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AAIA

Air Accident Investigation Authority

Deviation from Intended Flightpath (DEV)

Investigation Report

Serious Incident
Boeing 787-8 VT-ANE
Approach to
Hong Kong International Airport
20 October 2018

IVR-2025-02

AAIA Investigations

Pursuant to Annex 13 to the Convention on International Civil Aviation and the Hong Kong Civil Aviation (Investigation of Accidents) Regulations (Cap. 448B), the sole objective of the investigation and the Investigation Report is the prevention of accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

The Chief Inspector ordered an inspector's investigation into the serious incident in accordance with the provisions in Cap. 448B.

This serious incident investigation report contains information of an occurrence involving a Boeing 787-8, VT-ANE, operated by Air India which occurred on 20 October 2018.

The Government of India Aircraft Accident Investigation Bureau (AAIB), being the investigation authority representing the State of Registry and State of Operator, the National Transport Safety Board (NTSB) being the investigation authority representing the State of Design and the State of Manufacture and Boeing Company provided assistance to the investigation.

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

This Investigation Report supersedes the Preliminary Report and all previous Interim Statements concerning this serious incident investigation.

All times in this Investigation Report are in Hong Kong Local Time unless otherwise stated.

Hong Kong Local Time is Coordinated Universal Time (UTC) + 8 hours.

Chief Accident and Safety

Investigator Air Accident Investigation

Authority Transport and Logistics

Bureau Hong Kong

April 2025

Synopsis

On 20 October 2018, an Air India (AIC) Boeing 787-8 aircraft, registration VT-ANE, flight number AIC314, departed from the Indira Gandhi International Airport (VIDP), India to Hong Kong International Airport (VHHH).

Prior to the approach into VHHH, the crew had both briefed and received cautionary information from the Hong Kong arrival Automatic Terminal Information Service (ATIS) regarding the possibility of Instrument Landing System (ILS) glideslope fluctuation under the single runway operation on Runway 07R.

At 0608 hours, Air Traffic Control (ATC) further advised the crew of the possible glide path signal fluctuation. At 0611 hours, ATC cleared the aircraft for the ILS approach for Runway 07R. During the approach, the aircraft descended rapidly, triggering a series of Ground Proximity Warning System (GPWS) alerts. The aircraft descended to 280 feet radio altitude, approximately 2.6 nautical miles from Runway 07R when the crew performed a go-around. The aircraft landed uneventfully on Runway 07R on the second approach.

There was no injury to the crew and the passengers on board the aircraft, or ground personnel.

The investigation team has made three safety recommendations.

Contents

1. FACTUAL INFORMATION

1.1. History of the Flight

(1) On 20 October 2018, Air India (AIC) Boeing 787-8 (B787) aircraft, registration VT-ANE, flight number AIC314, departed from Indira Gandhi International Airport (VIDP), India, to Hong Kong International Airport (VHHH).

(2) The crew had previously operated from Mumbai (VABB) to VIDP, and after a turnaround, proceeded to VHHH.

(3) During the flight, the pilot-in-command was the Pilot Flying (PF) while the co-pilot was the Pilot Monitoring (PM)[1].

(4) The crew briefed for the arrival into Hong Kong and were expecting the Instrument Landing System (ILS)[2] approach on Runway (Rwy) 07R. The briefing mentioned that the Rwy 07R approach and landing chart contained the notation that the glideslope (GS) signal may be liable to interference from ground traffic during CAT I operations. This information was also received by the crew on the Hong Kong arrival Automatic Terminal Information Service (ATIS)[3] which advised the possibility of ILS glideslope fluctuation.

(5) During the briefing, it was stated by the PF that should the GS fail, the strategy was to continue with a localiser-only (LOC)[4] approach.

(6) A normal descent followed and at 0608 hours whilst being radar vectored for the ILS, Air Traffic Control (ATC) further advised the crew of possible glide path signal fluctuation due to an aircraft being inside the sensitive area. This advice was repeated at the request of the flight crew.

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1 Pilot Flying (PF) and Pilot Monitoring (PM) procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, while the PM carries out support duties and monitors the PF's actions and the aircraft's flight path. The nominated pilot in command still has overall responsibility for the safe operation of the flight.

2 Instrument Landing System (ILS) is defined as a precision runway approach aid based on two radio beams which together provide pilots with both vertical and horizontal guidance during an approach to land. The glideslope (GS) provides the vertical and the localiser (LOC) provides the horizontal guidance. An approach can be flown using the LOC with the crew manually adjusting the vertical guidance by other means.

3 Automatic Terminal Information Service (ATIS) is an automated system for continuous dissemination of vital information including airfield, meteorological and navigational aids serviceability information to aircraft via radio broadcasts and data link.

4 Localiser (LOC) approaches are defined as non-precision runway approach aids based on a single ground based radio beam which provides pilots with horizontal guidance during an approach to land. Vertical guidance is not provided and the crew have to control the descent adhering to altitude restrictions published on the appropriate chart.

(7) At 0611hours, ATC cleared the B787 for the ILS approach for Rwy 07R. The B787 was flying level at 2,000 ft and at a speed of 160 kt, established on the localiser and tracking inbound to the runway. The intention was to intercept the GS from below and follow the guidance to a landing.

(8) At the airfield, a Boeing 747-8F (B748) had been positioned at the CAT I holding point 'K1' of Rwy 07R and was cleared for take-off. The B748 taxied onto the runway past the GS transmitter.

(9) At this time, the B787, still maintaining 2,000 ft with the autopilot engaged and with GS armed, flying with a normal nose up pitch of plus 4.5 degrees transitioned to a GS capture, still one dot below the glideslope. This was accompanied by an aggressive pitch down and the aircraft started to descend rapidly.

(10) This pitch down continued with the B787 reaching a rate of descent of 2,800 ft/min. The airspeed increased from 160 to 178 kt and the nose down attitude reached minus 8 degrees.

(11) A Master Caution activated and the PM observed that the G/S mode had an amber line through it signifying that it was unreliable.

(12) At 1,400 ft, the PF disconnected the autopilot and 2 degrees of nose up control column was applied which reduced the pitch attitude and decreased the descent rate to 900 ft/min.

(13) Forward input was then commanded on the control column and the descent rate increased to approximately 2,000 ft/min.

(14) The airspeed had reached a maximum of 184 kt at this stage and then began to decrease.

(15) The descent below the GS continued to 1,200 ft, which was reached at 6 nautical miles (NM) DME.

(16) The flap handle was selected to 30 but the flaps were prevented from extending by the flap load relief[5] until the speed decreased.

[5] The flap load relief protection protects the flaps from air load damage. When the airspeed limit is exceeded with the flaps in the 15 through 30 position, the flaps retract to a safe position appropriate to the airspeed. When airspeed is reduced, the flaps automatically re-extend as airspeed allows. If a flap overspeed exists, load relief prevents flap extension beyond the 5, 15 or 20/25 positions until airspeed is sufficiently reduced. The flap lever does not move during load relief operation.

(17) At 1,000 ft, the PM recycled the flight directors. The pitch mode changed to vertical speed and the roll mode to heading hold. The crew then selected ARM to capture the APPR mode again.

(18) Coincidently at this time, there was a Master Caution and a series of Ground Proximity Warning System (GPWS)[6] Mode 5 GS caution 'Glide Slope' indications commenced.

(19) A nose up input to the control column was made, which increased the pitch and reduced the rate of descent.

(20) Between 1,000 ft and 700 ft, the rate of descent was 2,200 ft/min.

(21) The PF stated that they were in VMC daylight conditions with the approach lights in sight so 'we decided to continue a visual approach and try to achieve stabilised parameters by 500 ft'… 'we disregarded the GPWS glideslope caution and concentrated on the second increased rate of descent'…

(22) Passing 600 ft there was another Mode 5 GS caution 'Glide Slope' followed rapidly by another. At this stage, the aircraft was 3.2 dots below the GS.

(23) The PM called "Four Reds"[7]. This was in reference to the precision approach path indicator lights (PAPI)[8].

(24) The PM called "Go Around"[9] on two occasions.

(25) A Master Caution accompanied by a terrain clearance warning then occurred, "Too Low Terrain", and after five seconds a go-around was commenced 2.6 miles from the runway threshold at an altitude of 280 ft.

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6 The Ground Proximity Warning System (GPWS) generates advisory Alerts and mandatory response Warnings to the flight crew in respect of their proximity to terrain. SOPs will state the actions required and whether there is any element of discretion in the response depending on whether it is an 'Alert' or a 'Warning' which been generated. This may therefore mean that the flight crew will take the specified action e.g. initiating a mandatory 'terrain avoidance manoeuvre' to climb away from the terrain. It should be noted that SOPs typically state that if the pilot has visual contact with the terrain during daylight and is assured that physical contact with the terrain is not a factor, then an 'Alert' may be ignored.

7 Flight crew interview.

8 PAPI Precision Approach Path Indicator - visual aid that provides guidance information to help a pilot acquire and maintain the correct approach in the vertical plane to an airport. A pilot on the correct glideslope will see two white lights and two red lights. Four red lights indicate that the aircraft is well below the nominal flight path and immediate corrective action needs to be taken.

9 Flight crew interview.

(26) During the time elapse between the warning and commencement of the go-around, the aircraft continued to descend at a shallow rate.

(27) The crew performed the go-around without further incident, and made an uneventful second approach and landing on Rwy 07R.

(28) ATC contacted the pilot for the reason for the go-around. The pilots reported they lost the glideslope signal during the final approach.

(29) No entry was made by the crew in the aircraft technical log relating to the event.

