from fuel in the left-wing tank, after impact at ‘5’. Fuselage of the aircraft at ‘5’ was largely destroyed by fire, as seen in Figure 12.

Tribhuvan International Airport maintains Category IX- Firefighting services. Four fire vehicles including one medium foam tender, a large foam tender, and two ambulances carrying rescue tool kit were deployed for rescue operation. The capacity of each fire vehicle was 12,500 liters of water and 500 liters of foam which can discharge 9000 lit/min with all outlets. No roof turret and sideline were found to have been used for wreckage distribution area ‘4’, where cockpit portion had detached.

As per analysis of the available CCTV footage, the fire broke immediately after the impact of the right wing on the ground at ‘1’, following which one medium foam tender and a large foam tender were dispatched. It was observed that large foam tenders, medium foam tenders and water tankers were not used effectively and in coordination, as explained further in the following section.

1.15 Survival Aspect

The aircraft sank approximately 130 feet in 4 seconds. As a result of the blunt impact and disintegration of the aircraft, the most common cause of the death of persons onboard was blunt force trauma, followed by burn injury.

One fire vehicle arrived near marker ‘7’ at 1 minute 40 seconds after impact and first started spraying water over marker ‘4’ after 15 seconds of arrival. The fire vehicle intermittently sprayed water over markers ‘4’ and ‘5’. While two other fire vehicles also arrived near the crash site, they did not participate in the firefighting efforts simultaneously with the first vehicle. In the meantime, the PIC escaping from ‘4’ was rescued by personnel on the ground before fire broke out in the cockpit. Therefore, a timely firefighting effort was not apparent, or readiness displayed, to tackle the impending fate of the crew stuck in the cockpit.

The lack of a well-planned runway strip also contributed to the confusion related to accessibility of the RFF crew. As explained in Section 1.10, a runway strip (safety area) enhances the safety of aircraft that undershoot, overrun, or veer off the runway, and it provides greater accessibility for firefighting and rescue equipment during such incidents. If the runway strip existed at TIA in accordance with ICAO Annex-14, Volume-1 SARPs, the 9N-AME aircraft’s crash would have occurred within the safety area, leading to more effective rescue and firefighting efforts.

The survival of the PIC shows that the accident was survivable, at least, for the crew stuck in the cockpit had the rescue efforts were properly coordinated or well prepared.

1.15.1 Rescue Operation

Tribhuvan International Airport frequently conducts aerodrome emergency mock drills to assess the readiness levels of airport rescue and firefighting staff. The team coordinates national emergency response planning through dedicated contingency units that can be activated to support search and rescue efforts in potential aviation accident scenarios. A review of the latest emergency exercise report and discussions with the Airport Firefighting Officer and Chief of Division revealed that there was no specific discussion on critical areas.

The rescue and firefighting service at VNKT is provided as a Category-IX service, complete with necessary ancillaries and equipment. The Fire Watch Tower's watchman observed the crash of the occurrence aircraft, activated the crash siren, and announced the incident via Public Address (PA) system. The first responding vehicle arrived at the crash site within 1 minute 40 seconds, meeting the response time outlined in the Airport Rescue Fire Fighting Service Manual.

The location of the crash site falls in a rugged area with difficult terrain, making it challenging for the first responder fire vehicle to access the fuselage and cockpit. The Task Resource Analysis (TRA) for equipment and manpower in the ICAO Service Manual 9137 - Part 1 and the Airport Services Manual was not followed, impacting the ARFF Service during the accident.

Out of the 19 occupants on board, the PIC was successfully rescued, while 18 others lost their lives. The impact forces of the accident seemed survivable for some occupants. The cockpit personnel, including the S/N crew, had the highest chance of survival provided the rescue operation was systematic, well-coordinated and proactively planned such scenarios. The crash site area was not discussed in full-scale emergency exercises or tabletop exercises. The inappropriate use of fire vehicles and failure to utilize equipment such as sidelining, foam tendering, and dry chemical agents led to inadequate rescue and firefighting efforts.

One of the emergency access gates closest to the crash site was found closed and obstructed by construction materials and debris. No Safety Risk Analysis or Management of Change process was completed for this area, contributing to deficiencies in the rescue operation. The blocked-off emergency gate can be seen in Figure 13, and among the site images provided in Appendix 7.

No Task Resource Analysis was conducted for equipment and manpower resources as per ICAO Service Manual 9137 - Part 1 and the TIA Airport Services Manual to provide a Category-IX airport firefighting service. It was noted that there is a lack of training in the Safety Management System within the Airport Rescue and Fire Fighting unit of TIA. In particular, blind regions were found in the coverage of the airport area. The assessment of the crash site by the Commission revealed that, despite being within the airport premises, the crash site was difficult to access on foot and via ground vehicle. These details are shown in Figure 13.

Figure 13: Blind region in the area of interest that hindered effective rescue and firefighting efforts. The markers 5, 7 and 10 are as listed in Figure 9. The blocked access marked near 5 is shown on the right.

1.15.2 Use of Seat Belt

As per the post-mortem report, the most common cause of death was attributed to blunt force injuries. Since no flight attendants were onboard and as the crew did not ensure any cabin safety measures or make cabin safety announcements, the use of seat belts could not be ascertained. The lack of coordination during rescue efforts also meant that information on the use of seat belts was not received in the ARFF report.

1.15.3 Autopsy Report

The result of pathological examination showed negative test for common pesticides, common narcotic drugs, and common phosphine for both flight crew. The autopsy report for the F/O is provided in Appendix 6.

1.16 Tests and Research

1.16.1 Retrieval of Flight Data

The commission relied on raw flight data retrieved from TSIB facilities to run an independent analysis of the flight parameters. The data was used to compute vital aspects such as flight profile, aircraft weight and balance information, aircraft dynamics and performance, among others.

In addition to the retrieval of flight data from FDR of the event flight, the commission also retrieved historical data from the aircraft in Saurya Airlines fleet, namely, tail numbers 9N-AME and 9N-ANM. The retrieved data dated back to the start of 2023 to the date of the event flight. The raw historical data was analyzed, and was used for:

- Estimation of aircraft weight and balance conditions
- Analysis of cockpit crew performance and practices
- Analysis of the aircraft response
- Review of issues regarding unrecorded flight data
- Identifying past incidents that could have been flagged to mitigate future incidents/accidents
- Validation of weight estimation
- Analysis of pilot-flyings' inputs
- Analysis of actual rotation speed versus rotation speed required, based on the stated weight of the aircraft
- Review of values of flight angles during normal as well as abnormal rotations for take-off

Typical flight parameters of two different flights, from February 20, 2024, are shown in Figure 14. The data presented in the figure was plotted in the same sequence as they were retrieved in the FDR, without clipping the time on the ground. The data presented is among the volume of historical flight data from the Saurya Airlines fleet that was analyzed as part of this investigation.

The rotation rates (pitch rates) in the cases presented in Figure 14 are within a nominal range of 3 degrees-per-second. The required elevator deflection for rotation ranged approximately between 6° to 10°, and the angle of attack increases approximately by up to 8°. As shown, during a typical take-off, the share of flight path angle gradually increases in the value of pitch angle, as the angle of attack should be limited within a safe range below stall margin. As the aircraft begins the climb, the pitch angle is increased to a target pitch angle, and the take-off sequence is completed. These sequences can also be interpreted from the data presented in Figure 14.

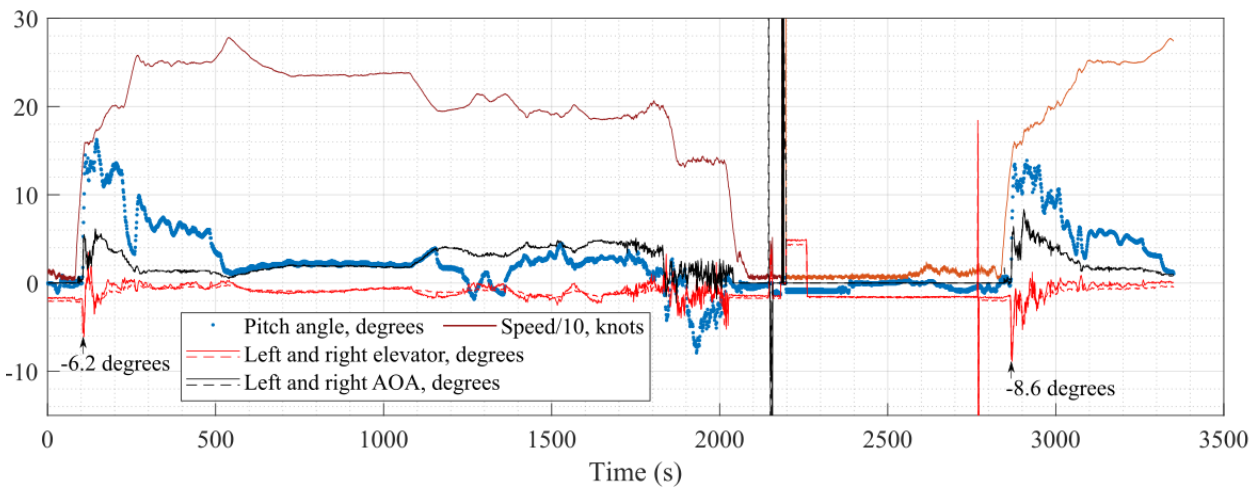


Figure 14: Flight parameters of typical flights (first flight from 0 s to ~2100 s and second flight from ~2800 s onwards), showing nominal elevator commands required and angle of attack and pitch angle responses during take-off and climb.

1.16.2 Simulation at IOE Pulchowk Campus Simulator

An X-Plane based flight simulator was used at the flight simulator facility at the Tribhuvan University, Institute of Engineering Pulchowk Campus's Department of Mechanical and Aerospace Engineering to aid in the verification of some of the methods adopted during the flight data analysis and in understanding the general flight characteristics and handling quality of a CRJ 200. The simulator was not used to directly simulate or test any aspects of the event flight.

1.16.3 Lab test at TSB Canada Facility

The CVR and FDR were sent to the Transport Safety Investigation Board of Singapore (TSIB) for readout and decoding. Additionally, the observations and discussions on the FDR data provided by TSB Canada supported the analysis of the event flight sequences.

It was noted that the following control surface positions and force parameters were not recorded properly on the FDR:

- Rudder Pedal Force Pilot/Copilot Left/Right
- Rudder Pedal Position
- Flap Position Handle
- Control Column Left/Right Forces
- Control Column Left/Right Position
- Control Wheel Left/Right Force
- Brake Pedal Application Pilot/Copilot Left/Right

- Brake Pressure Left/Right Inboard/Outboard

During the investigation, no entry related to this matter was found in the logbook of the 9N-AME aircraft. It was found during the investigation of the event aircraft's historical FDR data that 9N-AME's FDR did not record these parameters since at least 2021. The Commission could not access data dating prior to 2021. It should be noted that the aircraft 9N-ANM in the Saurya Airlines fleet also did not record some of these parameters, including the control column positions and forces. The CAAN Airworthiness Division, the entity responsible for monitoring FDR status, was not aware of the missing FDR parameters.

1.17 Organization and Management Information

1.17.1 Saurya Airlines Pvt. Ltd.

Saurya Airlines is a Nepalese domestic airline, permitted to operate in the domestic sector with a fleet of MHIRJ CL-600-2B19 aircraft in 2014. It is certified by CAAN and authorized for its operations specifications with principal base of operations located at VNKT. It was established with the aim to provide scheduled and charter flights to various domestic destinations in Nepal, but it currently operates in only two destinations, i.e. VNKT-VNVT and VNKT-VNCG. After completing the licensing phase with the Ministry of Culture, Tourism, and Civil Aviation, Saurya Airlines applied for an Air Operator Certification on July 8, 2012, to CAAN. During the certification phase, CAAN completely revised its Air Operator Certification Requirements (AOCR) and promulgated AOCR 2012, replacing AOCR 1998, effective from November 2012. This new AOCR certification process was structured in five phases, as required by ICAO Annex 6. After successfully passing these five phases, Saurya Airlines achieved its AOC on November 13, 2014.

Saurya Airlines purchased its first aircraft on August 22, 2014, after receiving a No Objection Certificate (NOC) from CAAN, as per AOCR, 2012. It commenced its first operation on November 17, 2014, by conducting a mountain flight and a round trip to Biratnagar Airport from Kathmandu Airport with its single CRJ 200. The company later added a daily service to Bhadrapur. On June 22, 2015, it launched flights to Nepalgunj, which have since been discontinued.

At the beginning of 2016, Saurya Airlines was restricted to operating charter flights because it failed to meet the requirements of minimum number of aircrafts. On May 13, 2017, the company was granted approval to operate scheduled flights again after adding another aircraft (9N-AME).

