सत्यमेव जयते

Final Investigation Report on Accident involving Pawan Hans' S-76D helicopter bearing registration VT-PWI at Mumbai Off-Shore on 28 June 2022

Aircraft Accident Investigation Bureau

Government of India

Ministry of Civil Aviation

FOREWORD

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2017, the sole objective of the investigation of an Accident/Incident shall be the prevention of accidents and incidents and not to apportion blame or liability. The investigation conducted in accordance with the provisions of the above said rules shall be separate from any judicial or administrative proceedings to apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

Contents

GLOSSARY

AAIB	Aircraft Accident Investigation Bureau
AFCS	Automatic flight control systems
AMSL	Above Mean Sea Level
AOC	Air Operator Certificate
AOP	Air Operator Permit
AP	Autopilot
APCP	Auto pilot control panel
ARC	Airworthiness Review Certificate
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATO	Approved Training Organisation
ATPL	Aircraft Transport Pilot License
AUMCC	Australian Mission Control Center
AUW	All Up Weight
AVSEC	Aviation Security Basic Course
C of A	Certificate of Airworthiness
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CAR	Civil Aviation Requirements
CCD	Cursor Control Device
CoA	Certificate Of Authorization
CPL	Commercial Pilot Licence
CRM	Crew Resource Management
CVFDR	Cockpit Voice & Flight Data Recorder
CVR	Cockpit Voice Recorder
DCU	Digital Control Unit
DFDR	Digital Flight Data Recorder
DGCA	Directorate General of Civil Aviation
DME	Distance Measuring Equipment
EEC	Electronic Engine Controller
EEPROM	Electrically Erasable Programmable Read-Only Memory
EGPWS	Enhanced Ground Proximity Warning Systems
ERBS	Emergency Re-Breathing System
ETA	Estimated Time of Arrival
F/O	First Officer
FADEC	Full Authority Digital Engine Control System
FATA	Foreign Aircrew Temporary Authorization
FCM	Flight Control Module
FCOM	Flight Crew Operation Manual
FCTM	Flight Crew Training Manual
FCU	Fuel Control Unit
FD	Flight Director
FOQA	Flight Operations Quality Assurance
FTROL	Flight Radio Telephony Operators License
GPS	Global Positioning System
Hrs	Hours
HUET	Helicopter Underwater Escape Training
HUMS	Health and Usage Monitoring System

ICAO	International Civil Aviation Organisation
IESI	Integrated Electronic Standby Instrument
ILS	Instrument Landing System
INMCC	Indian Mission Control Centre
Kgs	Kilograms
KIAS	Knots-Indicated Air Speed
Kts	Knots
LH	Left Hand
LLZ	Localiser
m	meter
MBES	Multi Beam Echo Sounder
MEL	Minimum Equipment List
MFD	Multi Functional Display
MHz	Megahertz
MLG	Main Landing Gear
MRCC	Maritime Rescue Co-ordination Centre
MTOW	Maximum Take Off Weight
MV	Merchant Vessel
NDB	Non Directional Beacon
NLG	Nose Landing Gear
NM	Nautical Miles
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
ONGC	Oil and Natural Gas Corporation
OSV	Off-Shore Supply Vessel
PA	Passenger Address
PCP	PFD control panel
PF	Pilot Flying
PFD	Primary Flight Display
PIC	Pilot in Command
PLB	Personal Locator Beacon
PM	Pilot Monitoring
QRH	Quick Reference Handbook
RA	Radio Altitude
RFM	Rotorcraft Flight Manual
RH	Right Hand
SAR	Search and Rescue
SB	Service Bulletin
SEP	Safety and Emergency Procedures
SSB	Single Side Band
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
TRE/TRI	Type Rating Examiner / Type Rating Instructor
ULB	Underwater Locator Beacon
USBL	Ultra Short Baseline
UTC	Universal Time Coordinated
VCP	Virtual Control Panel
VHF	Very high frequency
VOR	VHF Omnidirectional Range
VRS	Vessel Reference System

SYNOPSIS

On 28 June 2022, Pawan Hans Limited's (PHL) Sikorsky S-76D helicopter bearing registration VT-PWI was planned to operate a crew change sortie to Sagar Kiran Rig of Oil And Natural Gas Corporation (ONGC) in Mumbai off-Shore. The helicopter was under the command of an ATPL (H) holder with another CPL (H) holder acting as a First Officer. There were 07 passengers on board.

The helicopter took off from Juhu at 0538 UTC for Mumbai off-Shore following "K" routing (K019). Estimated Time of Arrival (ETA) for Sagar Kiran was 0610 UTC. At about 0611 UTC, while the helicopter was at 500 feet and nearing approach, the crew lost control of helicopter and the helicopter crashed into the Arabian Sea about 1.5 NM from Sagar Kiran Rig.

The floatation devices got deployed as helicopter impacted sea. However, the helicopter toppled and turned upside down, though it continued to float. All the occupants could come out of the helicopter. Four persons including both pilots were able to hold on to the floating helicopter till the arrival of OSV Malviya – 16, which rescued them. Five passengers drifted into the sea out of which one was rescued by Sagar Kiran's rescue boat. Four passengers lost their life in the occurrence.

The occurrence was classified as an Accident as per Aircraft (Investigation of Accidents and Incidents) Rules, 2017 and Shri Jasbir Singh Larhga Deputy Director, along with Shri K Ramachandran, Assistant Director were appointed as Investigators to carry out investigation into circumstances of this accident vide order no. INV-11011/11/2022-AAIB dated 29 June 2022, under Rule 11(1) of Aircraft (Investigation of Accidents and Incidents) Rules, 2017. Assistance of Shri R S Passi, Ex-Director, AAIB; Capt. Y P Marathe, Type Qualified Pilot and Shri Shashi Raju Type Qualified AME was obtained as Subject Matter Experts during the course of Investigation.

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

SUMMARY

Final Report on Accident involving Pawan Hans' S-76D helicopter bearing registration VT-PWI at Mumbai Off-Shore on 28 June 2022			
1.	**Aircraft**	**Type**	Sikorsky S-76D
		Nationality	Indian
		Registration	VT-PWI
2.	**Owner**		M/s Vertical Aviation Group No1 Ltd
3.	**Operator**		Pawan Hans Limited
4.	**Pilot in Command**		ATPL (H)
5.	**Co-Pilot**		CPL (H)
6.	**No. of Persons on board**		02 Crew and 07 Passengers
7.	**Date & Time of Incident**		28 June 2022, 0611 UTC
8.	**Place of Incident**		Sagar Kiran (Offshore Helideck)
9.	**Co-ordinates of Accident Site**		19° 26' 30.048"N, 71° 54' 39.636"E
10.	**Last point of Departure**		Juhu
11.	**Intended landing place**		Sagar Kiran (Off-shore Helideck)
12.	**Type of Operation**		Off-shore Operation
13.	**Phase of operation**		Approach
14.	**Type of Occurrence**		Loss of Control In-Flight
15.	**Extent of Injuries**		04 Fatalities

(All the timings in this report are in UTC unless otherwise specified.)

1. Factual Information

1.1 History of Flight

On 28 June 2022, a Pawan Hans Limited's Sikorsky S-76D helicopter bearing registration VT-PWI was planned to operate a crew change sortie to Sagar Kiran Rig in Mumbai off-shore. Sagar Kiran is an off-shore rig operated by Oil and Natural Gas Corporation (ONGC) in the Arabian Sea at a distance of 57 NM from Juhu on radial 291. The helicopter was under the command of an ATPL (H) holder with another CPL (H) holder acting as a First Officer. There were 07 passengers on board.

The flight crew was detailed to carry out "crew change sorties" on VT-PWI as per the Flight Roster which was informed to them on the previous day i.e. 27 June 2022. On 28 June 2022, both the flight crew reported at Pawan Hans' Operations Centre at Juhu around 03:20 UTC. Both of them underwent their Preflight Medical checks including breath analyzer test. PIC also submitted an undertaking that he was not under influence of alcohol or any other psychoactive substance.

The crew was provided flight briefing by the Operations Control Personnel about the sortie to helideck on Sagar Kiran Rig. This was the first flight of the day, both for the flight crew as well as for the helicopter. There were seven passengers with 110 kgs of cargo on board. Fuel on board was 522 kgs. A signed copy of load and trim sheet was handed over to Operations Control Personnel by the flight crew.

Pre-flight inspection was carried out by an authorized AME and the helicopter was offered to the flight crew, which the PIC accepted. Helicopter taxied out to dispersal area where passengers boarded the helicopter and cargo was loaded. Pre-start, start up and after start up checks were carried out.

Safety briefing for the passengers was done through Passenger Safety Briefing video that is played in the Terminal Building. After briefing, all passengers moved to dispersal area for boarding the helicopter.

The helicopter took off from Juhu at 0538 UTC for off-shore following the "K" routing (K019). ETA for Sagar Kiran was 0610 UTC. The weather reported at the time of departure, as per the METAR showed winds as 170°/06 kts and visibility of 2500 m.

Take-off was uneventful and the helicopter climbed to 700 feet as instructed by the ATC. The helicopter was advised to report reaching 310°/25 NM. 'After take-off checks' were carried out by flight crew, the helicopter followed Radial 310° on Auto Pilot. Due to presence of CB clouds on course, helicopter took a diversion after getting clearance from the ATC. Later the original track 310° was resumed and ATC was intimated.

As instructed by the ATC, the helicopter changed over from Juhu ATC to ONGC control at 0548 UTC. After reporting to ONGC control (on 118.2 Mhz), the helicopter commenced climb to 3000 ft en-route at point 'P', the flight crew passed details of passengers, load, altitude and ETA to ONGC control. There was no other traffic *en-route*.

Approximately at a distance of 16 NM from destination helideck, descent was commenced by the flight crew. At a distance of 6-7 NM, the helicopter was at 500 feet AMSL. At about 5 NM from destination, crew carried out pre-landing checks. During the pre-landing checks, PIC who was Pilot Flying instructed the Co-Pilot, who was Pilot Monitoring to keep his side weather radar ON, due to poor visibility. Thereafter, FMS was programmed to position the aircraft on final approach track of 290° at 02 NM.

At about 06:07 UTC, the helicopter had contacted the Radio Officer of the Sagar Kiran Rig. As per the latest weather details shared by the Radio Officer, the prevailing winds were varying between 03-05 knots with bearing 340° and temperature of 26° with light rain/ precipitation.

At 1.5 NM from the Rig, the helicopter was aligned on finals. At that time, the helicopter was at a height of about 500 feet and maintaining speed of about 70 kts. Hereafter, PIC handed over controls to the Co-Pilot. Autopilot was decoupled at about 01 NM from destination helideck and visual approach was continued. PIC who was now Pilot Monitoring carried out checks on Finals. At about 300 feet altitude PIC called SPEED and went on to switch off the Co-Pilot side Weather Radar which had been left ON.

While the PIC was switching off the Weather Radar on Co-Pilot side, his attention was directed to EGPWS warning and an alarmed reaction from Co-Pilot with helicopter sinking at a high rate of descent. PIC took over control and tried to take recovery action. The helicopter, however, continued to descent and impacted the sea at 06:11:51 UTC.

The floatation devices got deployed on impact. However, the helicopter toppled and turned upside down, but continued floating. All the occupants could come out of the helicopter. The helicopter continued to float, but cabin was completely submerged. Wheels of the landing gear and a portion of tail rotor were visible. Initially five occupants including both pilots managed to hold on to the floating helicopter. Three passengers drifted into the sea.

Emergency Response was triggered by Sagar Kiran for “helicopter ditching near the rig” and a rescue boat was launched with a rescue team. At the same time, an Off-shore Supply Vessel (OSV Malviya-16) was also instructed to make immediate approach for Search & Rescue and a team was constituted for continuous monitoring.

At that point the helicopter was visible at a distance of about 1 NM from the rig. The rescue team observed two persons floating in the sea, motionless. One person was observed swimming and calling for help and was rescued by the rescue team.

The rescue boat after rescuing one survivor headed to the Rig. The rescue boat did not attempt to retrieve motionless passengers who were observed floating in the sea or offer any assistance to those holding on to the floating helicopter keeping safety of rescue team in mind. Meanwhile, one of the passengers who had initially held on to the floating helicopter lost his grip and also drifted into the sea. After arrival of Malviya-16 at around 0655 UTC, all four persons holding on to the floating helicopter were rescued and brought aboard. Thereafter, the helicopter sank into the sea.

In the meantime, Navy and Coast Guard aircraft also launched search and rescue. Remaining 04 persons who were reported unconscious were picked up by Coast Guard/ Navy helicopter between 0750 – 0835 UTC and transported to Hospital at Juhu, where they were declared dead. Survivors were also flown to Juhu and hospitalized. Search and Rescue was terminated at 0900 UTC.

Thereafter, search for the helicopter wreckage was initiated with the help of SONAR and associated equipment installed on “Great Ship Aarti” in the area surrounding the point of ditching. Search for wreckage continued till early morning of 03 July 2022 when location of wreckage was confirmed on the sea bed. Retrieval of the wreckage was carried out on 06 July 2022 with the help of crane & other equipment by the divers from ONGC ship “Samudra Sevak”.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	Nil	04	Nil
Serious	Nil	02	Nil
Minor	02	01	Nil

1.3 Damage to Aircraft

The helicopter was destroyed in the accident. The helicopter wreckage was lying on the sea bed in up-side down position and retrieved in same condition on 06 July 2022. The wreckage was positioned on the ship by crane and later set upright on the ship deck. The wreckage was brought ashore at Nhava port and transferred to a shipping container for transportation to Juhu by road.

Figure 1: Damage to helicopter

Major damages and observations made on the helicopter wreckage are as below:

Cabin and Nose Section

- There was no significant damage to Nose portion, Passenger cabin and Flight control deck.
- All pylon fairings, MGB fairing, Engine intake, Engine cowling and exhaust cowling were found intact on both sides.

- Right side pilot door was found damaged and middle row window was found jettisoned and missing.
- Left side pilot door was not available and Left side passenger windows were not available.
- Nose landing gear was found detached. There was impact damage on the belly below pilot's seat forward of Right side wheel well.
- Actuators and struts linkages of both main landing gears were found broken.
- MLG assemblies were found partially folded under the aircraft. NLG shock-strut and wheel and tire assembly were separated from the NLG cylinder and had protruded into the passenger cabin.

Tail Section

- Bottom side of tail boom was found ruptured from fuselage attachment.
- Tail cone assembly was found detached from forward of the tail stabilizer.
- Tail drive shaft faring was found damaged and partially detached.
- Right side stabilizer was found damaged but attached.
- IGB casing was found damaged. TGB was found broken and separated.
- Tail rotor blades (03 in number) were found broken and missing. One blade was found damaged.
- Tail rotor retaining plates, pitch change horn were intact and pitch link was found broken.
- TGB casing was found damaged and TGB faring was not available.

Main Rotor

- Yellow, blue and red blades had fractured from very close to the root (attachment). The black blade got sheared off from the hub assembly on the main rotor head.
- The main rotor head bifilar assembly on the left side of the black blade was bent approximately 45° at a downward angle. The yellow blade pitch control link was missing. It had broken at the swash plate attachment point and was not attached to the main rotor head.
- Output side of the Section V tail rotor drive shaft was sheared at the point where the driveshaft goes into the intermittent gearbox fairing.
- The yellow tail rotor blade root end was intact. This blade sustained damage to the leading edge and was broken off at the blade root. The other three blades were not available and had separated at the blade root assembly with rotational damage.

Engines

- Both engines did not show any sign of damage, other than corrosion from the saltwater and element exposure. Visual inspection of both engines was conducted and no significant damage was noted. Boroscopic inspection did not reveal any abnormality in the core engine.

Floats and Life Rafts

- Nose LH and RH floats had operated, but got damaged though they remained attached to the helicopter.
- LH and RH floats of main wheel were found attached to the helicopter in deflated condition.
- LH and RH Life rafts pods got sheared off from the hinges and had separated from the inflation system.

- Pneumatic pipe lines to RH Life Raft Pod broke off from the attachment points and the RH Raft was missing. LH Life Raft Pod was missing along with the pneumatic pipe lines connecting it to the Inflation System.

Figure 2: Aircraft side pneumatic connection to Life Raft Pods (left side and right side)

- External life raft release handle was found intact with protection cover intact. The above damages include impact damages and those unavoidable additional damages which were suffered during retrieval.

1.4 Other damage

There was no other damage.

1.5 Personnel Information

1.5.1 Pilot in Command

Age	54 yrs
License	ATPL (H)
Date of Initial Issue of ATPL(H)	01/12/2016
Valid up to	30/11/2026
Date of last Medical Exam	16/09/2021
Medical Exam valid up to	20/09/2022
FRTOL issued on	31/01/2013
FRTOL valid up to	30/01/2023
Total flying experience	6763 hrs (approx.)
Total flying experience as PIC on helicopters	3772 hrs (approx.)
Total flying experience as on Type	94:22 hrs
Total flying experience as PIC on Type	51:10 hrs
Total flying experience as Co-pilot on Type	43:12 hrs
Total flying experience in Off-shore operations	2600 hrs (approx.)
Total Flying experience as PIC in Offshore operations	910 hrs (500 Hrs as Pilot under supervision)
Total flying experience during last 30 days	73:52 hrs
Total flying experience during last 07 days	28:42 hrs
Total flying experience during last 24 hrs	03:59 hrs

PIC is an ex-military pilot. He had his initial flying training and experience on single engine Cheetah and Chetak Helicopters. He later moved on to flying twin engine Mi-25/35 helicopters. He had his first off-shore flying experience while on deputation with the Indian Coast Guard.

The PIC took premature retirement from military in 2013 and took employment with a non-scheduled helicopter operator flying Dauphin N3 helicopter. After about 1.5 year of flying with the said operator, PIC joined Pawan Hans in May 2015 and continued to fly Dauphin N3 helicopters in different environment like Andaman & Nicobar Islands, North-East part of India, Off-shore oil fields etc.

PIC was amongst the 08 pilots initially shortlisted by Pawan Hans for conversion to S-76D helicopter. PIC underwent Simulator Training and Ground Training in June-July 2021. The training consisted of 56.50 hrs of Ground Training and 32 hrs of Flying Training on Simulator. His skill test (Day & Night) was done on 03 July 2021 and he returned back to Pawan Hans. Since S-76D helicopters were not operational yet, he continued flying on Dauphin N3.

PIC could start flying S-76D helicopter nearly nine months after undergoing Simulator training at ATO when he underwent PPC on 05 April 2022. He also underwent 04 off-Shore Training Exercise with TRI on 08 and 09 April 2022. On 11 April 2022, he cleared his functional Flight Check and on 12 April 2022, he cleared off-shore release check. On 13 April 2022, PIC underwent IR renewal check. During the IR renewal check, the TRI gave the following remarks on the checklist:

'PIC need to get more familiar with Cyclic Trim Release'.

PIC was accepted by ONGC for off-shore flying on 02 May 2022 and started flying S-76D. He had accumulated 94:22 hrs on S-76D till the day of accident. Details of Ground Recurrent Training are given in the table below:

Type of training	**Date of Conduct**	**Validity**
Technical & performance refresher	07/04/2022	04/04/2023
SEP Training	13/04/2022	12/04/2023
Specific Ground Training	26/02/2022	25/02/2023
CRM Training	12/08/2021	11/08/2022
AVSEC Training	12/11/2021	11/11/2023
DGR Training	22/02/2022	10/03/2024
HUET	29/12/2021	28/12/2024

1.5.2 Co-Pilot

Age	54 yrs
Licence	CPL (H)
Date of Initial Issue of CPL(H)	27/05/2009
Valid up to	07/03/2026
Date of last Medical Exam	04/01/2022
Medical Exam valid up to	03/02/2023
FRTOL issued on	11/12/2008
FRTOL valid up to	Life time
Instrument rating	Valid
Total flying experience	5281 hrs
Total flying experience as PIC on helicopters	3300 hrs

Total Flying experience in Off-shore operations	956 hrs (co-pilot)
Total Flying experience as PIC in Offshore operations	Nil
Total flying experience as Co-pilot on Type(S-76D)	72:41 hrs
Total flying experience during last 30 days	39:35 hrs
Total flying experience during last 07 days	15:04 hrs
Total flying experience during last 24 hrs	03:59 hrs

Co-Pilot is also an ex-military pilot. He had mainly flown Mi-8, Mi-17, Mi-17-1V & V5 helicopter while serving military. He joined Pawan Hans in March 2019 under MoU between Pawan Hans and Indian Air Force wherein volunteers are sought from IAF by Pawan Hans and selected based on qualification requirements decided by PHL.

At Pawan Hans, he underwent Type training on Dauphin N3 and started flying Dauphin N3 from Sep 2019. He flew as co-pilot on Dauphin N3 flying on-shore before being moved to Pawan Hans' Western Region. In March 2020, he was cleared for off-shore flying and gained over 900 hrs of off-shore experience as Co-Pilot.

In response to an Internal Circular issued by Pawan Hans in early 2021, Co-Pilot applied for S-76D training. He underwent Simulator Training and Ground Training in Aug 2021. Training consisted of 56:50 Hrs of Ground Training and 32 Hours of Flying Training on Simulator. His skill test Day & Night was done on 14 Aug 2021 and he returned back to Pawan Hans. Since S-76D helicopters were not operational yet, he continued flying on Dauphin N3 as co-pilot.

Co-Pilot could start flying S-76D helicopter nearly 7 months after undergoing Simulator Training at ATO when he underwent proficiency check on 06 Apr 2022 with the TRI on S-76D. On 10 Apr 2022 he did his off-shore flying and was released for off-shore flying on 12 April 2022. ONGC accepted co-pilot for off-shore flying on 16 May 2022 and co-pilot started flying S-76D helicopter. He had accumulated 72:41 hrs on S-76D till the day of accident. Details of Ground Recurrent Training are given in the table below:

Type of training	Date of Conduct	Validity
Technical & performance refresher	07/04/2022	04/04/2023
SEP Training	13/04/2022	12/04/2023
Specific Ground Training	08/12/2021	07/12/2022
CRM Training	07/12/2021	06/12/2022
AVSEC Training	17/09/2021	16/09/2023
DGR Training	03/03/2021	31/03/2023
HUET	01/08/2019	31/07/2022

1.6 Aircraft Information

1.6.1 General Description: S-76D

Sikorsky S-76D is a twin engine transport helicopter, which can carry up to 14 passengers. The accident helicopter has the offshore/ utility configuration and has got two flight crew seats and twelve forward facing seats. It has a four bladed fully articulated main rotor system and a four bladed tail rotor. It is equipped with Dual Automatic Flight Control Systems (AFCS) and is single-pilot certified helicopter. It is powered by two PW210S engines, has a fixed stabilizer and a fully retractable tricycle landing gear.

The S-76D has a four-axis autopilot. This means there are actuators that control the aircraft in each axis: pitch, roll, yaw, and collective. The four-axis control is fundamental to the AFCS which provides fully automatic vertical and lateral autopilot guidance.

The term “Coupling” refers to flight director modes. The pilot will engage coupled modes using the Auto Pilot Control Panel (APCP). 3-Cue coupling means airspeed is controlled in the pitch axis (trim beeper adjusts airspeed), the heading is controlled in the roll axis (This is heading mode or NAV), Altitude is controlled in the collective axis (collective trim adjusts altitude)

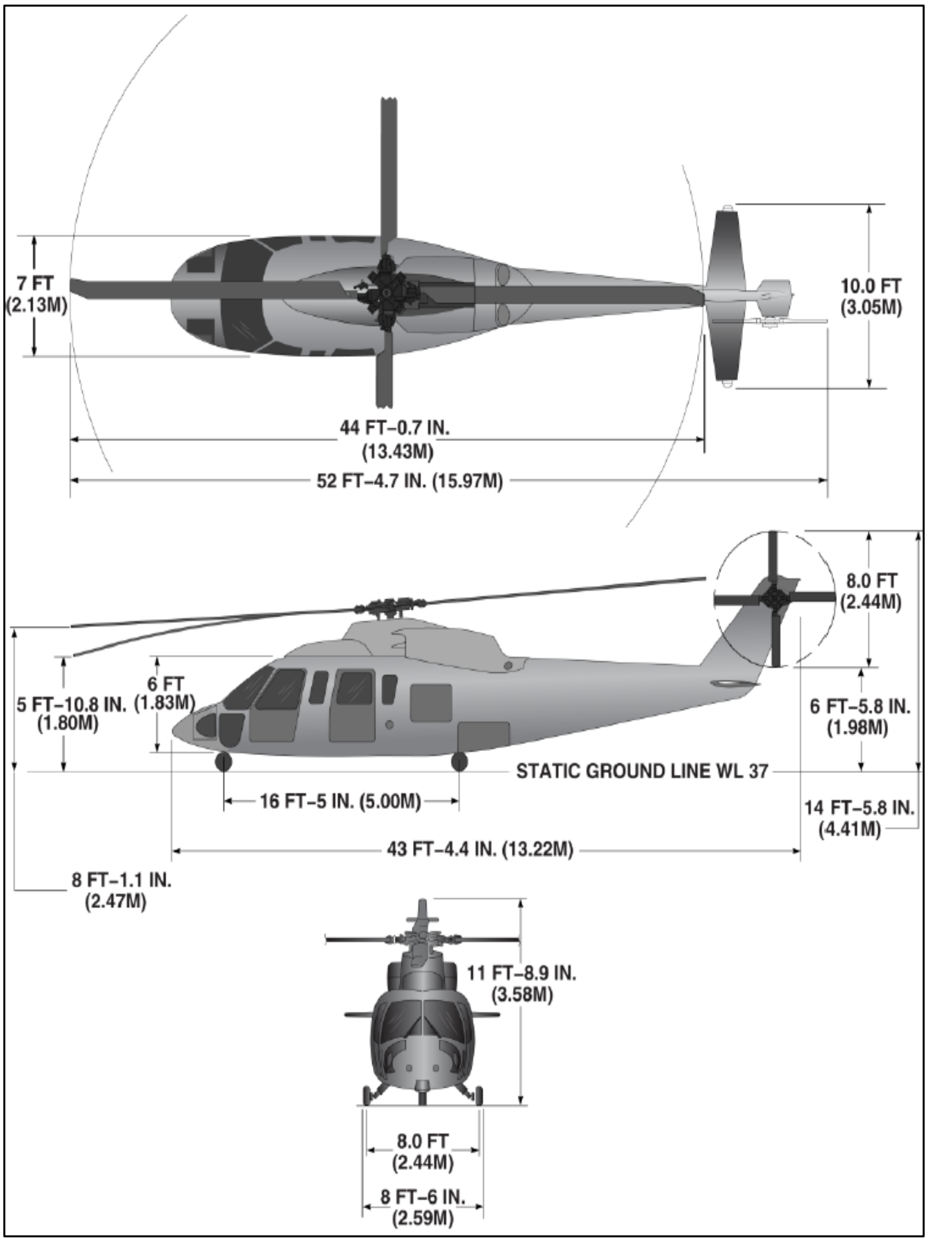


Figure 3: Sikorsky S-76D Helicopter dimensions

The three trim switches on the center console allows the pilot to turn trim ON or OFF. The RFM Normal Procedures direct the pilot to verify trims are ON. The stick trims must be ON for normal full AFCS operation. The trim actuators provide full authority slow rate AFCS inputs to the flight controls. The trim actuators also provide an artificial trim force gradient resulting in a positive and increased centering force as the controls are displaced from the centered positions. There are trim release buttons on the cyclic, collective, and pedals that when pressed release the control forces until the trim release button is released.

The helicopter is equipped with a dual channel full authority AFCS that is integrated into the avionics suite. Communications, navigation, radar, EGPWS (HTAWS) are all fully integrated into the system.

Being a recent introduction, only a very limited numbers of S-76D have been built. These are mostly operated by agencies like paramilitary forces, offshore operators on contract with oil companies and corporate entities. Whereas there are number of operator flying S-76C and S-76C++ helicopters in India, only one operator was flying S-76D helicopter in India at the time of induction of this helicopter in Pawan Hans.

1.6.1.1 Cockpit Displays

There are seven displays in the cockpit. Four are Display Units (DUs) located in the instrument panel. The DUs located in the outboard positions of the instrument panel function only as Primary Flight Displays (PFDs). The DUs located inboard of the PFDs function primarily as Multi-Function Displays (MFDs).

Additionally, there are two Multifunction Control and Display Units (MCDUs) located in the forward portion of the lower console. One Integrated Electronic Standby Instrument (IESI) is installed in the upper centre position of the instrument panel.

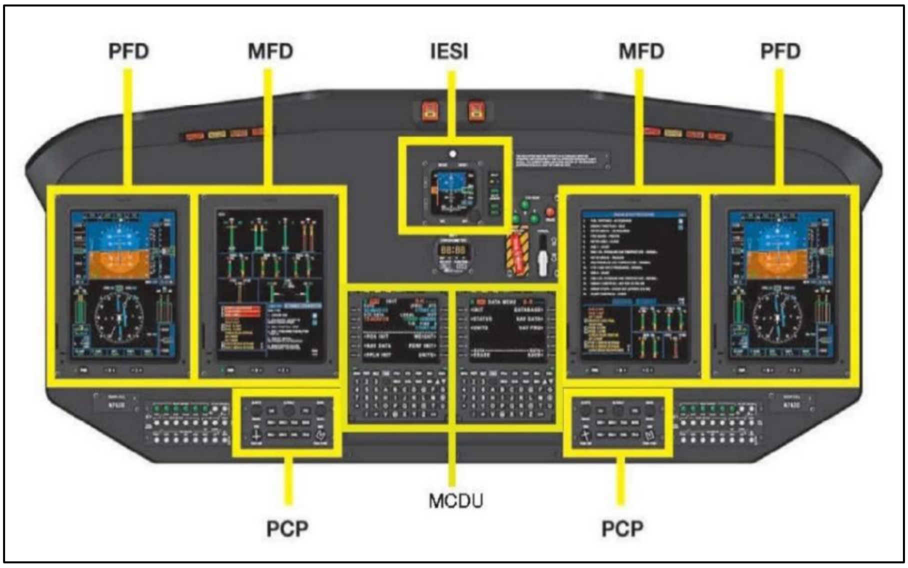


Figure 4: Cockpit display

1.6.1.2 Weather Avoidance Radar

The aircraft is equipped with Primus 660 weather avoidance radar. It is powered on by the switch on the overhead switch panel which puts it into the standby mode. Thereafter, the individual pilot needs to select own side radar display to be switched on using the Virtual Control Panel (VCP). The process requires manipulating the cursor using the Cursor Control Device (CCD) and mouse and is a multi-step process. The Cursor Control Devices are the primary means for interacting with FD menus and features.

The radar can be placed in standby mode (non-radiation) by selecting standby on both pilot and co-pilot VPCs. In addition, Forced standby is an automatic, non-selectable mode that inhibits the transmitter on the ground (weight-on-wheels detected) to eliminate an X-Band microwave radiation hazard. But forced standby is not an option for a helicopter that is in flight and going to land in vicinity of personnel or oil installation, as equipment would continue radiating during approach, hover and touchdown.