(30) An AIC Flight Safety Report was filed by the crew regarding the GPWS which stated … “ATIS and TWR had reported possible GS fluctuations. Subsequent to GS signal failure GPWS Warning Go Around carried out. Followed by uneventful radar vector ILS approach 07R”… The report stated that the go-around was initiated at 800 ft.

(31) The occurrence was advised to the AAIA by Hong Kong ATC. The AAIA then contacted the operator and based on the information it received, the AAIA determined that a safety investigation was required. The AAIA classified it as a serious incident involving circumstances indicating that there was a high probability of an accident.

(32) Figure 1 indicates the desired 3° GS and the actual aircraft flight path. The data is from the Enhanced Airborne Flight Recorder (EAFR) via the Boeing Company.

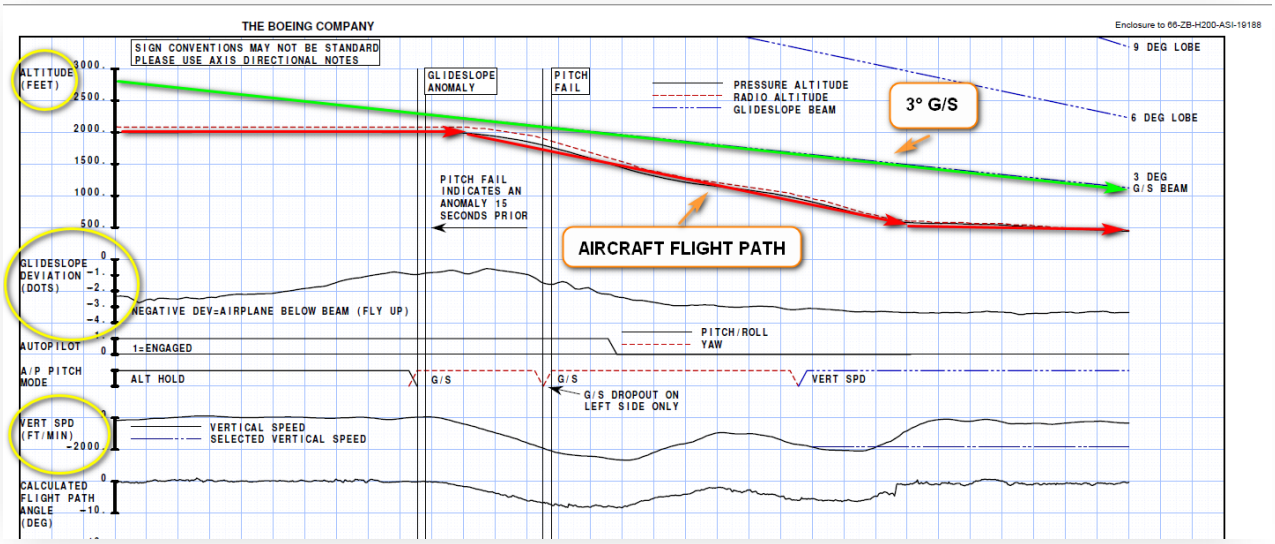


Figure 1: Aircraft Flight Path

(33) The desired 3° GS is indicated in green along with the actual flight path attained in red. The Altitude, GS deviation and vertical descent rate can be read from left to right.

1.2. Injuries to Persons

There were two pilots, eight cabin crew and 197 passengers on board the aircraft. There was no injury to any crew or passengers, or to any third party.

Injuries to Persons						
Persons on board:	Crew	10	Passengers	197	Others	0
Injuries	Crew	0	Passengers	0		

Table 1: Injuries to Persons

1.3. Damage - Aircraft

There was no damage to the aircraft.

1.4. Other Damage

There was no other damage.

1.5. Personnel Information

1.5.1. Flight Crew

(1) The Pilot-in-command (PIC) and the first officer (FO) held valid licences and medical certificates.

(2) The crew information is in Section 6.2.

1.6. Aircraft Information

1.6.1. Aircraft

The Boeing 787-8 aircraft, serial number 36280, was delivered to Air India in 2013. The aircraft had valid Certificate of Registration and Certificate of Airworthiness. The aircraft details are in Section 6.3.

1.6.2. Engines

The aircraft was fitted with two General Electric (GE) GEnx-1B67 engines.

1.6.3. Boeing 787 ILS Navigation System

(1) The ILS system supplies precision approach guidance to the display crew alerting systems (DCAS) and the auto flight function (AFF). The ILS receiver is a module of each integrated navigation receiver (INR) and can be either tuned automatically or by the flight crew.

(2) The localiser and glideslope deviation show on scales on the primary flight display (PFD). The magenta localiser and glideslope pointers are termed diamonds which indicate the accuracy of the ILS approach being flown.

(3) When the G/S mode is active, the AFF keeps the airplane on the vertical descent flight path. The G/S mode uses the ILS glideslope to capture and maintain a vertical flight path to a runway.

(4) Figure 2 shows an overview of the PFD showing a normal ILS with the indications a flight crew would expect to observe.

Figure 2: Exemplar PFD showing Indications of a Normal ILS

(5) In an enlarged view, the magenta glideslope diamond is in view on the right vertical glideslope scale, circled in red, indicating that the aircraft is accurately following the glide path. At the top, the green G/S, also circled in red, indicates the glideslope has been captured and the autoflight system is following the glideslope guidance. See Figure 3.

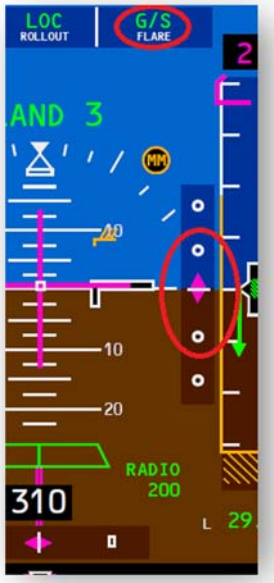


Figure 3: Enlarged View of Exemplar PFD Glideslope Indications

(6) The aircraft is equipped with Head Up Display (HUD[10]) for both flight crew. The PM monitoring stated that it was in use for the approach. The green G/S indication and green diamond middle right reflects the modes shown on the PFD. See figure 4.

Figure 4: Exemplar HUD Display

[10] HUD – Head Up Display – is a means of presenting information to the pilot in their line of external forward vision which projects key flight instrument data onto a small 'see-through' screen positioned just in front of the pilot's line of sight looking ahead out of the aircraft. https://skybrary.aero/articles/head-display

(7) If a degradation or instability of ILS signals that support specific autopilot modes occurs, this will be detected by the AFF system.

(8) When the AFF detects a degraded or unstable signal during an ILS approach, with the autopilot engaged, the affected AFF mode changes to an attitude stabilising mode based on inertial data at the time of the signal degradation or instability.

(9) The purpose of the attitude stabilising mode is to prevent large and abrupt pitch and roll changes during short periods of localiser or glideslope signal interference.

(10) When the glideslope signal stabilises and the aircraft is within the parameters for capturing, the AFF returns to tracking the localiser or glideslope.

(11) If the localiser or glideslope signal does not stabilise or the airplane is not within parameters for capture, the attitude stabilising mode remains active but is not directly indicated to the flight crew.

(12) During glideslope interference for short periods, there is no annunciation to the crew other than erratic movement of the ILS raw data.

(13) If the condition persists for 15 seconds,

- The annunciation on the PFD is an amber line through the flight mode G/S and the respective fight director bar is removed. Concurrently, a green line will appear through the HUD G/S indication. Refer to Figure 5.

- Additionaly, an amber AUTOPILOT message appears on the Engine Indicating and Crew Alerting System (EICAS) accompanied by an aural beeper.

Figure 5: PFD and HUD Indications after 15 Seconds of Glideslope Interference

1.7. Meteorological Information

(1) The arrival ATIS weather report for VHHH at 0533 hours advised that Information Golf (G) was current.

Arrival Runway 07R (Runway 07L closed for maintenance)
Caution Possible GP (glide path) fluctuation due to aircraft in the sensitive area
Wind from 080 at 14 kt
Visibility 10 km
Cloud few at 2000 ft scattered at 3000 ft
Temperature 24 and Dewpoint 20
QNH 1018 hPa

Table 2: ATIS 'Golf' Information

(2) Sunrise was at 0621 hours.

1.8. Navigation Aids

Ground-based navigation aids and aerodrome visual ground aids were serviceable.

1.9. Communications

The aircraft was equipped with VHF radio communication systems. All VHF radios were serviceable. All communications between Hong Kong ATC and the crew were recorded by Voice Recording System in the ATC System.

1.10. Aerodrome Information

The information on the departure and destination aerodrome is listed in Section 6.4.

1.11. Flight Recorders

(1) The aircraft was installed with a Cockpit Voice Recorder (CVR) and an EAFR with recording durations of 2 hours and 25 hours respectively.

(2) Both recorders were intact and undamaged in the incident. The EAFR data was available and retrieved for analysis in this investigation, but the CVR data had been over-written by the time the AAIA was informed and decided to open an investigation on this incident.

(3) Records from the ATC Voice Recording System, Advanced Surface Movement Guidance and Control Systems (A-SMGCS) and the Integrated Instrument Display System (IIDS) were also retrieved for the purpose of the investigation.

1.12. Wreckage and Impact

Not applicable.

1.13. Medical/Pathological Information

No medical or pathological investigations were conducted as a result of this occurrence, nor were they required.

1.14. Smoke, Fire, and Fumes

Not applicable.

1.15. Survival Aspects

There was no damage to the aircraft and no injuries to the crew and passengers, therefore no investigation on the survival aspects was required.

1.16. Tests and Research

Not applicable.

1.17. Organisation, Management, System Safety

1.17.1. Air India

Air India is the flag carrier airline of India, headquartered at New Delhi. It operates a fleet of Airbus and Boeing aircraft serving 102 domestic and international destinations. The airline has its hub at Indira Gandhi International Airport, New Delhi.