In March 2017, the operator added a second CRJ 200 to its fleet and regained the certificate to operate scheduled flights. Saurya Airlines temporarily suspended all operations due to a financial crisis from July 7, 2018, to August 21, 2018, and again from November 27, 2018, reopening on March 7, 2019. The aircrafts were also technically grounded from December 24, 2019, to October 18, 2020, due to COVID-19 restrictions.

1.17.2 Civil Aviation Authority of Nepal (CAAN)

CAAN was established as an autonomous regulatory body on December 31, 1998, under Civil Aviation Authority Act, 1996. Currently, CAAN acts as both the regulator and service provider in terms of airport operations and air navigation services amongst others. It issues Requirements, Directives, Manuals, Order and Circulars for implementation of the rule, annex, manual and standards prescribed by the international organizations in relation to air service operation. The authority also issues Air Operator Certificates and Aerodrome Operator Certifications. Additionally, CAAN is responsible for certification and licensing for Air Navigation Certificates. It also oversees the safety monitoring of organizations to which it issues, suspends, or revokes certificates.

An EU-led on-site assessment in September 2023 evaluated CAAN’s safety oversight. It revealed discrepancies in organizational structure, personnel licensing, and flight examiner systems, highlighting the urgent need for compliance with international standards. Specific concerns included insufficient frameworks for monitoring flight examiners, gaps in managing fatigue-related duty limitations, and inadequate inspector training, all of which affect certification and operational surveillance.

While Nepal's efforts to enhance air safety are commendable, significant improvements in CAAN’s oversight capabilities, personnel management, and training frameworks are essential to align with global safety standards.

1.17.3 Tribhuvan International Airport (VNKT)

Tribhuvan International Airport is an international airport in Kathmandu, Nepal. VNKT operates under the certification granted by CAAN according to the provisions of Rule 6 of CAAN's Airport Certificate Regulation, 2004 based on CAAN Act, 1996. The operation and usage of VNKT are governed by Rule 4 of CAAN's Aerodrome Certificate Regulation, alongside any relevant directives and conditions endorsed by the Director-General of CAAN.

1.17.4 Ministry of Culture Tourism and Civil Aviation (MoCTCA)

The Ministry of Culture, Tourism, and Civil Aviation is responsible for state-level duties related to civil aviation, including accident and serious incident investigations. Currently, Nepal does not have a permanent body for the investigations. Instead, each incident is investigated by a separate Accident and Serious Incident Investigation Commission or Committee, constituted by the state as per Rule 9 of the Civil Aviation (Accident Investigation) Rules, 2014 AD (2071 BS). The Ministry’s Aviation Safety and Accident Investigation Section acts as the secretariat for the commissions.

1.18 Additional Information

1.18.1 Flight Permission

On July 21, 2024, Saurya Airlines requested Air Transport Department of CAAN for approval of ferry flight in VNKT-VNPR sector to conduct Base maintenance of 9N-AME aircraft in the hanger of VNPR. Air Transport Department of CAAN approved and issued the ferry flight (SAU-FER) permission on July 23, 2024. Ferry Flight has been defined in CAAN requirements and Saurya Airlines' manual which are as follows:

i. **FOR(A) Nepal Para 17.10.2:**

Special VFR flights may be conducted by commercial air transport operators for ferry/test flights and recovery of aeroplanes provided no passengers are carried and requisite safety assessment has been carried out.

ii. **FOR(A) Nepal Para 8.7.4 Ferry Flights**

Ferry flights are flights to position aircraft for maintenance. They may be conducted with minimum flight crew and reduced airworthiness as permitted by AFM or its supplements. The Engineering/Technical Department shall arrange necessary permission from CAAN as required. In such flight the person on board shall be limited to flight crew and maintenance people. Such flights shall not be conducted in weather conditions that will jeopardize the safety of the aircraft and shall operate in accordance with the conditions of the flight permit issued by CAAN.

iii. **NCAR Issue 6 Chapter A.4 Para 4.3**

An aircraft may be classified in the Special Category if it is temporarily ineligible to be classified in another category. This may apply if:

a) the aircraft is approved to operate at an overload for a ferry flight,

b) the aircraft incorporates a modification which is not yet fully approved, or

c) the damaged or defective aircraft is to be flown to a place where the damage or defect can be rectified.

iv. **Saurya Ground handling Manual: Definition**

Ferry: A positioning flight (i.e. operated empty of commercial load under normal circumstances)

v. **Saurya Operation Manual Part A Para 8.7.4**

Ferry flights are flights to position aircraft for maintenance. They may be conducted with minimum flight crew and reduced airworthiness as permitted by AFM or its supplements.

vi. Guidance Material to Regulation (EU) No 965/2012- Issue-1, Amendment 3

Ferry Flight- Changing the location of the aircraft

A ferry flight could be performed for the following purposes:

(e) The aircraft is moved to and from a maintenance base. The aircraft may be operated under the permit-to-flight conditions. Examples:

(1) Unpressurized flight,

(2) Gear-down Flight,

(3) Flight with one engine inoperative

A ferry flight is a non-revenue flight used to move an aircraft from one position to another. The term "ferry flight" is usually specially reserved for maintenance, new aircraft deliveries from the factory, or flights operated under a Special Flight Permit. A ferry permit is a written authorization issued by a National Airworthiness Authority to move a non-airworthy civil aircraft from its present location to a maintenance facility to be inspected, repaired and returned to an airworthy state. Airlines moving planes around for schedules purposes is usually referred to as a "positioning flight."

Considering the above definitions, the documents of CAAN lack consistency between the Flight Operations Requirements (FOR) and Nepal Civil Aviation Regulations (NCAR). Furthermore, provisions for ferry flights are defined in Saurya Airlines' Operation Manual and Ground Handling Manual in accordance with CAAN's Flight Operation Requirements. While Saurya Airlines requested a ferry flight permission based on its Operation Manual and was granted approval by CAAN for the said ferry flight operation, it did not conduct flights as per the provisions outlined in the FOR (Nepal), NCAR, or its own Operations Manual.

2. Analysis

2.1 Introduction

The analysis of the events leading to the accident began with a review of factual information and evidence. This included scrutinizing technical logs, relevant documents, manuals, Standard Operating Procedures (SOP), CVR/FDR data analysis, interviews, and witness statements, as well as expert consultations, medical and pathological reports, analysis of Safety Management System, and human factor analysis. Each of these aspects was reviewed and analyzed.

This investigation was conducted following ICAO SARPs and related documents, and AIG procedure manual of Nepal.

2.2 Methodology

The Commission adopted the following methodologies during the course of the investigation:

1. Visual assessment of wreckage and crash site
2. Inspection and study of technical documents
3. Study and analysis of cockpit avionics
4. Review of crew training and company procedures
5. Study and analysis of aircraft weight and balance
6. Information gathered from interviews and written statements from all concerned parties
7. Examination and analysis of personnel records and other related information about the crew members
8. Review of CAAN regulations and requirements regarding aircraft operations
9. Analysis of CVR and FDR data
10. Study and analysis of the Safety Management System
11. Review of safety reports

2.2.1 Visual Assessment of Wreckage

After formation of the accident investigation commission, a team of investigators visited the crash site to collect relevant data and information. Upon the arrival of the investigators at the site, the team noticed and recorded that the wreckage had been disturbed during rescue operations. The team also noted that the visit to the crash site was affected by the weather the days following the event.

Upon arrival at the crash site, the investigators gathered initial information, examined the wreckage, mapped out the wreckage distribution, collected potentially critical components and materials, and interviewed relevant people and witnesses. Photographs and videos were taken for detailed study and analysis. The team's primary considerations were to establish:

a. The probable flight path
b. The impact angle
c. The impact speeds
d. Whether the aircraft was under control
e. Whether any structural failure occurred prior to impact

Following the first visit, the team revisited the crash site over the following months to assess the crash site and collect updated information as the investigation progressed. A number of components from the wreckage were also brought to the commission office at the Ministry of Culture, Tourism and Civil Aviation for inspection.

2.2.2 Inspection and Study of Technical Documents

The airframe, engine, and aircraft technical logbooks were thoroughly reviewed and examined to identify any discrepancies or malfunctions in the aircraft system. The Operations Manual, Flight Safety Manual, Aircraft Flight Manual, Standard Operating Procedure, and pilot training records pilot flight records were also checked and reviewed. Additionally, CAAN's updated FOR, NCAR, AOCR, AIP, and operator's manuals were examined. It was found that the technical logbooks, records, documents, and manuals were maintained in accordance with CAAN regulations. There were no indications of any pre-existing technical defects that could have directly caused or contributed to the accident. Since no anomalies were recorded in the FDR and CVR, there was no evidence of any system or primary flight controls failure up to the time of the take-off. Hence, the failure of aircraft systems such as hydraulics, flight controls, and other major components can be ruled out. The probability that the power-plant system, or structural failures or any other mechanical malfunction contributed to the accident can be ruled out.

The Commission examined the maintenance history of the aircraft and found that all the applicable airworthiness directives and mandatory service bulletins had been complied with as per the maintenance requirements within the prescribed time frame. The technical logs and logbooks show that the maintenance works, major inspection works and modifications were carried out as per the approved maintenance program and approved maintenance data. No technical defects were reported in the technical logbook prior to the flight.

The analysis of performance charts in the aircraft flight manual showed that the aircraft's recorded rotation speed was lower than required. Upon detailed review of operations documents, the

Commission also noted that the page for 18,500 kg TOW provided in the Saurya Airlines speedcard booklet, which was being used by the crew, contained incorrect V-speeds.

2.2.3 Study and Analysis of Cockpit Avionics

The avionics in the cockpit were found to be functioning satisfactorily and, as their role in this type of accident was not particularly impactful, they cannot be considered a cause or contributing factor of the accident.

2.2.4 Review of Crew Training and Company Procedures

Pilot Proficiency Checks (PPC) are conducted twice a year, and Route Checks are conducted once a year, in addition to other mandatory training sessions. Flight Simulator training for all flight crew of the operator’s CRJ 200 aircraft for IFR currency is conducted at Lufthansa Aviation Training Operations, Germany GmbH. The simulator remarks for the PIC are Excellent, and for the Copilot, Satisfactory. All other training requirements, as per PELR and FOR Nepal, have been found satisfactory. However, it was noted that the syllabus and duration of the training do not match, either in Initial or continuation training. Additionally, in Saurya Airlines' in-house training, there was an inconsistency between the syllabus and the specified duration, as the duration seems minimized.

2.3 Interview and Statements

Interviews and statements were collected from several individuals, including colleague pilots, co-pilots, airline staff, loaders, dispatchers, the Ground Handling Manager, and the Marketing Manager. Local officials, family members of the crew, the tower duty officer, security personnel, and the Airport Rescue and Fire Fighting officer on duty were also interviewed. From the organization’s side, key officials such as the CAMO Manager, Maintenance Manager, Airline Safety Manager, and QA Manager, who were also fatally involved in the accident, therefore they were not available for consultation. Additionally, concerned officials from CAAN were also summoned to gather written statements regarding major concerns and for relevant discussions.

Photographs and video clips from CCTV recorded within the airport were also gathered and reviewed. During the inquiry with eyewitnesses, it was observed that the firefighters were confused about the route to take with the fire truck. Complaints were noted that firefighters did not use the water tender and foam tender according to the SOP, resulting in an inability to save some persons onboard.

Interviews related to flight preparation

The Ground Handling Department stated that since it was an internal flight, there was no coordination with them, and engineering personnel loaded the cargo themselves. During the inquiry with Saurya Airlines' Flight Dispatcher, it was revealed that the Load and Trim sheet was prepared using the weight data provided by engineering personnel. All calculations were performed according to Saurya Airline's manual. However, the provisions specified in Saurya Airline's Ground Handling Manual were not followed.

Interviews with the parents of the F/O and his colleague revealed that the employees of Saurya Airlines may have been working under strained conditions. Despite being assertive in some respects, the F/O also did not raise any concern as the baggage and equipment were haphazardly placed in the cabin. The PIC also witnessed these issues while entering the cockpit but did not raise any concern. This points to a significant fault in the organization's safety culture. Saurya Airlines' Marketing Manager, in their written response, acknowledged that an error occurred during the preparation of this flight.

Interviews related to F/O

Since the F/O was unable to pass the simulator test on his first attempt, he was advised to undergo additional theoretical sessions before retaking the test. This prolonged his stay in Germany by three months and significantly increased the type training cost. The additional training cost was added to the F/O bond, and as he had to cover his own expenses for food and accommodation, he reportedly secured a loan in Germany. Interviews with his parents revealed that he had not informed them about this loan, while he had been repaying it in installments from his salary. It was also noted that the F/O incurred other expenses during his initial training, which might have contributed to financial strain both on himself and his family.

The F/O was described as confident and enthusiastic, particularly about flying and the aviation industry. While he expressed satisfaction with the aircraft and equipment he operated, he was dissatisfied with the company due to issues such as layoffs, low remuneration, and a lack of benefits.