Figure 5: Weather avoidance radar – CCD and VCP

The weather radar can quickly be turned OFF, with a single button press using the weather radar button on the pilot's overhead panel. This procedure is published in FCOM as below:

> *"In some environments, the crew may need to secure the weather radar prior to landing. This is normally done using the weather radar's Virtual Control Panel (VCP). Of note, the pilot and co-pilot weather radar VCP controls are independent, therefore, both sides must be secured independently. If the PF workload is too high during the approach, the PM should use the offside Control Cursor Device (CCD) and VCP to secure the PF's weather radar. If the crew needs to immediately secure the weather radar, this can be done by pressing the WX RADAR button on the pilot's overhead switch panel; this turns the weather radar off. The disadvantage is that the weather radar will need to "warm up" after turning back on, which can take up to 2 minutes."*

1.6.1.3 Cyclic and collective controls

Cyclic Control Stick

The cyclic control stick changes the pitch of the main rotor blades to provide longitudinal and lateral control. Displacement of the cyclic stick is limited by system stops in the control channel.

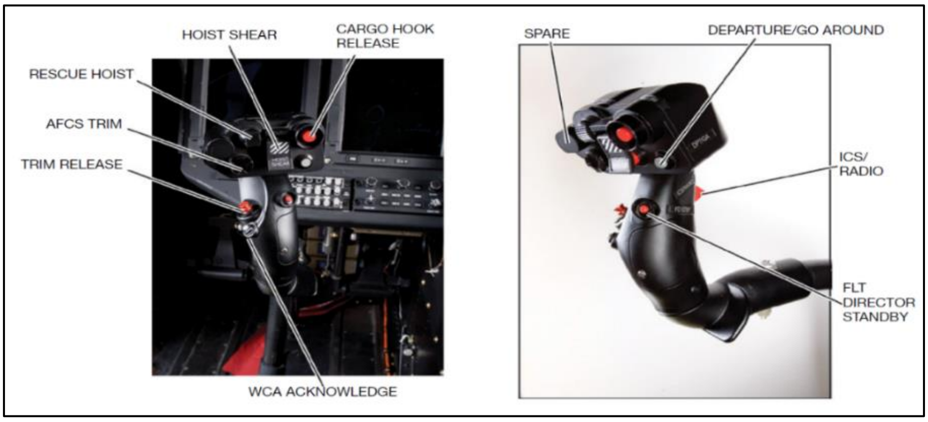


Figure 6: Cyclic Control Stick

Collective Pitch Lever

The collective pitch lever increases or decreases the pitch of the main rotor blades. Displacement of the collective stick is limited by system stops in the control channel. The collective pitch lever may be trimmed to any desired position by use of the trim system.

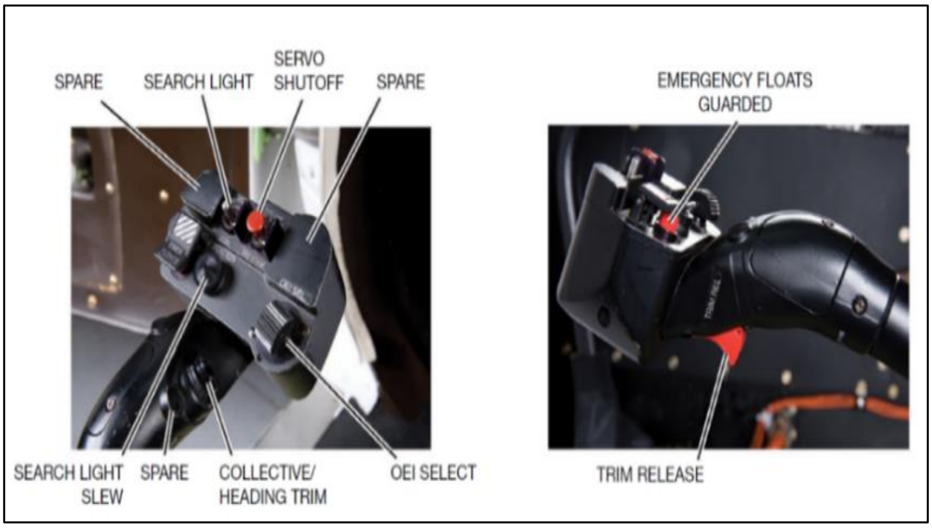


Figure 7: Collective Pitch Lever

1.6.1.4 Autopilot

The Automatic Flight Control System (AFCS) enhances aircraft stability and handling qualities and permits fully automatic vertical and lateral autopilot guidance. The AFCS is fully dual redundant design in all features except trim actuators and provides continued basic operation after any single failure. Pilots can control the two autopilots *via* a single Autopilot Control Panel (APCP) located in the center console. APCP is centrally located on the cockpit lower console and can be accessed from either pilot or co-pilot position.

Pilot interacts with the Flight Control Module (FCM) using the APCP and by setting values of course, speed, and altitude on the PFD and FMS.

Figure 8: Autopilot controls

Additional pilot interface is made through the PFD Control Panels (PCP) located on the instrument panel and through switches located on the cyclic and collective grips. The main components of the AFCS are the two separate and identical Flight Control Modules (FCM) that receive data from various aircraft sensors. Each FCM performs the functions of an Autopilot (AP) and Flight Director (FD). AFCS control inputs are enabled *via* electrically powered series actuators and parallel trim actuators.

1.6.1.5 Flight Control Module

Each FCM consists of two independent computers running the same software. These two processors compare their calculated results to detect any processing or computation error. The FCMs receive data from aircraft sensors and commands from pilot interface switches. These data are processed and signals are sent to the flight control servos to increase aircraft stability and/or control its flight path. FCM inputs are also made to the PFD to provide flight path guidance. Each FCM performs continuous internal health monitoring.

The pilot primarily interfaces with the AFCS through the APCP. Pilot can select simplex autopilot (AP 1 or AP 2) or duplex autopilot (AP 1 and AP 2) operation, select a primary stability mode (SAS or ATT), and engage and couple the flight director modes. It provides visual annunciation of any engaged or armed autopilot modes, the selected PFD providing the navigation source to the autopilot and flight director couple status. Pilots can use the PFD Control Panel (PCP) to select heading (HDG), course (CRS), altitude (ALT SEL), and navigation (NAV) source. The PCPs are located below the MFDs.

The ATT mode provides stabilization and attitude retention, heading hold and turn coordination, and auto trim. The ATT mode is activated by pressing the ATT button on the APCP. As per the Normal Procedures ATT mode is required to be engaged before taxi out and kept engaged throughout the flight.

Attitude Retention Mode is a basic AFCS function and not a Flight Director Function. When coupled to the FD 3-cue, the aircraft will maintain a set airspeed, altitude, and flight path. If the aircraft flight path is disturbed by environmental conditions, the FD will return the aircraft to the defined flight path when coupled. The FD modes cannot be coupled below 50 KIAS.

The Basic AFCS modes include SAS and ATT. SAS provides rate stabilization and ATT provide attitude retention, heading hold, turn coordination, and auto trim. These features improve aircraft flight handling qualities and reduce overall pilot workload through the flight envelope.

When flying the Basic AFCS the pilot must “trim” the aircraft. This is done in the pitch and roll axes by pressing the trim release switch on the cyclic, flying the aircraft to the desired pitch attitude, then releasing the trim release button. While flying the aircraft using Basic AFCS, the pilot will frequently press, then release the cyclic trim button to re-reference pitch attitude. This is required when taking off, changing airspeeds, or establishing an approach to landing. If the pilot does not re-reference trim by pressing and releasing the trim release switch, the ATT mode will return the cyclic to the previously trimmed position.

In flight the pilot can make small pitch attitude changes using the cyclic trim beeper, this can provide greater precision in achieving airspeed or making a gradual deceleration. In flight, ATT will maintain the roll attitude within 1 degree. In the roll axis, the pilot can press and release the cyclic trim button to re-reference the roll attitude. But the pilot should turn the aircraft by using the cyclic trim beeper or apply force on the cyclic, against trim "fly through" to attain a desired heading. These methods provide better precision than trim release and will not upset pitch attitude.

The Flight Check Procedures Manual describes the expected performance of Basic AFCS. Review of the ATT Mode Checks, SAS Modes, Heading Hold and Yaw Beep Check, and Collective Trim Check outlines basic AFCS performance and characteristics. Autopilot control inputs for this mode are made *via* the SAS and trim actuators. Adjustments to the trim attitudes can be made with the cyclic beeper switch or by utilizing the trim release to establish a new trim attitude.

While operating in ATT mode, the reference roll attitude (which the autopilot is attempting to hold) is indicated on the PFD by a blue triangle located on the roll scale as can be seen in Figure 9**.**

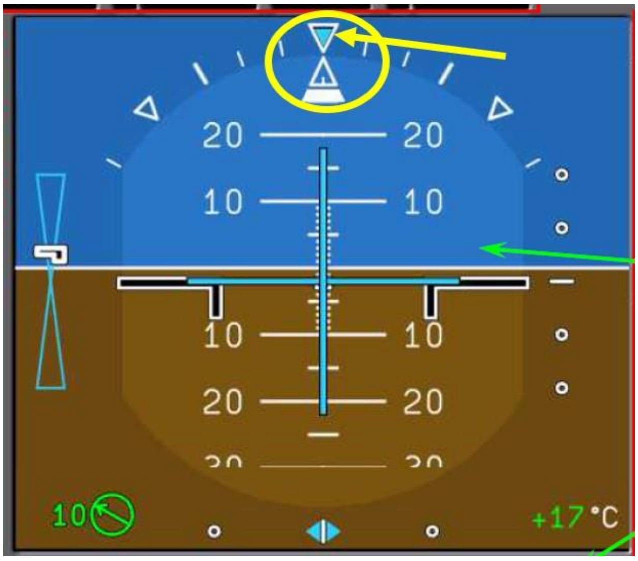


Figure 9: Blue triangle on PFD

This reference is crucial for operation of stabilised flight in the absence of a clear horizon when flying uncoupled.

A note in the S-76D RFM states that *"Manually flying against trim on the collective (or cyclic if ALT is engaged on the pitch) will not change the commanded reference altitude. During this manoeuvring the reference will be kept which the AFCS will recapture and maintain after the controls are released".*

1.6.1.6 Trim

Trim provides a force gradient that holds the cyclic, collective and pedals in their set position and moves the flight controls in response to flight director inputs. Inputs provided are observed in the flight controls and are referred to as outer-loop inputs. Trim is the component of the AFCS which provides the 'muscle' to provide attitude retention and long-term stability. Trim has 100% control authority.

Trim is turned ON and OFF using the Stick Trim Control panel. Trim switches are always kept in the ON position as per normal procedures. Trim release switches on the cyclic, collective, and pedals allow the pilot to intermittently release the force gradient, move the controls and then re-trim the flight controls in a new position. Trim also allows 'fly-through', which means the pilot can apply force against cyclic pressure without pressing trim-release and manoeuvre the aircraft. When the flight controls are released, the flight controls return to their previously trimmed (or 'reference') position.

Further, extract from the Flight Crew Operating Manual states:

> ***Basic AFCS and Handling Qualities*** *- Pilots are highly encouraged to maintain basic piloting skills to include proficiency flying the aircraft uncoupled (basic AFCS) and with degraded AFCS modes. Knowledge of the aircraft handling qualities and the AFCS will enable the pilot to better utilise the higher-level autopilot functions and be better prepared to deal with system malfunctions.*
>
> *When flying the aircraft with basic AFCS modes engaged, the most important action for the pilot is to trim the aircraft to properly leverage AFCS functions.* ***Pressing and holding the trim switches constantly will not allow the AFCS to function as intended.*** *Pilots who are not familiar with the AFCS or sub-systems will often continuously press and hold the trim release during flight. SAS will still function with the trim release buttons pressed, other AFCS function are not provided, increasing pilot workload. This is not to say that under gusty or turbulent conditions the pilot will not be required to frequently re-trim the aircraft. It is repeating several times for emphasis; in flight or at a hover, the pilot should trim the aircraft to the extent if the flight controls were released, the aircraft would remain roughly on the same flight plane."*

In ATT mode the AFCS provides attitude retention in the pitch and roll axes, heading hold and turn coordination in the roll and yaw axes. With the AFCS on, SAS provides inner-loop inputs in the pitch, roll, and yaw axes in response to excursions within the 10% control authority reducing pilot workload. ATT mode is the normal mode of operation during flights. ATT mode is essentially required for engaging any of the coupled modes. Both autopilots are required to be engaged for coupling the upper modes.

1.6.1.7 Attitude Retention Mode (ATT)

In flight (> 60 KIAS) the ATT mode provides attitude retention in the pitch and roll axes, heading hold and turn coordination in the yaw axis. At a hover and low speed flight (< 60 KIAS) the ATT mode provides attitude retention in the pitch and roll axes and heading hold in the yaw axis. Properly trimmed, the AFCS in ATT mode provides excellent stability; pitch, roll and heading are retained within 1 degree. In calm conditions using only basic AFCS the aircraft can be trimmed to maintain a constant airspeed and heading.

In a flight or at a hover, the pilot should trim the aircraft to the maximum extent. If the flight controls were released, the aircraft would remain roughly in the same flight condition.

In the pitch and roll axes, the flight controls are trimmed to attain a desired airspeed and heading. This can done by pressing the trim release switch, positioning the cyclic to the desired pitch and roll attitude, then releasing the cyclic trim switch. After setting the pitch and roll attitudes, the pilot should use the cyclic trim beeper to make minor adjustments.

At a hover, the pedals are used to control the heading. Each time the pedals are pressed, the switches on the pedals release trim forces. The pilot will set the desired heading using the pedals and then allow the AFCS to maintain heading. To do this, the pilot will take their feet off the trim release switches and guard the pedals. Even with large collective inputs, the AFCS will maintain heading within a few degrees. Minor heading changes at a hover should be done using the collective trim beeper.

1.6.1.8 Emergency Flotation System

The emergency floatation system is designed for emergency landing on water. It is not designed for long-term towing or takeoff after landing. The system permits the helicopter to remain afloat with the cabin above water long enough to permit passengers and crew to exit. The emergency floatation system consists of two urethane-coated nylon pop out type floats folded in compartments near the nose landing gear. A folded float is attached to the inside of each main landing gear door. Total four

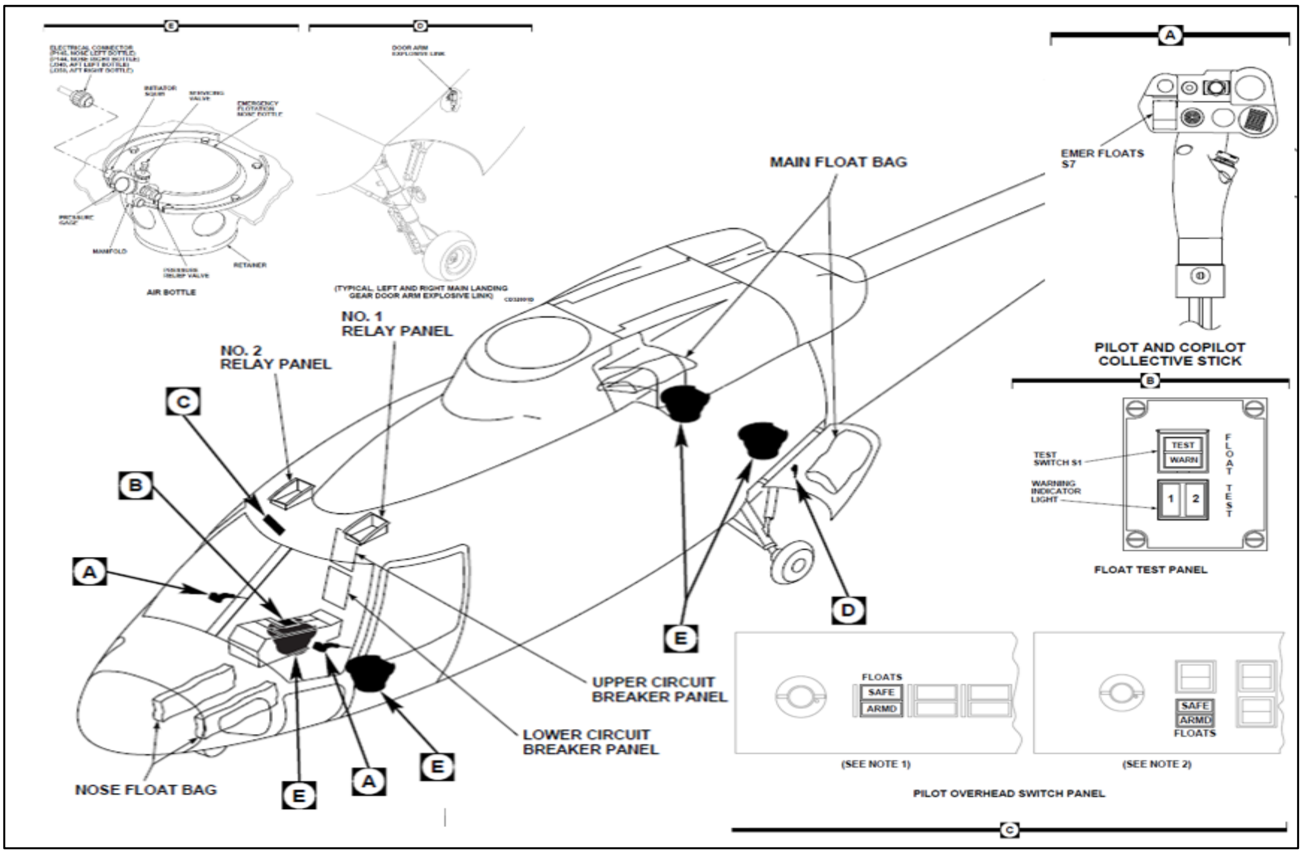


Figure 10: Emergency Floatation System

3,000 psi helium or nitrogen gas charged bottles are interconnected as a pair to each pair of floats. The nose float bottles are located under the pilot and copilot seats. The main float bottles are located in each main landing gear wheel well.

When the ARMD position is selected on the floats arming switch FLOATS ARMED advisory will illuminate on the MFD's. The floats are deployed by ensuring the MLG are extended, airspeed is less than 75 knots and then depressing the pilot or copilot float switch on the collective grip (must lift the protective guard in order to push the button). When the nose floats bags are inflated, they unsnap and release their covers which remain attached to the floats. When the main floats are inflated, the MLG door links sever and thus separate each door from its main landing gear allowing the door to fully open. Normal inflation time is five seconds with helium charged bottles and 7-10 seconds when nitrogen is used. The floatation system has following limitations:

- 75 knots maximum airspeed to inflate float
- 75 knots maximum airspeed with floats inflated
- 33 knots maximum floats water contact at 300 fpm rate of descent
- Landing gear should be down before float inflation

- If landing gear is up, do not lower the gear due to possible float puncture during extension
- 5000 ft pressure altitude maximum with floats inflated
- Maximum demonstrated airspeed for sideward or crosswind hover is 20 knots

The flotation system operates independently of the landing gear extension and retraction system; however the flotation system should be actuated with the landing gear extended. If the floats are activated with the landing gear retracted, it is recommended to leave the gear up as the floats could be damaged during the extension cycle.

1.6.1.9 External Life Raft System

Figure 11: External Life Raft System (S-76D)

The External Life Raft System has urethane coated nylon reversible life raft installed on the exterior of the helicopter attached to the left and right sides. The Life Raft has a capacity to carry 10–12 persons. The life rafts are contained within the aluminum pods which are attached to the fuselage under the cabin doors on the LH and RH side of the aircraft as shown in Figure 11. Each pod has a built-in step.

The brief description of the main components of life raft system installed on S76D/VT-PWI is as below:

a) Life Raft Pod Assembly

Two Life Raft Pod assemblies comprise of an aluminum mounting structure, a fabric top cover and an aluminum bottom cover is mounted outboard below the cabin doors. These two life raft pods house the life raft and are attached to the fuselage on a three point hinge and held in place by a pneumatically operated plunger mechanism. The figure 12(top) shows Life Raft Pod and its hinges.

b) Life Raft

The life rafts are housed in the Life Raft Pods in a deflated condition. Once the release handle is operated, the pods open and the Life Raft inflate and fall out of the pod into the water. The figure 12 (bottom) shows the inflated life raft.

Figure 12: Life raft pod assembly (top) and Inflated Life Raft (bottom)

c) Life Raft Reservoir

One Life Raft Reservoir, a pressurized bottle, is mounted underneath the floorboards at STA 168. Hoses attached to the life raft reservoir outlet lead to each life raft for inflation.

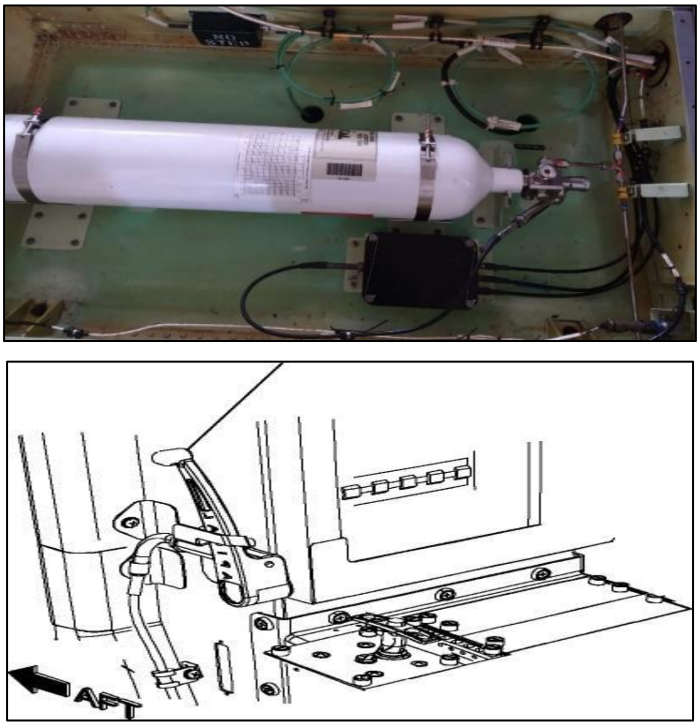


Figure 13: Life Raft Reservoir (top) and Release Handle (bottom)

d) Release Handle

There are two options of the pilot Release Handle that may be installed in the S-76D cockpit. A T-Handle Release Lever, that is installed in the center console or a Handle Release that is installed on RH side of the controls console. VT-PWI was installed with handle release on RH side of the controls console. The pilot is required to manually disengage the safety mechanism and pull lever. The handle was found in released condition on VT-PWI during wreckage examination after retrieval from sea. In addition to Release Handle in the cockpit, there are two Release Handles installed on the exterior belly of the helicopter one on each side to deploy the life raft. The external handle has a clear cover. The entire assembly is pinned in the locked position to avoid unintentional operation.

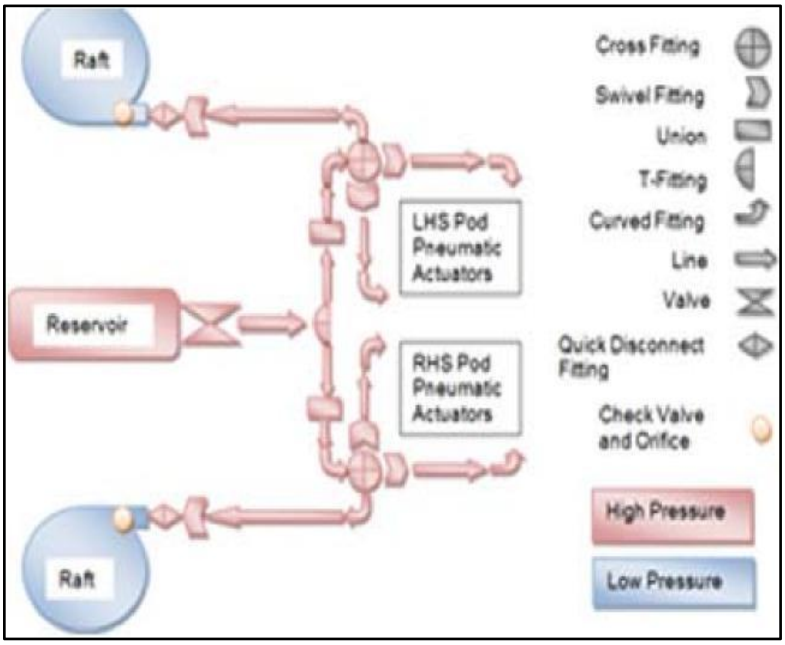


Figure 14: Mechanism for deployment of life rafts

The Release Handle in the cockpit and externally mounted release handles are attached to the multi cable box assembly by a cable installed beneath the floorboards. Each release lever pulls a cable that is connected to the multi-cable box mounted in the subfloor. When the release levers are pulled, it releases the life raft reservoir pressure valve. The high-pressure gas line from reservoir is split into three lines through a cross fitting installed inside each pod. One line inflates the life raft and other two lines actuate Pneumatic actuators which simultaneously opens the pod to release the life raft.

1.6.1.10 Engine

The helicopter is powered by two Pratt & Whitney PW210S turbo shaft engines. It consists of a gas generator section and a power section. The gas generator section includes an accessory gear box and a two-stage compressor driven by a single stage compressor turbine. The power section is a two stage axial flow power turbine that drives the output shaft. A reduction gear box couples the engine output shaft to the main gear box.

Each engine has an independent Full Authority Digital Engine Control System (FADEC) which controls the engine's operation. The engine control system consists of an Electronic Engine Control (EEC) and a Fuel Control Unit (FCU).

1.6.2 VT-PWI Specific Information

The helicopter was owned by M/s Vertical Aviation No1 Ltd. and leased to Pawan Hans. The lease was valid up to 17 Feb 2028. The aircraft was earlier operated by Thai Aviation Services Ltd. The aircraft arrived at Pawan Hans on 26 Aug 2021 in disassembled condition. Aircraft had 4636:42 hrs at the time of delivery to Pawan Hans. Aircraft was assembled and ground run was carried out on 23 Oct 2021.The test flight for issue of ARC was carried out on 11 Jan 2022, and Certificate of Airworthiness and ARC was issued by DGCA on 28 Mar 2022. The details of VT-PWI are as follows:

Aircraft Model	S-76D
Aircraft S/N	761060
Year of Manufacturer	2014
Name of Owner	M/s Vertical Aviation Group No1 Ltd
Certificate of Registration	Issued on 27 Aug 2021
Certificate of Airworthiness	Issued on 28 Mar 2022, valid subject to validity of ARC
Category	Normal/Passengers
ARC valid up to	27 Mar 2023
Maximum Take-off weight	5386 Kg
Total Aircraft Hours / Landings	4793:49 Hrs till 27 June 2022
Last major inspection	36 Month inspection carried out on 11 May 2022 at 4679:34 Hrs.
Engine Type	PW210S
Engine Sl. No.(LH)	PCE-BM-0116
Date of Manufacture (LH)	2014
Last major inspection (LH)	36 Month inspection on 11 May 2022 at 4082:27 Hrs/3493 CSN
Total Engine Hours/Cycles (LH)	4196:42 Hrs/3599 CSN
Engine Sl. No. (RH)	PCE -BM-0117
Date of Manufacture (RH)	2014
Last major inspection(RH)	36 Month inspection on 11 May 2022 at 4194:22 Hrs/3584 CSN
Total Engine Hours/Cycles(RH)	4308:42 Hrs/3690 CSN

The aircraft had flown approx. 4600 airframe hours before it was brought to India on lease by Pawan Hans Limited. With Pawan Hans, the helicopter had flown for 153:37 hrs prior to the accident. The Flight Log was obtained from Pawan Hans and indicated that there were no major snag reported by Pilots during any of the flights since issue of CoA.

1.6.3 Aircraft Maintenance

The Aircraft Maintenance program was approved by DGCA vide letter no. 2020/DAW/ARA/0000000041 dated 21 Sept 2021. Details of maintenance activities carried out on aircraft are as below:

- 12 Month Inspection was done at 4640:12 Hrs on 22 Mar 2022
- 600hrs / 06 months check carried out on 22 Apr 2022.
- 36 Month Inspection was done at 4679:34 Hrs on 11 May 2022. After inspection, IGNITION LSS snag (amber) was reported during start up for flight test. Same was rectified and was not reported again. Flight Test was satisfactory.
- 100 hours inspection carried out at 4734:34 hrs on 02 June 2022.
- 50 Hrs inspection carried out at 4782:34 Hrs on 23 June 2022
- Routine power assurance check carried out on 24.06.2022.

The following are the details of maintenance(s) carried out on the Helicopter Life Raft System/Floatation Gear System:

- 12 months inspection on life raft / floatation gear system carried out on 22.03.2022
- 3 years inspection on external life raft system carried out on 26.04.2022.
- New life raft and reservoir were installed on 31.05.2022.

The aircraft was manufactured in 2014 and the FDR is required to be inspected for continued serviceability as per Para 8.3 and Para 4 of Appendix I of CAR Section 2, Series I, Part V. The AME of the operator had certified the FDR data to be satisfactory on 11 Jan 2022 in respect of recording of parameters, continuity of data and realistic value of parameters.

However, the DFDR data readout report from Sikorsky for the accident flight showed that the Radio Altitude values were erratic. The DFDR data from earlier downloads carried out by PHL were also shared with Sikorsky. After DFDR analysis, Sikorsky stated that the Radio Altitude value from these files too were erratic.

Later, DFDR readout reports of other S-76D helicopter in PHL fleet were subjected to inspection and analysis. The Radio Altitude recordings from other helicopters were also observed to be showing similar erratic values as the accident flight. The matter was referred to Sikorsky, and it was found that the word definition for Radio Altitude parameter in the Data Frame File provided by Sikorsky in its Parameter Definition Document SER-76040335 was incorrect and required to be corrected/revised. Sikorsky came up with necessary corrections and after incorporating the corrections for word definition in the software, the values of Radio Altitude in the readout were observed to be logical.

1.7 Meteorological Information

The helicopter took off from Juhu. The IMD office issues half hourly METARs. Relevant METAR reports are given below:

Met Report at VAJJ	At 0630Z	At 0600Z	At 0530Z	At 0500Z
Wind	200°/04KT	130°/04KT	170°/06KT	180°/06KT
Visibility	2500	2500	2500	3000
Wx	FBL DZ	FBL DZ	FBL DZ	HZ
Cloud	FEW 1200 SCT 1800 FEW 3000 CB BKN 9000	FEW 1200 SCT 1800 FEW 3000 CB BKN 9000	FEW 1200 SCT 1800 FEW 3000 CB BKN 9000	FEW 1200 SCT 1800 FEW 3000 CB BKN 9000
Temperature	26°C	27°C	27°C	27°C
Dew Point	25°C	26°C	26°C	26°C
QNH	1005	1005	1005	1005
Trend	TEMPO VIS 1500 IN SHRA			
Remark	CB TO SSW/S/W TOP 7KM			

As per the log of weather and sea state maintained by Sagar Kiran the weather and sea state on 28 June 2022 was as follows. The visibility was not reported at the platform.