1.17.2. Air Traffic Control at Hong Kong Airport

(1) ATC service is one of the air navigation services provided by the Air Traffic Management Division of the Civil Aviation Department (CAD) to all flights operating within the Hong Kong Flight Information Region as assigned by the International Civil Aviation Organization (ICAO).

(2) The Air Traffic Management Standards Office is a separate office established under a separate Division namely, Air Services and Safety

Management Division, within CAD, responsible for the safety oversight of the provision of air navigation services, including ATC service, in the Hong Kong SAR, China.

1.18. Additional Information

1.18.1. Lack of CVR

(1) In the absence of CVR data, the pilot's recollections were the principal source of information regarding their actions during the approach.

(2) The flight crew were interviewed by the investigation team after the event. Due to logistics, this was accomplished at the AAIA in Hong Kong on 30 January 2019.

1.18.2. Navigation Aids and Single Runway Operations at VHHH

1.18.2.1. VHHH Runway (Rwy) 07R Instrument Landing System (ILS)

(1) Rwy 07R was the duty runway and the ILS was operating for approaching aircraft.

(2) There were no reports of abnormal operation of the Rwy 07R ILS prior to the subject B787. The ground monitoring station confirmed there was no fault indicated on the ILS glide path signal during the incident.

(3) There were no reports of unserviceability on other visual ground aids including the Rwy 07R approach lights.

1.18.2.2. ILS Signal Interference

(1) Safeguarding Requirements to be adopted by CAD for ILS operation at VHHH are specified in the document "Final System Specification for ILS at CLK Airport (VHHH)".

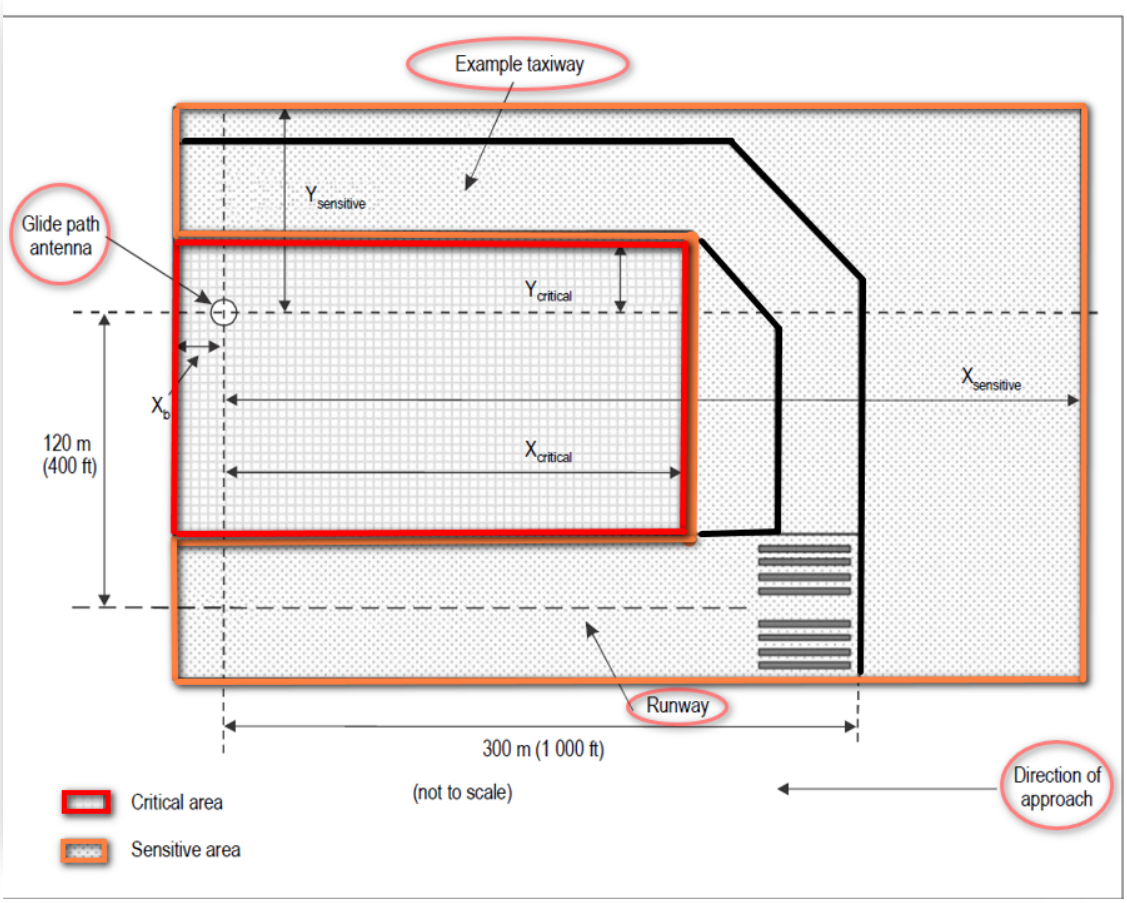
(2) Disturbances to ILS localiser and glideslope courses may be caused by fixed structures, such as buildings (static distortion), or moving vehicles or aircraft (dynamic distortion). The total ILS course distortion is determined by the summation of static and dynamic distortion, and this is used to define critical areas near each localiser and glideslope antenna.[11] The critical area is surrounded by a sensitive area. These areas will differ for

[11] The critical area is a volume of airspace encompassing lateral and vertical dimensions based around the localiser and glideslope antennas to protect the ILS signal transmissions to airborne aircraft.

each category of approach. Figure 6 shows an example of the critical and sensitive areas around an ILS antenna.

(3) In certain conditions, the integrity of an ILS is not protected, and signal disturbances may be experienced, even while the flight crew are conducting an instrument approach. Pilots may experience ILS beam bends and other interference in circumstances where the critical or sensitive areas of the ILS are not protected.

(4) Operators are advised in the Hong Kong Aeronautical Information Publication (HKAIP) regarding ILS approaches to Rwy 07R that GP signals may be liable to interference from aircraft taxiing in the vicinity of the GP area and warns pilots to closely monitor the ILS profile and rate of descent.



Source: ICAO Annex 10 (2018) annotated by AAIA

Figure 6: Exemplar Glide Path Critical and Sensitive Area

1.18.2.3. VHHH Single Runway Operations

(1) The north runway was closed for scheduled maintenance, thus Rwy 07R was in use.

(2) The following stipulations in the Hong Kong Aeronautical Information Publication (HKAIP) at the time of the event are relevant for single runway operations:

(3) VHHH AD 1.1 para. 6.1 - “At VHHH, pilots are to expect an ILS CAT I approach unless otherwise informed. Therefore, the type of approach to be expected will not normally be included in the ATIS Arrival broadcast.”

(4) VHHH AD 2.22 para. 10.6 - “Pilots are warned that during ILS CAT I operations RWY 07R and RWY 25L GP signals may be liable to interference from aircraft taxiing in the vicinity of the GP aerial. Pilots should therefore closely monitor their ILS approach profile and rate of descent.”

(5) VHHH AD 2.22 para. 13.2 - “Pilots are warned that RWY 07R GP signals may be liable to interference from aircraft taxiing in the vicinity of the GP aerial. Pilots should therefore closely monitor their ILS approach profile and rate of descent.”

(6) In the Manual of Air Traffic Control, Part 3 Chapter 3, para. 14 specifies procedures and weather requirements controllers are to follow in allowing aircraft or vehicles to transit active ILS critical and sensitive areas. Essentially and in relation to the subject incident:

(a) RWY 07R CAT II holding point (HP) on TWY K complies with ILS CAT I and CAT II requirements and holding traffic is outside of the ILS CAT I and CAT II sensitive and critical areas.

(b) The portion of TWY K between RWY 07R CAT II HP and RWY 07R CAT I HP is within the GP sensitive area.

(c) When Low Visibility Procedures are in force or the cloud base is 1,000 ft or less or the visibility is 5,000 m or less, traffic shall hold at RWY 07R CAT II HP when RWY 07R arriving aircraft is within 15 NM from touchdown.

(d) When weather conditions are better than those in (3.) above, taxiing traffic shall be permitted to proceed beyond RWY 07R CAT II HP and arriving traffic within 15 NM of touchdown shall be advised of possible GP signal interference.

(e) During single south runway operations, a cautionary message about GP signal fluctuations shall be included in the ATIS Arrival broadcast.

1.18.3. Standard Operating Procedures (SOP)

(1) In Flight Operations, strict procedures are defined covering every aspect of flight deck activity and embracing normal, abnormal and emergency situations. This wide range of procedures and checklists is essential because of the large number of situations which can arise and the critical nature of some of these situations.

(2) Although these procedures are written down in checklists and quick reference handbooks (QRH), pilots must be able to perform certain vital actions from memory, referring to the written procedure later to confirm that correct action has been taken.

(3) Deviations from SOPs occur for a variety of reasons; intentional deviations and inadvertent deviations from SOPs have been identified as causal factors in many aircraft accidents and serious incidents.

(4) Crew Resource Management (CRM) [12] … is not effective without adherence to SOPs, because SOPs provide a standard reference… for the crew's tasks on the flight deck. SOPs are effective only if they are clear and concise.

(5) SOPs are the result of a careful process, often conducted over a period of many years, which considers all likely outcomes; deviation from a standard procedure may lead to an unexpected and unsafe outcome[13].

1.18.4. Stable Approach Criteria

(1) Most airlines and other aviation organisations specify minimum acceptable criteria for the continuation of an approach to land. These vary in detail but the following summary published by the Flight Safety Foundation is one view of the important considerations.