The F/O was from a financially middle-class family. As an only child, the F/O received full support from his parents in pursuing his education and career. The F/O was passionate about flying and was regarded as a sincere and well-mannered individual by his peers. However, interviews with his parents and colleagues indicated that he concealed his financial difficulties from his family and may have been dealing with internal stress.

Interviews related to FSSD, CAAN

Interview with FSSD Director, Chief of Airworthiness, PAI, POI and operations personnel at CAAN showed that there is a lack of human resources in FSSD, but also severely in the flight operations department of CAAN, which is limiting its monitoring and regulatory functions. Clear evidence of this can be seen in the context of the current accident, where the operator was not complying with its own ground handling manual, yet the check and audit processes have been ineffective against such violations. The flight operations division was found to be functioning with limited permanent staff. FSSD also does not have the resources or capability to monitor the FDM/FDA programs across all operators.

From the interviews and collected responses, it was evident that there were lapses in the Safety Management System at TIA as well as at Saurya Airlines.

2.4 Flight Data Analysis

This section contains technical analysis prepared based on the flight data of the event flight. The analyses were performed from raw data, relying on validated mathematical models. The discussion of verification and validation of the methods are provided in the appendix.

2.4.1 Aircraft Weight and V-Speeds

The baggage carried on the 9N-AME aircraft during the event flight comprised primarily of the equipment, materials and supplies for base maintenance, and the personal items of the persons onboard. However, since the persons on board did not follow the normal check-in procedures, the marketing department of the airline did not have the data on the exact amount of baggage onboard. As per the interviews conducted with the ground personnel of Saurya airlines, a crude estimation of the baggage was provided by the store incharge, which was then used in the loading manifest. This was also corroborated from the CVR data of the event flight, where the ground and maintenance personnel were heard verbally discussing a rough baggage weight estimation during the pre-flight preparations, which was then stated in the load and trim sheet by the flight dispatcher for the event flight.

Given the inconsistencies in the V-speeds used for the event flight, the exact weight of the aircraft was a major parameter that needed to be estimated to inform further analysis. Therefore, the weight of the aircraft at take-off was numerically computed for the event flight using flight performance equations and FDR data. The results presented below use the most fundamental approach, which is the take-off force balance equation in the longitudinal direction, namely:

$$\textit{Thrust} - \textit{Drag} - \textit{Runway Friction} = \textit{Mass} \times \textit{Acceleration}$$

FDR data was used for all parameters required. *Mass* is the unknown in the above equation, which was computed for the event flight.

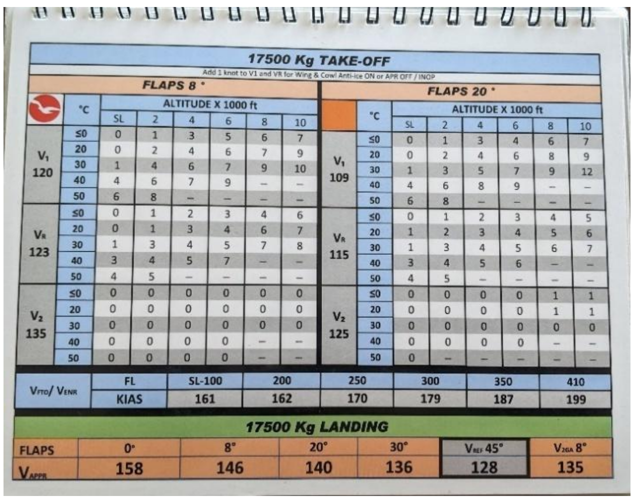
The most reliable estimate for *Mass* is obtained at a speed where the *Runway Friction* is negligible, which occurs as the aircraft speed on the runway approaches stall speed (or close to V_1 speed, depending on whichever is the closest recorded data in the FDR). In all cases, the recorded speed close to the rotation speed followed immediately after the recorded speed close to the V_1 speed. Hence, the parameters for speed above V_1 speed was not considered for the analysis.

Using this method, the actual weight of the aircraft of the event flight was computed to be 18,300±200 kg. Verification analysis was also performed using prior flights of the 9N-AME aircraft. The analysis is elaborated in Appendix 11, while the exact outcome of the analysis relevant to further discussions is presented below. Appendix 12 presents verification from flight simulation.

Based on the calculated aircraft weight and flap setting of 20°, the V-speeds for the event flight should have been (using upper limits for speed correction) as provided in Table 15, as referenced from QRH and verified from AFM charts. Note that the recorded value of rotation speed during the event flight, at 119.75 knots, is close to the V_1 speed.

Table 15: Speeds based on stated and computed TOW, interpolated from QRH tables

Stated weight	18,137 kg	Computed Weight	18,300 ±200 kg
V_1	117 knots	V_1	118 ±1 knots
V_R	122 knots	V_R	123 ±1 knots
V_2	127 knots	V_2	127.5 ±0.5 knots



17500 Kg TAKE-OFF

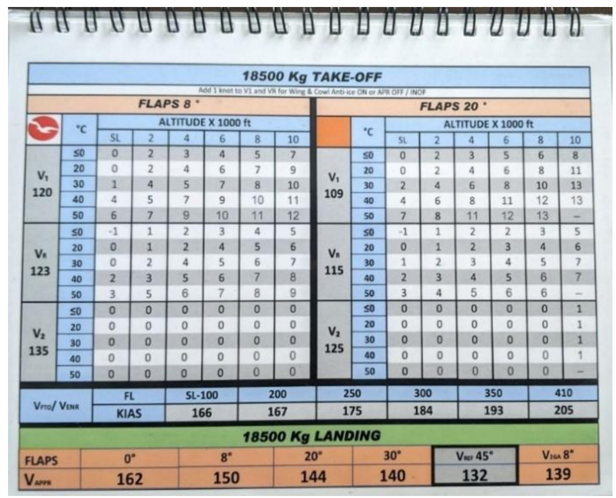
Add 1 knot to V1 and VR for Wing & Cowl Anti-ice ON or APR OFF / INOP

	°C	FLAPS 8° SL	2	4	6	8	10		°C	FLAPS 20° SL	2	4	6	8	10
V_1 120	≤0	0	1	3	5	6	7	V_1 109	≤0	0	1	3	4	6	7
	20	0	2	4	6	7	9		20	0	2	4	6	8	9
	30	1	4	6	7	9	10		30	1	3	5	7	9	12
	40	4	6	7	9	–	–		40	4	6	8	9	–	–
	50	6	8	–	–	–	–		50	6	8	–	–	–	–
V_R 123	≤0	0	1	2	3	4	6	V_R 115	≤0	0	1	2	3	4	5
	20	0	1	3	4	6	7		20	1	2	3	4	5	6
	30	1	3	4	5	7	8		30	1	3	4	5	6	7
	40	3	4	5	7	–	–		40	3	4	5	6	–	–
	50	4	5	–	–	–	–		50	4	5	–	–	–	–
V_2 135	≤0	0	0	0	0	0	0	V_2 125	≤0	0	0	0	0	1	1
	20	0	0	0	0	0	0		20	0	0	0	0	1	1
	30	0	0	0	0	0	0		30	0	0	0	0	0	0
	40	0	0	0	0	–	–		40	0	0	0	0	–	–
	50	0	0	0	0	–	–		50	0	–	–	–	–	–

V_{FTO}/ V_{ENR}	FL	SL-100	200	250	300	350	410
	KIAS	161	162	170	179	187	199

17500 Kg LANDING

FLAPS	0°	8°	20°	30°	V_{REF} 45°	V_{2GA} 8°
V_{APPR}	158	146	140	136	128	135



18500 Kg TAKE-OFF

Add 1 knot to V1 and VR for Wing & Cowl Anti-ice ON or APR OFF / INOP

	°C	FLAPS 8° SL	2	4	6	8	10		°C	FLAPS 20° SL	2	4	6	8	10
V_1 120	≤0	0	2	3	4	5	7	V_1 109	≤0	0	2	3	5	6	8
	20	0	2	4	6	7	9		20	0	2	4	6	8	11
	30	1	4	5	7	8	10		30	2	4	6	8	10	13
	40	4	5	7	9	10	11		40	4	6	8	11	12	13
	50	6	7	9	10	11	12		50	7	8	11	12	13	–
V_R 123	≤0	-1	1	2	3	4	5	V_R 115	≤0	-1	1	2	2	3	5
	20	0	1	2	4	5	6		20	0	1	2	3	4	6
	30	0	2	4	5	6	7		30	1	2	3	4	5	7
	40	2	3	5	6	7	8		40	2	3	4	5	6	7
	50	3	5	6	7	8	9		50	3	4	5	6	6	–
V_2 135	≤0	0	0	0	0	0	0	V_2 125	≤0	0	0	0	0	0	1
	20	0	0	0	0	0	0		20	0	0	0	0	0	1
	30	0	0	0	0	0	0		30	0	0	0	0	0	1
	40	0	0	0	0	0	0		40	0	0	0	0	0	1
	50	0	0	0	0	0	0		50	0	0	0	0	0	–

V_{FTO}/ V_{ENR}	FL	SL-100	200	250	300	350	410
	KIAS	166	167	175	184	193	205

18500 Kg LANDING

FLAPS	0°	8°	20°	30°	V_{REF} 45°	V_{2GA} 8°
V_{APPR}	162	150	144	140	132	139

Figure 15: Incorrect V-speeds for 18,500 kg TOW as listed in the speedcard booklet provided to the flight crew by Saurya Airlines

The clear inconsistency arose from the incorrect data in the speedcard for 18,500 kg TOW provided in the Saurya airlines speedcard booklet provided to the crew. The page for 18,500 kg was supposed to an interpolated data sheet based on data for 18,000 kg and 19,000 kg in the QRH. However, the page for 18,500 kg in the booklet appears to be copied over from the page for 17,500 kg while the base V-speed values for take-off were not modified, as shown in Figure 15. The incorrect values stated in the Saurya airlines speedcard for the aircraft is provided in the following paragraph. The base V_1, V_R and V_2 speeds in the speedcard are the same between 17,500 kg and 18,500 kg TOW.

Interview with Saurya Airlines pilots showed that none of them were aware that the relevant page of the booklet was incorrect. Therefore, during the event flight, when the F/O referred to this page for estimation of the V-speeds. The F/O followed correct calculation process to obtain the recorded V_1, V_R and V_2 of 114 knots, 118 knots and 126 knots, respectively, with altitude correction albeit not considering that the speedcard itself was incorrect. The fact that none of the flight crew noticed the blunder in the speedcard though-out the history of the airline is a critical failure of the flight operations and safety management.

As per the interviews conducted, the PIC was likewise not aware of the error in the speedcard. The PIC also did not verify the speeds estimated by the F/O for the event flight, hence he was unaware of the incorrect values being used. In best practice, the roles and responsibilities of the PIC required that he cross-checked the V-speed values entered by the F/O.

2.4.2 Take-Off Performance

Following the estimations presented above, using a TOW of 18,300±200 kg the take-off performance parameters of the aircraft were obtained from AFM† performance charts as follows:

Table 16: Take-off performance for estimated weight of 18,300±200 kg

Parameter	Value	Remark
Altitude	4400 ft	For OAT = 26 +/- 1 ° C (AFM Chart 02-01-2)
Stall speed	111 knots	+/- 1 knot, Flap 20/gear up (AFM Chart 06-02-32)
N1 Fan speed (%)	92.1	+/- 0.1
Take-off distance required	5200 ft (1585 m)	+/- 100 ft, Margin = 1.15
Take-off distance without margin	4500 ft (1370 m)	+/- 100 ft
Rotation speed (V_R)	123 knots	+/- 1 knot

† Saurya Airlines Aircraft Flight Manual Rev 77D, 22 December 2022

The relevant performance charts are provided in Appendix 10. For the stated weight of 18,137 kg, the above values would be lower by around 100 ft in lengths.

During the event flight, computations from the FDR data showed that the aircraft rotated for take-off at around 1100 m from roll start on the runway. Since the aircraft did not complete an adequate rotation for take-off to the obstacle height, the actual take-off distance covered was not reasonable for comparison.

2.4.3 Take-Off Characteristics

The aircraft rotated for take-off near 120 knots. This speed fell short from required rotation speed stated in Tables 15 and 16. The elevator deflection (up) for take-off went from around 1.5° to 10° within 1 second. Two seconds after the elevator deflection to ~10°, the angle of attack of both wings reached around 10°. At this instance, the aircraft started undergoing a right-low roll motion and the right stick shaker became active. Both stick shakers became active 1 second later, while the right-low bank angle reached 25°. This sequence is shown in the Figure 16. The instance where both stick-shakers became active is at 406 s in the figure, marked by a vertical dotted line.