Time	Winds	Swell	Baro
0600 Hrs IST/0030 UTC	250°/12KT	1.5-2 m	1001
1800 Hrs IST/1230 UTC	190°/10KT	1.5-2 m	1001

The weather reported to crew by Sagar Kiran was *"Reported Light winds about 3 to 4 knots, temperature 26, Baro 1001 and light drizzling".*

1.8 Aids to Navigation

The helicopter was equipped with VHF, VOR, DME, ILS, ATC transponder, Radio altimeter, weather radar and GPS. In addition, the helicopter was equipped with AIS for monitoring purposes as per the requirements of ONGC.

1.9 Communication

The flight crew did not face any problem in maintaining two-way communication between the helicopter and ground stations. The intra cockpit conversation has not indicated any problems faced by the flight crew in communicating with the ground stations during the flight. The ATC recording of communication between VT-PWI and Juhu was obtained from Juhu ATC and used for investigation.

An attempt was made to obtain recording of VHF communication between Sagar Kiran and VT-PWI from Sagar Kiran during the visit of Investigation Team to Sagar Kiran Rig. It was found that recording facility for VHF communication was not serviceable and recordings of conversation with VT-PWI were not available. There was no mention of any such snag in any of the equipment serviceability reports that were being sent regularly to base at Nhava port on a daily basis. All efforts to retrieve VHF recordings from Sagar Kiran were made but did not yield any results. Hence, the VHF recording from nearby rigs operating on same frequency, which contained transmission between VT-PWI and Sagar Kiran were sought. The same was provided to the Investigation Team by ONGC.

1.10 Aerodrome Information

1.10.1 Juhu Aerodrome

Juhu Aerodrome is located 1.9 NM north-west of main Mumbai International airport adjoining the sea coast. It is owned and maintained by Airports Authority of India (AAI). Its ICAO nomenclature is VAJJ. The aerodrome is used mainly by non-scheduled operators and for general aviation flying.

Pawan Hans has its office and main base located at Juhu Aerodrome. All operators involved in off-shore flying operations for ONGC operate from Juhu. ONGC also has got its infrastructure in form of a terminal building at Juhu for embarking and disembarking of passengers. The infrastructure consists of passenger facilitation arrangements including security, waiting area, briefing hall etc.

As per published e-AIP, the co-ordinates of Juhu Airport are 190551N, 0725002E and elevation is 16 Feet ASL. The airport is a VFR airport with day operations only. The airport has two intersecting runways, RWY 08/26 and RWY 16/34. The primary runway is RWY 26. The runway characteristics and dimensions are as follows:

Rwy Orientation	Dimension	PCN
08/26	1142mx30m	PCN 17 F/D/Y/T
16/34	726mx20m	--

The VHF tower frequency is 124.35 MHz and the alternate frequency is 118.75 MHz. Helicopter VFR routes are established to streamline the flow of helicopter movement within Mumbai Control Zone to various helipads and Bombay High. The **Figure 15** here shows the helicopter routes for Mumbai High. The conditions for operations are laid in Para ENR 3.3.1 of AIP Part 2. For flight over sea the procedures are meant for helicopter suitably equipped to meet DGCA requirements for undertaking flight over sea.

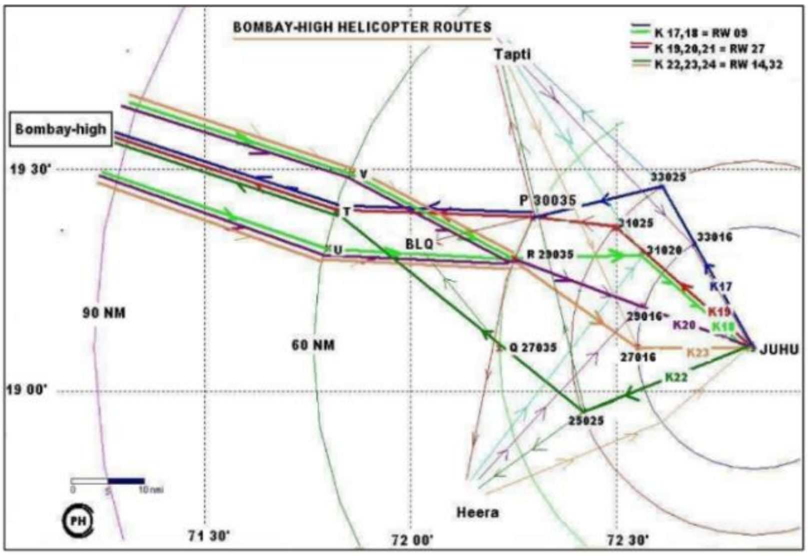


Figure 15: Helicopter routes for Mumbai High

Operations from Juhu aerodrome are based on visibility at Juhu airfield. Incoming helicopter are required to pass their position and ETA-Juhu when 30NM from Mumbai "BBB" VOR/DME. List of various off-shore helicopter VFR Routes based on runway in use at Mumbai airport is given below:

Helicopter VFR route designator	Route	Runway in use at Mumbai airport
K017	Juhu - Bombay High	09
K018	Bombay High - Juhu	09
K019	**Juhu - Bombay High**	**27**
K020	Bombay High - Juhu (Arrival from South and South-West)	27

Helicopter VFR route designator	Route	Runway in use at Mumbai airport
K021	Bombay High - Juhu (Arrival from North and North -West)	27
K022	Juhu - Bombay High	14 or 32
K023	Bombay High - Juhu (Arrival from South)	14 or 32
K024	Bombay High - Juhu (Arrival from North)	14 or 32

On the day of accident VT-PWI was cleared for K019 route. The details of K019 route is given in **Appendix A** to this report.

1.10.2 Sagar Kiran

Sagar Kiran Rig is one of the various rigs and installation operated by ONGC for the production and exploration activities in Bombay High. The location of the rig is approximately 57 Nm west of the Mumbai coastline. It is a jack-up rig and is anchored to the Sea Floor on three legs and is equipped with a heli deck. **Figure 16** shows the location of Sagar Kiran on the Oil Rig map.

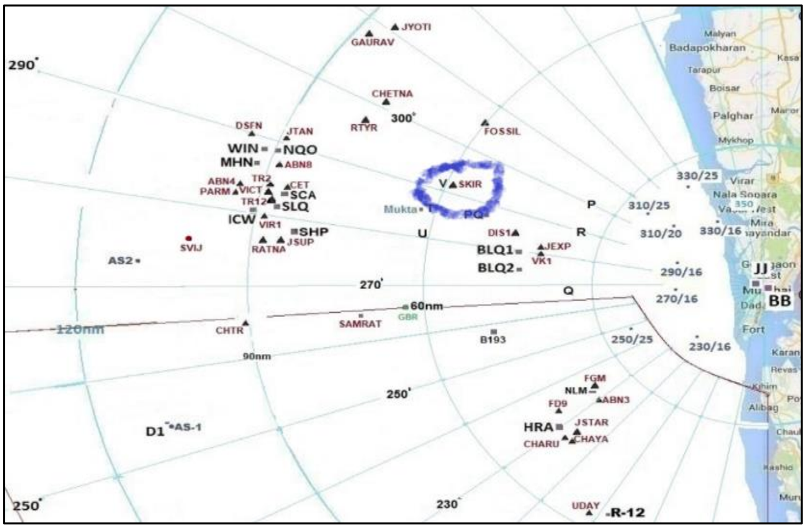


Figure 16: Location of Sagar Kiran on the oil rig map

The helideck has a clear obstacle free environment of 210°. Helideck is equipped with HAPI lights and an illuminated windsock. Standard lightings and markings as per DGCA CAR Section 4, Part B, Series C are available at the helideck. Helideck is capable of Night Landing operations. Foam type fire protection system is available at the Helideck. Helideck is equipped with HF SSB, Marine VHF, Aero VHF, NDB, VRS,

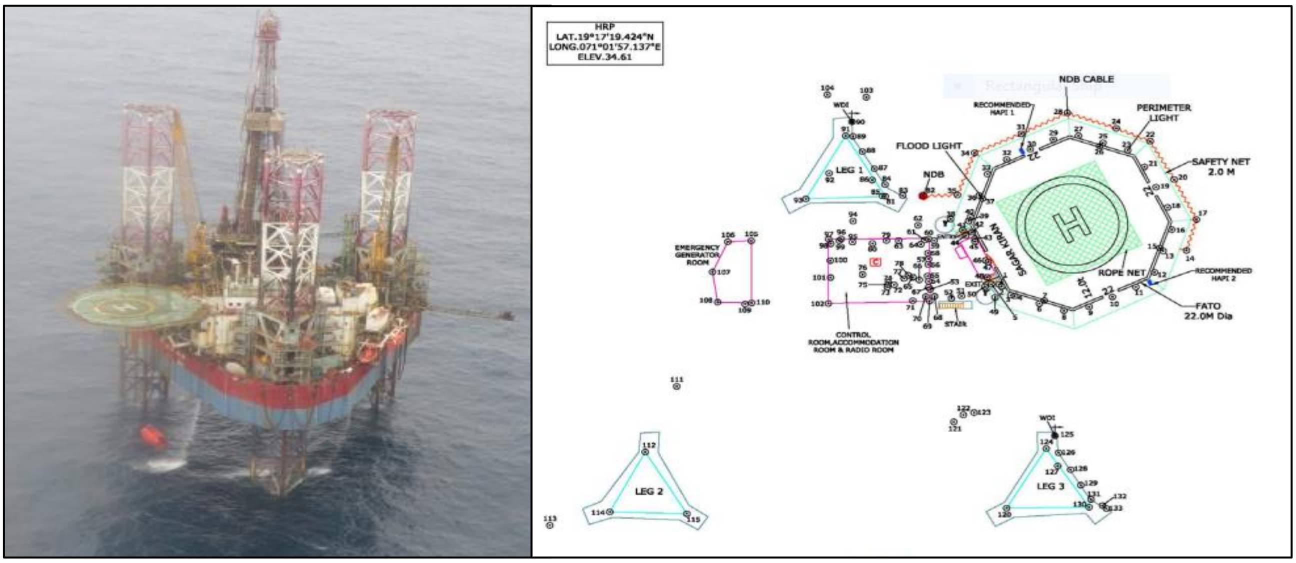


Figure 17: Sagar Kiran Helideck; Base map of Sagar Kiran

INMARSAT and Automated Weather Station. As per their internal procedure, Sagar Kiran sends an Equipment Serviceability Report to Nhava base every day.

The copy of Equipment Serviceability Reports sent to NHAVA on the day of accident was obtained from the Rig during visit of Investigation Team to the Rig. It was observed that all equipment except INMARSAT Phone and Anemometer were reported serviceable on the day of accident. As per the equipment serviceability report, the anemometer was not working properly and additional weather monitor for all parameters was required.

1.11 Flight Recorders

The helicopter was equipped with a Combo CVFDR unit Part No. 1605-01-01 & Sr. No. 745. The unit was retrieved from the sea along with the wreckage. The unit was found intact with Underwater Locator Beacon (ULB) in position. There was no damage to the unit as seen from outside. The unit was kept submerged in fresh water and brought to Delhi after taking all necessary precautions.

Since unit was retrieved from sea, special data recovery techniques were required to download data from Flight Recorders so as to ensure that no data is lost. Assistance of NTSB, USA was taken and data download was carried out at NTSB's Flight Recorders Lab in Washington DC, USA.

FDR & CVR Readouts were analyzed and copy of the readout was also provided to OEM for their analysis of the events and to carry CVR Audio Spectrum Analysis. The reports have been used to analyze and corroborate the circumstances leading to the accident.

1.11.1 Cockpit Voice Recorder

The CVR data was retrieved in ".uvr" format and converted to ".wav" files. Recordings from all four channels were retrieved. Duration of recordings in each channel was of 02:02:45 Hrs. Transcript of the CVR recording was prepared and relevant portion of recording is given below:

Time	Narrator	Narrative
1.00.31	PIC	No. 2 Engine started
1.01.30	PIC	No. 1 engine started
1.03.05	ATC	*"VWI hold short of Runway 26"*
1.09.35	Copilot	Passenger and load callout
1.11.30	PIC, Copilot	Discussion about departure sequence
1.15.50	PIC, Copilot	Discussion about flight plan and MCDU
1.19.42	ATC	Departure clearance for VWI. "*VWI clear to destination Kiran 291 radial 57 miles 3000 feet departure right turn 0019."*
1.19.56	Copilot	Read back of clearance
1.22.32	Copilot, PIC	Before taxi check carried out
1.24.30	Copilot, PIC	Discussion about departure sequence
1.27.24	ATC	*"VTPWI runway 26 Cleared for takeoff wind 160/04 knots"*
1.27.43	Copilot	"*Hovering at 80 percent"*
1.28.08	Copilot	*"Undercarriage up, Heading, IAS, ALTP engaged"*
1.28.21	PIC	*"You should keep weather radar ON for yourself "*
1.28.24	Co-pilot	*"Yes Sir"*
1.28.30	PIC	*"Parameters all normal"*
1.28.36	ATC	*"VWI airborne time 39, report 31025"* *(call acknowledged by co-pilot)*
1.30.12	PIC	*"I think we can deviate by 2 mile due weather"*

Time	Narrator	Narrative
1.30.26	Copilot to ATC	"Traffic permitting would like to deviate 2 miles to the right due weather" (Approved by ATC)
1:31:28	Co-pilot	*"Helibase VWI Namashkar"*
1:31:32	Co-pilot	*"Airborne crew change to Kiran Z0539, Papa at 0553 and Kiran at 0605, we are 2 + 7, 50 Kg cargo, 01 plus 45 on departure and 3000 after 25"*
1.34.33	*PIC to Copilot*	*"We are how many miles?*
	Copilot to PIC	*11 miles"*
1.34.55	PIC to Copilot	*"You can tell ATC we are resuming normal now"*
1:38:35	PIC to co-pilot	Discussion about navigation systems in the helicopter, how to intercept radial, how to set up destination, etc.
1.46.14	Copilot to 193 on RT	*"Bravo 193 this is VWI Namaskar"*
1:46:42	Co-pilot to Kiran	*"Kiran VWI Namshkar"*
1.47.47	KIRAN on RT	Reported Light winds about 3 to 4 knots, temperature 26, Baro 1001 and light drizzling
1.48.39	VVR & SQ on RT (Other aircraft & other deck)	- "*Requesting deck clearance*." - *"VVR SQ you are clear to land winds 230 15 knots and you are cleared to land………lightly drizzling on deck"*
1:49:20	*Co-pilot*	*"All parameters noted sir…normal sir"*
1.49.27	PIC to Copilot	*"He has not given us winds"*
1.49.30 – 1:49:47	Copilot to PIC	*"He said light winds 3 to 4 knots and light drizzle and 1001."*
	PIC to copilot	*"Han to kahin se bhi approach bana sakte hain fir (So we can approach from any side)"*
1.49.55	Some rig on RT	*"Winds 228 -18"*
1.50.05	PIC to Copilot	*"You can ask him for decent"*
1.53.10 till 1.56.00	PIC and Copilot	Discussion on offset and winds
1.56.38	PIC/ Copilot	Before landing checks carried out
1.57.08	PIC to Copilot	*"Wx radar, I will put it OFF. You keep it on."*
1.57.29	PIC to Copilot	"*Reducing speed further*"
1:57:35	Co-pilot to Kiran	*"Kiran VWI deck clearance and winds please"*
1.57.43	KIRAN on RT	*"Winds are 310 about 4 to 5 knots……and deck height is 115 feet."*
1.58.20	PIC to Copilot	"*It says offset cancelled, DTO KIRAN I can give 310 inbound intercept at 2….. execute*"
1.58.47	PIC to Copilot	*"Reducing speed further to 80 "*
1.59.19	PIC to Copilot	*"Floats on finals"*
1.59.49	PIC to copilot	"Okay visual now, dropping speed further to 65"
2.00.02	PIC to copilot	*"Appears to be your side"*
2.00.04	Copilot to PIC	*"Ya….looks like it's my approach… this is mine, I will land in the same direction, on H or slightly ahead"*
2.00.17	PIC to Copilot	"*You have controls*". Acknowledged by copilot *"I have controls"*
2.00.22	Copilot to PIC	Ground speed is 53 so we have head winds
2.00.25	PIC to Copilot	*"I will keep giving you height we are at 520 feet and speed is 65 you can reduce speed and get down slightly to about 300 feet."*
02.00.53	Copilot to PIC	"*Okay…okay visual..visual now sir*"

Time	Narrator	Narrative
02.00.56		"Decoupled" audio alert
02.00.58	Copilot to PIC	*"Ok now it's comfortable sir"*
02.01.01	PIC to Copilot	*"Maintain slower speed sir, maintain slower speed"*
02.01.03	Copilot to PIC	*"Okay ground speed is 50."*
02.01.05	PIC to Copilot	*"Okay no issues, 3 greens… parking brakes are ON, floats armed, landing lights is ON"*
02.01.14	PIC to Copilot	*"Putting your weather radar OFF sir"* Co-pilot: *"ok sir"*
02.01.31	PIC to Copilot	*"Ok we are 370 and speed reduced to…. "*
02:01:32.4	EGPWS	Sink Rate warning
02:01:33.6	EGPWS	Pull Up Warning
02:01:34.0	CAM AUDIO	Onset of NR Droop
02:01:34.7	THALES	Altitude Warning
02:01:35.8	EGPWS	Pull Up Warning
02:01:36	Audio Warning	Rotor Speed Low
02:01:36.2	CAM AUDIO	Increase in NR Droop rate
02:01:36.9	PIC	*"Hold Hold Hold…."*
02:01:37.4	CAM AUDIO	Max NR Droop Value
02:01:39.4	CAM AUDIO	Impact sound

1.11.2 Digital Flight Data Recorder

The DFDR data was downloaded in ".dat" format and converted in engineering parameters with assistance from the NTSB, USA and the OEM. The FDR recording was 268.65 hours long. The analysis of DFDR data was carried and the sequence of various relevant event from take-off to the point of impact are discussed in the following paragraphs.

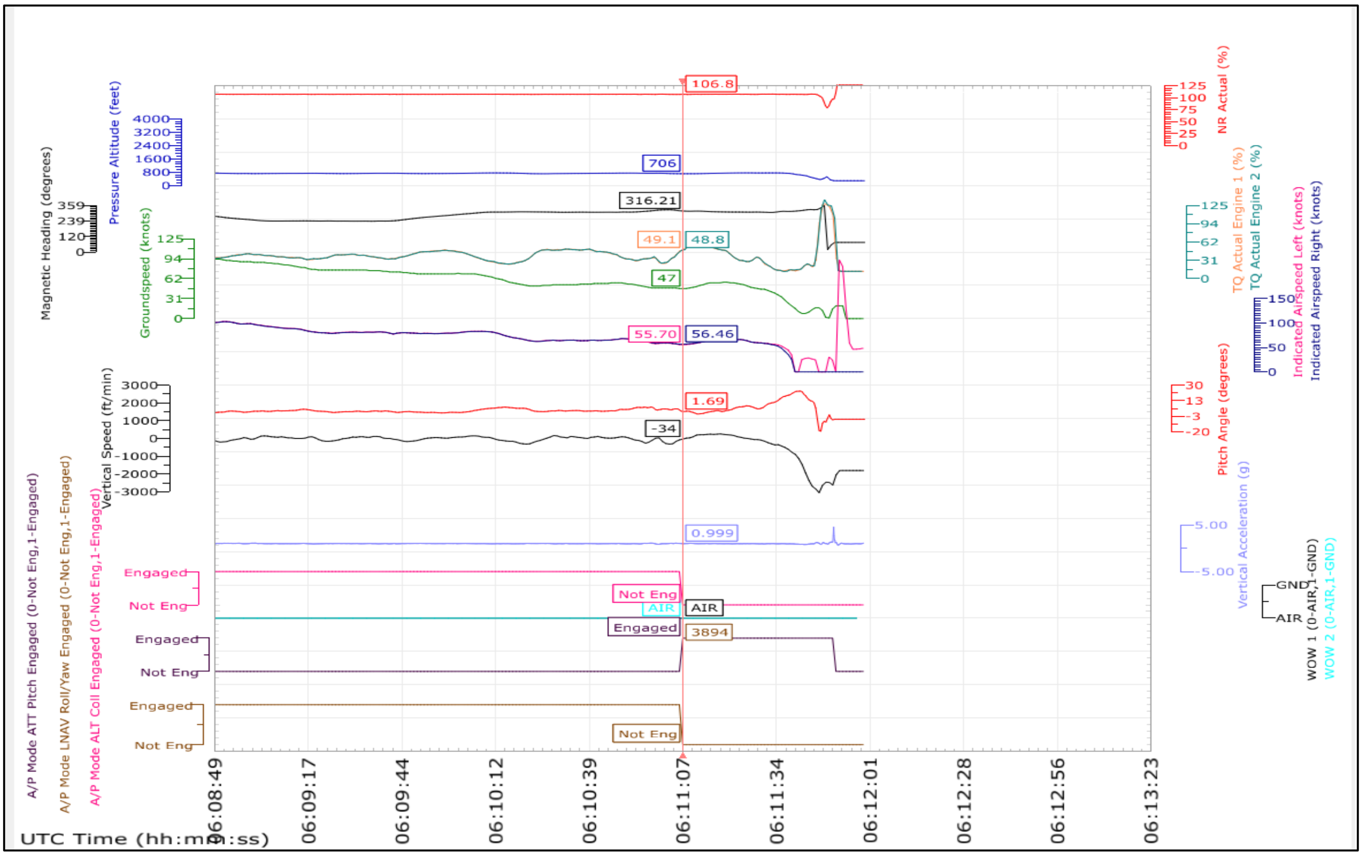


Figure 18: Graphical representation of flight data parameters before and after autopilot decoupling

The helicopter took-off at 05:37:55 UTC from Juhu. Helicopter climbed to a Pressure Altitude of 910 ft at 05:39:29 UTC and performed another climb to 3,210 ft at 05:54:29 UTC. Helicopter reached a maximum altitude of 3234 ft at 05:55:38 UTC. As per the DFDR data, the helicopter descended to a Pressure Altitude of 723 ft at about 06:07:02 UTC and at 06:11:07 UTC the autopilot was decoupled. **Figure 18** shows the graphical plot derived from DFDR data. The vertical line shows the point when the auto pilot was decoupled.

At the time of auto pilot decoupling, (06:11:07 UTC), the altitude as per the DFDR data was 706 ft and aircraft was descending at rate of -34 fpm. The pitch angle was 1.69 nose up and Ground Speed and IAS were 47 kts and 56 Kts respectively. Thereafter, the crew continued to fly the helicopter in a relatively stable attitude.

While the altitude was 750 ft, the helicopter began to decelerate. At about 06:11:31 the pitch was increased nose-up and the pilot continuously continued reducing the torque. The pitch angle increased to 7.1 Nose up and while Ground Speed and IAS were recorded as 46 Kt and 58 kt respectively. In another 3 seconds, while the Engine 1 and 2 torque setting was at 15% and altitude was 752 ft, Pitch angle increased to 12.1 Nose up. The ground speed and IAS were 39 kts and 54 kts respectively and rate of descent increased to 364 fpm.

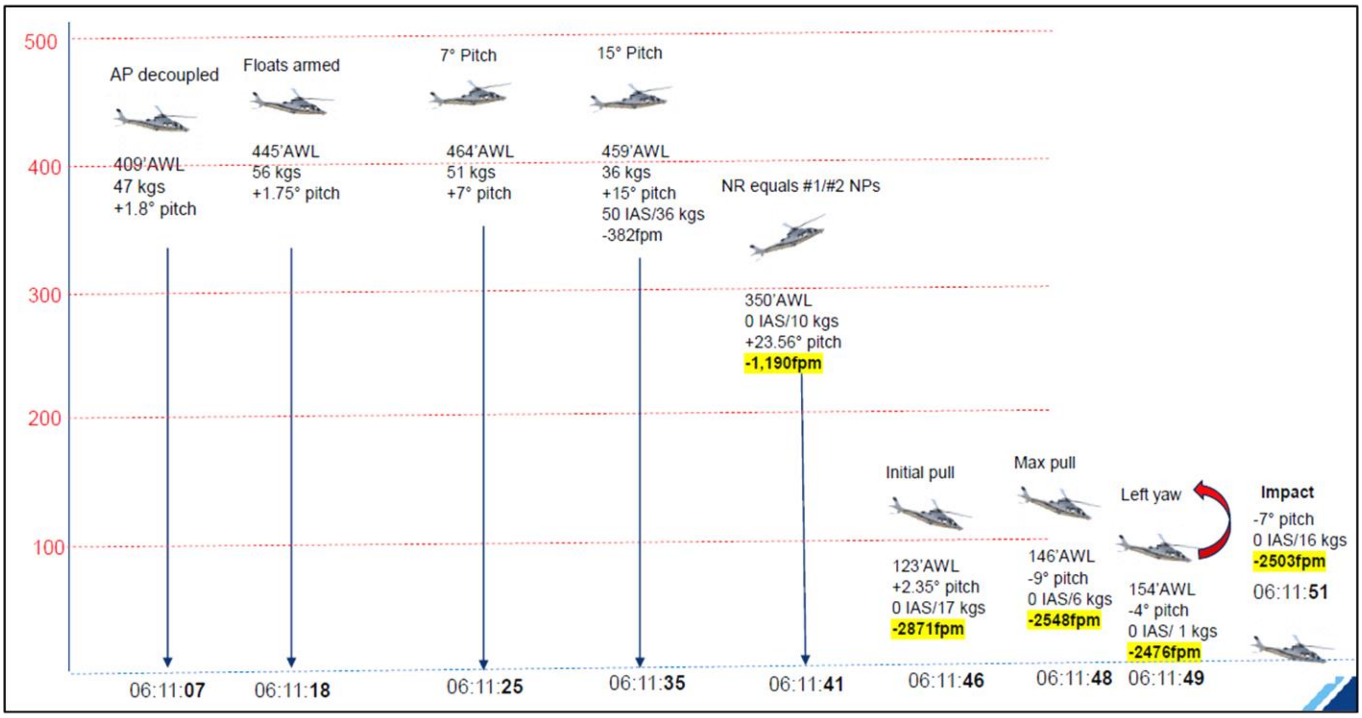


Figure 19: Approach Profile

At 06:11:41 the maximum pitch up angle of about 23.5° was recorded and this more or less coincides with the groundspeed reducing to almost zero. By this time the aircraft had entered an energy deficient state, due to the low torque value and near zero speed. The rate of descent increased to 1136 fpm. High nose-up attitude combined with reducing air speed at low altitude made it practically difficult to recover the helicopter from impact with the water. The onset of uncontrolled flight occurred when the aircraft was pitched to approximately 23° nose up while simultaneously lowering the collective to the full down position.

At 06:11:46, few seconds prior to impact the PIC initiated a full collective pull. At 06:11:48, the collective reached its maximum upward limit, resulting in engine torque increasing to 130%

(combined) and demanding maximum available torque. At this point the aircraft was approximately 153 ft above the surface of the water. This resulted in Nr dropping to below 90% Nr and a rapid left yaw of the aircraft. However, by this time due to a very low height above water, the recovery action did not yield the desired results and the helicopter impacted with the water at 06:11:51 UTC at vertical speed of -2,500 fpm (3.8G). The FDR file ends at 06:11:59 UTC. DFDR plots are appended to the report as **Appendix B**.

1.11.3 CVR Spectrum Analysis

A Sound Spectrum Analysis was performed upon the recorded signals from the Cockpit Area Microphone (CAM). Operational noises were examined for:

- Unusual frequencies not typically detected in the acoustic signature for the aircraft being examined
- Non-typical relationships between the relative loudness of the frequency peaks observed in the data
- Unusual changes in frequency for component identifiers which usually remain at a constant rate during flight operations

The analysis of the CVR data depicted a typical audio spectrum of an S-76D for frequency content and relative levels. The spectrum image is shown in the figure 20 below:

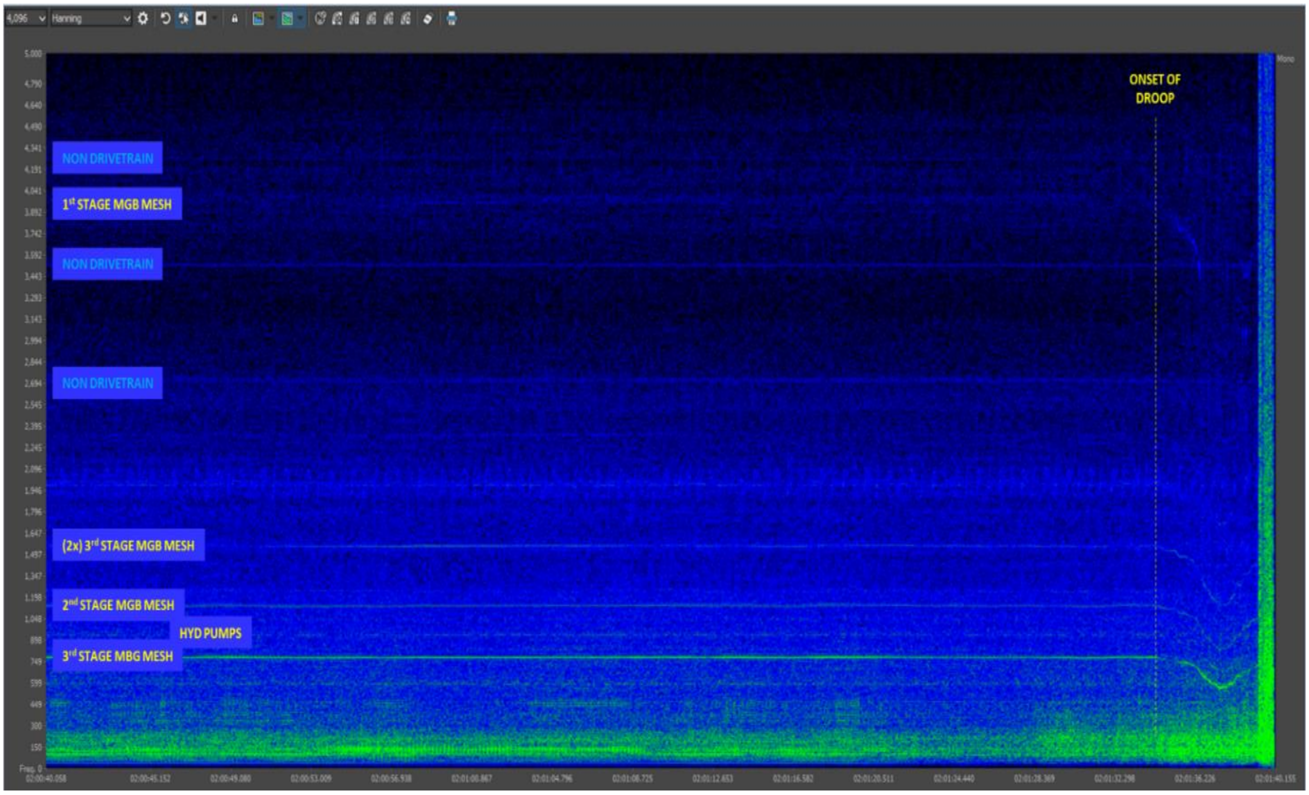


Figure 20: Audit spectrum image

The analysis detected unusual behavior in the form of a rotor speed droop which initiated ~5.4s prior to the aircraft impacting the surface of the water. The droop initiated at a rate of 3.9% per second to 99.5%N_R and then increased to a droop rate of 15.5% per second to 77.8%N_R. Rotor speed then began to recover at a rate of 10.9% per second to 99.6%N_R before impacting the water.