(2) A definition of a stable approach means that the aircraft will arrive at the runway in the correct configuration, at the correct speed and power setting and on the correct lateral and vertical path. This ensures that the aircraft commences the landing flare at the optimum speed and attitude for the landing.

[12] Crew Resource Management (CRM) is the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency.

[13] https://skybrary.aero/articles/standard-operating-procedures-sops

(3) After some accidents and serious incidents occurring related to aircraft not achieving this requirement, the airline industry and regulators formulated requirements to ensure that pilots should be trained to recognise that if the aircraft was not meeting these requirements below a certain level (usually 1,000 ft above the airport runway) a go-around was required. The majority of operators now have included instructions in their SOP to guide pilots in decision making should an approach become unstable.

(4) An unstable approach is an undesired aircraft state, which is recoverable with the execution of a go-around. ICAO Doc. 8168 Procedures for Air Navigation Services, Aircraft Operations Volume III Aircraft Operating Procedures states the need for operators to publish a go-around policy. “This policy should state that if an approach is not stabilised in accordance with the parameters previously defined by the operator in their operations manual or has become destabilised at any subsequent point during an approach, a go-around is required. Operators should reinforce this policy through training”.

1.18.4.1. Stabilised / Unstabilised Approaches

(1) The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Briefing Note 7.1[14] suggests that:

(a) "*All flights must be stabilized by 1,000 ft above airport elevation in instrument meteorological conditions (IMC) and by 500 ft above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:*

(b) *The aircraft is on the correct flight path;*

(c) *Only small changes in heading/pitch are required to maintain the correct flight path;*

(d) *The aircraft speed is not more than VREF + 20 kt indicated airspeed and not less than VREF;*

(e) *The aircraft is in the correct landing configuration;*

(f) *Sink rate is no greater than 1,000 ft/min; if an approach requires a sink rate greater than 1,000 ft/min, a special briefing should be conducted;*

[14] Flight Safety Foundation - The FSF Approach-and-landing Accident Reduction (ALAR) Briefing Note 7.1. Note: Stabilised/Unstabilised is used in the report format with Stabilized/Unstabilized used if quoted in reference sources.

(g) Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;

(h) All briefings and checklists have been conducted;

(i) Specific types of approaches are stabilized if they also fulfil the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 ft above airport elevation; and

(j) *Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing*.

(k) An approach that becomes unstabilized below 1,000 ft above airport elevation in IMC or below 500 ft above airport elevation in VMC requires an immediate go-around."

(l) "Continuation of an unstabilized approach to land may result in an aircraft arriving at the runway threshold too high, too fast, out of alignment with the runway centre-line, incorrectly configured or otherwise unprepared for landing. This can result in aircraft damage on touch-down, or runway excursion and consequent injury or damage to the aircraft or airfield installations."

1.18.4.2. Strategies to Ensure Go-Around Decision Making[15]

(1) *Strategy 1 – Enhance crew dynamic situational awareness.*

(2) *Strategy 2 – Refine the Policy (stable approach parameters and stable approach height).*

(3) *Strategy 3 – Minimise the subjectivity of go-around decision making.*

(4) *Strategy 4 – Ensure that go-around training and awareness appropriately reflect different risk execution scenarios.*

(5) *Strategy 5 – Review go-around policy, procedures and documentation to maximise their effectiveness, clarity and understanding.*

[15] Flight Safety Foundation – (Go-around Safety Forum 18 June 2013 Brussels Findings and Conclusions)

(6) *Strategy 6 – Ensure that low relevant experience of one or both crew does not prejudice the effectiveness of cross monitoring during approach, landing and go-around.*

1.18.4.3. Air India Standard Stabilised Approach Criteria

AIC state in their Operations Manual Part-B[16]…*If the G/S is not captured or the approach stabilized by 1,000 ft AFE, initiate a go-around. Because of G/S capture criteria, the G/S should be captured and stabilized approach criteria should be established by 1,000 ft AFE, even in VMC conditions*[17]…

1.18.5. Circadian Rhythm (CRD)

(1) CRD refers to the reduced performance during night time hours, particularly during an individual's "window of circadian low" (WOCL), typically between 0200 a.m. and 0559 a.m.

(2) CRD induced fatigue can have both physiological and psychological ramifications that can become a flight safety issue. A few of the effects are:

(a) Increased reaction time.

(b) Impaired responses in sequential tasks that require time synchronization.

(c) Omission or displacement of individual elements in sequential task.

(d) Channelized attention to one task at the expense of others.

(e) Impaired visual monitoring patterns.

(f) Difficulty in self-identifying performance impairment.

(g) Tendency to forget secondary tasks.

(3) Consequences of CRD on the Flight Environment include:

(a) Increased frequency and severity of piloting errors during aircraft operations.

[16] Flight Operation Manuals/Aircraft Operating Manuals/Flight Crew Operating Manuals (FOM/AOM/FCOM) constitute the primary flight crew reference for the operation of an aircraft under normal, abnormal, and emergency conditions. These publications include system descriptions, normal and emergency procedures, supplementary techniques, and performance data.

[17] Air India B787 SOP Issue 1 01AUG2013 PAGE II -115

(b) Increased frequency of operational incidents.

(c) Increased risk in aviation operations[18].

1.18.6. Crew Resource Management

(1) Crew Resource Management (CRM) is the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency.

(2) CRM was developed as a response to new insights into the causes of aircraft accidents, which followed from the introduction of flight data recorders (FDRs) and cockpit voice recorders (CVRs) into modern jet aircraft.

(3) Information gathered from these devices has suggested that many accidents do not result from a technical malfunction of the aircraft or its systems, nor from a failure of aircraft handling skills or a lack of technical knowledge on the part of the crew; it appears instead that they are caused by the inability of crews to respond appropriately to the situation in which they find themselves[19].

1.18.7. Authority Gradient

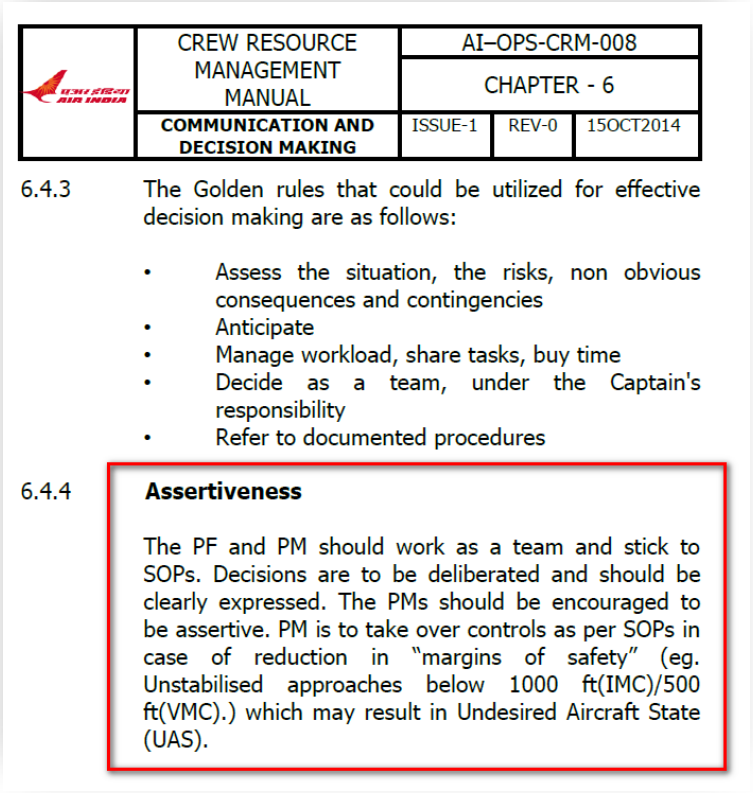
(1) Authority Gradient, commonly termed Cockpit Gradient in aviation, refers to the established, and/or perceived, command and decision-making power hierarchy in a Team, Crew or Group situation, and also how balanced the distribution of this power is experienced within the team, crew or group. Concentration of power in one person leads to a steep gradient, while more democratic and inclusive involvement of others results in a shallow gradient.

(2) In some situations, a shallow authority gradient may exist solely through the composition of the team and/or the type of task being conducted, rather than through an overly democratic leadership style.

(3) Modern globally accepted CRM, team resource management (TRM) and Human Factors training programmes provide trainers with the tools to invite feedback, ideas and challenges to their own decisions and performance - without becoming defensive and critical. These same programmes encourage junior crew members to challenge others with confidence, including senior members, openly, assertively and early to help reduce risk.[20]

[18] FAA AM-400-09/3 Circadian Rhythm Disruption and Flying
[19] Crew Resource Management https://skybrary.aero/articles/crew-resource-management-crm
[20] Authority Gradients https://skybrary.aero/articles/authority-gradients

(4) AIC has a section their CRM manual that states that 'PMs should be encouraged to be assertive'.[21] See Figure 7.



	CREW RESOURCE MANAGEMENT MANUAL	AI–OPS-CRM-008		
		CHAPTER - 6		
	COMMUNICATION AND DECISION MAKING	ISSUE-1	REV-0	15OCT2014

6.4.3 The Golden rules that could be utilized for effective decision making are as follows:

- Assess the situation, the risks, non obvious consequences and contingencies
- Anticipate
- Manage workload, share tasks, buy time
- Decide as a team, under the Captain's responsibility
- Refer to documented procedures

6.4.4 **Assertiveness**

The PF and PM should work as a team and stick to SOPs. Decisions are to be deliberated and should be clearly expressed. The PMs should be encouraged to be assertive. PM is to take over controls as per SOPs in case of reduction in "margins of safety" (eg. Unstabilised approaches below 1000 ft(IMC)/500 ft(VMC).) which may result in Undesired Aircraft State (UAS).