It should be noted that historical data reviewed for aircraft in Saurya Airlines fleet, 9N-AME and 9N-ANM, showed that the right-wing angle of attack consistently increased earlier than the left-wing angle of attack.

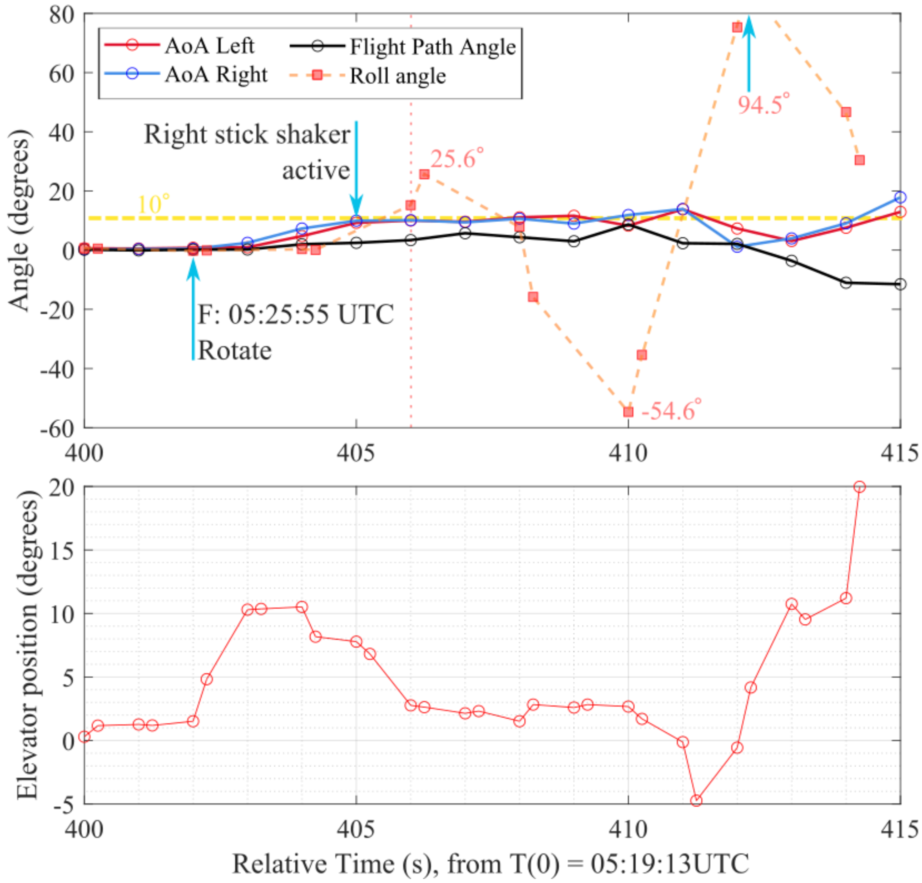


Figure 16: Flight angles and left elevator (up) position

2.4.4 Control Wheel Positions

The control wheel position for roll control indicated that the PIC began a roll correction from right-low roll condition at the instance when the right stick shaker was activated (at 405 s in figure above). In 1 second, at 406 s in Figure 16 as marked by the vertical dotted line, the control wheel position for left-roll response was at 32° that sustained for nearly 2 seconds. As a result, the aircraft underwent rapid left roll motion. The aircraft bank angle went from around 25° right-low to around 54° left-low attitude within 4 seconds.

Throughout this sequence, the angle of attack of both wings remained around 10°. Both stick pushers activated after 410 s mark in Figure 16.

2.4.5 Elevator Deflection and Rotation Characteristics

Historical data of the 9N-AME aircraft showed that the expected elevator deflection for take-off is from 1.5° to around 10° up within 3 seconds, leading to a typical maximum angle of attack in the vicinity of 6° to 8°. A case on June 19 of the 9N-AME aircraft while taking-off from VNCG was taken as a comparison case since the elevator deflection for rotation was also relatively high near 12°.

The response of the aircraft's rotation for take-off with respect to elevator deflection is analysed in Figure 17. In the responses shown, the angle of attack is taken 2 seconds from the corresponding elevator deflection. Response for the event flight shows that although the elevator deflection was decreased at an angle of attack of near 10°, the angle of attack continued to increase. This is unlike the comparison case, indicating that the longitudinal (pitch) control had been lost within 3 seconds after rotation.

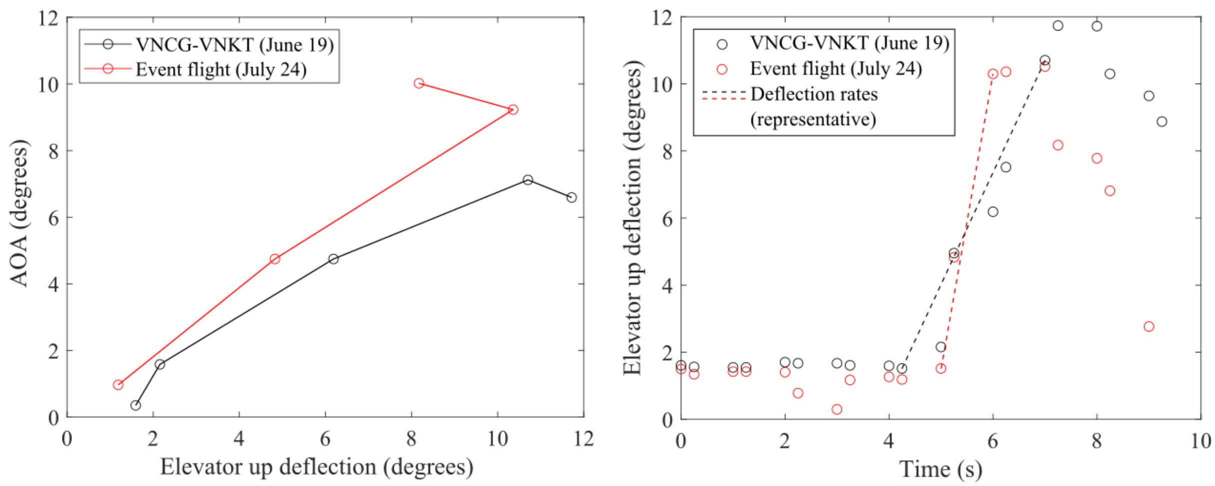


Figure 17: Elevator and airplane pitch responses. The angle of attack is for the left wing.

The reason for a rapid increase of pitch angle (mainly the angle of attack component for the first few seconds) can be attributed directly to the rapid rate of elevator deflection, as shown in Figure 17. During the rotation for take-off, the elevator deflection for nose pitch up attained a deflection angle of over 10° in 1 second. Discounting the approximately two-seconds time lag in the aircraft response, the left-wing angle of attack increased linearly from approximately 1° to 10° within 2 seconds. During this period, the right-wing angle of attack rose more rapidly than that of the left wing, as seen in Figure 16. Hence, the right stick shaker also activated first, followed by the left stick shaker becoming active after 1 second.

In summary, based on take-off weight of 18,137 kg, the reference V-speeds of the event take-off should have been based on the speedcard for 18,500 kg. However, the Commission established that the information in the speedcard for 18,500kg used by the operator is identical to the values for take-off weight of 17,500kg. These values would be erroneous. The flight crew performed the event take-off referring to reference V-speeds which were meant for 17,500kg, in accordance with the information contained in the speedcard provided to them by the operator.

In the event flight, the aircraft stalled shortly after rotation. Considering the event aircraft was of a T-tail design, the turbulent wake of the stalled wings would have blanketed horizontal stabilisers, reducing the effectiveness of the elevators. The elevator deflection was also abnormally rapid. The high rotation rate occurred while the aircraft was still under the influence of ground effect, which can further reduce the stall margin. As the stall happened shortly after rotation, there was insufficient altitude for recovery efforts by the pilot flying to be effective.

During the event flight, the maximum recorded pitch rate, occurring over a 0.25 second period, was 8.6 degrees-per-second. However, the maximum pitch rate over a 1-second period was 6.5 degrees-per-second, while the maximum average pitch-rate over a 2-second period was 4.2 degrees-per-second. These variations are noted because the FDR recorded data at 4 samples-per-second.

2.4.6 Analysis of Historical Flight Data of Saurya Airlines

An extensive analysis of the flight data retrieved from the current Saurya Airlines fleet, namely tail numbers 9N-AME and 9N-ANM, of periods dating back from the event flight was performed to investigate the take-off performance of the airline crew. Flight data for take-off analyzed between 2023 and the day of the event flight showed that maximum rotation rates of upto 4 degrees-per-second were common occurrence, particularly during the 2^{nd} second of the three-to-four seconds required for rotation for take-off in a typical scenario. However, these cases were considered non-optimal yet less significant for the current analysis.

Before further analysis, a criterion to deem significantly high rotation rates was set based on the event flight, as: maximum rotation rate equal to or greater than 5 degrees-per-second (sampling at 1 sample-per-second) while the average rotation rate also being more than 4 degrees-per-second over a 2-second period during the rotation. A summary of all the cases for the Saurya Airlines fleet between 2023 to the day that fully or partially met the above criterion are listed in Table A.10.1 of Appendix A.10.

The worse of these cases for 9N-AME happened during flights on 11 January 2024 and 19 March 2024, with the rotation rates as per the above criterion respectively as (5.8° /s, 4.35° /s) and (5.5° /s, 4.8° /s). The plots showing these rotation rates versus time, along with the elevator deflections, AOA and speed are shown in Figure 18. During the flight on January 11, the elevator deflection was commanded by around 8 degrees within 1 second, because of which a rapid pitch rate of 5.8° /s was achieved between 17 to 18 seconds in the figure. While on March 19, the elevator deflection was commanded by 11 degrees in 2 seconds that resulted in a maximum rotation rate of 5.5° /s. Rotation for the flights were performed at 132.25 knots and 127.75 knots computed airspeeds, respectively. The corresponding required rotation speeds were 130 knots and 127 knots. Unlike in the case of the event flight, the above cases rotated at sufficient rotation speeds.

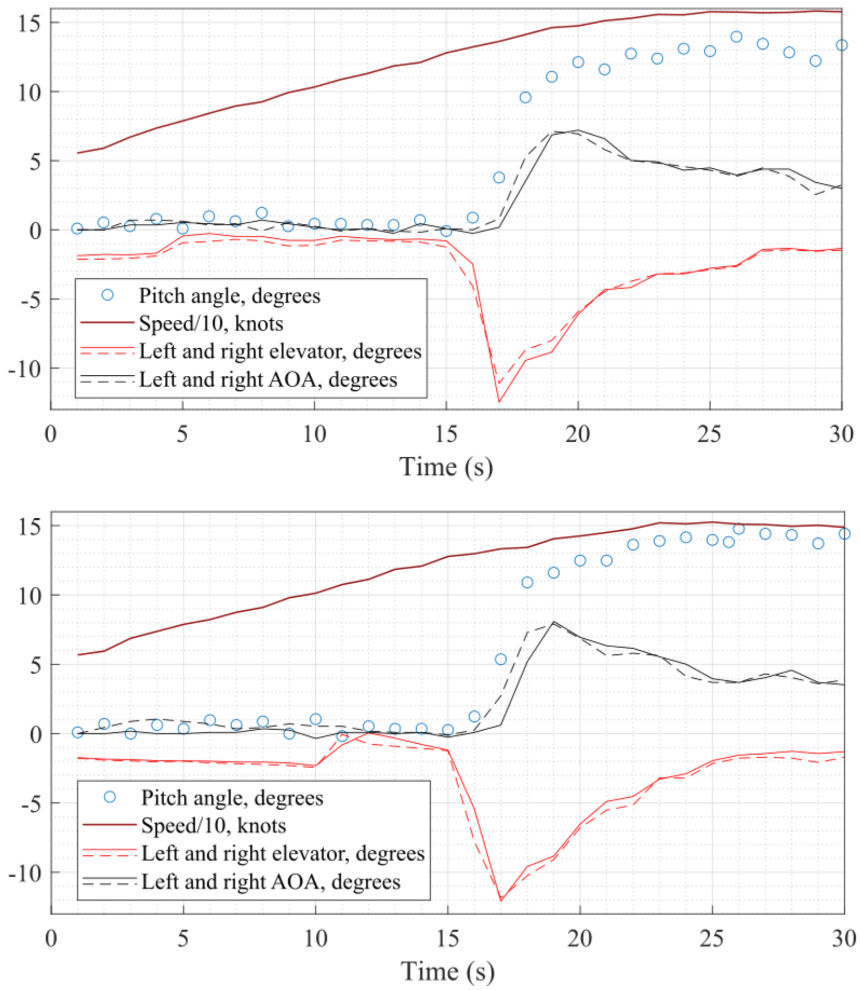


Figure 18: Take-off rotation data for 9N-AME flights on January 11, 2024 (top) and March 19, 2024 (bottom) that show excessive rotation rates during take-off