The events identified in the CVR recording between elapsed time 02:01:31 hrs and time of impact are correlated with the DFDR plots and shown in the figure 21 below.

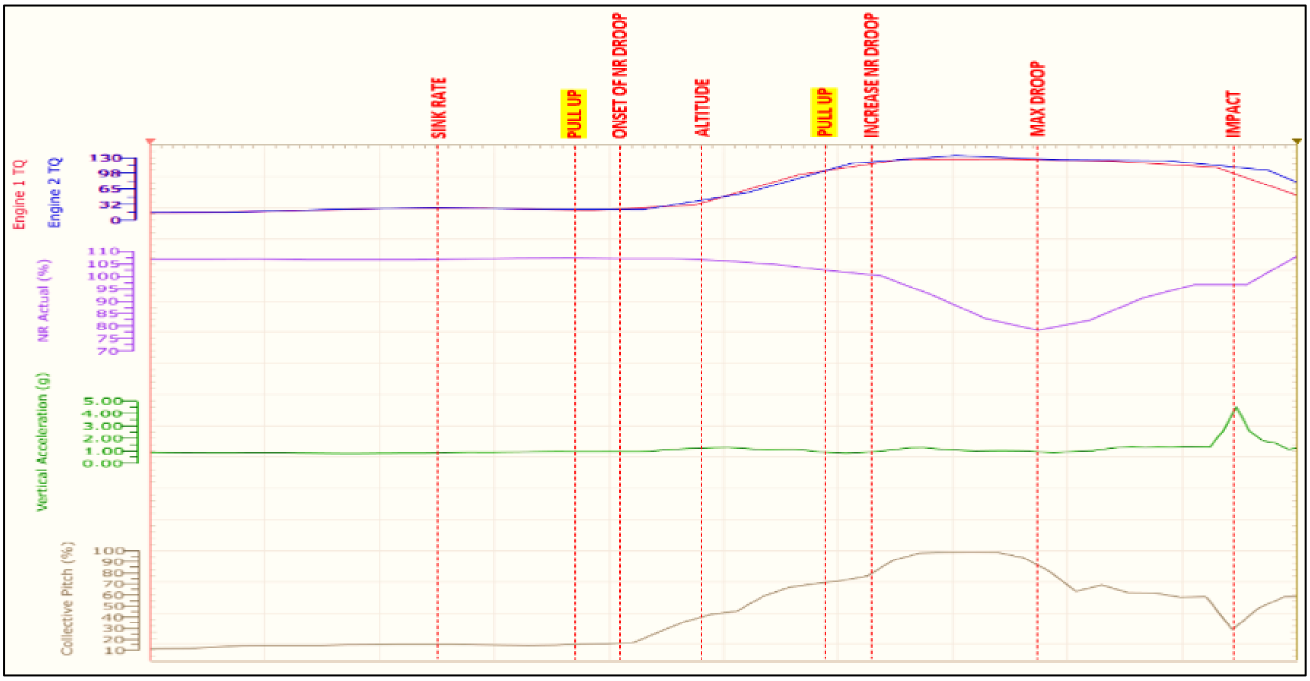


Figure 21: Graphical representation of flight data parameters with events identified in CVR recording

From the CVR data, the initiating event for the onset of the rotor speed droop appears to be in reaction to the first EGPWS alert to "PULL UP". This is corraborated by the FDR data which shows that just following the alert there is a rapid Collective up movement and an accompanying rise in Engine Torque. Further, the increased rate of rotor speed droop appears to be in reaction to the second EGPWS alert to "PULL UP". This is also corroborated by the FDR data which shows another rapid rise of the Collective and a demand in Engine Torque to greater than 125%.

1.12 Wreckage and Impact Information

The helicopter impacted the sea and sank after accident. Search of the helicopter was carried out by ONGC with help of ship "MV Great Ship Arti". The ship was equipped with Starfix DGNSS, Gyrocompass, Motion sensor, Multibeam echo-sounder system, Side scan sonar system, USBL system, Sound velocity meter, Digital acquisition systems and these were deployed for search of helicopter.

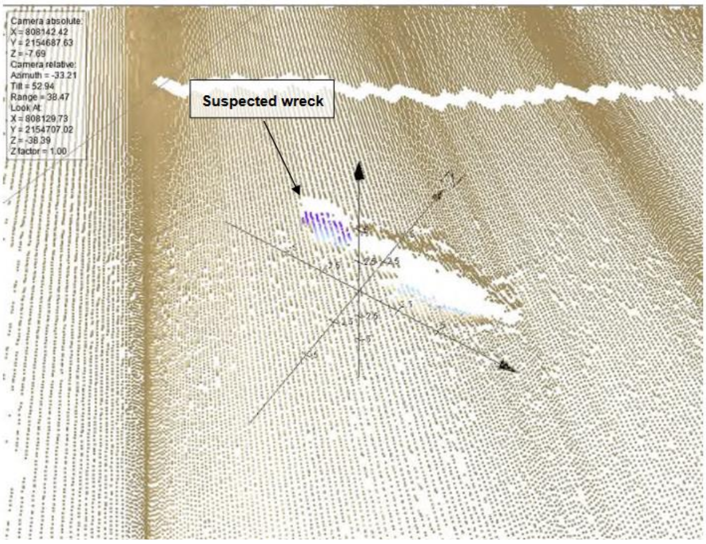


Figure 22: MBES 3D data image showing suspected wreck

The survey had to be aborted in the morning of 03rd July 2022 as MV "Great Ship Arti" had to return back to post for some repairs. The survey data collected by MV "Great Ship Arti" was analysed and suspected wreckage was later identified by the night of 03rd July 2022. MBES 3-D data image showing wreckage is shown in the figure 22.

Graphical depiction of wreckage as found on sea bed is shown in the Figure 23 below:

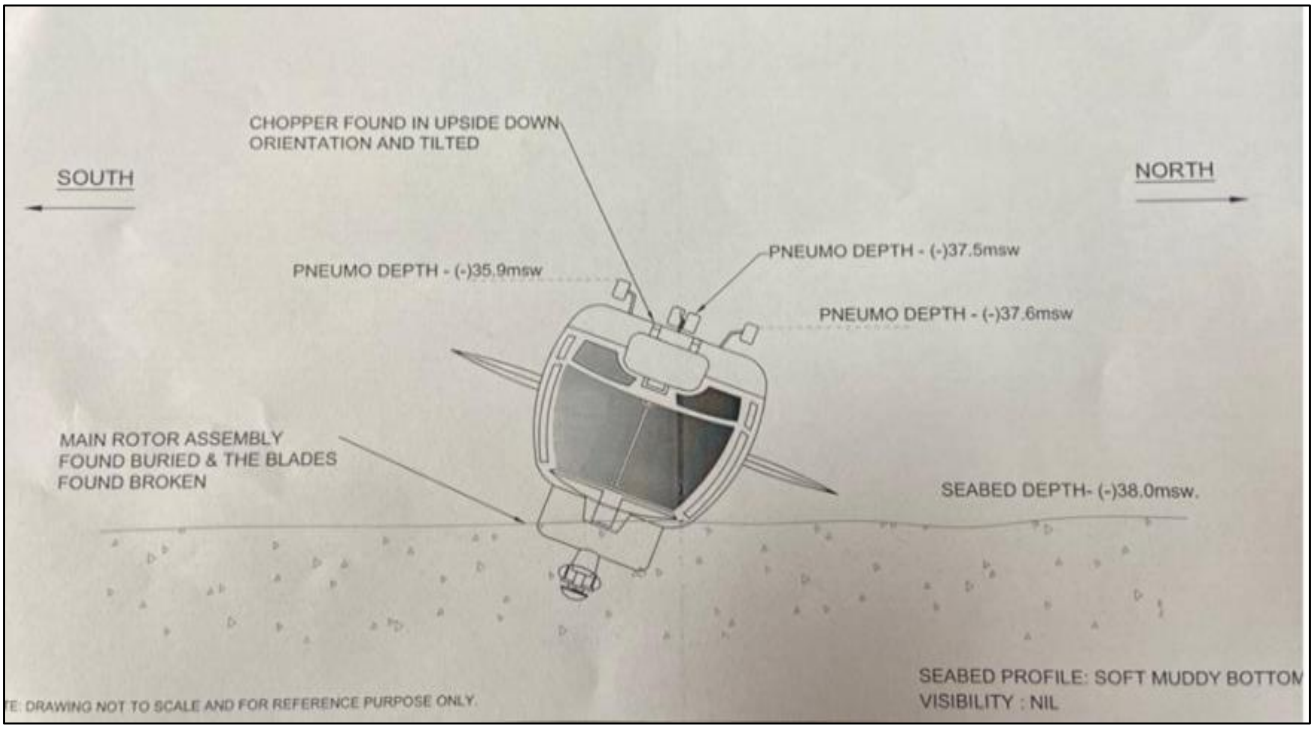


Figure 23: Graphical representation of wreckage

ONGC ship "Samudra Sewak" was deployed for retrieval of wreckage and the wreckage was finally retrieved from the sea bed on 06 July 2022. The wreckage was kept on board Samudra Sewak and arrived at Nhava port on 07 July 2022.

1.13 Medical and Pathological Information

Pre-flight Medical examination of both the cockpit crew members along with the breath-analyzer test were carried out as per requirement. They were found fit to fly and the breath analyzer test for alcohol consumption was negative. Both the flight crew were also subjected to Post accident medical (Drugs of Abuse) and the report was negative.

The surviving passenger rescued by Sagar Kiran Rescue Boat received minor injury. The two surviving passengers rescued by Malviya-16 had received serious injuries while holding on to the wreckage and while being pulled onboard Malviya-16. Both crew received minor injuries. All survivors were admitted to hospital for treatment and kept under observation for any complications.

The Post Mortem for the deceased passengers was carried out and the Post Mortem report stated *"Asphyxia due to drowning"* as the cause of death.

1.14 Fire

There was no Fire.

1.15 Survival Aspects

1.15.1 Safety Equipment on Aircraft

1.15.1.1 Safety Belt and Inertia Reel

The safety belts, shoulder harnesses, and inertia reels are provided for the safety of the pilot and co-pilot in case of a violent maneuver or crash. Occupant restraint is provided by a shoulder harness, attached to the inertia reels behind each seat. All points are secured by a single-point rotary release buckle.

Seat belts may be released by a rotary released marked TURN. In emergencies, 2-3G force will automatically lock the reel harness cable. The reel will then remain locked until the control lever is placed in the manually locked position and then returned to the unlocked position. The control is kept unlocked during normal flight. The manually locked position is used only when a crash landing is anticipated. It holds the pilot and co-pilot securely in their seats and prevents them from being thrown forward.

All passengers were able to open the seat belt and come out of the helicopter after it ditched into the sea and toppled.

1.15.1.2 Emergency Flotation System

The floats were armed and activated automatically at the time of impact. The aircraft toppled after impact, but the flotation system inflated and kept the aircraft on the surface allowing passengers and crew to egress the aircraft. The helicopter continued to float in an upside-down condition for more than 45 minutes until arrival of Malviya-16 and subsequent rescue of the survivors. After the rescue, the helicopter sank as the floats separated or punctured.

The flotation system is designed for emergency water landings only and is expected to keep the helicopter upright long enough to permit passengers and crew to exit to life rafts or rescue boats. The sea swell was reported at 1.5 to 2.0 meters (Sea State 4) on the date of the accident and the S-76D flotation system is rated for Sea State 4 conditions. However, it is critical to note the pilot did not make a controlled ditching. The aircraft impacted the sea with a vertical speed of about 2000 fpm which is far above the permissible water entry conditions of 300 fpm rate of descent.

1.15.1.3 External Life Raft System

VT-PWI was equipped with external Life Raft supplied by Dart Aerospace. The life raft is required to be inspected at intervals of 12 months, 18 months and 36 months. 18 month inspection required removal of both Life Rafts and dispatch to authorized service centre. The same was carried out on 26 April 2022 and Life Rafts from another aircraft were cannibalized to service VT-PWI. On 31 May 2022, new life rafts and reservoir were received and were installed on VT-PWI. As per information received from OEM the Life Raft Pod Assemblies are designed to sustain a maximum vertical entry speed of 300 fpm. As per the statement of the Pilots, life raft handle was activated and they could hear sound of bottle being discharged. However, the life raft did not inflate.

1.15.2 Personal Safety Equipment

The crew was provided with Life Jacket model number PO723E129P/PW (S7200-521). The annual maintenance on these life jackets was due in May 2023. The Personal Locater Beacon (PLB) fitted on the life jackets were valid up to Aug 2023. The crew did not report any problem in use of life jacket and their life jackets inflated as designed.

Figure 24: HP ETSO Lifejacket, model no LRS001

All passengers boarding the helicopter are provided with HP ETSO Lifejacket, model no LRS001. The lifejackets were procured by Pawan Hans in Dec 2020 and VT-PWI was provided with 11 such life jackets in consonance with maximum number of passengers that can be carried on S-76D helicopter as per Pawan Hans' contract with ONGC. This lifejacket includes Emergency Re-Breathing System (ERBS) and an option for mounting PLB. ERBS can be activated automatically by contact with water or by manually pulling the toggle of Hammar MA1 system. Accessories like spray hood, light, whistle and reflective patches are included. The adult size jacket is one size fits all, and is secured to body with a harness. It can be used by trained personnel only.

These Lifejackets are required to undergo maintenance every 12 months. As per the documentation available with Pawan Hans, all these life jackets were bought new and annual maintenance was due on 27 Dec 2022. The PLB fitted on the life jackets were valid up to Aug 2023.

The Life Jackets worn by the passengers were retrieved from the sea and those worn by survivors and deceased were identified. The figure 25 below shows life jackets worn by the deceased and the survivors. ***Asphyxia due to drowning*** *w*as the cause of death and hence the investigation team carried out detailed examination of the life jackets.

Figure 25: Lifejackets retrieved from deceased (left); Lifejackets retrieved from survivors (right)

Pawan Hans has a Safety Shop for carrying out maintenance on other types of lifejackets being used on other helicopters and it was initially informed that they had plans to obtain maintenance approval for HP ETSO LRS001 Life Jackets as well. Visual examination on the Life Jackets was carried out at this facility.

During the visual examination, it was observed that the 02 life jackets worn by the passengers who were rescued by Malviya-16 were in inflated condition. The life jackets of the four deceased passengers and one survivor whose life jacket was not inflated were subjected to detailed inspection by Investigation Team at Mumbai and later at OEM's facility to ascertain if the passenger could have faced any problem in operating and using the Life Jackets. During physical examination at Mumbai, it was observed that

- The inflation toggle of only one lifejacket (Sr. 20045484) was pulled. This was indicated by absence of green clip on the Inflation mechanism (Figure 26). The Hammar MA1 toggle for this life jacket was intact, but automatic operation had taken place as indicated by the red indicator on Hammar MA1 system (Figure 27).

Figure 26: Inflation mechanism – Green Clip present (left); Green clip absent (right)

- The inflation toggles on the other three life jackets were not pulled. On two of these life jackets (Sr. 20045469, Sr. 20045536) the Hammar MA1 system toggle had been pulled and ripped off (Figure 27).

Figure 27: Hammar MA1system with toggle intact (left) and toggle ripped off (right)

- Life jacket (Sr. 20045416) of passenger who had drifted away from the ditched helicopter and was rescued by Sagar Kiran Life Boat was not inflated. There was an attempt to use the re-breather as the re-breather pocket was open. The toggle of Hammar MA1 system had been pulled and ripped off. The inflation toggle of life jacket was intact and had not been operated.

After Pawan Hans informed in Oct 2022 that the plans to extend the scope of approval of Safety Shop to the new type of life jackets were shelved and a third part vendor was being engaged to carry out this activity for Pawan Hans, OEM was contacted to perform functional checks and detailed inspection on Life Jackets.

Detailed examination on the Life Jackets was carried out at OEM's EASA approved facility at Heemskerk, The Netherlands. The physical examination of life jackets at OEM's facility confirmed the observations made during inspection at Mumbai. Apart from physical examination, bladder pressure check was also performed. The final result of the inspections at OEM's facility are tabulated below.

S. no	Life Jacket Serial No.	Inflation System	Hammar MA1 system	Bladder Pressure Check
1	20045416	Inflation Toggle had not been operated CO2 cylinder was not punctured and Life Jackets were not activated	Indicator – Red Toggle ripped off Hammar	Pass
2	20045536		Indicator – Red Toggle ripped off Hammar	Pass
3	20045426		Indicator – Red Toggle not pulled	Pass
4	20045469		Indicator – Red Toggle ripped off Hammar	Pass
5	20045484	Inflation Toggle had been operated CO2 cylinder was punctured and Life Jacket was activated	Indicator – Red Toggle not pulled	Pass

After inspection and Bladder Pressure Check inflation toggle on Life Jackets 20045416, 20045536, 20045426 and 20045469 were operated and Life Jackets inflated normally.

1.15.3 Safety Briefing

ONGC has a passenger terminal at Juhu airport from where all personnel board helicopters for flying to various Oil Rigs and installation in Mumbai high that are operated by ONGC. The terminal building has passenger safety briefing hall where all passengers sit and watch the Safety Briefing videos before boarding the helicopter. As per requirements of AS4 standards issued by ONGC, operators are required to provide copy of Passenger Safety Briefing video to ONGC.

ONGC has contracted off-shore flying operations to three Helicopter Operators who fly different types of helicopter to ferry passengers to Mumbai High as per terms of the contract. Passenger Briefings are customized based on the type of Helicopter and Safety equipment available on the Helicopter. Passenger Safety Briefing Videos of all operators that are played in the Passenger Briefing Hall were obtained from ONGC.

Para 2.2.11 of CAR Section 8, Series O, Part IV requires that operator brief passengers on emergency procedures and use of emergency equipment including Life Jackets. Pawan Hans has laid its Passenger Briefing Procedure in para 17.3.16 of DGCA approved Operations Manual. As per the procedure laid in OM, passenger will be briefed on the various aspect of the sea escape by showing a video on the emergency and escape procedures for offshore/ long flights over water. In addition, Captain/Co-pilot, as decided by the Captain must brief the passengers. The passenger safety briefing video was part of submission by Pawan Hans to DGCA during CAP 3400 process. The Demonstration of Emergency Evacuation Procedures, Ditching Demonstration, Audio Video Briefing facilities were certified as part of Checklist 14 of Appendix D of CAP 3400 on 29 April 2022. Further, Passenger Briefing were also inspected and certified as part of Checklist 15 of Appendix D of CAP 3400 on 27 April 2022.

Passenger Safety Briefing video was available in English and Hindi. It was informed to the Investigation Team that the language of briefing video on the day of occurrence was Hindi. It was also informed that, the briefing is normally carried out in Hindi. The English language briefing video is played only when some foreign national is boarding. After safety briefing in the briefing hall, the passengers are taken to the boarding area and assisted with donning of the life jackets and boarding the aircraft.

On examination of the content of Safety Briefing video, Investigation Team observed that the 'Instructions for Inflating the Life Jacket' were incorrect.

While audio narrative was "*to inflate the life jacket pull the toggle sharply after jumping into water. This will inflate your lifejacket automatically*", the video pointed at the Hammer Toggle (which is meant for ERBS) (Refer Figure 28). The Inflation toggle, which is meant to inflate the life jacket was nowhere identified in the Passenger Safety Briefing video.

Figure 28: Hammer Toggle meant for ERBS

Investigation Team further noted that the inflated lifejacket shown in the video was also different from the LRS001 lifejacket which was actually available on the helicopter. The Figure 29 below shows the comparison of screenshot from Passenger Safety Briefing Video and actual image of inflated lifejacket from OEM's briefing card.

Figure 29: Comparison of Inflated Life Jacket shown in Passenger Safety Briefing Video (left) and actual image of inflated lifejacket from OEM's briefing card (right)

The safety briefing was also available in Hindi. The audio narrative from safety briefing video in Hindi was *"पानी में कूदने के बाद, रक्षा जैकेट को फुलाने के लिए दोनों तरफ लगी रस्सियों को ज़ोर से खीचें यह आपकी रक्षा जैकेट को अपने आप फुला देगा"*. This translates into *"After jumping into water, to inflate life jacket sharply pull toggles* *on both sides. This will inflate life jacket automatically”*. This narrative is not suitable for LRS001 life jackets worn by passengers, as it has only one toggle for inflation. The inflated life jacket shown in the video has two toggles and is different from LRS001 lifejacket available on-board accident flight. Hence, the video did not provide correct information to the passengers as to how the LRS001 Life Jacket is to be inflated.

In addition to Passenger Safety Briefing video, Passenger Safety Briefing Cards were available in the helicopter as required by CAR Section 2, Series X, Part VII. The Passenger Safety Briefing Card was approved by DGCA vide its letter dated 22 Dec 2021. Passenger Safety Briefing Card had the description and procedure for inflation of older type of life jackets while the helicopter was equipped with LRS001 lifejackets. Therefore, the briefing card was not providing correct information to the passengers as to how the LRS001 Life Jacket is to be inflated. The discrepancy was pointed by DGCA Airworthiness inspector during checks for ARC. Pawan Hans replaced the LRS001 life jackets in the helicopter with older type of life jackets and got ARC issued from DGCA.

Emergency Evacuation Demonstration required by CAP 3400 procedures was carried out on 12 April 2022. From the photos and video of the demonstration made available to the Investigation team it was observed that the older type of life jackets, similar to those depicted in the Passenger Briefing Card was used during the demonstration.

During the proving flight that was carried on 27 April 2022 with DGCA FOI on board, the passengers were however, reported to be wearing LRS001 lifejacket, which was same as the one depicted in the Passenger Safety Briefing Video but different from the DGCA approved Safety Briefing Card. Pawan Hans continued to use LRS001 lifejackets for all revenue and non-revenue operations.

Pawan Hans submitted an application to DGCA on 05 May 2022 for revision of Passenger Safety Briefing Card to include information on LRS001 life jackets. The Passenger Safety Briefing Card with description of correct lifejacket (LRS001) was approved by DGCA long after the accident on 30 Sept 2022.

1.15.4 Search and Rescue

Logs of calls and events maintained by MRCC, ONGC control center at Nhava port (NHAVA), Sagar Kiran and Malviya-16 were obtained and used to create a chronology of SAR activities.

VT-PWI was observed crashing into the Sea by the Radio Officer of Sagar Kiran Rig at about 0611 UTC. The helicopter impacted the sea about 1.5 NM from Sagar Kiran Rig. Sagar Kiran asked stand-by OSV Malviya 16 to approach ditching location at 0615 UTC. Malviya-16 informed Sagar Kiran an estimated time of about 45 minutes to reach the SAR location.

As per the statement of the Malviya-16 crew, they were at position close to Mukta Alpha Platform when distress signal was received. At that time the vessel position was reported to be 19° 22.30’ N, 071° 51.85’ E and the distance from Sagar Kiran was about 05 Nm.

At 0616 UTC, Rescue Boat from Sagar Kiran was lowered into the Sea. At the same time an ELT distress alert was received by AUMCC and passed on to MRCC and INMCC, indicating position 19° 27.4’ N , 071° 56.0’ E. MRCC traced 03 vessels near the site, including OSV Malviya-16, OSV Great Ship Asmi and OSV Anokhi. At 0625 UTC MRCC also contacted OSV Malviya-16 and asked it to proceed for assistance. Subsequently two more OSVs were asked to divert for SAR.

At 0627 UTC, a Pawan Hans helicopter (VT-PWB) which had diverted to accident site reported sighting VT-PWI at location. The Crew of VT-PWB video graphed the site with their mobile phone. The video was shared with the Investigation Team.

Screen shot from the video showing the helicopter floating in inverted position is shown below:

Figure 30: VT-PWI floating in the sea after impact

At 0633 UTC, NHAVA also directed Malviya-16 to proceed towards Sagar Kiran. At 0649 UTC, Malviya-16 had updated MRCC that it was proceeding towards the distress position.

Meanwhile, at 0635 UTC the Sagar Kiran Rescue boat had pulled up 01 survivor from the sea and Indian Coast Guard also diverted its sea and air assets for SAR with a Dornirer-228 (CG764), ICGS Samrat, ICGS Subhadra Kumari Chauhan augmenting the SAR efforts. Requisition for launch of Indian Navy helicopters was also dispatched and a Seaking helicopter, a Dhruv Helicopter joined SAR operations.

The Sagar Kiran Rescue boat after rescuing one person did not proceed to the floating helicopter and headed to the Rig. This caused panic amongst the survivors holding on to the helicopter, with one even attempting to swim towards the lifeboat.

At 0655 UTC OSV Malviya-16 reported MRCC of arriving near reported Datum and was requested to be on-scene commander by Sagar Kiran. At 0705 UTC, Sagar Kiran informed MRCC that Malviya-16 was making approach to pick up the survivors.

Malviya-16 did not launch Rescue Boat but threw buoys, rescue net and ladders down the hull to help the survivors. As per the statements of involved personnel, the sea state at that time was very rough with high tides. Malviya-16 used life buoys with rope to pull the survivors close to the vessel on the port side. While survivors were struggling to climb on to the ladder or scramble net, two of the survivors got separated and were pushed by the tide to the starboard side of vessel.

The two survivors on port side holding on to the buoys were pulled close to the vessel and asked to climb the ladder on port side. They were not able to hold on to the ladder as it was very high. Later scramble nets were used to pull these two survivors at 0715 UTC and 0726 UTC.

The vessel was then positioned to pick up other two survivors who had drifted to the starboard side. They were also rescued and pulled to the vessel with the use of buoys and scramble net at 0733 UTC.

At 0750 UTC, a Navy Helicopter picked up 01 unconscious person from the Sea. Three more persons were reported picked by Naval Helicopter at 0800 UTC, 0825 UTC and 0835 UTC in unconscious state. At 0753 UTC, Sagar Kiran had reported that VT-PWI was still floating.

At 0847 UTC, NHAVA ascertained on HF that all 09 helicopter occupants were accounted for, one occupant was rescued by Sagar Kiran Lifeboat, four occupants were rescued by Malviya-16 and 04 occupants picked from sea in un-conscious state by Naval Helicopters.

At 0853 UTC, Malviya-16 was asked to proceed to Sagar Kiran by NHAVA, so that the survivors can be transferred to the rig in order to be flown to shore from the helideck available on the rig. Survivor picked by Sagar Kiran Rescue Boat had already been brought to Rig by 0740 UTC.

The Search and Rescue was terminated at 0900 UTC.

All four unconscious person picked up by Naval Helicopter were flown to Juhu and taken to Hospital. They were declared brought dead by the Hospital. The five survivors were also flown from Sagar Kiran to Juhu and hospitalized.

After termination of Search and Rescue, MSV Seamac and NPP Nusantara reported at site for recovery of debris at 1030 UTC. At 1130 UTC, Malviya-16 proceeded for search of helicopters and recovery of its debris and both MSV Seamac and NPP Nusantara were then diverted to Mumbai High North by NHAVA.

1.15.5 Emergency Response Plan – Sagar Kiran

Sagar Kiran Rig has an Emergency Response Plan (ERP) published in Document QHSE/DS/SK/ERP/01 which is applicable when the Rig is conducting normal operations. It details the following:

- The emergency response organisation in the Rig.
- The roles and responsibilities of all personnel in an emergency.
- The specific actions to be taken during all reasonably foreseeable emergency situations.
- The generic actions to be taken by the individual members of the Rig Emergency Control Team.

The ERP also provides for Regional Contingency Plan in association with other Stakeholders when ONGC's internal resources may not be sufficient to handle the emergency. As per the Regional Contingency Plan the nearest installation is required to take the following actions in case of Helicopter Crash near installation.

1. Initiate Man Overboard Procedure.
2. Radio Officer with the approval of OIM / MASTER sends Distress Message with full details of the incidence on Distress Frequencies and DSC, if possible.
3. Call all known helicopters and vessels in the area for search and rescue.
4. Call nearest MSV, CREW BOAT and PATROL VESSEL for Search and Rescue.
5. OIM / Master to follow emergency management plan.
6. Inform Medical Officer on board to be in preparedness to attend the casualties and inform station in-charge if medical evacuation is required

The Annex A of the ERP document also contains Incident Management Guidelines for foreseeable emergencies situations including Helicopter Crash and Man-Overboard. In case of a Helicopter

Ditching at Sea, the Incident Management Guidelines contained in Annex A of ERP mainly consist of passing information to support vessel.

In case of Man over-board, the Incident Management Guidelines require passing information to the support vessel in addition to requirement for the Tool pusher to, *"Instruct SAR Team to mobilize directly to incident location. SAR Team Leader to Establish Direct Communications with Support Vessels in area. SAR team leader to assign team members for possible rescue of man overboard by efforts from rig. If Man overboard visible, SAR Team to throw life ring towards him and launch Rescue boat. SAR Team to keep constant watch on the man overboard. SAR team leader to throw Man overboard (MOB) Marker Buoy, keeping watch on the person overboard."*

The Sagar Kiran Rig is equipped with 02 lifeboats known as Totally Enclosed Motor Propelled Survival Craft (TEMPSC) which are installed on the port and starboard side of Rig. These life boats have capacity of 50 each. As per the ERP these boats are to be used for evacuation from the rig in

Figure 31: Lifeboat (TEMPSC) and Rescue Boat available on the Rig

case of an emergency. A Rescue Boat is also available on the Rig, but it was informed to the Investigation Team that the Rescue boat was not serviceable since last one year and hence the life boat (TEMPSC) was designated to be used as Rescue Boat as well. As per technical specifications of TEMPSC, it can be used as a Rescue Boat with capacity restricted to 06 persons.

On the day of accident, TEMPSC was as deployed with rescue team of eight persons towards the helicopter. The team noticed two passengers drifting in the sea in apparently unconscious state and one passenger struggling in the sea. The team rushed to rescue him. As they did not observe any movement by two unconscious persons, no further attempt was made to pull them with help rope, buoys or stick. The sea state at that time was stated to be rough with tides reaching approx 2-3 m, causing the rescuers to get sea sick. The rescue boat did not go back to the helicopter as they feared that debris from helicopter may damage the rescue boat. After rescuing one passenger, they headed back to the Rig.