Figure 7: Excerpt from Air India CRM Manual

1.18.8. Human Factors Considerations

1.18.8.1. Pilot Workload[22]

(1) Pilots have many tasks to perform; these are normally shared between the PF and the PM. Flight crew workload varies, even during routine flights, from low to high and will rise in the event of abnormal weather conditions or aircraft malfunctions.

(2) During high workload, flight crew are especially vulnerable to error if their strategies for effective multi-tasking break down. This is the aspect of workload considered here with uncommon situations such as equipment malfunction.

(3) The pilot may be distracted from his/her primary tasks resulting in an error in handling or managing the aircraft.

[21] Air India AI-OPS-CRM-008 15 OCT 2014
[22] Pilot workload https://www.skybrary.aero/articles/pilot-workload

(4) A defence is the cross-checking process that exists on the flight deck between the PF and the PM.

1.18.8.2. Startle Effect[23]

(1) In aviation, startle effect can be defined as an uncontrollable, automatic reflex that is elicited by exposure to a sudden, intense event that violates a pilot's expectations.

(2) The startle effect includes both the physical and mental responses to a sudden unexpected stimulus. While the physical responses are automatic and virtually instantaneous, the mental responses (the conscious processing and evaluation of the sensory information) can be much slower. In fact, the ability to process the sensory information (to evaluate the situation and take appropriate action) can be seriously impaired or even overwhelmed by the intense physiological responses.

(3) Studies have determined that, following a startling stimulus such as a loud noise, basic motor response performance can be disrupted for as much as 3 seconds and performance of more complex motor tasks may be impacted for up to 10 seconds.

(4) The immediate impact of the startle reflex may induce a brief period of disorientation as well as short term psychomotor impairment which may well lead to task interruptions and/or a brief period of confusion. Should this happen, a period of time will be required for reorientation and task resumption. While performance after a startle event can be affected to the detriment of safety of flight, the greater concern stems from what the crew did, or did not do, during the conditioned startle response itself. It is here that decision making can be most significantly impaired, especially higher-order functions necessary for making judgments about complex flight tasks.

1.18.8.3. Task Saturation

(1) Task saturation is a common challenge that occurs in many professions, but in the aviation world, it can be particularly challenging.

(2) The Federal Aviation Administration (FAA) Handbook of Aeronautical Knowledge describes task saturation in that the first effect of high workload is that the pilot may be working harder but accomplishing less. As workload increases, attention cannot be devoted to several tasks at one time, and the pilot may begin to focus on one item. When a pilot becomes task saturated, there is no awareness of input from various

[23] Startle Effect https://www.skybrary.aero/index.php/Startle Effect

sources, so decisions may be made on incomplete information and the possibility of error increases.

(3) A pilot has a certain capacity of doing work and handling tasks. However, there is a point where the tasking exceeds the pilot's capability. When this happens, tasks are either not performed properly or some are not performed at all[24].

(4) Saturation results when the brain takes in the maximum amount of stimulation it can handle, yet more and more information is coming in. When the brain gets completely saturated with task demands, it cannot process any more information.

(5) Without effective task management, pilots can easily become overwhelmed and struggle to maintain situational awareness. As task saturation increases, performance decreases. Therefore, when experiencing task overload, pilots are more likely to make errors, which can escalate the threat of loss of control.

1.19. Useful or Effective Investigation Techniques

Not applicable.

[24] FAA Pilot's Handbook of Aeronautical Knowledge, Chapter 2 FAA-H-8083-25B

2. Safety Analysis

The Safety Analysis provides a detailed discussion of the safety factors identified during the investigation, providing the evidence required to establish the findings, causes, contributing factors and the safety recommendations.

2.1. Introduction

(1) The serious incident occurred as the crew were completing a routine flight from Delhi to Hong Kong.

(2) While the B787 was manoeuvring to intercept the ILS for Rwy 07R, a B748 was taxing into position for takeoff on Rwy 07R. Subsequently, the B787 autoflight system aggressively captured the ILS glideslope prematurely and the aircraft descended at an abnormally high rate below the normal approach path.

(3) Correction to this departure from a normal flight profile took considerable time. The consequences of the continued descent below the ILS profile approach to Rwy 07R were mitigated, due to that there are no obstructions on the approach path compared to approaches over built up areas which may contain natural terrain and manmade obstructions.

(4) The investigation team examined the possibility of the glideslope signal instigating the initial upset and then investigated the events following this, which resulted in a deviation from the intended flight path with the aircraft narrowly avoiding contact with the surface before the Rwy 07R threshold.

2.2. Flight Operations

2.2.1. Crew Qualifications

(1) The flight crew members were licensed and qualified for the flight in accordance with existing regulations.

(2) The Captain (PF) converted to the B787 in 2016 and the last simulator proficiency check was on 18 October 2018.

(3) The First Officer (PM) had been flying the B787 for over a year and had accumulated 1,000 hours on the type.

(4) Prior to this flight duty, the crew had not flown together on the B787 but had previously crewed together on the B737.

2.2.2. ILS Approach

(1) The B787 was established on the LOC and tracking inbound to intercept the GS from below. Autopilot pitch and roll modes were engaged, with the pitch mode set to altitude hold (ALT HOLD) and the GS armed for capture.

(2) A B748 which had been cleared to line up and then take off passed through the projected GP beam as it taxied into position to enter the runway.

(3) As the B787 approached the GS, a GS signal fluctuation occurred which caused the B787 to capture the GS prematurely at about 6.9 NM from the runway threshold. The GS deviation data then exhibited several oscillations over the next 15 seconds.

(4) The GS signal fluctuation then possibly initiated an early capture of the GS, which became more aggressive and which likely triggered the B787 autoflight system to pitch the aircraft down.

(5) The B787 reached a high rate of descent up to 2,800 ft/min, where the expected rate on a normal glideslope would be around 700 ft/min, which would have startled the crew. At this stage, the Master Caution activated and the PM stated that the G/S mode on the PFD had an amber line through it.

(6) The PF then disconnected the autopilot at 1,400 ft and flew manually, applying two degrees of nose up pitch decreasing the descent rate slightly to 900 ft/min. This reduced the airspeed from a maximum of 184 kt, but the nose up pitch was insufficient to arrest the rate of descent which continued below the GS profile.

(7) It is uncertain if the PF made the required “manual flight” callout when he disconnected the autopilot thus alerting the PM that a high level of monitoring was desired.

(8) The PF then applied a nose down input on the control column possibly due to perceived flight director guidance, with the descent rate increasing again to 2,000 ft/min.

(9) The PF requested that the flap be selected to 30, which the PM complied with, but the flaps did not extend due to the load relief protection.

(10) Unrequested but possibly in an attempt to assist the PF, the PM then, unannounced, recycled the flight directors which changed the pitch and

roll modes. ARM was then selected in an attempt to capture the APPR mode again. This would have little effect on the situation, as the B787 was now well below the GS and diverging further.

(11) The crew's continuing inaction indicated a lack of situational awareness of the aircraft's position relative to the desired glide path and of cues in the cockpit that could have alerted them to this.

(12) Passing 1,000 ft a series of 'Glide Slope' aural cautions commenced, but the approach was continued and between 1, 000 ft and 700 ft the rate of descent was 2,200 ft/min. This rate of descent was considerably outside the maximum of 1,000 ft/min stabilised approached criteria, and the trigger for a go-around was ignored with the flight crew continuing the increasingly unstabilised approach. At that rate, the crew had approximately 18 seconds before impacting the surface.

(13) The PF stated that as they considered they were in daylight conditions and with the approach lights in sight, they decided to continue for a visual approach and try to achieve stabilised parameters by 500 ft. The 'Glide Slope' cautions continued with the B787 continuing to descend through 600 ft.

(14) As the aircraft neared the runway, the PAPI lights and the visual aspect of the runway surface should have provided additional cues and the PM stated that he called "Four Reds" in relation to the PAPI and "Go Around" on two occasions.

(15) At this stage, the cautions along with the glideslope indication and the too-low indication of four red PAPI lights along with the PM's calls of "Four Reds" and "Go Around" should have prompted an immediate go-around.

(16) Until the PM's go-around calls, the investigation team could not find any evidence that there were any previous prompts from the PM concerning the multitude of factors indicating that an increasing deviation from the intended flight path had occurred with controlled flight into terrain imminent.

(17) It is probable that the PF's visual attention was focused primarily outside the aircraft below 500 ft, as he was manually flying and attempting to correct the vertical deviation to establish on the glideslope.

(18) Passing 500 ft, the aircraft did not meet any of AIC's stabilised approach criteria.

(19) The descent continued and after a Master Caution "Too Low Terrain", the B787 continued in a shallow descent for another five seconds before the PF commenced a go-around at a pressure and radio altitude of

approximately 280 ft, 2.6 NM before the Rwy 07R threshold, approximately 500 ft below the normal profile.

(20) The crew reported no problems with the following ILS approach and subsequent landing.

(21) The PF stated that as it was daylight, the cautions could be ignored.[25] However, sunrise was at 0621 hrs, and there had been a first quarter moon two days previously with a moonset approximately four hours prior to the approach, which would indicate that there would have been minimal light.[26] The PM stated that "it was quite dark"[27].

(22) Considering the possibility that the PF considered it was daylight, the compounding unstabilised approach with the rate of descent involved made a go-around mandatory in any case.

(23) The crew's decision to continue whilst not meeting stabilised approach criteria was not unusual, as industry statistics indicate about 97% of unstable approaches are continued to a landing.[28]

(24) Apart from the EAFR readout, the lack of any CVR information meant the investigation team had to rely on crew interviews which were some time after the event.