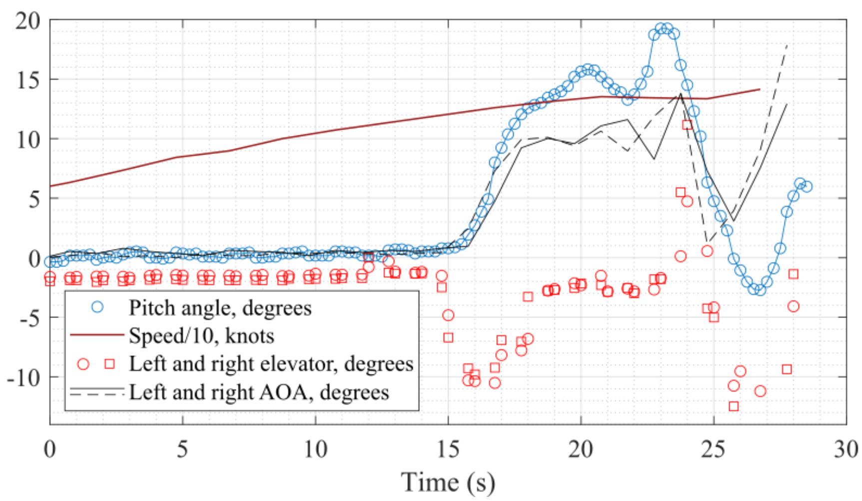


Figure 19: Take-off rotation data for the event flight, shown in comparison to Figure 18

For comparison, the elevator deflections for the event flight are shown in Figure 19. Elevator up is recorded as negative value in FDR. The rates for the event flight are abnormally high- even in comparison to the cases presented in Figure 18. In the event flight, the elevator deflection was commanded from ~1° to ~10° distinctly within a second, which is made clearer by the marker symbols in the plot style. This rate of pitch up response commanded was higher than any cases studied under this analysis, at (6.5° /s, 4.2° /s) based on the above criterion.

It should be noted that the pitch rates are still proportional to the elevator command, when compared to the historical flights. This contradicts the possibility that the pitch rate was driven by weight and balance factors, or that an abnormal CG location could be the characteristic factor.

The analysis presented above shows that the Saurya airlines crew has a repeated history of excessive rotation rates during take-off, indicating a systemic issue with flight operations. During the event flight, the aircraft entered a deep stall during take-off. The rotation for take-off was attempted at a lower than optimal rotation speed.

2.5 Study and Analysis of the Safety Management System

2.5.1 Saurya Airlines

The Commission conducted an in-depth study on the ineffective implementation of the Safety Management System (SMS) at Saurya Airlines. The study highlights critical deficiencies across various safety processes and organizational accountability, as detailed below.

1. Non-Adherence to Ground Handling Procedures

The following issues were observed:

i. The Ground Handling Manual was not followed during cargo loading operations.

ii. Non-ground handling staff and untrained engineering personnel were involved in loading goods onto aircraft.

iii. Goods were not properly secured, leading to potential safety risks during flight operations.

These examples underline a lack of adherence to established safety protocols, compromising operational safety.

2. Ineffectiveness in Utilizing FDM Program

i. FDA system was purchased but remains unused under the flight data analysis program.

ii. This demonstrates an inability to leverage tools aimed at enhancing safety monitoring and data-driven improvements.

3. Absence of Safety Data and Risk Assessment (Flight Safety)

i. No Significant data or safety risk assessments have been conducted to address discrepancies in flight operations.
ii. Internal safety assessments, which are critical to identifying and mitigating risks, are not being performed.

4. Ineffective Accountability

i. The SMS does not clearly define lines of accountability throughout the organization.
ii. There is no established direct accountability for safety on the part of senior management, leading to ambiguity in decision-making and oversight.

5. Deficiencies in Training and Awareness

i. Training programs for staff are not conducted, resulting in a lack of awareness and competency in safety protocols.
ii. This failure contributes to procedural lapses and safety violations.

6. Audit and Feedback Mechanisms

i. Absence of Flight Operations Quality Assurance Manager (FOQA Manager) as per Saurya Operation Manual OM Part 1 1.5.1.7.
ii. The absence of internal audits and feedback mechanisms impedes the continuous improvement of safety practices.
iii. Without these systems, gaps in the SMS remain unidentified and unaddressed.

7. Reporting and Incident Address Mechanisms

i. A transparent and efficient mechanism for reporting and addressing safety incidents or violations has not been established.
ii. This discourages proactive reporting and timely resolution of safety concerns.

The current state of SMS at Saurya Airlines reveals significant gaps that hinder its effectiveness in ensuring operational safety. Immediate attention to the identified shortcomings and the implementation of the recommended actions are crucial to fostering a safer organizational culture and meeting safety compliance standards.

2.5.2 Tribhuvan International Airport

The commission thoroughly studied and analyzed the implementation of the SMS at Tribhuvan International Airport by examining the TIA audit report dated January 24, 2024. The evaluation adhered to the guidelines presented in the 6th version of the 2023 SMS Manual, as stipulated in paragraph 1.4 of Civil Aviation Requirements (CAR)-14 part 1 and CAR-19.

The audit utilized the 'SMS Evaluation Checklist' and revealed the following implementation rates:

1. SMS Safety Policy and Objective: 95.24%
2. Safety Risk Management: 80%
3. Safety Assurance: 66.67%
4. Safety Promotion: 75%

While these figures indicate a substantial implementation effort, the audit report's conclusion highlighted several recommendations that suggest that the airport’s SMS implementation is not yet fully adequate or effectively executed. The SMS report is attached in Appendix 9.

2.6 Human Factor Analysis

A human factor analysis was conducted with support from FAA upon request by the current commission.

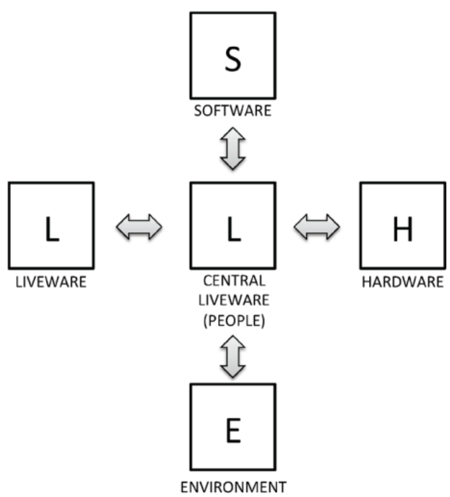


Figure 20: The SHELL model

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 system components. First developed in 1972 by Elwyn Edwards, it remains a useful tool today and suggests that the human is rarely the sole causal factor of an event. The SHELL model is divided into four components: software, hardware, environment, and liveware. It was determined that the SHELL model may be most suitable in the analysis of crew actions of Saurya Airlines 9N-AME.

Liveware

A 72-hour history of both crew members was reviewed. Based on the data received from the surviving captain, no areas of interest were noted. The PIC indicated his last flight prior to the accident was on July 19, 2024, approximately 5 days prior to the accident. He indicated a normal rest and activity schedule during that time.

Official flight time for the preceding 7 days, 30 days, 3 months and 12 months, as well as the previous rest period was provided for the PIC and the F/O. Based on the information provided, no areas of interest were identified.

The PIC indicated that his most recent training history included Cockpit Resource Management (June 6, 2024), SMS (June 18, 2024), CFIT (Aug 5, 2023), UPRT (Feb 26, 2024). Additionally, he had last taken simulator training Feb 26, 2024.

During the commission's analysis of prior rotation rates on the accident flight and a different CRJ-200 of the Saurya fleet, it was noted that the airline has a pattern of crew members performing take-offs well above the 3º per second rotation standard. This is a very concerning trend. One such data set indicated that the accident PIC performed a take-off on March 19, 2024, with a peak rotation rate of 5.5° per second.

The Commission noted 18 such instances of excessive pitch rates on 9N-AME from 2023 to 2024. In all 18 cases, rotation rates were above 4º per second. The worst recorded case was in January 2024 where the peak value was 5.8° per second. Of note, the prior case involving the PIC of the event was the second highest recorded value.

Areas for improvement here include the role of Pilot Monitoring to call out exceedances, such as high rates of rotation or excessive pitch angles. The Pilot Monitoring must be clear in their communication. The CVR transcript indicates the Pilot Monitoring (F/O) stated "Woah....woah...woah" and then "sir-sir-sir". It is clear the Pilot Monitoring attempted to speak up, but a more articulate command such as “reduce pitch” would more clearly communicate the problem and what the corrective action should have been. Additionally, monitoring of rotation performance by training examiners and check airman should be emphasized in training and checking activities and during routine line operations.

Environment

Tribhuvan International Airport was the home base for the PIC and for Saurya Airlines. PIC indicated in his interview that he has been flying from Tribhuvan International Airport for more than a decade and is very familiar with the airport environment.

Despite the PIC's familiarity with the airport, the operating environment of the accident flight was specifically evaluated closely. The purpose of the flight that day was to reposition the aircraft to Pokhara International Airport for a base maintenance check. The flight was being conducted as a ferry flight, and not a regularly scheduled revenue flight. As the flight was not being conducted as a regularly scheduled revenue flight, it is of note that non-airline personnel and non-required crew were present onboard.

Areas for improvement here include the proper adherence to SOP regarding ferry flights and authorized personnel onboard.

Hardware

The accident aircraft had been grounded for 34 days prior to the accident flight. Preservation procedures were reportedly conducted for storage, and procedures for return-to-service were conducted prior to the flight.

The CRJ series aircraft has known aerodynamic characteristics that make it susceptible to control issues on take-off with wing contamination (ice/snow) or with excessive pitch rates / over-rotation on take-off. High pitch rates can result in a deep stall, as seen in the flight data for the accident flight. A warning in the CRJ manual alerts crew to this issue. Despite the warning, it appears that the crew allowed the pitch-rate to get excessively high. This could indicate a training and standardization or a checking inconsistency within the airline.

Areas for improvement here include ensuring the aerodynamic characteristics of the CRJ aircraft are adequately explained in training manuals and during simulator events. Routine download and evaluation of FDR parameters could assist in identifying parameters that are producing erroneous or suspect values.

Software

The ferry flight did not fully comply with essential procedures. The flight operated with 17 persons onboard and no cabin crew for emergency procedures.

The Saurya Airlines Operations Manual (Part A) indicates that ferry flights:

- “may be conducted with minimum crew and reduced airworthiness as permitted by AFM”
- “Engineering/Technical Department shall arrange permission from CAAN as required”
- “Persons on board shall be limited to flight crew and maintenance people”
- “Cabin crew shall not be required for ferry flights”

The take-off section of the Saurya SOP manual outlines the expanded procedures for take-off. However, this portion of the manual does not reference the importance of a 3º per second target for rotation rate, and it does not reference the warning that appeared in other manuals (see page 8, paragraph G).

Areas for improvement here include the clarification of manuals to incorporate detailed take-off rotation rate explanations, as well as ensuring training personnel routinely look for adherence to this standard.

3. Conclusion

3.1 Findings

1) The crew were qualified and certified in accordance with the prevailing regulations of the CAAN.
2) The duty time of the crew was within the prescribed limit prior to the flight, and they had adequate rest period.
3) The aircraft possessed a valid certificate of airworthiness and registration at the time of the occurrence.
4) The aircraft had been grounded for 34 days before the event flight. The preservation of aircraft and return to service maintenance checks were carried out as per maintenance manual.
5) The aircraft was maintained as per the airworthiness 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 known damage to the aircraft occurred after the ground impact.
7) At the time of departure, the weather was fair with 8 km visibility and the wind was calm.
8) The operator failed to comply with the provisions of the operational manual and ground handling manual.
   a) The equipment and materials loaded on the aircraft were neither weighed during dispatch from the operator's store nor prior to loading on the aircraft.
   b) Maintenance equipment and materials were also loaded in the cabin.
   c) The load was not secured with straps, tie-downs, or nets.
   d) Supervision of loading was not done adequately and responsibly.
   e) The distribution of the weight was not considered while calculating the position of CG.
9) Non-airline personnel and non-required crew were present onboard.
10) An abnormal CG location could not be determined as the characteristic factor for rapid rotation rate of the aircraft.
11) The presence of flammable items onboard exacerbated the fire situation in the cabin.
12) Flammable fluids and other dangerous goods were also found among the wreckage.
13) The relevant V-speeds used for the event flight were V_1 = 114 knots, V_R = 118 knots, calculated based on the incorrect page for 18,500 kg TOW in the speedcard for 18,137 kg TOW stated in the load and trim sheet. The required V-speeds for 18,137 kg should be V_1 = 117 knots and V_R = 122 knots.

14) The required relevant V-speeds for the estimated revised TOW of 18,300 kg are V_1 = 118 knots and V_R = 123 knots.