As per the statements of the crew, who were waiting to be rescued, they were surprised when the Rescue Boat started going back to the Rig and tried to draw its attention towards them. One of the crew even attempted to swim towards the rescue boat, but swam back to the helicopter when there was no response from the rescue boat.

1.15.6 Rescue and Survival equipment available on Malviya-16

The Investigation Team carried out inspection of equipment and facilities available on Malviya-16 on 03 July 2022 on its arrival at Nhava port. It was informed that as per procedure, the vessel is inspected by DG, Shipping on arrival at Nhava port. As per the inspection report, the equipment in the vessel & preparedness of the vessel was found satisfactory. The investigation team also examined the equipment used for the rescue operation. The following observations were made:

(a) Life Buoys – The life buoys used for rescuing the survivors were found in good condition.

Figure 32: Life buoys

(b) Scramble net – The scramble net used for rescuing the survivors was found in good condition.

Figure 33: Scramble Net

(c) Rope Ladders used for rescue – The ladders used for rescuing the 04 survivors were examined. The length of ladder on starboard side door was measured to be approx. 2 meters long and on the port side door it was approx. 3 meters long. These were found to be in good condition. As per the specification of Malviya-16, the total depth of main deck is 7 m. The depth from the base of the door where the ladders are attached to the sea upper surface was measured to be more than 5 meters. This indicates that although the ladders were in good condition, their length (2 m and 3 m) was not sufficient to touch the sea surface, so as to help rescuing people from sea. The survivors reported that they faced difficulty in getting hold of the ladder due to its length, which was way shorter than the height of the ship.

Figure 34: Rescue ladders

1.16 Tests and Research

1.16.1 HUMS

S-76D helicopter has an Integrated Mechanical Diagnostics (IMD) Health and Usage Monitoring System (HUMS) which collects, analyses, and records health and usage data from various helicopter systems during flight. The IMD-HUMS performs the following functions:

- Rotor Track and Balance for Main Rotor
- Balance for the Tail Rotor
- Event and Exceedance Monitoring
- Advanced Mechanical Diagnostics for Drivetrain Monitoring
- Airframe Vibration Analysis
- Engine Vibration Analysis
- Engine Output Shaft Balancing
- Accessories and Oil Cooler Blower Vibration Recording

Monitoring of HUMS data was part of Aircraft Maintenance Program approved by DGCA. HUMS data was downloaded on a regular basis and analyzed using Sikorsky Ground Based Application (SGBA).

In May 2022, Pawan Hans engineers monitored elevated swash plate bearing trends on SGBA. The issue was raised to the OEM and PHL was advised to re-grease the swash plate bearings and monitor. The re-greasing of swash plate bearing was carried out and subsequently, no alerts were observed on SGBA related to Swash Plate bearing. On 7 June 2022, Pawan Hans also confirmed to OEM that no further alerts related to swash plate bearing were noticed. The last HUMS data download was carried out on 27 June 2022.

The data was in *.mud file format and shared with the OEM. The OEM confirmed the Swashplate

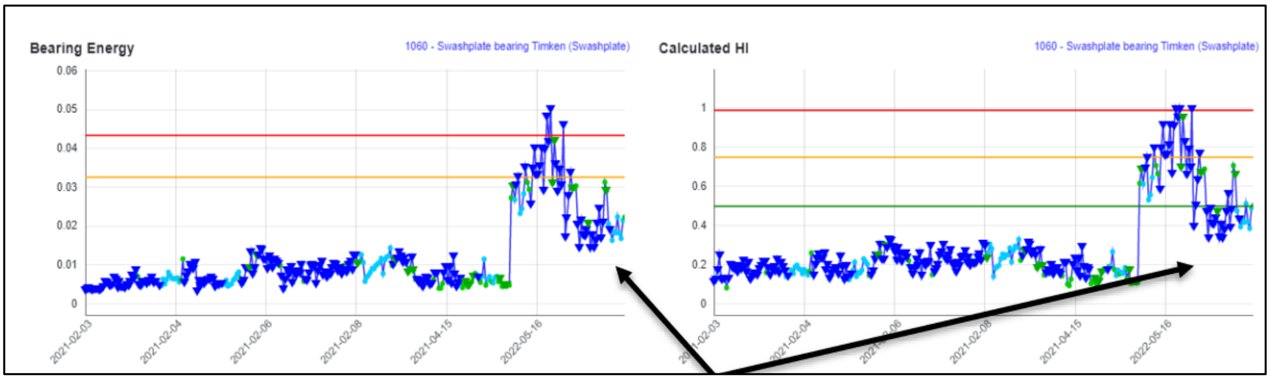


Figure 35: Swash plate bearing trends dropping to normal range

Bearing Energy and Calculated HI readings went back to normal fleet range.

The onboard acquisition unit of HUMS was removed from the helicopter wreckage and an attempt was made to retrieve the HUMS data of the accident flight at NTSB. The HUMS data card was retrieved from the onboard acquisition unit and binary image of the data was copied and shared with the OEM. However, as per the OEM the data was corrupted and could not be used for further analysis.

1.16.2 Flight Control Modules

The Flight Control Module (FCM) is a part of the Automatic Flight Control System (AFCS). It receives data from the other equipment and from the helicopter and controls the serial and parallel actuators. Two Flight Control Modules, Part No. C13172AC06 bearing Serial no. 506 and 546 were also retrieved from the helicopter and transported to NTSB for data download. Both FCM were dried and their EEPROM were removed. During disassembly and removal process one of the four EEPROM chips cracked as it was lifted off the board. Other three chips could be safely retrieved and binary image of the data obtained from the EPROM chips was shared with the OEM.

The OEM analysed the data and concluded the following:

- The dump of the three EEPROMs showed that the tests carried out at the start-up of the FCM (Pbits) did not detect any errors.
- The error management of the 2 EEPROMs of the FCM Serial no. 506 showed old failures, but no error was recorded during the last flight.
- The recording of the results of the PFTs of the COM card of the FCM Serial no. 506 showed that the last PFTs were carried out successfully.
- The EEPROM error management of FCM Serial no. 546 shows a PFT error but with the analysis of the PFT result of FCM Serial no. 506 it could be concluded that the PFTs in DUPLEX mode were successfully executed on both FCMs. The PFT failure recorded was old, no errors were detected.

1.16.3 Engine Electronic Controller (EEC) and Digital Control Unit (DCU)

EEC and DCU for both engines were retrieved from the helicopter and shipped to TSB-Canada to retrieve data from the units. Since, the units were exposed to sea water, specialised technique was required to download the data. The data download could be attempted after necessary precautions and repair and shared with the engine manufacturer P&W for analysis.

The review of the data from last run trace of EEC / DCU of engines PCE-BM-0117 and PCE-BM-0116 showed that both engines were providing power and the EECs (control system) were governing to match the CLP position well within the operational limits.

1.16.4 Engine

Both Engines were examined by the Investigation team in association with representative of OEM. Physical examination and boroscope inspection of the engines was carried out *in-situ*, in association with representative from OEM. The boroscope inspection did not reveal any significant damage or failure. The only defects observed were from corrosion due to seawater and environmental exposure. Based on the results from analysis of data from EEC and DCU, no further examination on the engines was carried out.

1.17 Organizational and Management information

1.17.1 Pawan Hans Limited (PHL)

Pawan Hans Limited was incorporated as a company in October 1985. It is a non-scheduled air transport operator with valid NSOP and is engaged in helicopter charter operations. It gives support to petroleum sector mainly ONGC; connecting areas in the North and North East; travel tourism and intra city transportation. The company carries out operations and maintenance contract of helicopters across the country. The Corporate Office of the PHL is located at Noida. The Accountable Manager and all regulatory post holders work from the Corporate Office. Three regions (Eastern, Western and Northern) have also been established to assist the post holders at CO in efficient discharge of their duties.

Pawan Hans maintains 08 different types of helicopters in its fleet and accordingly part B of the Operations Manual is subdivided into 08 parts starting from B1 to B8, each part comprising of information specific to different variant of helicopter held in the inventory of PHL as shown below.

- B1 Dhruv (ALH)
- B2 Mi-172
- B3 AS 365 N3
- B4 AS 365 N
- B5 AS 350 B3
- B6 Bell 407
- B7 Bell 206 L4
- B8 S-76D

PHL is operating under AOP which was initially issued in March 1998 for Non-Scheduled Air Transport Services and last renewed on 28 June 2019.

1.17.1.1 Induction of Sikorsky

Off-shore operations had been the backbone of Pawan Hans' revenue stream. ONGC which was its largest customer had put the criteria that aircraft being made available for operations should not be more than 07 years old. Pawan Hans was not in a position to meet the customer demand without induction of newer aircraft in its fleet. Further, vintage below 15 years was also a pre-requisite in tenders issued by majority of Indian customers. Thereby, PHL's top management decided to go for induction of new helicopters through leasing option.

An attempt to lease S-76D and S-76C++ helicopters from a leasing Company was made earlier but could not fructify. Hence, alternate leasing options were explored and PHL processed for leasing seven S-76D helicopters with planned induction in 2019-2020. After disruptions and delays owing to Covid-19, a master lease agreement was signed with lessor in October 2020.

As per the DGCA requirements, Pawan Hans was required to comply with provisions contained in the Air Operators Certification Procedure CAP 3400 for induction of new helicopter in its fleet. Pawan Hans submitted request for pre-application meeting to DGCA on 10 Nov 2020 stating that the first S-76D helicopter is expected to be delivered by end of Dec 2020 and pre-application meeting was held on 29 Dec 2020. During the meeting, PHL submitted that there is some delay in acquisition of helicopter. However, to avoid further delays, DGCA advised PHL to submit the Manuals required as per procedure laid down in CAP 3400. Pawan Hans was also asked to arrange for Type Training of DGCA Inspectors as required by Chapter 2, Para 1.1(b) of CAP 3400 and CAR Section 3, Series C, Part III.

DGCA granted in-principle approval for import of aircraft to Pawan Hans vide letter dated 22 Feb 2021. On 23 Mar 2021, PHL approached DGCA with request to issue Final Import Clearance. The request was followed up with another letter dated 05 April 2021. Meanwhile, Pawan Hans had also submitted Appendix A, B and C of CAP 3400 on 01 April and requested for a Formal meeting. DGCA on 12 April 2021 informed Pawan Hans that they have completed only the Phase 1 of the 05 phase CAP 3400 process and import at this stage may lead to situation where aircraft will remain grounded due want of completion of CAP 3400 process. Pawan Hans responded by providing timelines for submission of all pending documents and undertook to submit all pending documents by end of April 2021. Final Import clearance was issued by DGCA on 23 April 2021.

The helicopter arrived in Pawan Hans on 16 Aug 2021 and was cleared by customs on 24 Aug 2021. On 23 Aug 2021, Pawan Hans had re-submitted the Appendix A, B and C of CAP 3400 and again requested for a Formal Meeting.

Permission for assembly of helicopter was issued by DGCA on 08 Oct 2021 and helicopter assembly was completed by 20 Oct 2021. The first ground run was carried on 23 Oct 2021 by cross utilization of S-76D pilot of another operator.

By this time, one expat pilot (Check Airman) had joined Pawan Hans and application for issue of FATA was submitted to DGCA. However, his FATA oral examination at DGCA could not happen as he had to go back to his home country due to personal reasons. Owing to Covid-19 related quarantine requirements, his return was delayed. In the meantime his PPC lapsed on 05 Nov 2021. Expecting delays in obtaining FATA for this expat pilot, Pawan Hans wrote to DGCA requesting to process its application for CoA, ARC and Noise Certificate for the aircraft pending Flight Test since they did not have qualified pilot at that stage to carry out Flight Test.

Meanwhile, based on shortfalls and observations communicated by DGCA, revised Appendix A, B and C were re-submitted to DGCA and on 16 Sept 2021, Pawan Hans again wrote to expedite CAP 3400 process and again requested for a Formal Meeting.

As required by CAR Section 3, Series C, Part III and CAP 3400, Pawan Hans had not arranged for type training of DGCA inspectors before start of CAP 3400. DGCA FOI expressed inability to evaluate SOPs, Ops Manual, Passenger Briefing Cards and other checklist for approval process. Pawan Hans was asked to get its documents evaluated from a type qualified pilot available with another operator.

A meeting was held between Pawan Hans and DGCA on the issue of conduct of CAP 3400 Formal meeting on 27 Oct 2021 to follow-up on CAP 3400 process and conduct of Formal Meeting. DGCA asked Pawan Hans to revise SOP for Mumbai High, provide details of Off-Shore training program, carry some revisions in Appendix B and submit Part A, C and D of OM as well.

Pawan Hans resubmitted all said documents to DGCA on 01 Nov 2021. DGCA FOI however, continued to express inability to examine and approve these documents being untrained on type.

The Formal Application meeting was held on 15 Nov 2021 when Pawan Hans agreed to provide training to DGCA Inspectors as required by Chapter 2, Para 1.1(b) of CAP 3400. The approval process progressed, thereafter and approval of various manuals/ documents required by CAP 3400 were obtained although with significant delays.

Flight Test Proforma was approved by DGCA on 21 Dec 2021, but Pawan Hans was not able to obtain FATA for any of its pilot by then. The Flight Test was finally carried out on 11 Jan 2022 by cross utilization of a type qualified PIC from another operator. As the type qualified pilot available with other operator had only about 45 hrs of experience as PIC on type against 100 hrs required by CAR Section 2, Series T, Part II, the Test Flight was carried out on 11 Jan 2022 after exemption was granted by DGCA. Subsequent to Test Flight, the CoA was issued on 28 March 2023.

Ditching and Evacuation demonstration was held at Juhu on 12 April 2022 and Proving Flight was carried out on 27 April 2022. CAP 3400 process which started in Nov 2020 finally culminated with endorsement of VT-PWI in AOP of Pawan Hans on 2 May 2022 taking nearly 16 months.

1.17.1.2 Selection & Training of S-76D Flight Crew

Selection of internal pilots for S-76 D was started in 2020 by HR department of Pawan Hans and after internal discussions, the process was initiated for approval of internal candidates on 23 November 2020. The first batch for S-76 D training was finalized on 10 December 2020.

After negotiations with the ATO, the training agreement was finalized and signed on 29th January 2021. Slots were obtained from ATO for training. It was planned to send pilots for training in five batches. Based on the availability of slots, 04 batches comprising 08 pilots underwent training at the ATO between 22 Feb 2021 and 14 Aug 2021. The fifth batch comprising 04 pilots could not proceed for training due to issues related to settlement of old dues.

Pawan Hans had planned to hire an expat TRE to carry out training of these pilots on helicopter. As the process for obtaining FATA for Expat Check Airman who was hired got delayed, these pilots did not get to carry out flying on actual helicopter till April 2022, when Expat Check Airman was issued FATA by DGCA. By that time, type training of few pilots had also lapsed and only four pilots could be operationalized for flying duties by PHL.

1.17.1.3 Hiring of Expat Pilots

Requirement of having experienced off-shore pilots on S-76D was projected by the Ops department to the PHL management in Nov 2020 through a Departmental Note. Lack of Experienced pilots was also projected as a Hazard in the Risk Assessment Matrix prepared by the Ops Department.

Recruitment process for selection of Expat pilots including TRE/TRI was initiated in April 2021. By this time two batches of PHL pilots had already been trained at ATO. A total of 11 applications from expat pilots were received and interviews were held through virtual mode in June 2021. Eight pilots were shortlisted and recommended by the selection committee and three were given offer of appointment.

HR department issued letter to one Expat Pilot, who had Check Airman endorsement on his license and more than 3000 hrs of flying experience on S-76 helicopters including 1384 hrs as PIC on S-76D helicopter, to join in Sept 2021. By this time all PHL pilots had completed training at ATO in Florida, USA and the first helicopter had been assembled. Other two expat pilots, both having about 1200 hrs as PIC on S-76D helicopter were asked to join in Nov and Dec 2021.

Application for issue of FATA to Expat Check Airman Pilot was submitted to DGCA on 14 Oct 2021 but he had to return to his home country due to some personal problems and the FATA could not be issued as he was not available for Oral exam. In the meantime, his PPC also lapsed on 05 Nov 2021.

The Expat Check Airman, who was to be utilized as TRE by Pawan Hans was crucial to operationalization of VT-PWI helicopter as well as training of its pilots. Issue of FATA to the Expat Check Airman without a valid PPC would not have allowed PHL to utilize the expat pilot to undertake Air Test or training of its Pilots on aircraft. Pawan Hans explored various avenues to get PPC for expat pilot done, but was not able to get immediate slots from the ATO. Due to limited number of Civil Operators flying S-76D world over, efforts to get PPC done with other operators also did not materialize.

Pawan Hans had also requested DGCA on 05 Nov 2021 to give extension for PPC validity to the expat pilot, proposing that he would only be utilized for non-commercial flying that too after dedicated 01 hour sortie with another Type endorsed Pilot. The request was not acceded to by the DGCA.

PPC of the other two expat pilots who had been hired by Pawan Hans was also not valid. In addition, these two expat did not meet the requirement for issue of FATA as they did not possess current flying experience of 05 Hrs/05 Landings within previous 06 months which was a prerequisite for issue of FATA as per Para 2.2.1 (iv) of CAR Section 3, Series G Part II.

After significant efforts to obtain training slots from ATO and visas, all three expat pilots were sent to ATO for undergoing PPC. On return from ATO after undergoing PPC, the Expat Check Airman was issued FATA on 14 Jan 2022 for an initial period of three months. He was required to clear Air Regulation Exam for extension of his FATA approval beyond 3 months. However, the pilot returned back to his home country on 16 Jan 2021 without permission, while raising various demands over and above the agreed terms of his employment contract. Pawan Hans was unable to enforce the conditions of contract and ensure his availability for flying duties when required. Due to his unauthorized absence, Pawan Hans was also not able to apply for Air Regulation paper which was required for extension of FATA beyond 03 months.

The application for TRE approval of Expat Check Airman was submitted by Pawan Hans to DGCA on 22 Jan 2022. Since there is no term as TRE in Thai regulations, there was some ambiguity in interpretation of privileges that could be exercised by Check Airman. After making necessary enquiries with the Expat Check Airman and CAA Thailand, DGCA found that the he did not qualify to be a TRE, but qualify only to be a TRI. DGCA issued him TRI approval with effect from 04 April 2022 vide letter dated 13 May 2022. As FATA lapsed on 13 April 2022, he could not fly beyond this date.

For extension of FATA, expat pilot was required to clear air regulations exam, but he could not clear the exam in his first attempt in May 2022. He could not fill the online application in next exam due to some technical reasons. He could appear for Air Regulations exam only on 30 June 2022 after the accident, but this exam was cancelled by DGCA.

In case of other two expat pilots, since they did not have current flying experience required as per CAR Section 3, Series G Part II they could also not be issued FATA by DGCA. Pawan Hans approached DGCA on 31 Mar 2022 seeking exemption of requirement for current flying experience so that they can apply for FATA. Pawan Hans proposed that these expat pilots would carry necessary recency flying with the TRI on non-revenue flights, before utilization on revenue flights. However, the proposal was not concurred by DGCA and these expats could not be utilized by Pawan Hans.

For the brief period when Expat Pilot (Check Airman) had valid FATA and was not on unauthorized leave, he was utilized by Pawan Hans to carry out Engine Ground runs on VT-PWI and conduct training of Pawan Hans' type trained pilots on helicopter. Since his joining the company in Sept 2021 till the date of accident, he performed flying duties only for 10 days during which he carried out about 32 Hrs of non-revenue flying for Pawan Hans.

Non-availability of the expat examiner pilot at crucial juncture has had a detrimental cascading effect on the induction process and operations. Pawan Hans did not take suitable action to hire another Expat TRE or additional Expat pilots, when the initial plans did not materialize.

1.17.1.4 SMS Manual

In compliance with CAR Section 1, Series C, Part I, Pawan Hans has established a Safety Management System and prepared Safety Management System Manual. Acceptance of SMS Manual was obtained from DGCA in March 2022. As per requirement of Para 9 and Para 10.2 of the said CAR, Pawan Hans has laid its process for Safety Risk Management and Management of Change in its SMS Manual.

a. Management of Change process

In accordance with the Para 10.2 of CAR Section 1, Series C, Part I, Pawan Hans has included process for Management of Change in Chapter 14 of its SMS Manual. It lays down a formal process to identify changes which may affect the level of safety risks and to manage those risks. Introduction of new equipment and/or facilities is identified as once such change where Management of Change Process shall be carried out.

The systematic approach to managing and monitoring organizational change is part of the risk management process. Safety issues associated with change are identified and standards associated with change are maintained during the change process. Safety Review Board at Pawan Hans' Corporate Office and Safety Action Group at Regions are responsible for identifying the change and initiating the change process for addressing all safety concerns. Management of Change process has been described in detail in Pawan Hans' SMS Manual.

b. Risk Management process

The risk analysis is first element of the risk management process. It covers the detection and assessment of risks. To determine the Risk level posed by any hazard, Pawan Hans carries out Risk Assessment in terms of severity and probability using Assessment Matrix as shown in Figure 36.

	Catastrophic	Hazardous	Major	Minor	Negligible
	A	B	C	D	E
Frequent 5	5A	5B	5C	5D	5E
Occasional 4	4A	4B	4C	4D	4E
Remote 3	3A	3B	3C	3D	3E
Improbable 2	2A	2B	2C	2D	2E
Extremely Improbable 1	1A	1B	1C	1D	1E

Fiaure 36: Risk Assessment Matrix

The risk is broadly categorized into Acceptable/ Medium, Serious Risk and Undesirable/ Unacceptable.

- ***Acceptable or Medium Risk*** is the lowest risk likely to be reasonably reached and under which the remaining part of the risk can be controlled appropriately. No measure is required to mitigate the risk. Such risk falls in the green zone of the Safety Risk Assessment Matrix. GM-Region, Base Manager, HoD-Ops and HoD-Engg are authorized to take decision on such risks.
- ***Serious Risk*** is defined as the Risk level at which the organization accepts to move in order to benefit from some advantages for its activity and on the condition that risk is mitigated as much as possible. This kind of risk falls in yellow zone of the Safety Risk Assessment Matrix. Only Accountable Executive is authorized to take decision on acceptance of such risk.

- ***Undesirable or Unacceptable Risk*** is means that the activity cannot be continued as is and that it cannot be resumed unless the risk is brought back to "Acceptable" or "Medium" level or at least to "Serious" level. Immediate action to mitigate such risk is required or operation are to be stopped for such risks. Accountable Executive is responsible for taking decisions regarding tolerability of safety risks in case of Undesirable or Unacceptable Risk.

c. Risks identified by Pawan Hans in respect to starting S-76D off-shore operations

Investigation Team sought the details of Management of Change process undertaken by Pawan Hans for induction of S-76D helicopter from Pawan Hans. Pawan Hans provided copies of Safety Risk Assessment carried out by its Safety, Operations and Engineering departments. Pawan Hans had identified various hazards which amounted to serious or unacceptable risk levels for starting S76D off-shore operations. In the operational area, the following actions were proposed as mitigation measure to bring the risk to acceptable level before the start of operations.

- Existing fleet off-shore PICs will be trained on S-76D and utilized as Co-Pilots to mitigate identified "Unacceptable Risk".
- S76D Off-shore experienced PIC will be hired/deployed in initial stages with PHL Co-Pilots to mitigate identified "Serious Risk".
- Off-shore PIC, TRE/TRI to be recruited to mitigate identified "Serious Risk".
- S-76D related operational documents like Ops Manual, Normal and Emergency Checklists, Passenger Safety Briefing Cards to be prepared and approval obtained from DGCA for mitigating identified "Serious Risk".

These mitigation measures did not fructify nor were in place when S-76D off-shore operations started in May 2022.

d. Safety Objectives and monitoring of safety indicators

The SMS Manual also laid down safety objectives for Pawan Hans operations, which included reduction in number of FOQA exceedance and vertical speed/ acceleration exceedance (high rate of descent at low forward speed and low altitudes). The SMS Manual laid following Safety Indicators for monitoring Safety Performance including but not limited to the following:

- Average number of FOQA exceedance per quarter in a year (Fleet wise)
- Vertical speed/acceleration exceedance (high rate of descent at low forward speed and low altitudes) events per 10,000 hrs
- Attitude (High/Low Pitch, High Roll) exceedance events per 10,000 hrs
- Excessive control input events per 10,000 hrs: - excessive lateral cyclic (flight) - excessive longitudinal cyclic (ground) - max pedal (ground/ flight)
- Attitude exceedance events in a year (High/Low Pitch, Excess Roll)

Effective Flight Data Analysis or FOQA program was essential to achieve above objectives or monitors the performance indicators. During the Management of Change process, unavailability of FOQA parameters for S-76D was flagged as a "serious risk" by Pawan Hans and incorporation of these FOQA parameters in Flight Safety Manual was accepted as a mitigation measure.

1.17.1.5 Flight Safety Manual

Pawan Hans obtained approval for its revised FSM in March 2022, during the CAP 3400 process for induction of S-76D helicopters. As per the requirement laid in CAR Section 5, Series F, Part II all helicopter operator engaged in off-shore operations are required to develop procedures and establish facilities to capture flight data of all flights and analyze the same in the Flight Data Analysis Program.

The CAR states that an operator may contract the operation of a Flight Data Analysis Program to another party while retaining overall responsibility for the maintenance of such a programme. Pawan Hans outsourced the data analysis to another party which carries out exceedance monitoring based on the limits defined by Pawan Hans in its Flight Safety Manual.

From the scrutiny of the exceedance parameter given in the DGCA approved FSM, the Investigation team observed that

- There are 26 parameters for which exceedance limits have been defined.
- No limits have been defined for Normal, Lateral and Longitudinal Acceleration, even though these parameters are mentioned in the guidelines given in the CAR.
- Preconditions or phase of flight for most of the operations parameters are not defined.
- There is no severity grading for the exceedance.
- The exceedance limits are not restrictive enough, e.g. Pitch exceedance limit was +/- 25°, which is the extreme limit and would normally not be applicable during most phases of a safe flight. As per caution mentioned in the RFM, pitch attitude should not be more than 10° while below 20 ft height to prevent tail ground contact.

CoFS, Pawn Hans stated since Pawan Hans pilots were inexperienced at that stage, exceedance limits were decided based on performance limits given in FCOM. The severity grading of parameters and inclusion of all parameters as required by CAR Section 5, Series F, Part II was not carried out, and same was planned to be carried out after Pilots gained sufficient operational experience on the helicopter.

No exceedance was ever recorded for any parameters during any S-76D flight since start of operations to the date of accident. Considering that all Pawan Hans pilots were relatively inexperienced on S76D, better defined operations exceedance parameters would have led to effective monitoring and helped in providing training/counselling interventions at the right time.

1.17.2 Oil and Natural Gas Corporation (ONGC)

ONGC is the largest producer of crude oil and natural gas in India. It has an in-house service capability in all areas of Exploration and Production of oil & gas and related oil-field services. The Group General Manger (Head Air logistic) ONGC work as Installation Manager for Air Logistics providing support of helicopter services for offshore operations.

As per the information provided by ONGC during various interactions, ONGC had appointed DGM (Air Safety) to look after Aviation Safety. As per the organogram, he reports to the Head (Air Logistics), through GM (Logistics). His duties include:

- Ensuring that pilots/ helicopters deployed by operators are as per ONGC AS 4 standards.
- Monitoring helicopter performance standards.
- Inspecting and auditing document of helicopter and carrying out physical check when helicopters are offered to ONGC for operation.
- Carrying out investigations whenever any incident takes place.
- Ensuring continuous airworthiness of helicopters whenever helicopters are offered to ONGC after snags.
- To ensure compliance of instructions of DGCA India.
- To audit the documents of pilots and verify the suitability of pilots for adherence to ONGC Aviation policy and DGCA.
- To monitor and liaise with various Assets & Services and operators for implementations of observations received through Hazard Alert Cards. Inspect helidecks for its condition and safe operation of helicopters.

ONGC is 49 per cent stakeholder in Pawan Hans Limited. Pawan Hans is also required to bid for tenders issued by ONGC for off-shore helicopter services. VT-PWI was being utilized by ONGC based on contract agreement signed between ONGC and Pawan Hans on 01 April 2022.

1.17.2.1 AS4 Standards

ONGC has prepared AS4 standard for Off-shore Helicopter Operations. Helicopter operators contracted by ONGC are required to meet these standards by ONGC. After Pawan Hans demonstrated compliance of AS4 standard, the first off-shore flight by S-76D was carried out on 12 May 2022. Some of the relevant AS4 requirements are stated in the following paras.

- Para 4: The aircraft operator are required to have a Flight Operations Quality Assurance program with the following minimum components:
  - Flight Safety Audits
  - Flight Data Monitoring Program
  - Line Operation Safety Audits
- Para 11: This para lays down requirement on Safety Briefing, which requires that contractors shall provide video briefing material and equipment for each aircraft type demonstrating all relevant safety information in English (and any additional languages as required for the operational area). The video is shown to all passengers prior to boarding the aircraft both on land and on the offshore installation. As per the requirement contained in AS4, the video shall include but not be limited to the following:
  - An introduction to the aircraft type and location of emergency exits;
  - A demonstration of the use of the passenger seat belts in use in that helicopter;
  - A demonstration of use of the lifejackets in use in that helicopter;
  - A demonstration of the brace position to be used by passengers in the event of an emergency landing;
  - A demonstration of the life raft deployment and boarding;
  - A demonstration of EPIRB/ELT deployment;

- Instructions for not smoking in and around the aircraft;
- Boarding and disembarking instructions;
- The location of all safety equipment.

The helicopter shall be provided with safety briefing cards for each seat. The cards shall be in English as well as the appropriate language(s) for the operational area.

1.17.3 Directorate General of Civil Aviation (DGCA)

DGCA has issued Civil Aviation requirements on different subject for compliance of concerned operators and stakeholders. Some of the requirements relevant to the case are given below:

1.17.3.1 CAR Section 8 Series H Part II

Off-shore Flying is considered as Special Operations as defined by CAR Section 8 Series H Part II. The training requirements for offshore flying in helicopters is laid in the para 11.2 of the CAR. Offshore flying is a very demanding environment and hence there are very stringent and extensive minimum flying regulations made by DGCA.

As Pawan Hans crew were already offshore qualified in individual roles on the Dauphin, the reduced requirements for qualification on new type S76D were as under:

Role	Training	Release	Remarks
PIC	5:00 hours with TRE / TRI	1:00 independent release check with TRE/TRI	Release check was done by same TRI with FOI on board
Co-pilot	1:00 hour with TRE / TRI	1:00 release check with role qualified TRE/TRI	Release check was done by same TRI with FOI on board

1.17.3.2 CAR Section 7 Series G Part II

This Civil Aviation Requirement lays down the requirements Validation of Foreign Licenses (Foreign Aircrew Temporary Authorization - FATA) under rule 45 and issued under the provision of Rule of 133A of the Aircraft Rules, 1937. The experience required for helicopters with max AUW exceeding 3175 Kg to be eligible for issue of FATA is as below:

- Minimum flying experience on helicopters - 1000Hrs
- Minimum PIC on Type/variant - 50 hrs
- Recent flying experience - Minimum 5 hrs including 5 takes-off and landings within preceding six months, only on the type of helicopter.