2.3. Operational Procedures

2.3.1. Pilot Monitoring and Announcing Deviations During Approach

(1) A high degree of discipline is required by both pilots during an approach. The PM is required to monitor the flight path, draw attention to any deviations from the normal flight path parameters, and make the required height check calls.

(2) Initially, the approach was normal as the aircraft continued on the LOC anticipating GS intercept.

(3) The stable approach criteria tolerances were reached in the event sequence when the oscillation started, which according to the operator's operating manual required the PM to alert the PF when a significant deviation is observed.

[25] Flight Crew interview.
[26] HKO Almanac 2018 Index 19/20 Oct https://www.hko.gov.hk/en/gts/astron2018/files/2018cal10.pdf
[27] Flight crew interview.
[28] J. Burin Director Technical Programs Flight Safety Foundation 2011

(4) The PM did not call for a go-around when the onset of the oscillation was detectable. There was also an opportunity for the PM to take control, if it had been recognised that the PF had become fixated on continuing the unstable approach.

2.3.2. Manual Flight Operations

(1) Flying a go-around places special demands on the pilots, especially when the go-around is unexpected and the aircraft is being flown manually.

(2) The FAA issued Safety Alert for Operators (SAFO) 13002, “Manual Flight Operations,” on January 4, 2013, encouraging operators to promote manual flight operations when appropriate. It stated that a recent analysis of flight operations data (including normal flight operations, incidents, and accidents) identified an increase in manual handling errors.

(3) The SAFO acknowledged that autoflight systems are useful tools for pilots and have improved safety and workload management, but cautioned that continuous use of autoflight systems could lead to degradation of the pilot’s ability to quickly recover the aircraft from an undesired state.

(4) It encouraged operators to take an integrated approach by incorporating emphasis of manual flight operations into both line operations and training.

(5) Automation technology is intended to aid flight crews in executing their responsibilities; it is not intended to replace a well-trained and proficient crew. When automation fails or does not react as expected and the aircraft is manually flown, it remains incumbent upon the crew to be prepared and able to operate the aircraft safely.

(6) The lack of corrective input from the PF to recover from the undesired state may prompt the operator to encourage the practice of manual flying when appropriate to maintain pilot skills.

2.3.3. VHHH Rwy 07R Glideslope Disturbance

(1) The glideslope signal disturbance occurred at about the same time that a B748 aircraft taxied past holding point ‘K1’ and departed. The B748 had been in the Rwy 07R GP sensitive area waiting for landing traffic for 5 minutes and 34 seconds, prior to being cleared to line up on Rwy 07R. During this period, two arriving aircraft made ILS approaches without any problem and made no comments to ATC.

(2) The investigation team established the movement of the B748 was within the Rwy 07R GP sensitive area, and it is possible that this aircraft’s proximity to the antenna along with its large mass as it entered and lined

up on the runway caused the interference to the glideslope signal. See Figure 8.

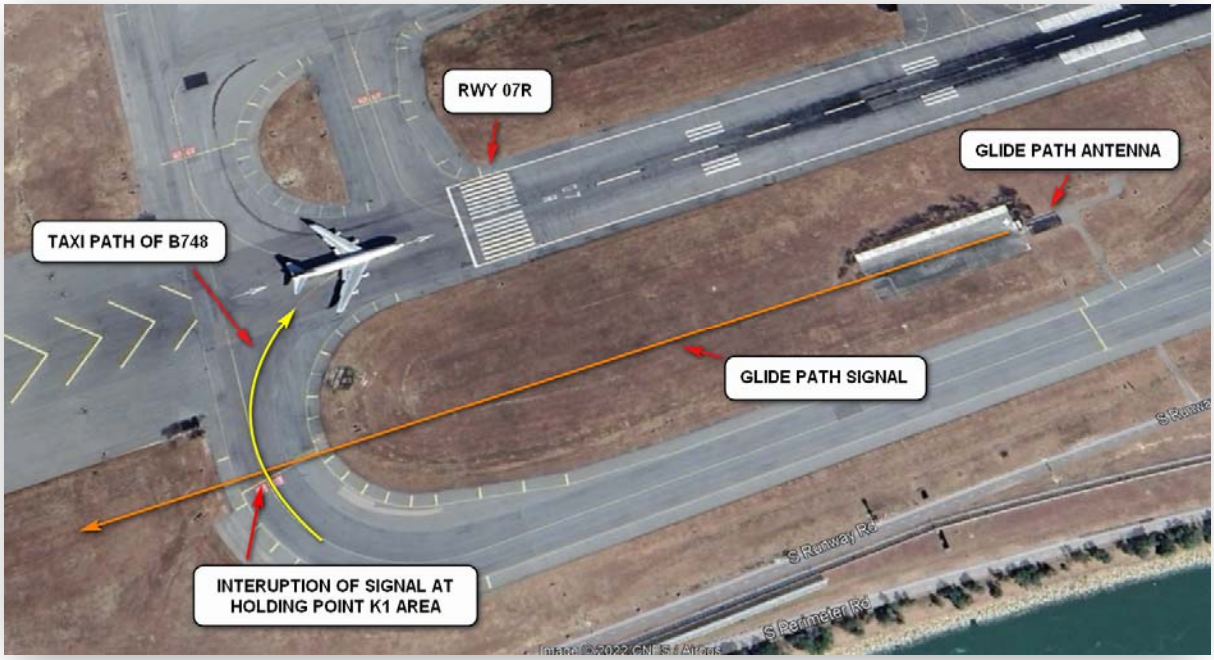


Figure 8: Exemplar Glide Path Disturbance

(3) The possibility that the presence of the B748 in the sensitive area would cause GP signal fluctuations was not able to be ascertained definitively by the investigation team.

(4) The investigation team considers that the known possibility of glideslope disturbance on Rwy 07R is sufficiently promulgated with warnings in the HKAIP, ATIS broadcast and by ATC in real time. Additionally, AIC emphasized the possibility in their approach briefing notes as do many operators.

2.3.4. Air Traffic Control

(1) Based on the interview statement of the Tower controller on duty during the incident, the controller was familiar with laid down procedures for single south runway operations. The controller was also aware that the required cautionary message about Rwy 07R GP signal fluctuations was included in the Arrival ATIS.

(2) When the B787 came up on Tower frequency, the controller visually checked the position of the aircraft and made cross reference with the

corresponding target on the radar. The controller was satisfied with the position of the aircraft in terms of distance on final approach and corresponding height on descent and assessed that the inter-arrival spacing between the B787 and the preceding arrival was sufficient to release a departure.

(3) The duty controller, being cognisant of aircraft movements in the Rwy 07R GP sensitive area having effects on the glideslope, cleared the B748 into position and takeoff and had then proactively asked the approach controller to remind the B787 crew that there could be a possible disturbance.

2.3.5. Air India SOP

2.3.5.1. Stabilised Approach Criteria

(1) AIC state in their Operations Manual Part-B[29]…*If the G/S is not captured or the approach stabilized by 1,000 ft AFE, initiate a go-around. Due to the G/S capture criteria, the G/S should be captured and stabilized approach criteria should be established by 1,000 ft AFE, even in VMC conditions...*

(2) The investigation team considered that there were numerous occasions during the approach when a go-around call and action could have been taken either by the PF or intervention by the PM.

(3) At the onset and when the high rate of descent commenced, there were triggers for an unstable approach call, and at the 1,000 ft AFE when the aircraft was not stabilised and well below the glideslope.

2.3.5.2. Crew Action after Landing

(1) The pilot in command was responsible as per the operator's policy and procedures manual for the correct completion of all paperwork, including entries into the aircraft technical log. Post flight, the operating flight crew were required to complete the entries for the flight, including defect reporting where necessary.

(2) The investigation team found that the glideslope signal fluctuation and its effect had not been entered into the aircraft technical log as a defect.

[29] Flight Operation Manuals/Aircraft Operating Manuals/Flight Crew Operating Manuals (FOM/AOM/FCOM) constitute the primary flight crew reference for the operation of an aircraft under normal, abnormal, and emergency conditions. These publications include system descriptions, normal and emergency procedures, supplementary techniques, and performance data.

(3) This resulted in a delay to any possible investigative or maintenance corrective action required until further sectors had been flown by the aircraft.

(4) The internal company Flight Safety Report that was filed by the crew regarding the GPWS warning stated that the go-around was initiated at 800 ft. The EAFR data indicating that the go-around was initiated at approximately 280 ft radio altitude. This delayed notification of the extent of the serious incident, until details were requested by the AAIA.

2.3.6. Weather

Weather was not a factor in this event.

2.3.7. Aids to Navigation

All navigation systems were serviceable.

2.3.8. Aerodrome

All appropriate runway and PAPI systems were serviceable.

2.4. Aircraft

2.4.1. Aircraft Maintenance

(1) The maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures.

(2) The aircraft was airworthy when dispatched for the flight.

2.4.2. Mass and Balance

The mass and the center of gravity were within the prescribed limits.

2.4.3. Aircraft Automation

(1) According to the crew interviews conducted sometime after the event, both pilots exhibited adequate knowledge of the effect of a glideslope signal fluctuation and what indications and cautions to expect.

(2) The situation developed into a highly dynamic and non-routine situation. During such situations, a flight crew faces increased workload and

operational distractions that can reduce systematic scanning of the Flight Mode Annunciator (FMA) and flight instruments.

2.5. Human Factors

2.5.1. Startle Effect and Task Saturation

(1) Periods of high workload are a normal function of the various stages of a flight including the approach and landing. During these periods, the workload is managed by following SOP and effective communication and teamwork between the pilots.

(2) Following the initial upset caused by the glideslope signal fluctuation, due to the resultant startle effect the crew allowed the aircraft to attain a higher than normal rate of descent and a subsequent unstable approach descending to approximately 280 ft radio altitude, at a distance of 2.6 NM from the runway threshold.