15) The interpolated speedcard of the operator for 18,500 kg TOW mentions incorrect V-speeds for take-off. The operator had been using the incorrect speedcard in all its flights, and the crew had neither noticed nor reported the error.

16) The operator failed to establish a robust Flight Safety Document System for the use and guidance of operational personnel as provisioned in CAAN FOR section 3.3.6.

17) An abnormally rapid pitch rate, as high as 8.6 degrees-per-second was calculated during take-off rotation.

18) Historical flight data of the operator revealed numerous noteworthy instances of abnormally high pitch rate during take-off.

19) A lack of operator's functioning FDM program/Flight Data Analysis (FDA)prevented the proactive identification and addressing of safety issues including repeated abnormally high pitch rate during take-off.

20) The ferry flight planning, preparation and execution of the event flight lacked efficient safety management capabilities including Management of Change principles.

21) Critical zones inside the airport and its periphery were neither classified nor discussed/practiced during the airport emergency exercises of TIA. An emergency periphery access gate (located near the accident site) of the airport was unserviceable/blocked for securing construction materials stored in the adjacent area.

22) Removal of baggage from the crash site on the event day and their transportation to the Saurya Airlines office, Sinamangal, is equivalent to evidence tampering. It shows negligence of airport authority to effectively perform responsibilities in the events of aircraft accident.

23) A Task Resource Analysis (TRA) for equipment and manpower in TIA was not conducted according to ICAO Service Manual 9137 - Part 1 and the Airport Services Manual which impacted the ARFF service during rescue operations.

24) There are inadequate requirements and SOP for the permission and operation of non-scheduled flights. CAAN lacked adequate acceptable means of compliance to provide permission for a ferry flight.

25) There is no specific checklist developed or available for the approval or acceptance of RTOW.

26) Routine ramp inspections weren't adequately performed by CAAN. Had it been done effectively, noncompliance regarding baggage/cargo loading and securing would have been proactively identified.

27) Important FDR parameters - Control Column, Rudder Pedals, Brake Pedal, and Flap Handle Position were not recorded in FDR of both fleet 9N-AME and 9N-ANM. The parameters included the control column positions and forces, which was of vital importance to the

analysis of the accident of 9N-AME aircraft. Both Operator and Airworthiness Division of CAAN were unaware of these lacking.

28) Saurya Airlines was found to have not fully complied with the provisions specified in section 4.2.4.3 of the sixth edition of FOR Nepal regarding issuance of operating instructions and providing information on airplane climb performance.

29) The Saurya Airlines operations manual does not reference the importance of a 3 degrees-per-second target for rotation rate.

3.2 Most Probable Cause

The most probable cause of the accident was a deep stall during take-off because of an abnormally rapid pitch rate commanded at a lower than optimal rotation speed.

3.3 Contributing Factors

The contributory factors to the accident are:

1. Incorrect speeds calculated based on erroneous speedcard. The interpolated speedcard of the operator for 18,500 kg TOW mentions incorrect V-speeds for take-off. This error in the speedcard went unnoticed since its development. There was no acceptance/approval of the speedcard booklet.
2. Failure to identify and address multiple previous events of high pitch rate during take-off by the operator.
3. The operator showed gross negligence in complying with the prevailing practices of ferry flight planning, preparation and execution. There is a lack of consistent definition of ferry flights.
4. Gross negligence and non-compliances by the operator during the entire process of cargo and baggage handling (weighing, loading, distribution and latching), while violating the provisions of operational manual and ground handling manual. The load was not adequately secured with straps, tie-downs, or nets, while the flight preparation was rushed.

4. Safety Recommendations

4.1 Interim Safety Recommendations

The AAIC had provided the following interim safety recommendations:

1. All operators shall immediately review their speed cards and RTOW charts.
2. All operators shall comply with the requirements of the cargo and baggage handling. Baggage and cargo weighing, its distribution and latching should be ensured as stipulated in the operation manual and ground handling manual.
3. Civil Aviation Authority of Nepal shall review and update the procedure and requirements for the permission of non-scheduled flights including all non-revenue and ferry flights.

4.2 All Operators

1. All operators of aircrafts in Nepal that have FDR/LDR installed shall immediately implement a FDM program and maintain a system of compliance with the findings of the program.
2. Operators shall revise and enforce SOPs to emphasize the requirement for achieving optimal rotation speeds during take-off. They shall include clear guidelines to address conditions where achieving such speeds may be challenging.
3. Operators shall clearly explain aircraft target rotation rates in their operating manuals and standard operating procedures. These target rotation rates should be evaluated and checked regularly during initial training, recurrent training, and routine line checks.
4. Operators should implement rigorous training programs focusing on proper rotation speed determination and recognizing pitch-up anomalies during take-off.
5. Operators shall move to digitize their flight operations resources such as speedcards and RTOW charts.
6. Operators shall implement robust training on cockpit authority management, which promotes voluntary occurrence reporting, and encourages the non-flying pilot to be assertive during mistakes made by pilot flying.
7. Operators shall conduct regular and comprehensive training sessions for ramp handling staff to reinforce their responsibilities, including supervising loading, identifying damaged or leaking packages, and ensuring proper cargo securing methods.
8. Operators shall strengthen mechanisms and assign accountability to supervisory personnel for overseeing cargo handling and loading operations. Supervisors must ensure strict compliance with established procedures, including the proper use of straps, nets, and verification of the integrity of netting straps to secure cargo effectively.

9. Operators shall implement a digital system to calculate cargo limits, distribution, and CG location during the loading process.
10. Operators shall immediately review and establish a thorough validation process to verify the accuracy of speedcards before use.
11. Operators shall update the airline's SOPs to include a mandatory pre-flight cross-check of V-speed values as part of the flight preparation process.
12. Operators shall develop SOPs for ferry, positioning and other non-revenue flights, and that only required personnel are on board. Additionally, when many personnel are on board, cabin crew be present for emergency evacuations.

4.3 Saurya Airlines

1. The airline shall establish and maintain a healthy and robust FDM program, staffed with capable human resources, as part of its Safety Management System. A competent FDM/FDA program would have noticed erratic judgements or shortcomings of the crew, such as rapid or unusually high pitch rates/angles during rotation for takeoff. A healthy and robust FDM program can identify risks and may identify erroneous FDR parameters proactively.
2. The airline shall revise and implement SOPs to emphasize the requirement for achieving optimal rotation speeds during take-off. They shall include clear guidelines to address conditions where achieving such speeds may be challenging.
3. The airline shall clearly explain aircraft target rotation rates in their operating manuals and standard operating procedures. These target rotation rates should be evaluated and checked regularly during initial training, recurrent training, and routine line checks.
4. The airline shall implement rigorous training programs focusing on proper rotation speed determination and recognizing pitch-up anomalies during take-off. Specifically, the airline shall revise and implement SOPs to align with the requirements of FOR section 4.2.4.3, ensuring clarity and accountability.
5. The airline shall immediately develop and issue the corrected speedcards to all operating crew members.
6. The airline shall strictly comply with weighing, loading, distribution and weighing, loading, distribution and securing of loads as per the provisions in the Operation Manual and Ground Handling Manual in all flights (including non-revenue) and ensure only trained personnel handle cargo operations.
7. The airline shall design and implement a comprehensive Fight Safety Document System tailored to the airline's operations.
8. The airline shall revise and implement SOPs to align with the requirements of FOR section 4.2.4.3, ensuring clarity and accountability.

9. The airline shall establish a transparent and efficient mechanism for reporting and addressing safety incidents or violations.
10. To ensure the effective implementation of flight safety functions, it is imperative that the position of Flight Operations Quality Assurance (FOQA) Manager, as required by Saurya Operations Manual (OM Part A, Section 1.5.1.7), shall be duly filled.
11. To rectify the notable discrepancies in the absence or improper functioning of critical roles, including the FOQA Manager and Instructor Pilot shall be addressed.

4.4 Civil Aviation Authority of Nepal (CAAN)

1. CAAN shall immediately establish a mandatory and robust flight data monitoring and analysis program applicable to all operators. CAAN shall also develop its own FDM/FDA capabilities.
2. As part of the renewal of C of A and ARC, CAAN shall mandate all the operators to submit the status of their flight data monitoring programs.
3. The Airworthiness Division of CAAN shall ensure that all required parameters are recorded in the FDR of all aircraft. CAAN shall conduct periodic checks of flight data to detect and rectify deviations from standard flight parameters.
4. CAAN shall include checks of all cockpit resources provided to crew, such as QRH or speedcards, as part of periodic flight safety inspections.
5. CAAN shall establish clear and detailed SOPs for the approval and operation of non-scheduled flights, including ferry flights. This shall cover application processes, criteria for approval, safety protocols, and post-operation reporting.
6. CAAN shall design and construct the runway strip in accordance with ICAO Annex-14 Volume-1 SARPs to minimize the damage to the aircrafts running off runway and to minimize the fatality during in-airport mishaps. The entire perimeter road at VNKT Airport shall be at a sufficient separation distance from the centerline of the runway as per ICAO standards.
7. CAAN shall enhance its oversight mechanisms to strictly enforce procedures, including securing cargo and baggage with straps, nets, and ensuring the integrity of netting straps. CAAN shall conduct random audits and spot checks to monitor compliance with the Ground Handling Manual.
8. CAAN shall develop a risk assessment framework to evaluate the operational, safety, and environmental risks associated with non-scheduled flights, with specific focus on ferry flights.
9. CAAN shall develop a specific checklist for the approval or acceptance of RTOW and landing weight.

10. CAAN shall monitor and enforce operators against including non-essential personnel to fly onboard the non-revenue flight.

4.5 Tribhuvan International Airport (VNKT)

1. The airport shall conduct a comprehensive risk assessment to identify and classify critical zones for rescue operations, based on proximity to runways, passenger terminals, fuel storage areas, and other high-risk locations within the airport and its surrounding areas.
   a. These critical zones shall be incorporated in the Airport Emergency Plans and revised to include comprehensive protocols tailored to each critical zone. These zones should be prioritized during emergency drills and exercises, while providing specialized training for airport staff and emergency responders on handling incidents.
   b. Establish and implement robust communication and coordination procedures to ensure smooth collaboration among various emergency response teams, including ARFF services, Nepal Army, Nepal police and airport authorities.
   c. Remove all obstructing construction materials from the vicinity of the emergency access door without delay and designate this access door as a no-storage zone and enforce strict compliance and conduct regular inspections to ensure that all emergency access points remain unobstructed at all times.
2. The airport shall perform a detailed TRA to evaluate the equipment and manpower requirements for ARFF services in accordance with ICAO Service Manual 9137 - Part 1 and the Airport Services Manual.
   a. Allocate sufficient resources based on the findings of the TRA to ensure ARFF services can operate at maximum capacity during emergencies.
   b. Provide advanced training to ARFF personnel to enhance their skills and readiness for diverse emergency situations.

4.6 Government of Nepal

1. Government of Nepal should establish a permanent investigation entity with sufficient financial, human and technical resources to competently meet the international obligation as per Annex 13 of the Chicago Convention.
2. The investigation commission should be tasked based on prevailing international practices.
3. The Government of Nepal should establish mechanisms to routinely review and investigate aviation related issues in Nepal.
4. The Government of Nepal should establish a mechanism to ensure implementation of all the safety recommendations made by the accident investigation commissions to the relevant organizations.

4.7 Manufacturer

1. The manufacturer shall review as to why the right angle of attack of the aircraft tends to rise earlier than the left. This is significant in the fact that the right wing may be prone to early stall.
2. The stick pusher activated after around 6 seconds of stick shaker activation. The stick pusher activation requirements should be further investigated.

5. Appendix

Appendix 1: Aircraft Weighing Report

See Attachment-1.

Appendix 2: Load Trim Sheet Submitted by Saurya Airlines

See Attachment-2.

Appendix 3: PIC Medical Examination Report

See Attachment-3.

Appendix 4: First Officer Medical Examination Report

See Attachment-4.

Appendix 5: Nepal Police Forensic Lab Report

See Attachment-5.

Appendix 6: Autopsy Report (National Public Health Laboratory)

See Attachment-6.

Appendix 7: Site Images

See Attachment-7.

Appendix 8: Aerodrome Safety Standard Department Audit Report

See Attachment-8.

Appendix 9: TIA SMS Audit Report

See Attachment-9.

Appendix 10: Flight Performance and Data Analysis

Aircraft Flight Manual

The flight manual (AFM) data were used to compute the aircraft stall speed, V speeds and other take-off performance and characteristics described in Chapter 2.4.