Upon qualifying the oral examination, FATA is issued initially for a period of three months. For Extension of FATA beyond three months, the foreign pilot is required to pass Air Regulation examination conducted by Central Examination Organization (CEO) and possess medical assessment issued by DGCA. On Passing of Air Regulation examination, the FATA is extended for a maximum period of one year at the time or as decided by Director General subject to overall policy of the Government.

1.17.3.3 CAR Section 2 Series I Part V

The CAR Section 2 Series I Part V provides requirements for Flight Data Recorders and parameter to be recorded. The requirements differ for different helicopters based on complexity, weight and date of issue of individual CoA etc. As per the CAR, all helicopters of a maximum certificated take-off mass of over 3175 kg, up to and including 7000 kg, for which the individual certificate of airworthiness is first issued on or after 1 January 1989 to be equipped with FDR which should record first 15 parameters listed in Table 2 of Appendix I of the CAR. S-76D helicopter fell into this category and Radio Altitude is listed at Sr. 22 in Table 2 of Appendix I.

Appendix I to the CAR also include procedures for operational checks and evaluations of recordings from the flight recorder system for ensuring continued serviceability of the recorders. The CAR mandates 15 parameters for S-76D helicopter, which are to be necessarily recorded in the FDR. While the FDR available in VT-PWI could record a large number of parameters, it was observed that, as a practice only 15 parameters were being inspected during annual inspections by AME and DGCA.

1.17.3.4 CAR Section 5 Series F Part II

This CAR lays down requirements for Flight Data Analysis Program. While ICAO Annex 6, Part III makes recommendation for the operator of a helicopter of a certified take-off mass in excess of 7000 kg or having a passenger seating configuration of more than 9, and fitted with a flight data recorder to establish and maintain a Flight Data Analysis Programme as part of its Safety Management System, DGCA has made it a standard requirement for all Helicopter operators engaged in offshore operations for having aircraft equipped with FDR. Operators are required to develop procedures and establish facilities to capture flight data of all flights and transform the data into an appropriate format. The data is required to be analyzed for generating reports / information. As per the CAR, an operator shall lay down its Flight Data Analysis Program in the Flight Safety/SMS Manual as applicable and; this program shall be implemented meticulously and periodically reviewed to maintain its effectiveness. Guidance on parameters for Flight Data Analysis Programme for Helicopters is provided in Annexure B of the said CAR.

1.17.3.5 CAP 3400

The certification process requires the DGCA to ascertain through a systematic process whether or not a prospective applicant has both the required ability and resources to comply with the applicable legislative requirements and to fulfill the applicant's actual and potential obligations for operation of safe, secure, efficient and regular air transport services as proposed. This process involves five distinct phases as stated below:

> ***Pre-application:*** *During this phase, the applicant conducts initial studies, prepares plans, makes inquiries from the DGCA in regard to the opportunities available under the existing air services agreements and seeks advice as to the validity of different proposals. The prospective applicant at this stage is required to submit a statement of intent to the DGCA outlining the proposal and apply to the Ministry of Civil Aviation for issuance of NOC.*
>
> ***Formal application:*** *In case no FOI / AWI is trained on type, for effective supervision the operator is required to propose training of Inspector on type in such a manner so that the certification process can be supervised. The DGCA will then make a formal assessment of the*

completeness of the applicant's proposal and invite the applicant for a Formal Application meeting where the details relating to the certification process would be formally discussed.

Document evaluation: *During this phase, the DGCA will undertake a detailed scrutiny of the applicant's manuals and other documents, which accompanied the formal application.*

Demonstration and Inspection prior to certification: *During this phase, the applicant needs to demonstrate to the DGCA that the applicant is in a position to conduct the proposed operations in accordance with the procedures detailed in the documents/ manuals reviewed during the previous phase utilizing the personnel/ facilities/ equipment identified in the formal application.*

Certification: *When all the previous phases have been satisfactorily completed, the DGCA will issue the Air Operator's Certificate/ Permit and the associated Operations Specifications*

CAP 3400 (Air Operator Certification Manual – Helicopters) which provides the guidance to an applicant seeking such a Certificate for helicopter operations explains the administrative procedure for the issue and renewal of an Air Operator Permit and to indicate the requirements to be met by an applicant for such a Permit.

Para 2.3 & 2.4 of Chapter 2 of CAP 3400 are reproduced below:

2.3 The type of aircraft proposed may require the applicant to provide the DGCA staff with type specific training if the DGCA does not have type qualified inspectors on its strength. The applicant will be responsible for the cost of training of a maximum of two Flight Operations Inspectors and two Airworthiness Inspectors as also any other officer(s) of the Certification Team as specified during the certification process. It should be noted that type endorsement training for the FOIs would involve ground and flight/ simulator time. The inspectors(s) must have completed their training either before any member of the operator commences their training or at the same time that the first crew members of the prospective operator receive their training.

2.4 In the event, the holder of an AOP/ AOC inducts or replaces any of their aircraft with a new type of aircraft or an aircraft for which type qualified inspectors are not available with DGCA at the time in service, the AOP/ AOC holder shall incur the same responsibilities and expenses as outlined in paragraph 2.3 above.

The above two paragraphs require DGCA to have type trained Inspector before the start of CAP 3400 and in turn mandates that the operator shall bear the cost of the type training of DGCA inspectors. Similar provisions are also contained in CAR Section 3, Series C, Part III. DGCA FOI was not type trained on S-76D Helicopter.

1.17.3.6 ICAO Doc 8335

ICAO Doc 8335, "Manual of Procedures for Operations Inspection, Certification and Continued Surveillance" outlines the duties and responsibilities of both the State of the Operator and the operator. It recognizes their interdependence in maintaining acceptable standards of operation and safe operating practices. It elaborates the procedures for the certification of commercial air transport operators by the State of the Operator and the continued safety oversight of the operator.

Para 5.3.7 of this Doc states that:

> *"A State that is unable to provide sufficient staff for its operations inspectorate could arrange for experienced personnel of an operator to be seconded to the CAA to act as civil aviation safety inspectors (CASIs). In this case, a strategy to mitigate potential conflict of interest issues should be established and documented. However, it may be impossible to ensure that a CASI in such a case would not be involved in inspections concerning the operator from which the secondment was effected".*

ICAO therefore agrees with an arrangement of secondment of FOIs, if required.

With respect to qualifications and training of the FOIs, it is stated in the Note in Para 6.2.3.1 of the states that:

> *"Note – It cannot be expected that in all cases the flight operations inspector would possess the same level of flying experience on the inspected aircraft type as the personnel being inspected."*

In para 6.2.3.2 which lays qualification for FOIs to conduct en-route Inspections, it is stated that FOI should *"be qualified or have been recently qualified on the type of aircraft used, or on a type of aircraft with similar operational characteristics. When establishing aircraft types with similar operational characteristics, the CAA should demonstrate how the different types are similar taking into consideration the following elements, and record the results of its assessment:*

1) engine technology;

2) certification basis;

3) level of automation;

4) flight controls logic; and

5) size and mass of the aircraft; and

… have experience with comparable types of operations to those which the inspection will cover, including any particular authorizations detailed on the operation specifications (e.g., EDTO, LVO, PBN).

At Para 6.3.1.3 of the same Doc it is stated that:

> *"For flight operations inspectors, the specialization training should also include training on aircraft-specific subjects, as appropriate to the role and tasks of the inspector, in particular on aircraft systems and operations. Flight Operations Inspectors may obtain aircraft type qualifications through courses conducted by aircraft manufacturers, approved training organizations or air operators' training courses. As a general rule, it is not desirable for the CASI to obtain qualifications from an operator under the CAA inspectional jurisdiction, unless adequate measures are in place to prevent any actual or perceived conflict of interest.*

The document therefore also provides for role and task specific training for Inspectors on aircraft systems and operations and utilization of Inspectors type qualified on aircraft with similar operational characteristics where required.

1.18 Additional Information

No further information.

1.19 Useful or effective Investigation Techniques

The investigation team reviewed the documents and evidences obtained from Pawan Hans, ONGC, DGCA, AAI and other stakeholders. Statements of witnesses including flight crew, passengers and rescuers were recorded and used for Investigation. Meetings and discussions were held with various post holders and personnel from all stakeholders to gather information and obtain clarifications. Consultations were held with other States during the finalization of the Investigation Report as per the requirements laid down in ICAO Annex 13.

The following techniques were employed during the Investigation and data analysis.

1. ***Flight Recorders Data***
   Specialized techniques were used to download data from the Flight Recorders as the units were retrieved from sea. The data download was successfully carried out with assistance of NTSB, USA in the presence of AAIB Investigation Team and used for analysis. (Refer Para 1.11.2)

2. ***CVR Spectrum Analysis***
   The cockpit voice recordings retrieved from the Flight Recorders were subjected to Spectrum Analysis and used for analysis of the events leading to accident. (Refer Para 1.11.3)

3. ***Verification of correctness of Radio Altitude parameter***
   To assess the correctness of the DFDR data for Radio Altimeter parameter, available data of all flights prior to accident flight including data of the period before the helicopter was inducted at Pawan Hans was analyzed. (Refer Para 1.6.3)

4. ***Examination of Life Jackets***
   Life jackets retrieved from a survivor and four deceased passengers were subjected to detailed inspection and testing at OEM's facility in Heemskerk, The Netherlands in the presence of the Investigation Team. (Refer Para 1.15.2)

5. ***Data from FCM***
   Data from the Flight Control Modules of the helicopter was retrieved with assistance from NTSB, USA and shared with the OEM for data analysis. (Refer Para 1.16.2)

6. ***Data from EEC and DCU***
   The data from the EEC and DCU was retrieved with assistance from TSB, Canada to make assessment about engine performance during the accident flight. (Refer Para 1.16.3)

7. ***Data from HUMS***
   An attempt was made to retrieve the HUMS data of the last flight with assistance from the NTSB, USA and the OEM but the data could not be retrieved and used for further analysis. (Refer Para 1.16.1)

8. ***Wreckage and Engine Examination***
   The boroscopic examination on the Engines was carried out and the wreckage of helicopter was examined by the Investigation team in association with representative of OEM. (Refer Para 1.3 and Para 1.16.4)

2. Analysis

2.1 Serviceability of Aircraft

On the day of accident, the aircraft held a valid certificate of airworthiness. All maintenance actions required as per the DGCA approved Aircraft Maintenance Programme (AMM) were carried out when due. The aircraft was assembled on 20 Oct 2021 and its first ground run was carried out on 23 Oct 2021. Thereafter, due to non-availability of qualified pilots on type, the operator either utilized services of pilots from other operator to carry out ground runs or kept aircraft under preservation. The Flight Test of aircraft was carried out on 11 Jan 2022, again by utilizing services of type qualified pilot from another operator.

After Expat pilot was available, regular ground runs could be carried out and non-revenue flying was carried out for training purpose. Since acceptance by ONGC for off-shore flying, the helicopter flew for 111:50 Hrs and carried out 180 landings till 27 June 2022. No significant snag or issue was reported by any pilots during these flights, except for "elevated swash plate bearing" trends which were observed on SGBA during monitoring of HUMS data. After required rectification action based on the advice of OEM, no further alerts were observed on SGBA and readings returned back to the fleet limits.

During the Boroscopic examination carried out after the accident, the helicopter engines did not show signs of any significant damage. The analysis of EEC data also did not indicate any anomaly or performance degradation.

2.1.1 Anomaly in Radio Altitude values in the Readout Report

The aircraft had flown about 157 hrs with the operator till the day of the accident without any major snag or issue reported by any of the pilots. No performance degradation or any other anomaly was observed from the DFDR data of the flight. All parameters were recorded in the DFDR of the accident flight. However, the radar altitude parameter in the DFDR readout was found erratic and illogical. This anomaly was present in full 157 hours of DFDR data, but was not captured by the operator in their Flight Data Analysis Program. Further, Radio Altitude is not in the first 15 parameters listed in Table 2 of Appendix I of Section 2 Series I Part V and thus was not being checked by AME or DGCA during annual inspection required as per the CAR or during issue of ARC.

Later it was found that, the word definition of Radio Altitude in the Data Frame file supplied by Sikorsky in its document SER-76040335 was incorrect. After Sikorsky provided the amended word definition, necessary revisions were incorporated in the data analysis software. The values of Radio Altitude in the readout became logical after applying word definition related changes in the software. The anomaly did not have any bearing on the accident, but should have been captured in the FDAP or Annual Inspections.

2.1.2 Life Raft

During, wreckage examination it was observed that the pneumatic line connecting reservoir to the Life Raft Pod on the RH side was sheared due to impact. However, on the LH side no remnants of pneumatic line were found. The Life Raft were installed on the helicopter on 31 May 2022 and duly certified by an authorized Engineer. The reasons for missing pneumatic line could not be established and integrity of inflation system could not be ascertained as life raft pods could not be retrieved from the sea and no further examination could be carried out on the system.

2.2 Operation of the Flight

The helicopter flight was commenced in Special VFR weather. The aircraft was started up normally and it took-off at 05:35 UTC. The take-off routing, including the heights maintained were as per the normal procedures and uneventful. The helicopter after take-off, took a slight deviation to avoid a CB, which has no bearing on the rest of the flight. The DFDR data also suggests that the aircraft maintained an uneventful stable flight profile leading to the approach for Sagar Kiran. Though the visibility was not reported at the platform, as per the statement of the pilots, the visibility was about 02 km and rig was in sight. During pre-landing checks it was decided to keep Co-pilot side Radar ON. The helideck was sighted and observed to be on Co-Pilot side, hence, the PIC (who was PF until then) handed over the controls to the co-pilot. From now onward the co-pilot becomes PF and PIC became PM. The helicopter remained coupled until 06:11:07 UTC when the FD was decoupled as a pilot action which was in keeping with the landing procedures. There was no significant flight path deviation immediately after the aircraft decoupled indicating that the AFCS was functioning normally. The PM continued to give speed and height callouts to the PF.

After decoupling the FD, to the point where the PM is heard saying “Putting your weather radar OFF” in CVR, 18 seconds had elapsed. Thereafter, the PM was occupied looking inside the cockpit to turn off the radar before landing. During this time the PF started raising the nose of the helicopter while reducing the collective in order to establish the glide slope. Progressive and excessive raising of the nose and simultaneous reduction in the collective pitch put the helicopter into a situation where available power was insufficient to maintain the altitude. The aircraft continued to deviate from the required approach path. Finally at one point, because of the aggressive pitch changes combined with very low collective pitch, the helicopter speed came to almost zero with no power available to sustain the altitude. The onset of uncontrolled flight occurred 36 seconds after decoupling, when the pitch attitude had reached to approximately 23° nose up and the collective was near full down position. The effects of the attitude / collective changes established a high sink rate leading to EGPWS “Sink Rate” and “Pull up” warning. The PIC took over controls at the last minute and attempted an unsuccessful recovery by increasing the torque and lowering the nose. However, the collective pull came too late to arrest the nearly 2,500 fpm rate of descent. The rotor RPM can be heard drooping in the CVR recording which was a result of the rapid collective increase in an effort to contain the sink. The aircraft impacted the water at 06:11:51 UTC.

Pawan Hans as part of its mitigation measures had planned to take only experienced off-shore Captains from its other fleet as co-pilots on S-76D, who would fly with experienced expat off-shore S-76D Captains. However, the plans did not materialize and the mitigation measure was not in place when the operations commenced. An experienced co-pilot (offshore Captain on earlier type (Dauphin or other)) and an experienced expat S-76D pilot as PIC, as was initially planned would have handled the situation in a different manner and a safe landing could have been achieved.

2.2.1 Weather Radar – Switching Off

Turning off the weather radar is essential before landing due to dangers of microwave radiation to persons on ground. The crew did not use switch on overhead panel to immediately turn-off the

Radar as described in the FCOM and used normal procedure as described in the RFM, for switching off the weather radar. Turning off the other side radar from the MFD takes a little more time, because it is across the centre console from the RHS and it requires accessing drop-down menus on the other side MFD to turn off the radar. Due to very little experience on aircraft type, the crew did not have adequate familiarity in accessing the menus and may not have been aware of possibility to switch off the radar from the overhead panel. Being involved in this activity at critical juncture using other side MFD, the PIC could not look outside or monitor other flight parameters that are presented only on the PFD (pitch attitude, torque, speed).

As such, the additional layer of safety monitoring by the PM was not available during crucial few seconds before the helicopter deviated from the approach path and the significant deviation of helicopter from the stable flight path could not be identified and prevented.

It must be noted here that due to limited flying on the new type, crew would have naturally taken more time for certain actions, such as switching off the weather radar as happened in this case. An experienced (expat) pilot as initially planned by Pawan Hans, would have coached the co-pilot to gain experience and be fully conversant with the cockpit instrumentation and controls.

2.2.2 AFCS Handling

When pilot is flying on only ATT mode, changes in the attitude or bank (for change in speed, altitude or direction) should normally be done only using the AFCS TRIM (beep trim) switch on the cyclic along with required collective inputs. Alternately, it can be done by pushing against the artificial feel which requires a lot of force to initiate and maintain, and is a deliberate action. This allows for a controlled and progressive deceleration or acceleration. Pressing the cyclic TRIM REL switch removes all artificial spring feel forces on the cyclic, and because the cyclic becomes completely free, this can cause overcorrection. It is not a recommended method to frequently press the TRIM REL switch to make changes in attitude or bank except during last stages of approach very close to the landing area necessitating larger attitude changes. The importance of not using the cyclic TRIM REL switch becomes more critical when flying in conditions without clear horizon and those that may severely reduce visibility.

A normal approach to land will usually not require more than 10°-15° nose-up pitch, increased in a gradual manner. The pitch-up for initial deceleration is usually accompanied by a slight reduction in the torque sufficient to ensure a stabilized descent on approach. In this case, the helicopter was never established on a stabilized descent and the DFDR data shows fluctuating pitch attitude and vertical speeds from +ve to -ve after a few seconds following decoupling. There was aggressive increase in pitch attitude up to 23° nose up while the collective was lowered to near full down position. Such a rapid and large change in pitch attitude is generally difficult to achieve when flying in AFCS basic mode, unless cyclic Trim Release (TRIM REL) switch is pressed.

Pressing the cyclic TRIM REL switch is not a standard practice, but appears to be a habit resultant from military training and flying on 'Mi' helicopter variants amongst Pawan Hans pilots as is evident from the remark *'Recommended to get more familiar with a cyclic trim release'* by TRE in the training report of the PIC.

2.3 Training and Qualification of the Crew

The training requirements for offshore helicopter flying are detailed in the Para 11.2 of CAR Section 8 Series H Part II. The PHL crew were already offshore qualified in respective roles on the Dauphin. Hence, the reduced requirements for qualification on new type S76D were flown as under:

Role	Training	Release	Remarks
PIC	5:00 hours with TRE / TRI	1:00 independent release check with TRE/TRI	Release check was done by same TRI with FOI on board
Co-pilot	1:00 hour with TRE / TRI	1:00 release check with role qualified TRE / TRI	Release check was done by same TRI with FOI on board

At the time of commencing offshore operations, the crew experience on the S76D was as under:

Type of flight	PIC	Co-pilot
Date of completion of Simulator training (Initial only)	03 Jul 2021	15 Aug 2021
Flying on helicopter with expat TRI April 2022		
PPC	1:00	1:00
IR Test	1:30	--
Offshore training	5:00 (P1 US)	1:00 (P2)
Offshore Release Check	1:00	1:00
P1 Offshore	--	--
Flying onshore with other PHL pilots only		
P1 Onshore	8:10	--
P2 Onshore	3:50	0:30 Instrument flying 0:30 Flight Check
Grand total on helicopter S76D (prior to commencing ONGC passenger flights)	**20:30**	**4:00**

All the crew had therefore met the bare minimum required training standards and flown the release check for off-shore. This was in compliance with existing regulations. However, it is a point to consider whether there was an appropriate level of total cockpit experience to start commercial specialised operations like offshore. Operator had acknowledged this in the Risk Assessment Matrix and had laid down the mitigating factor to overcome this unacceptable risk by ensuring to fly with S-76D experienced pilot(s).

Offshore flying is a very demanding environment. DGCA has laid down very stringent minimum flying regulations for such operations. The CAR however does not specify any minimum total cockpit experience on the type. Most of the other flying is over land environment and does not require specialised skills necessary in the dynamic and demanding offshore environment

2.4 Operator’s Safety Assurance

2.4.1 Safety Risk Assessment

Pawan Hans in its SMS Manual had laid down a formal process to identify changes which may affect the level of safety risks and to manage those risks. Introduction of a new type of helicopter in its fleet was definitely a major change, which needed a clearly defined plan for addressing any safety concerns that may follow such major change.

Interaction with the personnel responsible for maintenance of Safety Management System at Pawan Hans indicated that the exercise appeared to have been carried out only in letter without implementing the same in spirit.

2.4.2 Action taken to implement the mitigation measures

Pawan Hans had prepared a document providing a Safety Risk Assessment, wherein various types of risks were identified and mitigation measures proposed. However, sufficient documents could not be provided to the investigation team to demonstrate that they had put in place an action plan to mitigate these hazards and actual actions taken to address the same.

Pawan Hans identified lack of S-76D qualified experienced pilots, low experience level of co-pilots, un-availability of flying supervisors on S-76D and lack of operations/technical document as a Risk that could only be classified as 'Unacceptable' or 'Serious Risks'. Flying Operations without having mitigation measures in place were against the policy laid in the SMS Manual and which had also been accepted by DGCA.

However, none of the below mentioned mitigation measures to bring the risk to 'acceptable level' in Operations area, as stated in the SRA were practically in place prior to commencing commercial operations offshore.

- **Existing fleet off-shore PICs will be trained on S-76D and utilized as Co-Pilots** – In their mitigation plan, Pawan Hans had planned to engaged off-shore PICs on the existing fleet as Co-pilots to mitigate an 'unacceptable risk'. However, pilots who were not flying as PIC on existing fleet were trained on type and utilized for S-76D operations. The co-pilot of the accident flight had not flown as PIC on existing fleet of Pawan Hans.
- **S-76D Off-shore experienced PIC will be hired/deployed in initial stages with PHL Captains acting as Co-Pilots** – Pawan Hans hired experienced expat pilots so that they could be deployed as PICs with Pawan Hans captains acting as co-pilots to mitigate a 'Serious Risk'. However, the two expat pilots hired by PHL did not meet the DGCA's requirement for issue of FATA, and hence they could not be engaged for flying duties. The Expat Check airman could be issued FATA only in January 2022 and thereafter used for flying duties only for 10 days and 32 hrs which included carrying out PPC and other trainings for Pawan Hans pilots. No type qualified experienced pilot was available with PHL when the commercial operations started.
- **Off-shore PIC, TRE/TRI to be recruited** – PHL had got eight of its pilots type trained on S-76D from the ATO. Type Rated Examiner/Instructor was required by PHL to conduct flying training for its type trained pilots on helicopter and other recurrent trainings to mitigate a 'Serious Risk'. The expat pilot hired by PHL did not qualify to be a TRE and was issued TRI approval by DGCA. Delay in FATA and TRI approval meant that PHL pilots had gaps ranging between 07 to 14 months between type rating on Simulator and actual flying on helicopter when TRI and Helicopter became available. However, as this expat pilot could not pass Air Regulations exam, the initial FATA approval lapsed on 13 April 2022. Thus, PHL did not have any TRE or TRI at the start of commercial operations.
- **S-76D related Operational Documents like Ops Manual, Normal and Emergency Checklists, Passenger Briefing Cards to be prepared and approval obtained from DGCA** – Ops Manual, Checklists and Passenger Briefing Cards were prepared, but as DGCA FOI was not trained, he

expressed inability to certify these documents. The approval from DGCA could be obtained after a long delay. The Passenger Safety Briefing Card and Video although approved/certified by DGCA, did not have the complete and correct instructions for Passengers regarding operation of Life Jackets (LRS001) available in the helicopter.

The Accountable Manager and Safety Manager were required to ensure that operations under ‘unacceptable’ or ‘serious risks’ are not carried without having mitigation measures in place. However, the same was not done.

2.4.3 Flight Data Analysis Programme (FDAP)

During the Management of Change process, unavailability of FOQA parameters for S-76D was flagged as another ‘serious risk’ and incorporation of FOQA parameters in Flight Safety Manual was accepted as a mitigation measure. Pawan Hans had established Flight Data Analysis Program, in accordance with CAR Section 5, Series F, Part II. The parameters to be monitored and their exceedance limits were defined in the Flight Safety Manual by Pawan Hans and approval of the same was obtained from DGCA.

However, review of exceedance limits defined for various parameters indicated that the Flight Data Analysis Program was not geared to deliver safety benefits that have been envisaged in terms of proactive identification of hazards in aircraft operations before they may result in an accident, serious incident or an incident. It was observed that:

- Exceedance definition for Normal, Lateral and Longitudinal Acceleration which are also suggested for inclusion in FDAP by the CAR were not defined. The Safety Objectives to achieve reduction in the vertical speed/ acceleration exceedance (high rate of descent at low forward speed and low altitudes) which Pawan Hans had defined for itself in the Flight Safety Manual therefore was not possible. The program was hence rendered ineffective.
- The pitch attitude in the approach phase normally would vary between 10°-15°. However, in the FDAP the exceedance limit for this parameter was defined as +/- 25° for all phases of flight. During the accident flight, the pitch attitude went up to 23.5° with collective significantly lowered leading to helicopter entering an energy deficient state. With an exceedance limit of +/- 25° defined for this parameter in FDAP; had the PF been able to recover the helicopter from sharp descent and executed a safe landing thereafter, this unsafe situation would have remained undetected in the FDAP.
- FDAP exceedance limits were not made restrictive enough. Not a single exceedance was ever recorded for any parameters during any S-76D flight since the start of operations despite the fact that all Pawan Hans’ pilots were relatively inexperienced on S-76D.

The Safety Mitigation Measure to have FOQA program in place for S-76D operations though executed on paper, remained ineffective as the same did not provide any useful safety data trends for analysis and corrective action. An effective FDAP was absolutely necessary in view of the fact that the flight crew was relatively inexperienced. Role Specific Training on S-76D helicopter to DGCA officers engaged in evaluation and acceptance of Flight Data Analysis Program would have allowed better scrutiny of FDAP exceedance limits before acceptance.

2.5 Induction of Sikorsky - CAP 3400 process

In order to assess the competence of an Operator, the DGCA has to conduct an in-depth evaluation of the proposed operation, which should cover organization, staffing, equipment & facilities, proposed routes/ areas of operation, level and type of service and finances etc. The evaluations are carried out by DGCA inspectors who are guided by the requirements laid down in Air Operator Certification Manual to perform their duties. Air Operator Certification Manual- Helicopters (CAP 3400) lays down a 05 phase process to be followed for certification of Helicopter Operator. The pre-induction meeting was held in Dec 2020. Various approvals and certification were issued by different directorates of DGCA by the time formal meeting was held in Nov 2021. A majority of work however progressed only after the formal meeting, and CAP 3400 process culminated on 02 May 2022 taking more than a year.

The delay in completion of CAP 3400 process was a consequence of Pawan Hans' inability to comply with various requirements that are contained in DGCA regulations. The details and communications made available by the operator indicated that various approvals and certification were delayed due to Pawan Hans not being able to comply with the requirement to arrange Type Training for DGCA Inspectors, delay in securing training slots owing to financial issues, hiring of expat pilots ineligible for issue of FATA and not being able to obtain exemptions for extension of PPC and currency requirements etc.

While it can be clearly seen that Safety Mitigation Measures to address various risks identified for induction of new fleet were not in place at the time of start of operations, the discussions in the following sub-paras show how delays in CAP 3400 and inability to obtain exemptions from DGCA for issues resultant from a poorly planned induction made it practically impossible for both Pawan Hans and DGCA to have planned safety barriers in place.

2.5.1 CAP 3400 Process – Issues at Pawan Hans

Pawan Hans Limited is one of the largest helicopter operator in the country operating since 1985. Since Pawan Hans had not inducted new aircraft in its fleet in recent years, it was facing difficulty in renewing existing contracts or bidding for new contracts. The induction of Sikorsky S-76D was a major event for Pawan Hans and crucial to its profitability and market share. Sikorsky S-76D was being inducted first time by any Non-Scheduled Operator in India. It is evident from the correspondence and documents provided by Pawan Hans to AAIB that Pawan Hans considered the S-76D to be a major induction.

New type of helicopter induction should have been appropriately planned with defined timelines and to cater for perceived bottlenecks at the highest level. However, there was lack of clarity and coordination about roles and responsibilities of various internal departments and actions required for preparation. It is also evident that a thorough study and plan for induction was lacking.

As there were no S-76D off-shore qualified Indian pilots available for hiring, expatriate Pilots and TRE/TRI were required to fly these newly inducted aircraft with FATA approval. These expat pilots could have then helped the company train its pilots and meet other operational requirements. Selection process for hiring Expats was concluded and joining letters were issued to three pilots asking them to join in a staggered manner in Sept, Nov and Dec 2021.

The hiring itself was delayed as the aircraft had already been imported by this time and 08 Pawan Hans's pilots had received Type endorsements after undergoing Type Training at an ATO.

The expat pilot who held Check Airman approval from his country was asked to join in Sept 2021. He could not obtain FATA approval because of his absence from India due to personal reasons immediately after joining during which time his PPC also lapsed. Pawan Hans approached DGCA seeking relaxations from requirements so that he could be utilized for Flight Tests, hands on training for newly type rated Pawan Hans pilots etc. but this was not agreed to by DGCA. No alternate plan or arrangement was available with Pawan Hans. Non availability of qualified pilot at this crucial juncture delayed the CAP 3400 process as no qualified pilot was available to carry Test Flight or conduct training and checks for Simulator trained Pawan Hans pilots.

The other two expat pilots hired by Pawan Hans were not meeting the eligibility requirement for issue of FATA as they did not have current experience on Helicopter as required by CAR Section 7, Series G, Part II. These pilots joined Pawan Hans in Nov and Dec 2021. Hiring of ineligible Expat pilots shows lack of coordination between Pawan Hans' Operations and HR Department.

Due to delay in settlement of bills received from the ATO, Pawan Hans was not able to secure training slots for getting its fifth batch of four pilots trained at the ATO. Arranging training slots for Expats was an unplanned and additional burden. With great difficulty, Pawan Hans still managed to obtain training slots and send all three expat pilots for training.

After undergoing training at ATO, the Expat Check Airman was able to get FATA on 14 Jan 2022 and subsequently the TRI approval. However, as he was not able to clear Air Regulation exam, the FATA lapsed after period of three months leaving Pawan Hans without any TRI or experienced S-76D qualified off-shore pilot when the commercial operations started.