(3) Although the crew had been alert to possible glideslope signal fluctuation challenges, and had discussed defenses, the workload became increasingly high after the initial startle effect and surprise that the aggressive nose down pitch produced.

(4) The PF stated that even with the warnings, they did not anticipate that the aircraft could go into such a high rate of descent.

(5) The PF probably became task saturated manually flying the aircraft, possibly following misleading auto flight guidance, at the same time with the PM missing prompts and calls as the situation was evolving rapidly.

(6) The unstable approach was continued for some considerable time, before a go-round was suggested or commenced.

(7) The task saturation situation was resolved after the terrain advisories, which along with the repeated calls from the PM to go around, prompted the PF to commence a go-around.

2.5.2. CRD

(1) The crew had operated a flight from VABB to VIDP, and then after a turnaround, continued to VHHH. Being a night duty and considering the circadian rhythm, the possibility of the crew being fatigued was considered.

(2) The busy airspace environment of the first sector and the departure of the event sector are often challenging, and followed by the flight to VHHH, in

which there would be periods of low activity, it could be expected that the crew were at the end of the circadian cycle.

(3) For example, it has been acknowledged that the time awake prior to duties that start in the evening are more likely to cause fatigue than those beginning at 8 a.m.

(4) Both crew members informed the investigation team that they were “well rested” before the flight, and there is no evidence that any of the pilots began their duty period with a preexisting sleep debt or fatigue.

(5) The crew reported for duty at 1900 local time in Mumbai, and after two sectors arrived in the HKG area at 0330 local body clock time. This nighttime situation placed the crew in the window of circadian low (WOCL), typically between 0200 and 0559 which might have contributed to the delayed response to the occurrence.

(6) The event occurred at a time when the flight crew would normally have been asleep, during the pilots’ circadian trough, a period about midway through the normal sleep period when a person’s physiological state of arousal is normally at its lowest.

(7) Although the preflight rest was adequate and the flight duty time was within the company flight time limitations, the two sector flight which included a turnaround in the middle of the night may have had an effect on the alertness levels of the two pilots. The effects of which possibly degraded their performance during the approach which in turn, might have led to an increase in the number of errors, omissions and reaction time and to a decrease in CRM and decision-making abilities.

2.5.3. GS Fluctuations – Crew Awareness

(1) The crew had in their approach preparation briefed that the GS was subject to fluctuations.

(2) The crew were advised by ATC during the approach of possible fluctuations.

(3) The PF stated that in the event of a fluctuation they would continue with a LOC approach, although no additional briefing was given to cover this possibility. There is no record of the PM requesting how the reversion to a LOC approach would be conducted if it became necessary.

2.5.4. Crew Resource Management

(1) There is no evidence to indicate that CRM was less than optimal prior to the commencement of the approach.

(2) During the approach, after the initial aircraft pitch down, the CRM became less than optimal.

(3) Standard calls were omitted as the workload increased, including the 1,000 ft and 500 ft stabilised call.

(4) The PM recycled the flight directors without a request or advising the PF. This was actioned without the usual action and confirmation as required by normal SOP.

(5) There were four GS advisories and a “Too Low Terrain” warning. Although the PM stated that “Four Reds” and two times “Go Around” were called, the PF continued the approach with no action taken by the PM.

(6) The “Four Reds” was probably made as an intuitive call advising the PF that the aircraft was in an undesired profile in relation to the runway, and that the PF would take appropriate action. Generally, this call should alert a crew member that the aircraft is well below the intended approach profile and that immediate action has to be taken.

(7) The lack of receptiveness on the part of the PF and a corresponding lack of assertiveness on the part of the PM contributed to the continuation of the unstable approach, until the PF decided to go around.

(8) The concept of CRM encompasses that if the PF, in this case, the Captain was not doing what was expected and a go-around becomes necessary, the FO (PM) is required to take control and carry out a go-around.

(9) The ‘cockpit gradient’, which is the balance of perceived authority between the Captain and the FO can sometimes lead to a reluctance on the part of an FO to intervene and act assertively when unsafe situations develop. Operators should encourage crew members who may be perceived to be junior to challenge senior crew member’s actions or lack of, in both initial and recurrent training.

(10) The PM advised the investigation team that it was felt “too many things were not going right” and “would have taken command and happy to, per company policy”. However, the unsafe flight condition was allowed to continue, possibly due to the perceived authority of the PF.

(11) Crew members should be trained that another crew member can become task fixated, and in this instance, the PF was probably concentrating so

much on trying to salvage an increasing unstable flight condition that the PF became unreceptive to any ancillary inputs coming from the PM.

(12) There was reluctance on the part of the PM to take control and execute a missed approach, which was the correct procedure, as given in the SOP and is expected to be done without any hesitancy. A steep authority gradient probably discouraged the PM from doing so which is a serious safety concern.

(13) AIC in their CRM manual do not elaborate on whether the ‘PM’ should be read as ‘FO’ in certain situations, and could possibly be more emphatic that the PM in certain situations could be the FO.

(14) Although the crew were alert to possible glideslope signal fluctuation and had discussed the possibility of challenges, they were initially startled by the actual occurrence, with the PF becoming task saturated due to the increased workload, and the PM unable to apply any effective assistance or CRM to alleviate the situation.

3. Conclusions

3.1. Findings

(1) The flight crew members were licensed and qualified for the flight in accordance with existing regulations. [2.2.1. (1)]

(2) The B787 was established on the LOC and tracking inbound to intercept the GS from below. Autopilot pitch and roll modes were engaged, with the pitch mode set to altitude hold (ALT HOLD) and the GS armed for capture. [2.2.2. (1)]

(3) A B748 had been cleared to line up and then takeoff passed through the projected GP beam as it taxied into position to enter the runway. [2.2.2. (2)]

(4) The glideslope signal fluctuation then possibly initiated an early capture of the GS, which became more aggressive and which likely triggered the B787 autoflight system to pitch the aircraft down. [2.2.2. (4)]

(5) The B787 reached a high rate of descent up to 2,800 ft/min. [2.2.2. (5)]

(6) The PF then disconnected the autopilot at 1,400 ft and flew manually, applying two degrees of nose up pitch decreasing the descent rate slightly. [2.2.2. (6)]

(7) Passing 1,000 ft a series of “Glide Slope’ aural cautions commenced but the approach was continued and between 1,000 ft and 700 ft the rate of descent was 2,200 ft/min. [2.2.2. (12)]

(8) The descent continued and after a Master Caution “Too Low Terrain”, the B787 continued in a shallow descent for another five seconds before the PF commenced a go-around at a pressure and radio altitude of approximately 280 ft, 2.6 NM before the Rwy 07R threshold, well below the normal profile. [2.2.2. (19)]

(9) The PM did not call for a go-around when the onset of the oscillation was detectable. There was also an opportunity for the PM to take control if it had been recognised that the PF had become fixated on continuing the unstable approach. [2.3.1. (4)]

(10) The glideslope signal disturbance occurred at about the same time that a B748 aircraft taxied past holding point ‘K1’ in the ILS sensitive area and departed. [2.3.3. (1)]

(11) The investigation team established the movement of the B748 was within the Rwy 07R GP sensitive area, and it is possible that this aircraft's proximity to the antenna along with its large mass as it entered and lined up on the runway caused the interference to the glideslope signal. [2.3.3. (2)]

(12) The controller was familiar with laid down procedures for single south runway operations. The controller was aware that the required cautionary message about Rwy 07R GP signal fluctuations was included in the Arrival ATIS. [2.3.4. (1)]

(13) The duty controller being cognisant of aircraft movements in the Rwy 07R GP sensitive area having effects on the glideslope, cleared the B748 into position and takeoff and had then proactively asked the approach controller to remind the B787 crew that there could be a possible disturbance. [2.3.4. (3)]

(14) AIC state in their Operations Manual Part-B …*If the G/S is not captured or the approach stabilized by 1,000 ft AFE, initiate a go-around. Due to the G/S capture criteria, the G/S should be captured and stabilized approach criteria should be established by 1,000 ft AFE, even in VMC conditions...* [2.3.5.1. (1)]

(15) At the onset and when the high rate of descent commenced there were triggers for an unstable approach call, and at the 1,000 ft AFE when the aircraft was not stabilised and well below the glideslope. [2.3.5.1. (3)]

(16) The investigation team found that the signal fluctuation of the glideslope and its effect had not been entered into the aircraft technical log as a defect. [2.3.5.2. (2)]

(17) Maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures. [2.4.1 (1)]

(18) The aircraft was airworthy when dispatched for the flight. [2.4.1 (2)]

(19) The mass and the center of gravity were within the prescribed limits. [2.4.2]

(20) Although the crew had been alert to possible glideslope signal fluctuation challenges and had discussed defenses, the workload became increasingly high after the initial startle effect and surprise that the aggressive nose down pitch produced. [2.5.1. (3)]

(21) The PF probably became task saturated manually flying the aircraft, possibly following misleading auto flight guidance, at the same time with

the PM missing prompts and calls as the situation was evolving rapidly. [2.5.1. (5)]

(22) Although the preflight rest was adequate and the flight duty time was within the company flight time limitations, the two sector flight which included a turnaround in the middle of the night might have reduced the alertness levels of the two pilots. [2.5.2. (7)]

(23) The crew had in their approach preparation briefed that the GS was subject to fluctuations. [2.5.3. (1)]

(24) The crew were advised by ATC during the approach of possible fluctuations. [2.5.3. (2)]

(25) There is no evidence to indicate that CRM was less than optimal prior to the commencement of the approach. [2.5.4. (1)]