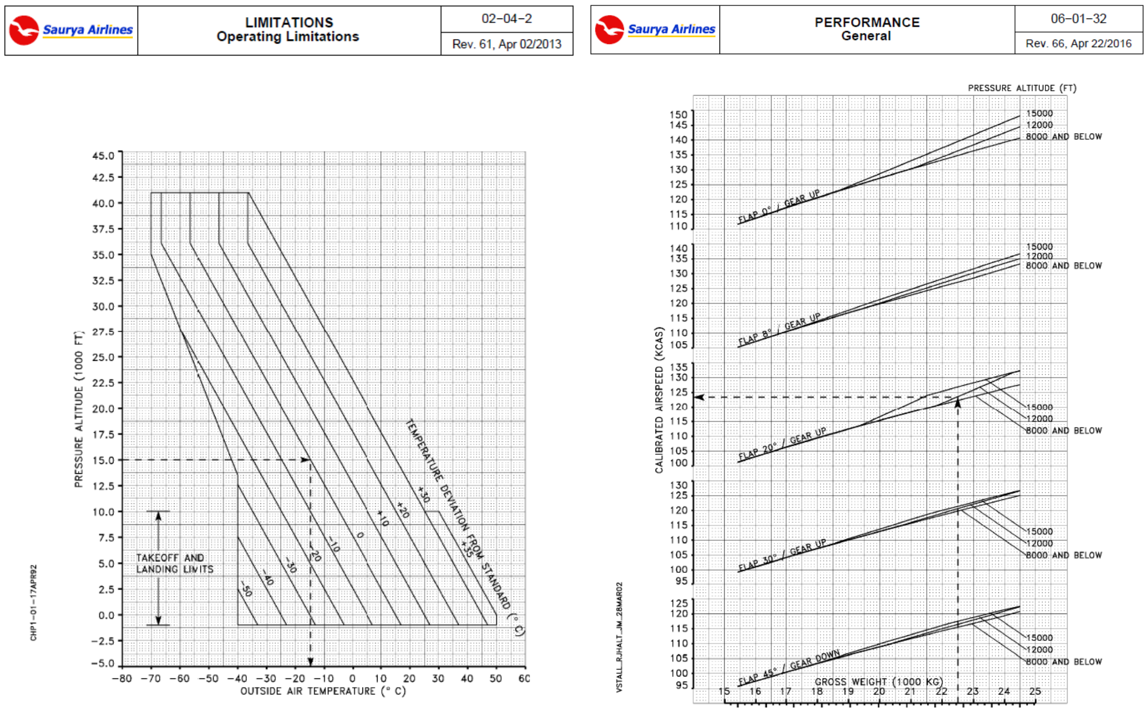
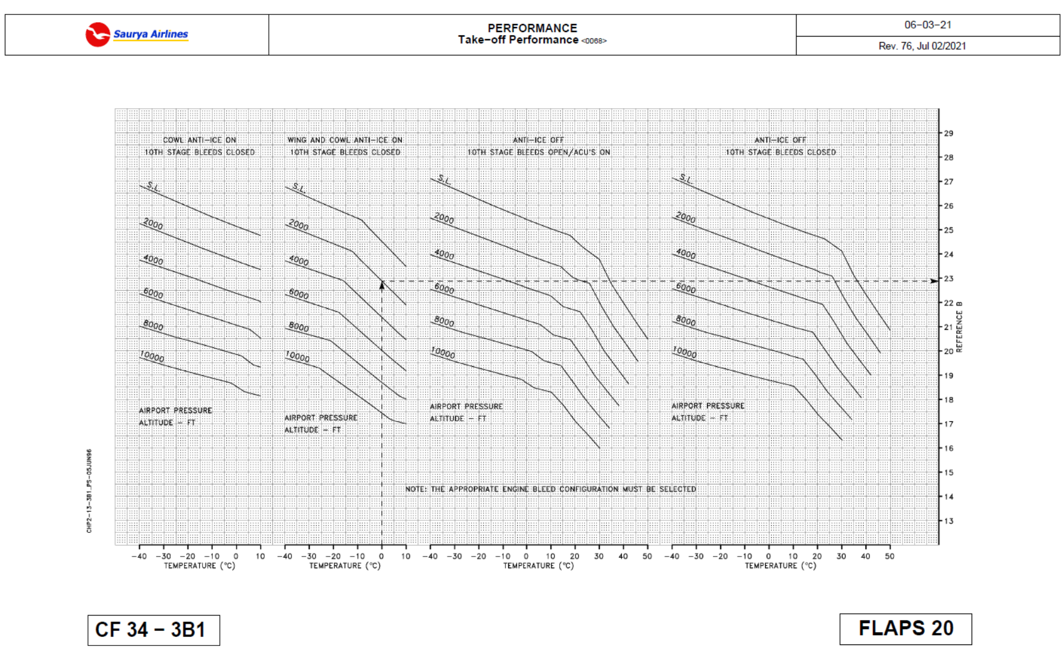
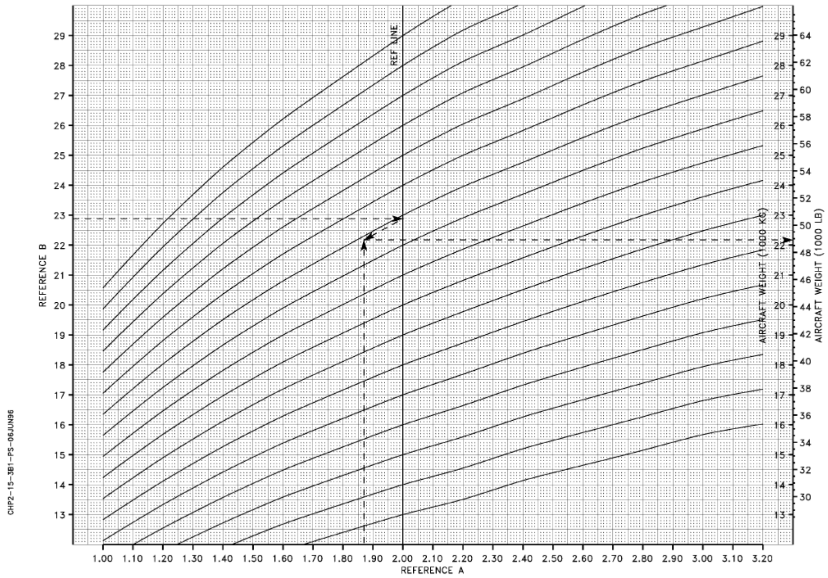


Figure A.10.1: Pressure altitude and stall speed



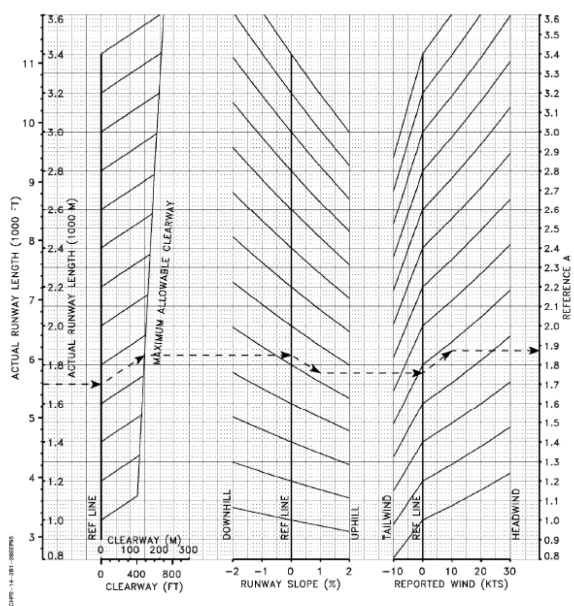
Saurya Airlines	PERFORMANCE Take-off Performance <0068>	06-03-22 Rev. 76, Jul 02/2021



CF 34 – 3B1 FLAPS 20

Take-off Weight Limited by Field Length Requirements (All Engines Operating) – FLAPS 20
Figure 06-03-5 (3 of 3)

Saurya Airlines	PERFORMANCE Take-off Performance <0068>	06-03-20 Rev. 76, Jul 02/2021

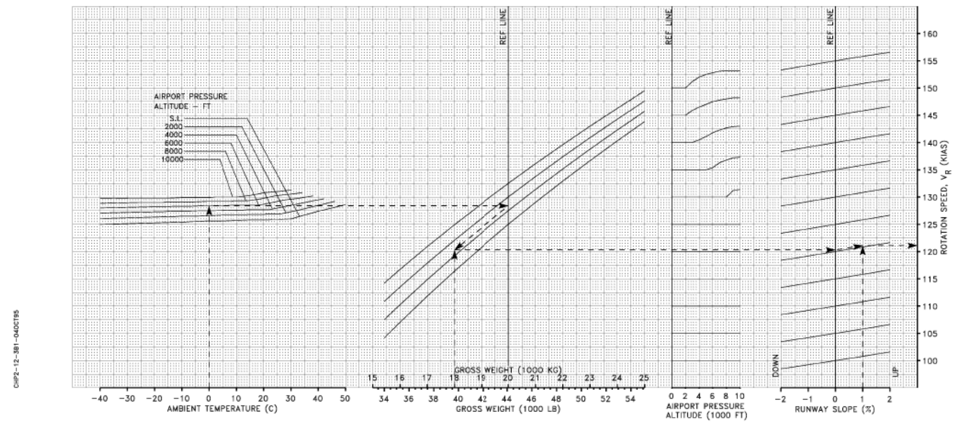


CF 34 – 3B1 FLAPS 20

Take-off Weight Limited by Field Length Requirements (All Engines Operating) – FLAPS 20
Figure 06-03-5 (1 of 3)

Figure A.10.2: Runway length requirement

Saurya Airlines	PERFORMANCE Take–off Performance <0068>	06–03–43
		Rev. 76, Jul 02/2021



CF 34 – 3B1

FLAPS 20

Rotation Speed (V_R) – FLAPS 20
Figure 06–03–11

DOT Approved	Airplane Flight Manual CSP A–012–140	

Figure A.10.3: Rotation speed

Saurya Airlines	PERF 1-24
	Rev. 74, Jul 02/2021

Speedcard – 18000 kg <TC> or <JAA> and <0006> and <0068> and <Metric>

18000 kg TAKE–OFF

Add 1 knot to V_1 & V_R for Wing & Cowl Anti–Ice ON or APR OFF/INOP

	Flaps 8 <0006>								Flaps 20						
	OAT	Altitude X 1000 ft							OAT	Altitude X 1000 ft					
	°C	SL	2	4	6	8	10		°C	SL	2	4	6	8	10
V_1 122	≤0	0	1	3	4	6	7	V_1 112	≤0	–1	1	3	4	6	7
	20	0	1	3	5	7	8		20	0	1	3	5	7	9
	30	0	2	5	7	8	9		30	0	2	4	6	8	10
	40	3	5	7	8	––	––		40	3	5	7	8	––	––
	50	5	7	––	––	––	––		50	5	7	––	––	––	––
V_R 125	≤0	0	1	2	3	4	5	V_R 117	≤0	0	1	2	3	4	5
	20	0	1	2	4	5	7		20	0	2	3	4	5	6
	30	0	2	4	5	6	7		30	1	2	3	5	6	7
	40	2	3	5	6	––	––		40	2	3	5	6	––	––
	50	4	5	––	––	––	––		50	4	5	––	––	––	––
V_2 137	≤0	0	0	0	0	0	0	V_2 126	≤0	0	0	0	0	1	1
	20	0	0	0	0	0	0		20	0	0	0	0	1	1
	30	0	0	0	0	0	0		30	0	0	0	0	1	1
	40	0	0	0	0	––	––		40	0	0	0	0	––	––
	50	0	0	––	––	––	––		50	0	0	––	––	––	––

V_{FTO} / V_{ENR}	FL	SL – 100	200	250	300	350	410
	KIAS	163	164	172	181	190	202

18000 kg LANDING

FLAPS	0°	8°	20°	30°	V_{REF} 45°	V_{2GA} 8°
V_{APPR}	160	148	142	138	130	137

<CRJ200_QRH_takeoff_hothigh_met_Jun09_18000.ps>

Saurya Airlines	PERF 1-25
	Rev. 74, Jul 02/2021

Speedcard – 19000 kg <TC> or <JAA> and <0006> and <0068> and <Metric>

19000 kg TAKE–OFF

Add 1 knot to V_1 & V_R for Wing & Cowl Anti–Ice ON or APR OFF/INOP

	Flaps 8 <0006>								Flaps 20						
	OAT	Altitude X 1000 ft							OAT	Altitude X 1000 ft					
	°C	SL	2	4	6	8	10		°C	SL	2	4	6	8	10
V_1 127	≤0	0	1	3	4	5	6	V_1 116	≤0	0	2	3	5	6	8
	20	0	1	3	5	6	8		20	0	2	3	5	7	10
	30	0	2	4	6	8	9		30	1	3	5	7	9	12
	40	3	5	6	8	––	––		40	3	5	7	9	––	––
	50	5	7	––	––	––	––		50	6	8	––	––	––	––
V_R 130	≤0	–1	1	2	3	4	5	V_R 122	≤0	–1	1	2	2	3	5
	20	0	1	2	3	5	6		20	0	1	2	3	4	6
	30	0	2	3	4	6	7		30	0	1	3	4	5	6
	40	2	3	4	5	––	––		40	1	3	4	5	––	––
	50	3	4	––	––	––	––		50	3	4	––	––	––	––
V_2 141	≤0	0	0	0	0	0	0	V_2 130	≤0	0	0	0	0	0	1
	20	0	0	0	0	0	0		20	0	0	0	0	0	1
	30	0	0	0	0	0	0		30	0	0	0	0	0	1
	40	0	0	0	0	––	––		40	0	0	0	0	––	––
	50	0	0	––	––	––	––		50	0	0	––	––	––	––

V_{FTO} / V_{ENR}	FL	SL – 100	200	250	300	350	410
	KIAS	168	169	177	186	196	208

19000 kg LANDING

FLAPS	0°	8°	20°	30°	V_{REF} 45°	V_{2GA} 8°
V_{APPR}	163	151	145	141	133	141

<CRJ200_QRH_takeoff_hothigh_met_Jun09_19000.ps>

Figure A.10.4: Tables for relevant V Speed references in QRH

Analysis of rotation for take-off

Analysis of the historical data of the Saurya airlines airplanes were performed to determine the rotation for take-off tendencies of the crew. Mainly, data from 2023 and 2024 were entirely analysed to monitor the pitch rate patterns.