The other two expat pilots completed full Recurrent training and PPC in Jan 2022 at ATO. Despite this they were still ineligible to be issued FATA due to requirements of current flying experience on helicopter; and without issue of FATA, PHL could not have provided flying experience to these Expats.

In-spite of hiring expat pilots and arranging required training and checks for these expat pilots at ATO, Pawan Hans could not utilize them to provide much needed and timely flying experience to its pilots for whom 7-14 months had lapsed between Simulator Training and availability of Instructor/Helicopter for actual flying. Better planned hiring and timely issue of FATA in addition to better planned CAP 3400 process would have allowed type qualified and experienced expat pilots to hand hold Pawan Hans' newly trained pilots for a longer duration so as to gain more experience before operating independent of expat pilots.

In absence of FATA, the expat pilots could have been involved in various induction activities like preparation of the Operations Manual, Offshore SOPs, FDAP and other CAP 3400 process. But Pawan Hans was not able to get even that job done by these pilots as they protested about their agreed terms of engagement and went on unauthorised leave on different occasions.

The most critical Safety Mitigation Measures to have experienced Type qualified off-shore pilots thus could not be put in place by Pawan Hans before start of commercial operations. Poorly executed induction plan led to Pawan Hans management commencing commercial operations without putting in place the planned mitigation measures for risks identified as 'Unacceptable' or 'Serious' in the Safety Risk Assessment.

2.5.2 CAP 3400 Process – Issues at DGCA

2.5.2.1 Secondment of Experts vis-à-vis DGCA Inspectors Training

From the available evidence it was observed that one of the reason for delay in obtaining CAP 3400 approval was inability of Pawan Hans to get DGCA inspectors trained on Type at the beginning of CAP 3400 process as required by CAR Section 3, Series C, Part III and CAP 3400 Manual. The requirement was also conveyed to Pawan Hans during pre-induction meeting. Pawan Hans, had got their flight crew trained between the months of February 2021 and August 2021, but DGCA FOI or AWI were not provided training by Pawan Hans.

Helicopter arrived in India in the month of August 2021 and various approvals were issued by Airworthiness, Air Safety etc. towards progress of CAP 3400 process. However, DGCA FOI was not able to evaluate SOPs, Ops Manual, Passenger Briefing Cards and other checklist for approval process owing to lack of Type Rating Training.

In the present case, S-76D helicopter was being flown by one operator in India and trained and current flying pilots were available. In addition, type qualified and current pilots were also available on other variants of S-76 helicopter amongst Indian Operators. On the suggestion of DGCA during initial stages, Pawan Hans got the documents and checklist examined by a current type qualified pilot available in the Industry, but acceptance of documents vetted by an external expert from a private operator remained an issue which delayed CAP 3400 approval.

Due to strict insistence of DGCA to provide Type Rating for its FOI, the formal meeting with the DGCA team, which is practically the first step of CAP 3400 process, was delayed. Pawan Hans was already facing problems in getting slots for training of its own pilots and Expats as previous dues had not been cleared on time. However, it committed to arranging training of DGCA inspectors vide its letter dated 16 Nov 2021 and thereafter the approval process picked pace.

ICAO Doc 8335 provides that the flight operations inspectors "***should"*** have specialization training including training on aircraft-specific subjects, as appropriate to the role and tasks of the inspector, in particular on aircraft systems and operations. This clearly can be achieved by means of aircraft specific ground training. The ICAO document further states that flight operations inspectors "***may"*** obtain aircraft type qualifications. It does not make it mandatory to undergo full type endorsement to carry out all role and tasks required to be carried out by the FOI. When done at cost to operator, adequate measures should be in place to prevent any actual or perceived conflict of interest.

Whereas it is desirable for DGCA inspectors to have acceptable level of proficiency and knowledge of aircraft performance, limitations, equipment, systems, operations, etc. to better perform their duties, DGCA could have opted for short term secondment of type qualified pilots from industry if its Inspector was unable to evaluate or certify any document due to lack of Type Qualification of S-76D helicopter. In this case, a strategy to mitigate potential conflict of interest issues should be established and documented as required by ICAO Doc 8335.

It is clear that ICAO provides for taking experienced pilots from industry where ever required and does not make type qualifications a mandatory requirement every time. The Para 2.3 & 2.4 of

Chapter 2 of DGCA CAP 3400, however, makes it a mandatory requirement to be fulfilled by an AOP holder, whenever it inducts or replaces any of their aircraft with a new type of aircraft. The CAR or CAP is silent on the process to be followed if the FOI is unable to undergo or complete the Type Endorsement Training done at cost to the Operator. DGCA had earlier certified one S-76D operator and various S-76C/C++ operators in the past without insisting on such requirement by utilizing FOIs qualified on similar type/class of helicopter.

In the present case also, the requirements could also have been interpreted keeping DGCA Safety policy of assisting stakeholders / service providers in hazard identification and risk management. This would have added more value to the process and job could have been completed with fewer delays. The training on aircraft-specific subjects, as appropriate to the role and tasks of the inspector would have been more beneficial to ensure that errors in the Passenger Safety Briefing Card and Video could be identified and corrected during CAP 3400 demonstrations. The Type endorsement training was anyway finally carried out in May 2022 after the CAP 3400 process was over. The delay or lack of Type Rated Training however, cannot be linked to the anomaly found during the investigations wherein the details of life jackets in PBC and video did not match.

While PHL was able to obtain approval of S-76D related Operational Documents like Ops Manual, Normal and Emergency Checklists, Passenger Briefing Cards etc. effective Safety Mitigation towards identified ‘unacceptable’ risks was not in place due to the above mismatch.

2.5.2.2 CAR Requirement and exemptions

CAR Section 7, Series G, Part II lays requirement for expat helicopter pilots to have 05 hrs of flying including 05 take-offs and landings in preceding six months on an actual helicopter in order to be eligible for issue of FATA. Incidentally, this requirement is only for helicopter and not fixed wing.

The deficient hiring process at Pawan Hans led to hiring of two expat pilots who did not meet the above said requirements. In addition, PPC of these expat pilots had also lapsed. Pawan Hans arranged slots at ATO to carry out PPC for these pilots, but even after undertaking PPC at ATO, they were ineligible to be issued FATA due to requirements of current flying experience which could have been met only by undergoing requisite flying on Helicopter. Pawan Hans was not is position to provide them flying experience on their helicopter without issue of FATA. This led to a catch-22 situation that could not be resolved unless DGCA granted exemption to them from this requirement of CAR.

Since, above said requirement does not exist for Fixed Wing pilots, PHL thought they could obtain exemptions from DGCA for this requirement and applied to DGCA for exemption on 30 Mar 2022. Pawan Hans proposed that if FATA is issued with waiver, it will carry out 05 hrs of training on company helicopter with TRI before they are utilized for commercial flying. The request was however, not accepted by DGCA.

In case of the Expat Check Airman who was hired by Pawan Hans, his PPC lapsed before he could appear for FATA oral exam due to some unexpected reasons. Obtaining FATA approval without valid PPC would not have allowed Pawan Hans to utilize this expat for flying duties. Therefore, Pawan Hans requested DGCA for extension of PPC by four months so that they are able to carry out Test Flight of newly inducted S-76D helicopter and meet other CAP 3400 related requirements.

DGCA did not grant Pawan Hans any extension due to which Test Flight was delayed as they were left with no Type Qualified pilot. The most experienced Type Qualified pilot of another operator available in the country at that time had only 45 hrs of PIC flying experience on S-76D. Hence, he did not have the requisite 100 hrs of flying experience on S-76D helicopter which was a requirement of CAR Section 2, Series T, Part II for conduct of Test Flight. The Test Flight was carried out after DGCA granted exemption from 100 hrs minimum flying experience requirement laid in CAR Section 2, Series T, Part II.

The grant of exemption by DGCA is governed by sub-rule (4) of Rule 133A and procedure laid in CAR Section 1, Series B, Part III. While exemptions can only be issued as an exception and not a rule, it was observed that DGCA granted exemption to a PIC for a test flight who did not have 100 hrs of minimum flying experience as required under CAR Section 2, Series T, Part II. However, exemption for recency requirement or extension of PPC for grant of FATA to an experienced expat with 1384 hrs of PIC flying experience on type was not considered, which could have obviated the need to get Flight Test carried by a Pilot not meeting the minimum experience requirement to carry out the test flight.

Since Pawan Hans failed to obtain exemptions from DGCA, it was not able to utilize experienced type and role qualified pilots so as to put in place the Mitigation Measure for identified 'Unacceptable' and 'Serious' Risks. Flight Test was carried under exemption from DGCA and commercial operations were started with only the minimum regulatory requirements in place.

2.5.2.3 Passengers Safety Briefing

2.5.2.3.1 Passenger Safety Briefing Card

The Passenger Emergency Briefing Card is provided in the passenger cabin for making passengers familiar with location and use of Life Jackets and other safety equipment available in the aircraft as required by CAR Section 8 Series O Part IV and Para 3.17 of CAP 3400.

Operator had submitted Passenger Safety Briefing Card to DGCA for approval as required by CAP 3400 process. Though, DGCA FOI had expressed inability to examine and certify Passenger Safety Briefing Card owing to lack of Type Training on helicopter, the same was later examined, certified and finally approved by DGCA vide letter dated 22 Dec 2021. It was found during the investigation that whereas helicopter was equipped with LRS001 lifejacket, the approved Passenger Safety Briefing Card provided in the helicopter did not have description of LRS001 life jacket.

The LRS001 lifejackets were available with Pawan Hans since Dec 2020 and were used during the proving flight and other non-revenue flights. The Passenger Safety Briefing Video which was shot in Oct 2021 was also shot with depiction of LRS001 life jackets. The submission of Passenger Briefing Card with older type of life jacket to DGCA by Pawan Hans for approval again points out at the lack of inter-departmental coordination within Pawan Hans.

When the discrepancy was pointed out by DGCA Airworthiness Inspector during checks for ARC, Pawan Hans replaced the LRS001 lifejackets with older type to close the finding and obtain the ARC on 28 March 2022. The helicopter however continued to be equipped with LRS001 life jackets during all flying by Pawan Hans, including proving flight with DGCA FOI on board carried out on 27

April 2022, whereas the Passenger Safety Briefing Card in flight continued to have details of old type life jackets.

The application for revision in Passenger Safety Briefing Card to include the description of LRS001 life jackets was submitted to DGCA by Pawan Hans only on 10 May 2022 after the VT-PWI was endorsed on its AOP. It is possible that Pawan Hans did not approach DGCA for revision earlier to endorsement of S-76D so that the CAP 3400 process does not get delayed further. The revised Passenger Safety Briefing Card was approved on 09 Sept 2022, nearly four months after submission of application.

2.5.2.3.2 Passengers Safety Briefing Video

As per procedure mentioned in the DGCA approved Ops Manual, in addition to Passenger Safety Briefing Card, Pawan Hans was required to brief passenger through Passenger Safety Briefing Video as well. The shooting of this Safety Briefing Video was done in Oct 2021. As per information made available by Pawan Hans, a copy of this video was also provided to DGCA as part of CAP 3400 approval submissions. The Audio-Visual Briefing facilities are required to be certified by DGCA FOI in Checklist 14 of Appendix D of CAP 3400 and the same was done on 29 April 2022. Passenger Safety Briefing Card and Passenger Safety Briefing are also inspected and certified as part of Checklist 15 of Appendix D of CAP 3400 which was done on 27 April 2022. Whereas the Passenger Safety Briefing video showed the correct life jacket i.e. LRS001, it did not correctly identify the inflation toggle either in English or Hindi versions of the video.

The contents of Passenger Safety Briefing Video were incorrect and the video did not provide correct procedure for inflating the life jacket in an emergency situation. As such, passengers were not made aware of the correct manner to inflate the life jacket through the toggle. This is corroborated by the fact that after the accident three passengers wrongly pulled the ERBS toggle to inflate the life jacket, of which only one passenger could survive.

Moreover, on the day of accident the video briefing was played only in Hindi against requirement to have it played in English and Hindi. This could lead to a situation where a non-native Hindi speaker might not have understood the briefing correctly.

2.6 AS4 Standards - Acceptance of VT-PWI helicopter by ONGC

ONGC has laid AS4 standards for its contracted operators and accepts aircraft and crew for undertaking off-shore flying to support its operations only after demonstration by Operator that it meets the AS4 standards. As stated in their letters dated 02 May 2022 both crew of accident flight were accepted by ONGC in accordance with standard laid in Note 7 of AS4. After endorsement on AOP, VT-PWI was accepted by ONGC on 12 May 2022. Although, anomaly in Passenger Safety Briefing Card should have been detected during CAP 3400 process, it escaped detection and the aircraft was offered to ONGC by Pawan Hans. During acceptance of aircraft as per AS4, the requirement laid at para 6 would have required that Emergency Equipment be evaluated for compliance. This would have required inspection of available emergency equipment against those approved in Passenger Briefing Card by ONGC. However, the anomaly was not captured at this final stage as well.

Similarly, the anomaly and inaccuracies in Passenger Safety Briefing Videos which escaped detection by Pawan Hans and DGCA during CAP 3400 could also have been captured if the content of

Passenger Safety Briefing Video were evaluated by ONGC against the requirements laid in para 11 of AS4 standards before acceptance. This was another reason as to why Mitigation Measure with respect to making available DGCA approved Operations guidance in form of Passenger Safety Briefing was not effectively in place.

2.7 Survivability

2.7.1 Survivability - Equipment Aspect

2.7.1.1 Floatation System

As the helicopter lost control and plummeted, the rate of descent reached a peak of 3000 fpm before slightly being arrested. The helicopter impacted the sea at a descent rate of about 2000 feet per minute. The impact caused major damages to its structures, rotors and various other equipment. The tail section had broken due impact and could be seen clinging to the helicopter as the helicopter floated.

The aircraft was equipped with floatation system that would allow helicopter to stay afloat on sea after ditching. The present case, however, was not a case of controlled ditching. The floats were armed and inflated as the helicopter impacted sea. The rough sea caused the helicopter to capsize but helicopter stayed afloat for nearly 1.5 hours till the passengers could be rescued.

2.7.1.2 Life Raft

The helicopter was also equipped with an externally mounted Life Raft System. The life raft release handle was operated by the pilots, but the life rafts were not seen anywhere after the crew and passengers evacuated from the helicopter.

The Life Rafts are designed for water entry conditions of 300 fpm rate of descent. The helicopter impact force of around 2000 fpm was way beyond design limit which affected ability of the Life Rafts to inflate. Life Rafts separated from the helicopter and were no more connected to the Reservoir or Inflation System after impact. The Life Raft if inflated could have been of assistance to the passengers after the accident and enhanced survivability.

2.7.1.3 Life Jackets

The helicopter toppled as it impacted the water in banked position, but all passengers were able to evacuate from the helicopter. As they surfaced only one of the seven passengers was able to operate the Life Jacket on his own, he along with the crew guided and assisted other two passengers to operate their life jackets. Five people including two pilots were therefore able to hold on to the helicopter with their life jackets inflated.

Four people drifted into the sea without being able to operate the life jackets. Three of these persons later drowned, while one was rescued by Sagar Kiran Rescue Boat. Two of these deceased persons had pulled the ERBS toggle hard enough to rip it off, indicating they presumed it to be the Inflation toggle. The rescued person had also pulled the ERBS toggle believing it to be the Inflation Toggle. The Passenger Safety Briefing video has referred to the ERBS toggle as Inflation Toggle which provided incorrect procedure to the passengers to operate the life jacket. Lack of awareness about the correct inflation toggle was a factor leading to reduced survivability in the accident.

2.7.2 Survivability – Rescue Aspect

The aircraft impacted water at 06:12 UTC. As per the Sagar Kiran's ERP procedure for "Helicopter Ditching near Rig", the information about crash was transmitted to all SAR stakeholder including Malviya-16 which was the nearest OSV at the time of crash. The Sagar Kiran also lowered its Life Boat which was designated for use as Rescue boat into sea at about 0616 UTC. The boat has capacity of 50 pax in role as Life Boat, however, the capacity is limited to 06 pax for use in role as a Rescue Boat. There were 08 rescuers on board the boat against stipulated 06 pax for use in role as a Rescue Boat during the rescue operation.

Sagar Kiran Rescue Boat noticed passengers drifted away from the helicopter and proceeded to rescue them. One passenger who was noticed struggling to stay afloat was retrieved from the sea. Sagar Kiran did not attempt to retrieve unconscious persons from the sea. After rescuing one passenger, Sagar Kiran Boat started returning to the Rig. No attempt to rescue the survivors holding on to the floating helicopter was made keeping in mind the safety of rescue boat and rescue personnel in rough sea as OSV Malviya-16 was on its way to the site.

OSV Malviya-16 arrived at site at about 0655 UTC, about 20 minutes after the rescue boat rescued one person and started returning back to rig. Meanwhile, one of the five person who were able to inflate their life jackets and hold on to the helicopter also lost grip of the helicopter and drifted into the sea and drowned. Four persons with inflated lifejackets who were able to hold on to the helicopter till arrival of Malviya-16 were later rescued. The rescue efforts were further impaired by short length of ladder that was thrown towards the survivors to climb on to the ship, but all managed to be rescued between 0701 - 0733 UTC.

The Sagar Kiran's ERP and ONGC's RCP required that the rescue boat maintain continuous watch over the survivors. The decision of Sagar Kiran Rescue boat may have been guided by safety of 09 occupants of the boat who were already in excess of its capacity as Rescue Boat, however, the rescue boat should have stayed at the site monitoring the survivors and offering them hope, lest they too lose grip of the helicopter due exhaustion or any other reason and drift away into the sea.

2.8 Serviceability of Essential Equipment at Sagar Kiran Rig

During the investigation it was found that the recording facility for VHF communication at Sagar Kiran Rig was not serviceable. The rig is required to send Equipment Serviceability report to base every day but there was no mention of this issue in Equipment Serviceability Report of the day of accident or previous days. This indicates that complete serviceability checks were not being carried out on daily basis before reporting to the base.

The ESR did mention that the Anemometer was not functioning properly and this had continued for a significant period before the day of accident. From the CVR recording of VT-PWI it was observed that the winds reported by Sagar Kiran Rig were at large variance from the winds reported by nearby rigs. Whereas, other rigs nearby had reported 15-18 kts winds with bearing between 220° and 330°, Sagar Kiran was reporting 4-5 kt winds with bearing 310°. It could not be established if the winds reported by Sagar Kiran were incorrect or they were indeed at variance due to local convective activity. The anemometer was finally replaced by ONGC in Oct 2022.

2.9 Circumstances leading to the Accident

PHL decided to have Sikorsky S-76D helicopters on lease in view of customer demand for newer helicopters. Even though this induction was key to maintaining competitiveness in the market and business growth, the level of preparation and planning did not indicate that all challenges and requirements for such major induction were understood and catered to by the Management.

During Management of Change exercise Safety Risk Assessment was carried by Pawan Hans and the need to have experienced pilots and TRE was visualized and projected by the Operations Department. The recruitment process, however, ended with selection of Expat Pilots who were not qualified to get FATA. The Expat Check Airman was selected without clearly understanding whether he qualified to be a TRE.

When due to some unavoidable circumstances, FATA for the Expat Check Airman got delayed all planning fell apart without any backup plan. The aircraft which had arrived in August 2021 remained grounded, and eight pilots who had already undergone Type Training at ATO could not fly on S-76D for period ranging from 7-14 months and therefore were not current to fly S-76D when the aircraft and TRI were finally available. The operator faced difficulty in arranging slots for training of its pilots and expat pilots.

Approval and certification of various documents and checklists could not happen in a timely manner due piece meal submission by Pawan Hans and DGCA insisting on Type Training of its FOI as required by CAP 3400. The Formal Meeting was delayed and various operations related approvals and certification were delayed due to unavailability of Type Training for DGCA FOI. DGCA did not use provision of ICAO Doc 8335 to get Type Specific information vetted and certified by a type qualified pilots who were available in the Industry, at initial stages itself.

The CAP 3400 process suffered delays and gathered some pace only after the formal meeting and commitment by Pawan Hans to arrange Type Training of FOI in due course. All approvals were issued and related checklists certified.

The passenger safety briefing card approved during CAP 3400 did not have correct description of Life Jackets available on VT-PWI. The Audio-Video Briefing Facilities were certified on 29 April 2022 including the Passenger Safety Briefing Video which was required as per DGCA approved OM. The video did not contain correct identification of the inflation toggle. The same was also accepted by ONGC without ascertaining adherence to the standards laid in AS4.

Due to unavailability of qualified pilot and delay in CAP 3400 process, it took 8 months to operationalize VT-PWI after import in Aug 2021. For a brief period when Pawan Hans was able to utilize the services of Expat Check Airman, minimum training for four Pilots of Pawan Hans as required by the CAR was carried out.

Once proving Flight was certified by DGCA and VT-PWI endorsed on Pawan Hans' AOP, ONGC too gave clearance for undertaking commercial off-shore operations, without ensuring that various standards laid in their AS4 documents vis-à-vis content of Passenger Safety Briefing Video, availability of emergency equipment as per Passenger Safety Briefing Card etc. were in place.

Commercial flying was started with relatively in-experienced crew, who did not get sufficient opportunity to hone their skill with experienced Captains because Pawan Hans failed to obtain exemptions from DGCA for issue of FATA. Mitigation measures to cater for the identified hazards which existed in the form of absence of experienced pilots, unavailability of TRE, unavailability of correct Passenger Safety Briefings and appropriate FDAP exceedance limits, were rendered ineffective due to incorrect certifications or lack of exemption from DGCA for issue of FATA.

On the day of accident flight, cockpit was occupied by pilots who were meeting all regulatory requirements, but were relatively in-experienced on S-76D Helicopter. The passengers including a first timer listened to the passenger briefing video, which did not provide them correct information about the emergency procedures and correct location of inflation toggle of the life jacket.

The accident flight was the first flight of the day both for the helicopter and the flight crew. The take-off was normal and flight uneventful till beginning of approach to Sagar Kiran. The PIC had given the controls to co-pilot to carry out approach and landing. As the helicopter set approach, due to change-over of controls, the PM got engaged in switching off the Weather Radar of the PF side during the crucial phase of the flight. The PF made an aggressive nose up maneuver which is likely to be the result of cyclic trim release switch pressed while simultaneously lowering the collective. The helicopter was sent into an energy deficient state and quickly lost altitude at near zero speed in a state of autorotation. PM who was still engaged in switching off the Radar, took over control after being alerted by the EGPWS warning and panic reaction from PF. The low altitude and high descent rate, however, did not offer much opportunity for PM to arrest the fall and helicopter impacted the sea.

While all occupants evacuated from the helicopter, only five out of nine occupants including crew, were able to inflate their life jackets. Three passengers tried to inflate the life jacket using the wrong toggle and ripped it off in the process. One passenger did not operate any toggle to inflate the life jacket.

The Sagar Kiran Rescue Boat picked only one passenger who had drifted away from the helicopter and returned to the Rig without making an attempt to recover unconscious passengers or monitor passengers who were holding on to the floating helicopter in the rough sea. Four more occupants could be rescued alive as OSV Malviya-16 arrived at the scene 45 minutes after the accident. Four occupants including the three who could not inflate their life jackets were recovered from the sea in un-conscious state and transported to Hospital where they were declared brought dead.

3. Conclusion

3.1 Findings

3.1.1 At the inception of induction of S-76D, challenges and requirements were not assessed and appropriately catered to, by the Pawan Hans Management. Planning for organizational change as per the SMS Change Management Process was not undertaken adequately by involving all the Departments to prevent hazards or address safety risks.

3.1.2 Two out of the three expat pilots hired by Pawan Hans were not eligible to obtain FATA. Pawan Hans spent time and resources on seeking exemptions from DGCA, that too at a very late stage. DGCA did not grant exemption for recency requirement for issue of FATA to the Expat Pilots or extension of PPC.

3.1.3 Safety Barriers as part of mitigation measures to be put in place for various ‘Un-acceptable’ or ‘Serious’ risks identified by Pawan Hans during the Safety Risk Assessment were either not in place or were rendered in-effective due to anomalies.

3.1.4 Though, assistance of type qualified pilots available in the Industry was taken during the CAP 3400 process, the means to formally accept such assistance (as per Para 5.3.7 of ICAO Doc 8335) are not available in CAP 3400.

3.1.5 From Pre-approval meeting to final endorsement on AOP, it took Pawan Hans and DGCA 16 months to complete the CAP 3400 process for induction of new type on the existing AOP. During this long process, it took Pawan Hans 08 months to operationalize the helicopter after import.

3.1.6 Inappropriate definition of parameter exceedance by Pawan Hans rendered FDAP ineffective not just for proactive identification of hazards but also to achieve the safety objectives that Pawan Hans had defined for itself.

3.1.7 The word definition of Radio Altitude in the Data Frame file supplied by Sikorsky in its document SER-76040335 was incorrect which was leading to illogical and erratic values in the readout reports. The same could not be identified by Pawan Hans during FDAP or Annual Inspections.

3.1.8 Since majority of pilots in Pawan Hans are from military background, flying with Cyclic Trim Release Switch held down appears to be a practice in the organization and pilots are not familiar with its ideal usage, as remarked by Expat Check Airman during a check flight of a Pawan Hans pilot.

3.1.9 The flight control inputs made by the co-pilot were inconsistent for a stabilized approach and the landing profiles outlined in the RFM, which requires a vertical profile of 300 FPM or less during the approach to landing. The pilots may not have understood or been proficient using the Basic AFCS.

3.1.10 The description of Life Jacket in Passenger Safety Briefing Card approved by DGCA was not matching the type of Life Jacket (LRS001) that was placed on the helicopter. Pawan Hans did not initiate any action to get amendments incorporated in the Passenger Safety Briefing Card until endorsement of S-76D on AOP, even though these life jackets were available with Pawan Hans since Dec 2020 and had been used during Proving Flight and other non-revenue flights before endorsement. It took Pawan Hans another four months after S-76D endorsement on AOP to get the revision of Passenger Briefing Card approved by DGCA.

3.1.11 Passenger Safety Briefing Video did not provide correct guidance for inflation of life jackets. ERBS toggle was wrongly depicted as the inflation toggle in the briefing video. The anomaly escaped detection during internal vetting at Pawan Hans, CAP 3400 certification by DGCA and acceptance as per AS4 standards by ONGC.

3.1.12 All occupants evacuated the helicopter and only 05 could inflate the life jackets. Three passengers apparently pulled the ERBS toggle in place of inflation toggle in an attempt to inflate the life jackets and one passenger did not pull any toggle, after evacuating from helicopter.

3.1.13 The external life rafts did not inflate and life raft pod assemblies separated from the aircraft during impact as a result of impact forces in excess of design criteria.

3.1.14 The rescue boat of Sagar Kiran was unserviceable and the Life Boat was designated to be used for Rescue role with limitations to not carry more than 06 occupants in rescue role. On the day of accident, eight rescuers went to sea for rescue operation on the Rescue Boat.

3.1.15 The Sagar Kiran rescue boat started returning to rig after picking one passenger who had drifted away from helicopter, rather than head to the floating helicopter or remain at site to monitor survivors lest they drift away in the sea.

3.1.16 The ladders used by Malviya-16 did not have adequate length for survivors to catch hold of it and scramble nets were used to pull them up.

3.1.17 Equipment for preserving VHF communication recordings at Sagar Kiran Rig were not serviceable, but there was no mention of it in the daily Equipment Serviceability Report.

3.1.18 Anemometer was reported as not functioning properly, but corrective action was taken only in Nov 2022.

3.2 Probable Cause of the Accident

The accident was caused as helicopter entered into uncontrolled flight during its final approach, because of undesired aggressive nose up maneuver coupled with full lowering of the collective by Pilot Flying, which resulted in steep autorotative descent at near zero speed leading to impact with sea.

The following were the contributory factors in the accident:

- Lack of familiarization and proficiency on use of the aircraft's AFCS, which led to inappropriate handling of controls; and
- Absence of monitoring by Pilot Monitoring due to involvement with switching-off of weather radar during crucial phase of flight leading to delayed take-over in emergency.

4. Safety Recommendations

4.1.1 Pawan Hans should ensure that the executive nominated to DGCA as Accountable Executive or other post holders have adequate experience in civil aviation and ability to put resources and authority at their disposal to achieve complete inter-departmental and inter-disciplinary coordination.

4.1.2 Pawan Hans should emphasize use of the Basic AFCS functions during normal flying operations by the pilots. It should be brought to the notice of all its pilots that use of the cyclic TRIM REL switch during normal flying operations should not be resorted to especially in low visibility conditions, other than during operations close to the take-off and landing areas. The use of the AFCS trim (beep trim) must be made to effect speed changes, and fly-through or fly against the spring used for smaller heading changes or turns.

4.1.3 Pawan Hans should raise awareness amongst their S-76D pilots about the procedure in FCOM which allows them to immediately secure the weather radar by pressing the WX RADAR button on the pilot's overhead switch panel in case of such requirement.

4.1.4 Pawan Hans should revise its FDAP to include additional parameters for effective monitoring of operational exceedance. Parameters should have the realistic exceedance limits and severity grading for applicable phases of flight, so as to proactively capture the undesired trends.

4.1.5 DGCA should review its CAR on FDAP to provide additional guidance to helicopter operators in terms of adverse operational events and operations related parameters.

4.1.6 DGCA should ensure Role Specific Training of its officers engaged in evaluation and acceptance of Flight Data Analysis Program for proper scrutiny of FDAP exceedance limits before acceptance.

4.1.7 DGCA should ensure that all parameters recorded in the DFDR are checked and certified to be satisfactory in respect of recording of parameter, continuity of data and realistic value of parameter during annual inspection required by CAR Section 2, Series I, Part V.

4.1.8 DGCA should revise the CAR on the subject to include a minimum experience on the new type specifically in the offshore role. The regulations should clearly define the minimum experience in such a way that at least one pilot on board with adequate role experience on the new type is available in the cockpit during offshore operations.

4.1.9 DGCA should review CAP 3400 procedure and CAR Section 3, Series C, Part III to incorporate the provisions of ICAO Doc 8335 for utilizing suitable experts on short-term secondment under supervision of DGCA officers for evaluation of Operations related documents wherever required.

4.1.10 In accordance with ICAO Doc 8335, DGCA should make provisions in its CAR and CAP for utilization of FOIs type qualified on similar type or class of aircraft based on complexity, automation, engine technology, flight control logics, size, mass etc. rather than mandating Type Qualification on each type/variant of aircraft every time.

4.1.11 DGCA should carry out one time audit of all operators to verify that Passenger Safety Briefing Cards used by the operators are in consonance with actual equipment available on aircraft.

4.1.12 DGCA should carry out one time audit of operators who are using Passenger Safety Briefing Videos, to verify that there is no anomaly in safety and emergency procedures being shown in the video.

4.1.13 DGCA should include content of Passenger Safety Briefing Videos as a distinct and separate item to be certified as part of CAP 3400.

4.1.14 ONGC should review its AS-4 standards, to revise the requirements for life jacket. It should be ensured that all operators contracted by ONGC use single type of Life Jacket so as to increase the level of awareness about usage of life jacket amongst its personnel.