Saurya Airlines	LIMITATIONS Operating Limitations	02−04−3 Rev. 61, Apr 02/2013

2. TAKE-OFF

A. Rotation Rate and Pitch Attitude

WARNING

Excessive rotation rates (exceeding 3 degrees per second) or over-rotations may lead to high pitch attitudes and angles of attack being attained while the aircraft is near the ground. This can reduce stall margins significantly, resulting in stick shaker/pusher activation and potentially loss of control. Pilots must rotate smoothly towards the target pitch attitude then transition to speed control.

Figure A.10.5 Limitations on rotation rates and angles provided in aircraft flight manual

Given that the suggested rotation for take-off should be performed smoothly with rotation/pitch rates of within 3 degrees-per-second (see Figure A.10.5), this rate was the initial criteria for the analysis of historical data. However, since the maximum rotation rates exceeded this value routinely, the analysis focused on cases where rotation rate were distinctly more than 4 degrees per second over a period of 2 seconds, and cases where the maximum rotation rates were close to or more than 5 degrees-per-second (degrees/second).

Table A.10.1 lists the cases of the 9N-AME flights that partially or fully meet the above criterion. The cases where, during take-off, the maximum rotation rates (*theta-by-t_max*) and the maximum average rotation rates over a two-seconds period (*theta-by-t_2s*) exceeded the above stated criteria are marked in bold.

Table A.10.1 Historical flight cases of 9N-AME with rotation rates deemed excessive

Date	**UTC**	***theta-by-t_max*** (degrees/second)	***theta-by-t_2s*** (degrees/second)	**Remarks**
March 11, 2023	03:08	4.5° /s	4.25° /s	
May 27, 2023	06:58	4.7° /s	3.85° /s	
May 27, 2023	09:07	4.6 °/s	3.8° /s	
May 30, 2023	**05:59**	**5.0° /s**	**4.05° /s**	

June 03, 2023	**08:43**	**5.1° /s**	**4.1 °/s**	
June 07, 2023	08:04	4.7° /s	3.4° /s	
June 08, 2023	**05:31**	**5.0° /s**	**4.0 °/s**	
June 09, 2023	10:13	4.1° /s	4.05° /s	
June 14, 2023	02:42	4.9° /s	3.3° /s	
June 30, 2023	05:27	4.7° /s	4.05° /s	
July 25, 2023	**05:34**	**5.1° /s**	**4.1° /s**	
September 26, 2023	**8:24**	**5.3° /s**	**4.6° /s**	
January 09, 2024	11:39	5° /s	3.8° /s	
January 11, 2024	**10:04**	**5.8° /s**	**4.35° /s**	• V_R.actual = 132.25 knots • TOW = 20,479 kg • V_R.required = 130 knots
February 15, 2024	09:03	5.1° /s	3.5° /s	
February 23, 2024	08:34	5.2° /s	3.2° /s	
March 19, 2024	**08:06**	**5.5° /s**	**4.8° /s**	• Flown by the same PIC as the event flight. • V_R.actual = 127.75 knots • TOW = 19,798 kg • V_R.req = 127 knots
May 04, 2024	04:03	5.6° /s	3.9° /s	

Table A.10.2 Selected historical flight cases of 9N-ANM with rotation rates deemed excessive

Date	**UTC**	***theta-by-t_max*** (degrees/second)	***theta-by-t_2s*** (degrees/second)	**Remarks**
June 24, 2023	06:51	5.98° /s	3.83° /s	
October 10, 2023	09:59	5.1° /s	3.3° /s	
May 07, 2024	**07:53**	**5.1° /s**	**4.2° /s**	

Appendix 11: Computation of Weight

Using the flight data for 9N-AME from June 19, 2024 (last day of the flight), Figure A.11.1 and Figure A.11.2 presents the probability density functions of the validation weight estimates of the 9N-AME aircraft. The gross weight was known from the load sheet to be 19,911 kg and 18,843 kg when it took-off from the VNCG and VNVT, respectively, on June 19, 2024. The validation has been conducted for aircrafts taking off from identical airfield conditions, while the computation of the weight for the event flight was performed relying solely on the take-off from VNKT, where the event took place. Hence, the data presented below is purely for validation of the weight estimation method.

The flight from VNCG in the Figure A.11.1 shows that the mean weight of the aircraft between 90 to 123 knots (V1 = 125 knots) is an approximate estimate of the actual aircraft weight within an error of the order of ±200 kg (corresponding to an uncertainty of ±1 knot in speed). Also, the weight estimated as 19,947 kg at V1 is the closest estimate of the aircraft weight at take-off. The same conclusion can be drawn for the data in Figure A.11.2. However, for the purpose of accounting for uncertainty of this computation method the mean values in the PDF could be referenced for a reasonable estimate of the aircraft weight at take-off, with a rounded error margin of 200 kg. The error in V-speed corresponding to the error in weight of 200 kg is approximately 1 knot.

Using the method explained above, the actual weight of the aircraft on the event flight was computed to be 18,300±200 kg. The mean value was obtained between a speed of 80 knots and 117 knots. The aircraft rotated for take-off near 120 knots. The weight of the aircraft computed at 114 knots was 18,236 kg.

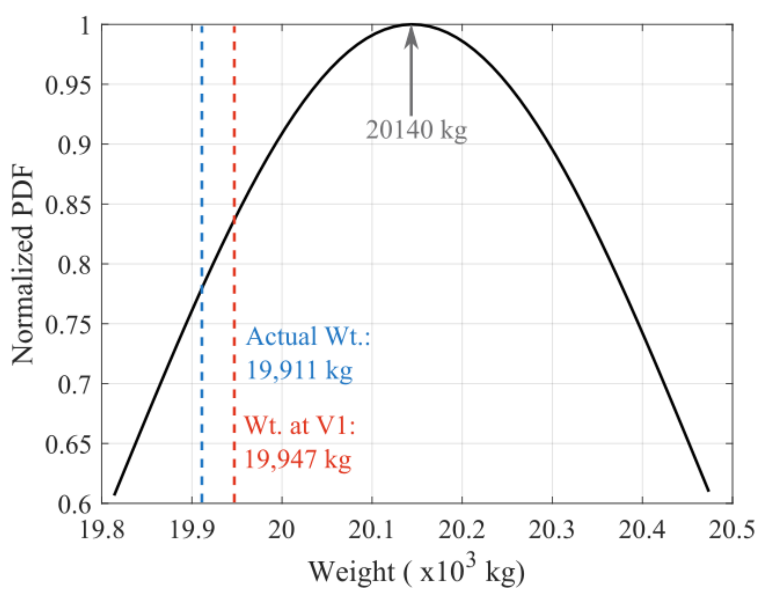


Figure A.11.1: Probability distribution function of the weight estimation ranged between of the 9N-AME flight taking off from VNCG on June 19, 2024.

The stated take-off weight of the aircraft in the load and trim sheet was 18,137 kg. Hence, the crude estimation of the aircraft weight was coincidentally close to the actual value. However, this does not imply that the weighing of baggage was done procedurally, and not weighing the baggage on board was a major lapse on the part of the ground operations and handling crew.

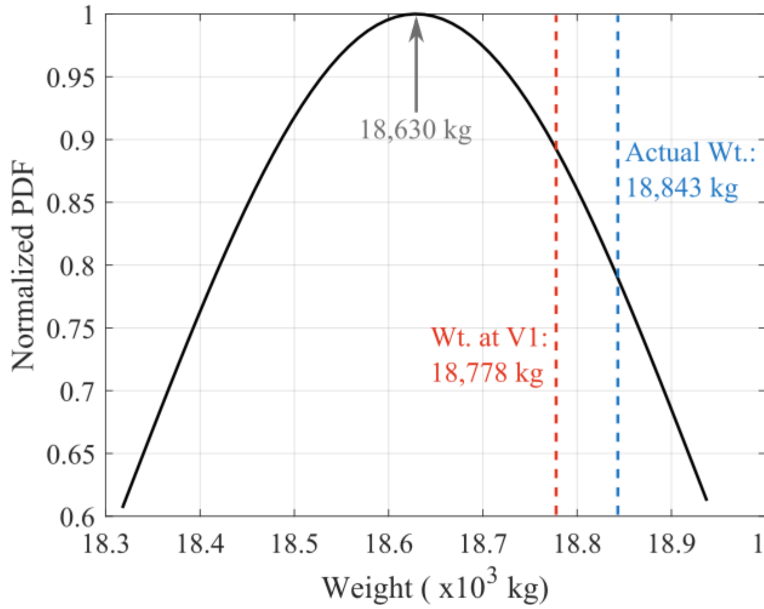


Figure A.11.2: Probability distribution function of the weight estimation ranged between of the 9N-AME flight taking off from VNVT on June 19, 2024.

Appendix 12: Simulator-Based Validation of Weight Computation Method

The weight of a simulated CRJ-200 aircraft was calculated using the current take-off equation method using X-Plane simulator. The figure below shows that the calculated aircraft weight approaches the actual weight of the aircraft at speeds close to rotation speed.

In the data presented, the mean weight of the aircraft computed between 90 and 120 knots is approximately 17900 and 19900 kg, for actual weights of 18000 and 20000 kg, respectively.

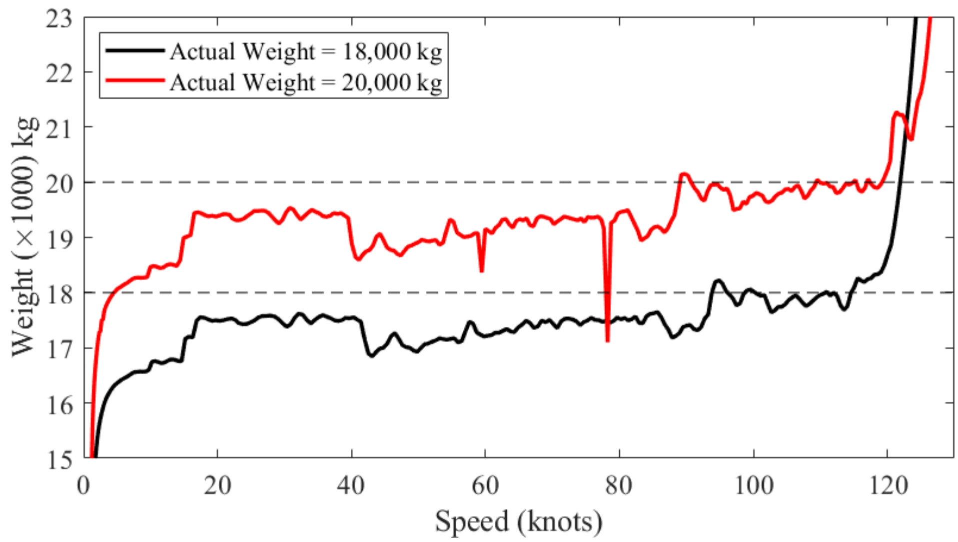


Figure A.12.1: Verification of the weight estimation method from flight simulation

Appendix 13: CAAN Comments on Draft Report

See Attachment-10.

Composition of Commission:

1)	Ratish Chandra Lal SUMAN	Chairman
2)	Deepu Raj JWARCHAN	Member
3)	Sanjay ADHIKARI	Member
4)	Dr. Sudip BHATTRAI	Member
5)	Mukesh DANGOL	Member Secretary