4.1.15 ONGC should ensure that Passenger Safety Briefing provided by the helicopter operators satisfy the requirement contained in Para 11 of AS4.

4.1.16 ONGC should ensure serviceability of all safety, communication & rescue equipment on its rigs and vessels.

4.1.17 ONGC should take suitable measures to ensure awareness amongst its personnel about capacity and limitations of its rescue boats.

4.1.18 ONGC should raise awareness about sanctity of ERP procedures amongst its off-shore personnel by means of training.

4.1.19 In view of anomaly noticed in word definition of Radio Altitude in the Sikorsky's Data Frame Document SER-76040335, Sikorsky should amend and revise the document.

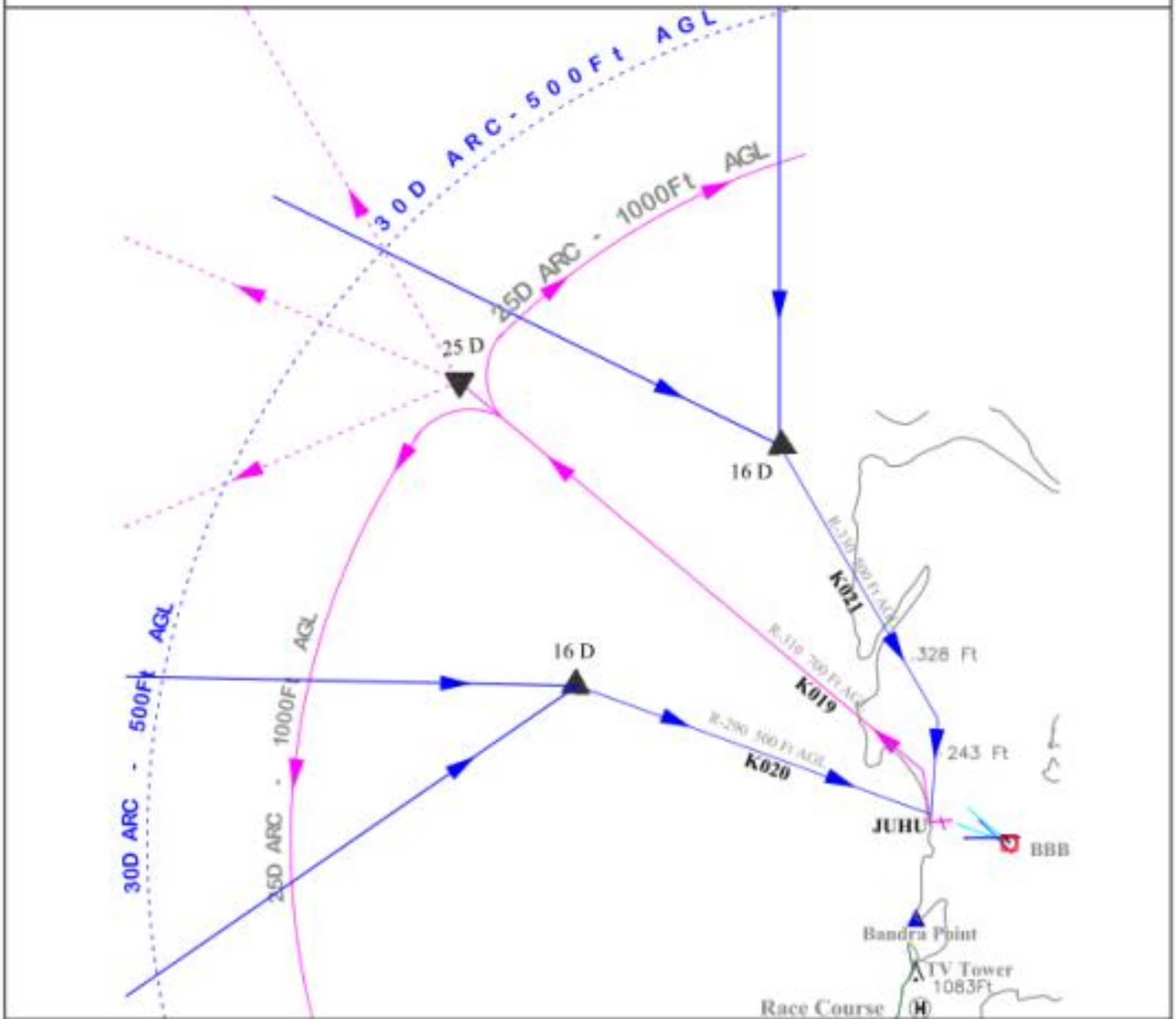
5. Appendices

Appendix A

JUHU AERODROME, MUMBAI

Juhu TWR - 118.750, 124.350
Mumbai TWR - 118.100
Mumbai APP - 127.900
INS Kunjali- SPARTAN- 126.8
All radial and DME distance from BBB VOR/DME

HELICOPTER VFR ROUTINGS
K019, K020, K21
(RWY 27 in use at Mumbai)



K019 - (Juhu aerodrome to Bombay High)

After departure from RWY26, proceed on R-310 (BBB) upto 25D maintaining 700 Ft AGL. At 25D climb to 1000 Ft and proceed direct to destination ensuring minimum distance of 25D from BBB at all times or join 25D arc from BBB-VOR. Beyond 25D climb to F60 Maximum.

K020 - (Bombay High to Juhu aerodrome) [Arrivals from South and South-West]

Descend and maintain 500 Ft AGL by 30D (BBB), thereafter proceed direct to establish R-290 at 16D from BBB, proceed on R-290 (BBB) to land on RWY26 at Juhu aerodrome.

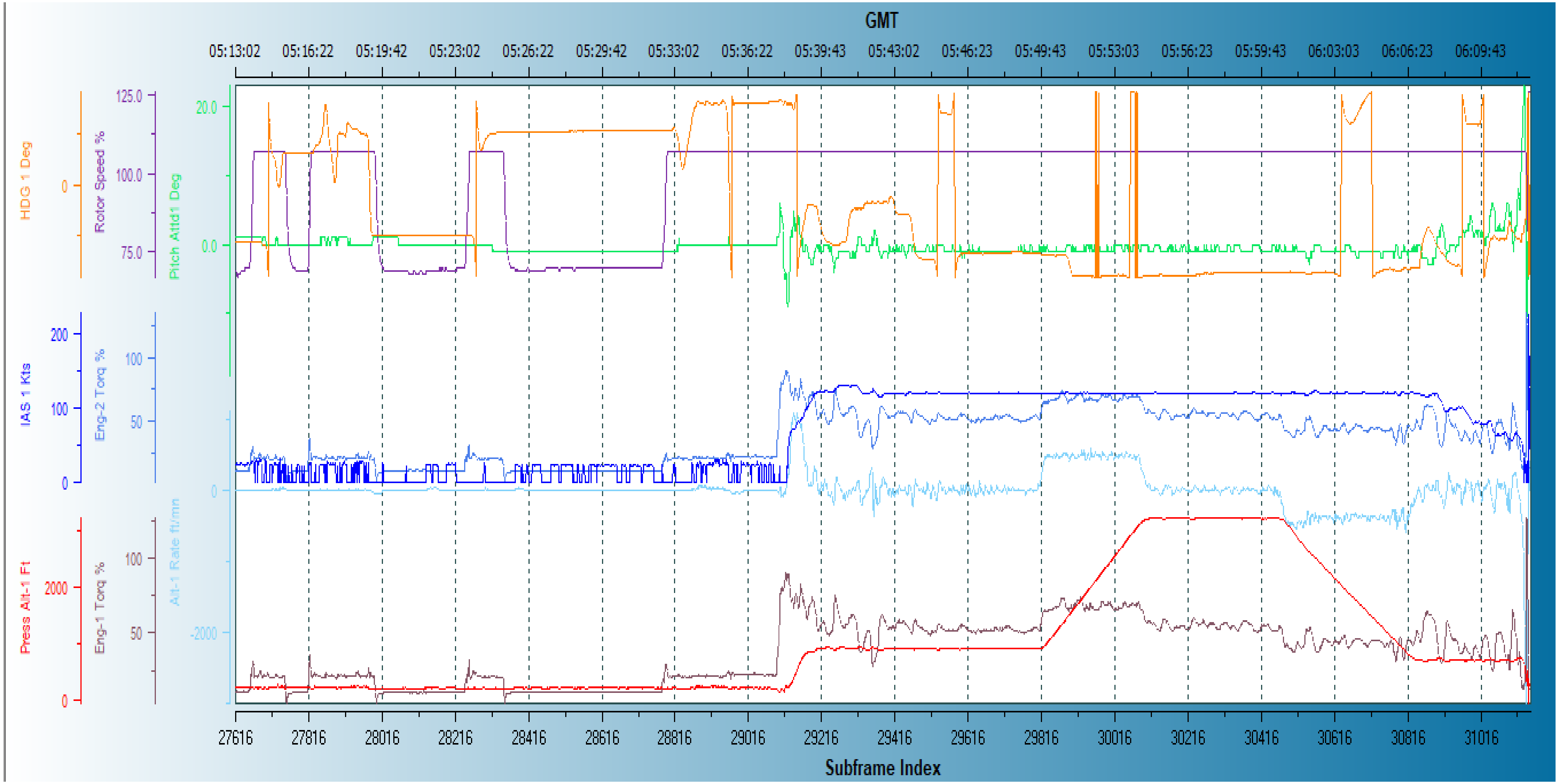
K021 - (Bombay High to Juhu aerodrome) [Arrivals from North and North-West]

Descend and maintain 500 Ft AGL by 30D (BBB), thereafter proceed direct to establish R-330 at 16D from BBB, proceed on R-330 (BBB) to land on RWY26 at Juhu aerodrome

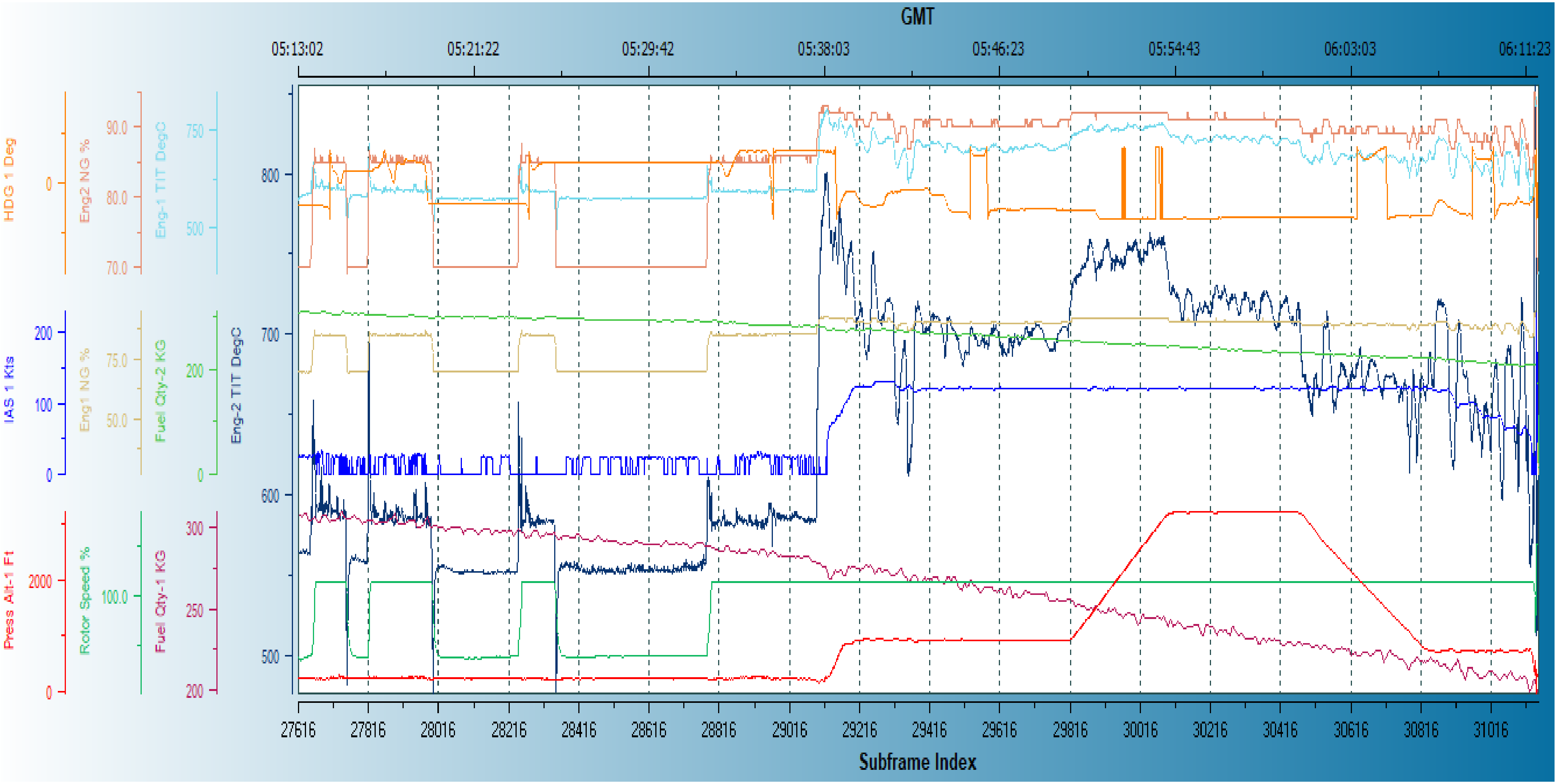
DRG. NO. AAI/XXIALC/21/15.07.21

Appendix B

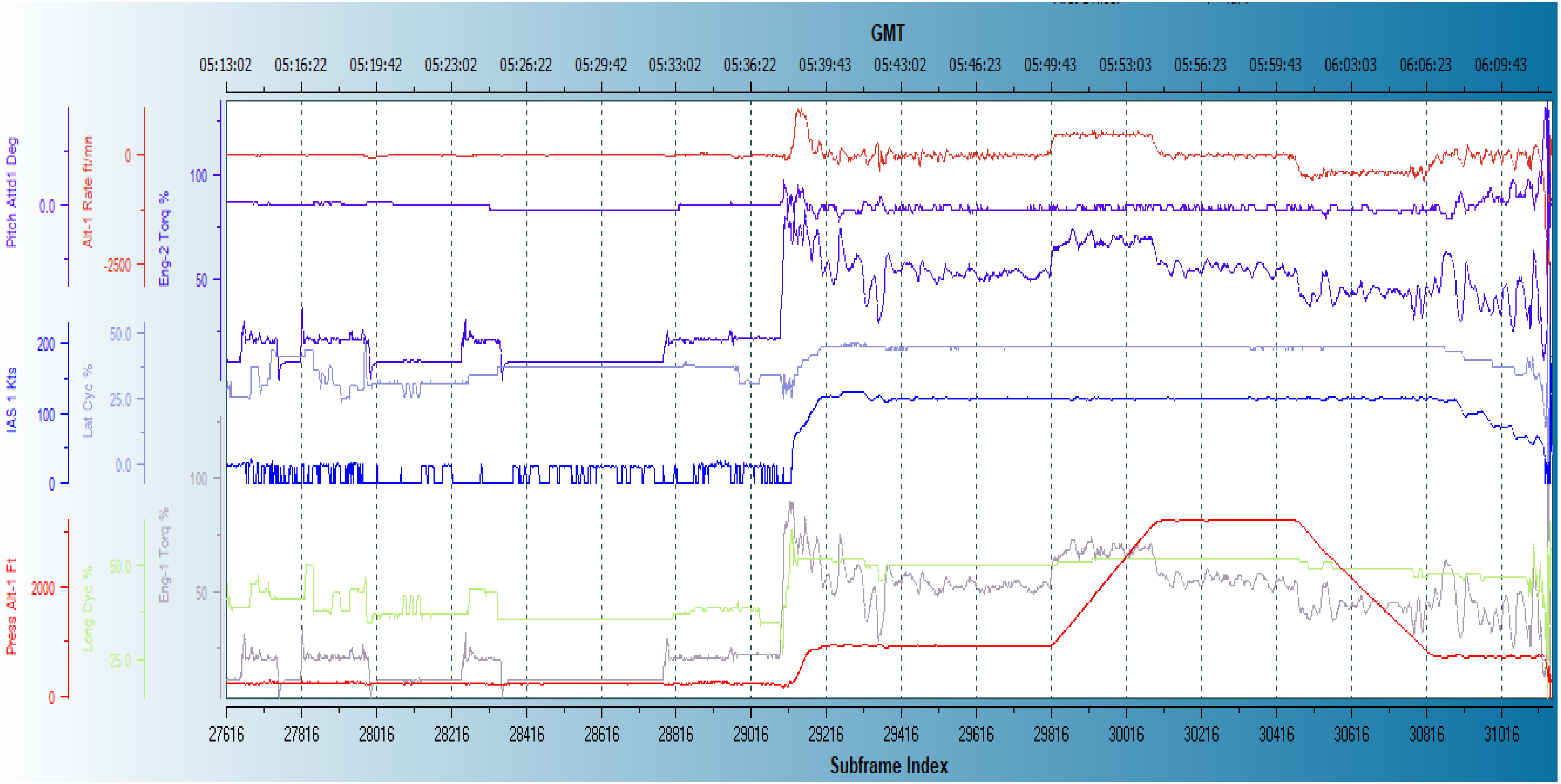
GRAPHICAL REPRESENTATION OF DFDR PARAMETERS WITH TIME FOR ACCIDENT FLIGHT



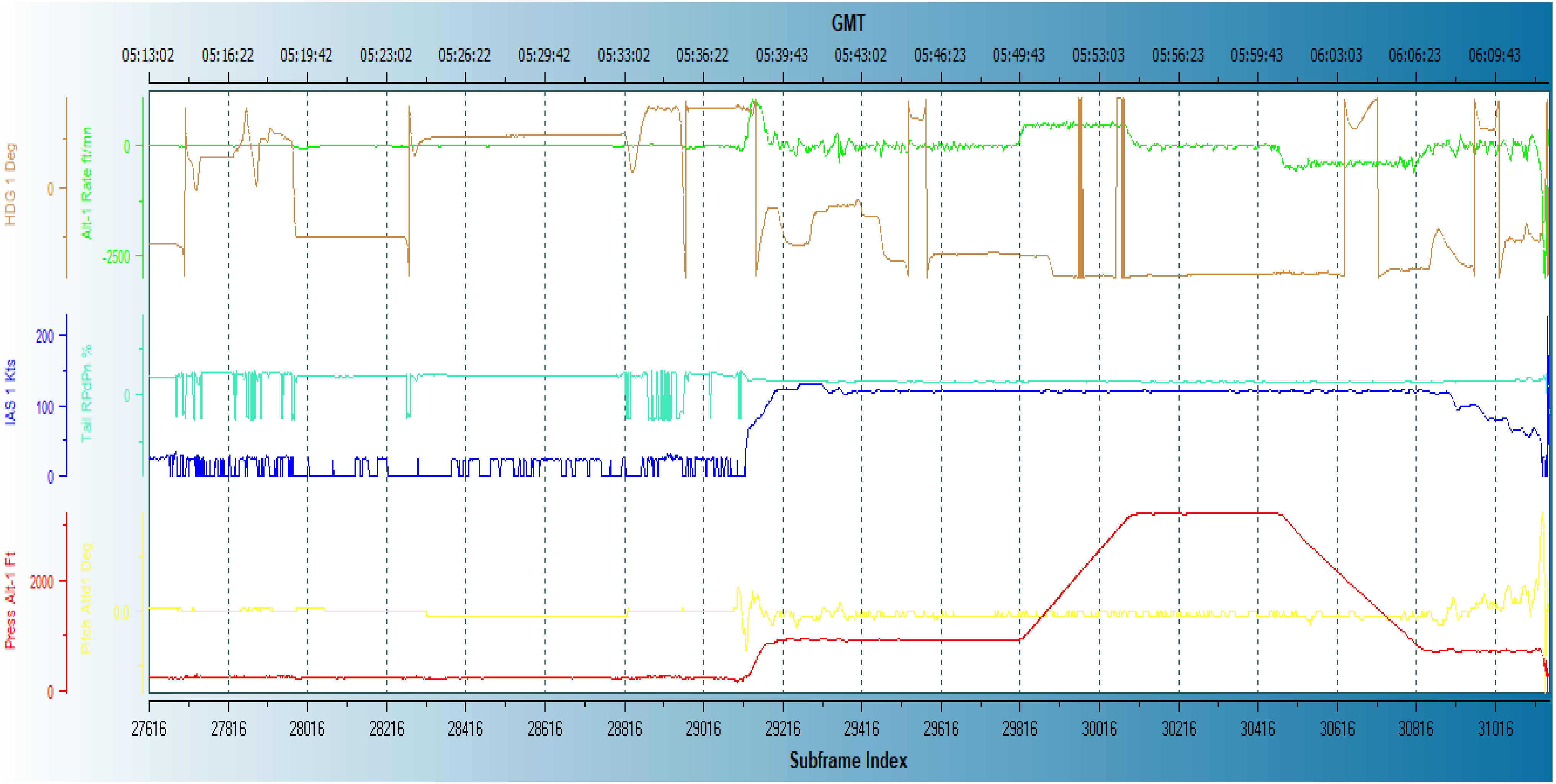
Graph 1


GMT
05:13:02
05:21:22
05:29:42
05:38:03
05:46:23
05:54:43
06:03:03
06:11:23
HDG 1 Deg
Eng2 NG %
Eng-1 TIT DegC
IAS 1 Kts
Eng1 NG %
Fuel Qty-2 KG
Eng-2 TIT DegC
Press Alt-1 Ft
Rotor Speed %
Fuel Qty-1 KG
Subframe Index
27616
27816
28016
28216
28416
28616
28816
29016
29216
29416
29616
29816
30016
30216
30416
30616
30816
31016

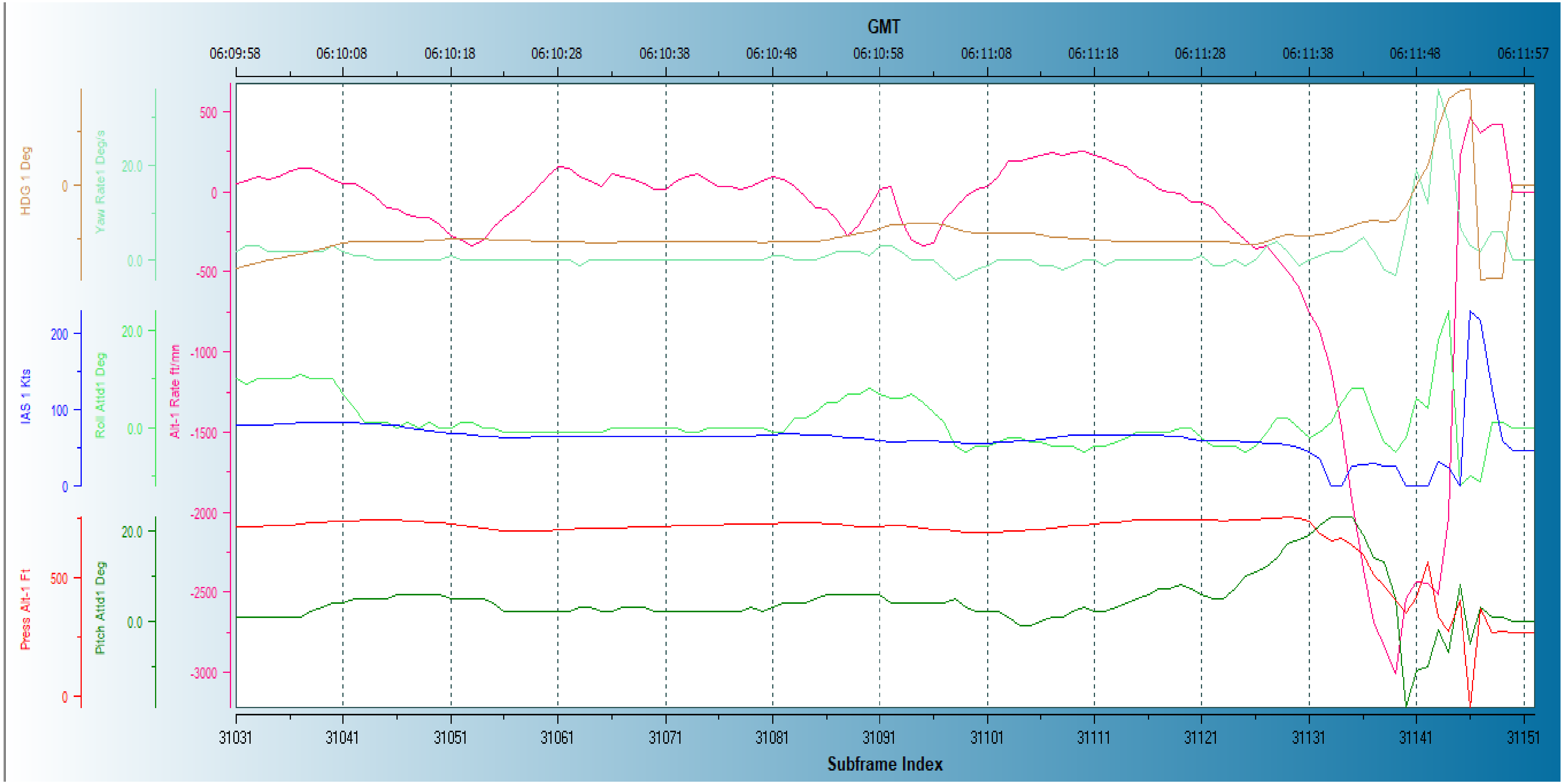
Graph 2


GMT
05:13:02
05:16:22
05:19:42
05:23:02
05:26:22
05:29:42
05:33:02
05:36:22
05:39:43
05:43:02
05:46:23
05:49:43
05:53:03
05:56:23
05:59:43
06:03:03
06:06:23
06:09:43
Pitch Attd1 Deg
Alt-1 Rate ft/mn
Eng-2 Torq %
IAS 1 Kts
Lat Cyc %
Press Alt-1 Ft
Long Cyc %
Eng-1 Torq %
Subframe Index
27616
27816
28016
28216
28416
28616
28816
29016
29216
29416
29616
29816
30016
30216
30416
30616
30816
31016

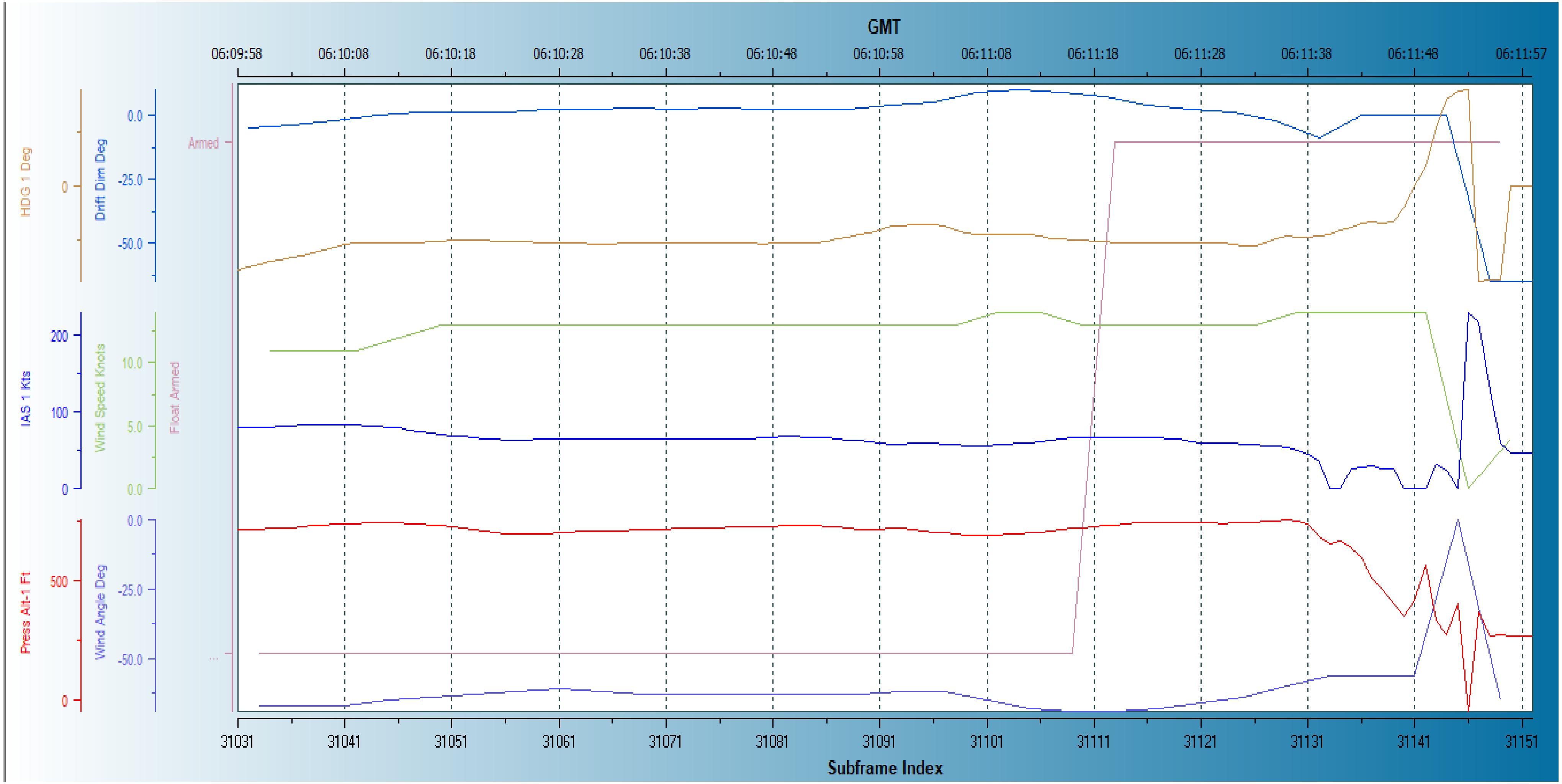
Graph 3


GMT
05:13:02
05:16:22
05:19:42
05:23:02
05:26:22
05:29:42
05:33:02
05:36:22
05:39:43
05:43:02
05:46:23
05:49:43
05:53:03
05:56:23
05:59:43
06:03:03
06:06:23
06:09:43
HDG 1 Deg
0
Alt-1 Rate ft/mn
0
-2500
IAS 1 Kts
200
100
0
Tail RPdPn %
0
Press Alt-1 Ft
2000
0
Pitch Attd1 Deg
0.0
27616
27816
28016
28216
28416
28616
28816
29016
29216
29416
29616
29816
30016
30216
30416
30616
30816
31016
Subframe Index

Graph 4



Graph 5: Graphical representation of parameters during last 02 minutes (Part 1).



Graph 6: Graphical representation of parameters during last 02 minutes (Part 2)

- End of Report -