(26) During the approach, after the initial aircraft pitch down, the CRM become less than optimal. [2.5.4. (2)]

(27) The lack of receptiveness on the part of the PF and a corresponding lack of assertiveness on the part of the PM contributed to the continuation of the unstable approach, until the PF decided to go around. [2.5.4. (7)]

(28) The ‘cockpit gradient’, which is the balance of perceived authority between the Captain and the FO can sometimes lead to a reluctance on the part of an FO to intervene and act assertively when unsafe situations develop. [2.5.4. (9)]

(29) There was reluctance on the part of the PM to take control and execute a missed approach, which was the correct procedure, as given in the SOP and is expected to be done without any hesitancy. A steep authority gradient probably discouraged the PM from doing so. [2.5.4. (12)]

(30) Although the crew were alert to possible glideslope fluctuations and had discussed challenges, they were initially startled by the actual occurrence with the PF becoming task saturated due to the increased workload, and the PM unable to apply any effective assistance or CRM to alleviate the situation. [2.5.4 (14)]

3.2. Causes

Following a glideslope signal fluctuation, which resulted in an undesired pitch down and deviation of the aircraft below the intended flight path, subsequent flight crew recovery actions were delayed with the continuation of an increasingly unstable approach from which a recovery was eventually conducted. [3.1(4), 3.1 (15), 3.1 (20), 3.1(30)]

3.3. Contributing Factors

(1) The aircraft prematurely captured the glideslope as a signal fluctuation occurred, which may have been caused by the B748 taxiing to take off on the same runway within the ILS sensitive area.[3.1(10)]

(2) The crew actions during the recovery might be attributable to reduced alertness and degraded performance during the approach. [3.1(22)]

(3) There was reluctance on the part of the PM to take control and execute a missed approach, which was the correct procedure, as given in the SOP and was expected to be done without any hesitancy. A steep authority gradient probably discouraged the PM from doing so. [3.1(29)]

(4) Although the crew were alert to possible glideslope fluctuations and had discussed challenges, they were initially startled by the actual occurrence, with the PF becoming task saturated due to the increased workload, and the PM unable to apply any effective assistance or CRM to alleviate the situation. [3.1(30)]

4. Additional Safety Issues

4.1. Safety Actions Already Implemented

4.1.1. Boeing Company

(1) Boeing Company proactively promulgated the following FCOM Bulletins and Fleet Digest Articles.

(2) Flight Crew Operations Manual Bulletin TBC-104

Erroneous Autopilot Flight Director System (AFDS) Guidance when Instrument Landing System (ILS) Signal Interference Occurs

Reason: To inform flight crews about erroneous AFDS guidance during ILS

18 October 2019, Updated on 15 July 2020

(3) Fleet Team Digest 787-FTD-22-19001

Glideslope Beam Anomaly Leads to Misleading Flight Director Guidance after Mode Fail and Autopilot Disconnect

Originated on 03 Dec 2019

Description: Glideslope beam anomalies that occur in a specific glideslope capture window can result in reversion to an attitude-stabilizing path. In certain circumstances, the flight directors can continue to provide vertical flight director (FD) guidance that diverges from the glideslope beam, potentially leading to possible high descent rates and significant deviation from the glideslope. Without flight crew intervention, the flight director guidance could contribute to a runway excursion or Controlled Flight Into Terrain (CFIT).

(4) The FAA published SAIB NM-20-07, April 16, 2020, that notified operators of this issue and the associated Boeing FCOM Bulletin.

(5) Boeing released a Flight Crew Operations Manual Bulletin (OMB) titled "Flight Controls Electronics CBBOEP5.1 Software Update" in January 2021 to describe the changes that will be seen by flight crews in the latest FCE software version that contains a software mitigation for this issue.

(6) Boeing released alert service bulletin 787-27A0053 in February 2021 to install FCE CBP 5.1 software which includes the changes to mitigate the issue described in 787-FTD-22-19001.

5. Safety Recommendations

5.1. Safety Recommendation 09-2023

It is recommended that Air India consider reviewing and where necessary revise their stable approach criteria and the requirements for a go-around to be carried out, setting out the requirements in a clear and unambiguous format to avoid any confusion that flight crew may have in interpreting them and the crew actions required.

Safety Recommendation Owner: **Air India**

5.2. Safety Recommendation 10-2023

It is recommended that Air India consider incorporating policy and guidelines in the company manual suite regarding the reporting of potentially hazardous occurrences, to the relevant authority in the most expeditious manner setting out the requirements in a clear and unambiguous format to avoid any confusion that flight crew may have in interpreting them.

Safety Recommendation Owner: Air India

5.3. Safety Recommendation 11-2023

It is recommended that Air India consider reviewing their Crew Resource Management training, to address any possible trans-cockpit authority gradient and adopt effective strategies to ensure that all flight crew follow standard operating procedures and take control of an aircraft should it be considered necessary without concern of any punitive consequences.

Safety Recommendation Owner: Air India

6. General Details

6.1. Occurrence Details

Date and time	20 October 2018, 0611 hours (local time)	
Occurrence category	Serious Incident	
Primary occurrence type	Deviation From Intended Flightpath (DEV)	
Location	Runway 07R, Hong Kong International Airport, Hong Kong	
	Latitude: 22°18'41.14"N	Longitude: 113°53'58.32"E

6.2. Pilot Information

6.2.1. Pilot-in-Command

Age	48
Licence	ATPL issued on 05 May 2006
Aircraft ratings	B787
Date of first issue of aircraft rating on type	18 August 2016
Instrument rating	Perpetual
Medical certificate	Class 1, valid to 16 August 2019
Limitations	Nil
ICAO Language Proficiency	5
Date of last proficiency check on type	12 July 2018
Date of last line check on type	04 December 2017
Date of last safety equipment and emergency drills course	05 June 2018

Date of initial CRM course and refresher	Initial 03 May 2016 Refresher 24 April 2018
Flying Experience	
Total all types	5674 hours
Total on type (B787)	1636:08 hours
Total in last 90 days	206 hours
Total in last 30 days	24:39 hours
Total in last 7 days	16 hours
Total in last 24 hours	06:03 hours
Duty Time	
Day up to the incident flight	08:30 hours
Day prior to incident	0 hours
Rest before flight	22 hours

6.2.2. First Officer

Age	38 years
Licence	ATPL issued on 25 Nov 2016
Aircraft ratings	B787
Date of first issue of aircraft rating on type	22 February 2017
Instrument rating	Perpetual
Medical certificate	Class 1, valid to 6 June 2019
Limitations	Nil
ICAO Language Proficiency:	6
Date of last proficiency check on type	17 June 2018
Date of last line check on type	05 April 2018

Date of last safety equipment /emergency drills course	17 December 2017
Date of initial CRM course and refresher	Initial 09 February 2017 Refresher 12 December 2017
Flying Experience	
Total all types	4954 hours
Total on type (B787)	1396 hours
Total in last 90 days	205 hours
Total in last 30 days	22 hours
Total in last 7 days	14 hours
Total in last 24 hours	06:30
Duty Time	
Duty Time in last 24 hours	08:30 hours
Duty Time day prior	0
Rest before flight	36

6.3. Aircraft Details

Manufacturer and model	Boeing 787-8
Registration	India VT-ANE
Aircraft Serial number	36280
Year of Manufacture	2013
Engine	2 General Electric GEnx-1B67
Operator	Air India (AIC)
Type of Operation	Commercial Air Transport (Passenger)
Certificate of Airworthiness	Valid to 02 December 2018
Departure	Indira Gandhi International Airport (VIDP)

Destination	Hong Kong International Airport (VHHH)	
Maximum Take-off Weight	502,500 lbs	
Persons on board	Crew – 10	Passengers – 197
Injuries	Crew – 0	Passengers – 0
Aircraft damage	Nil	

6.4. Aerodrome Information

6.4.1. Aerodrome of Departure

Aerodrome Code	VIDP
Airport Name	Indira Gandhi International Airport
Airport Address	New Delhi, Delhi 110037, India
Airport Authority	Delhi International Airport Limited (DIAL)
Air Navigation Services	Approach Control, Aerodrome Control, Ground Movement Control, Zone Control, Flight Information Service, Clearance Delivery Control, Automatic Terminal Information Service
Type of Traffic Permitted	IFR/VFR
Coordinates	28° 34’ 07” N, 077° 06' 44" E
Elevation	777 ft
Runway Length	09/27 - 2,816 m 10/28 - 3, 813 m 11R/29L - 4,430 m 11L/29R - 4,400 m
Runway Width	60 m

6.4.2. Aerodrome of Destination

Aerodrome Code	VHHH
Airport Name	Hong Kong International Airport
Airport Address	Chek Lap Kok, Lantau Island
Airport Authority	Airport Authority Hong Kong
Air Navigation Services	Approach Control, Aerodrome Control, Ground Movement Control, Zone Control, Flight Information Service, Clearance Delivery Control, Automatic Terminal Information Service
Type of Traffic Permitted	IFR/VFR
Coordinates	22° 18' 32" N, 113° 54' 53" E
Elevation	28 ft
Runway Length	07L / 25R, 07R/ 25L 3,800 m (at time of this flight)
Runway Width	60 m

7. Abbreviations

AAIA	Air Accident Investigation Authority, Hong Kong SAR, China
AAIB	Aircraft Accident Investigation Bureau India
ACC	Active Clearance Control
AFE	Above Field Elevation
AFF	Auto Flight Function
AIC	ICAO Code of Air India
A-SMGCS	Advanced Surface Movement Guidance and Control Systems
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
B737	Boeing 737
B748	Boeing 747-8F
B787	Boeing 787-8
Boeing	Boeing Company
CAD	Hong Kong Civil Aviation Department
Cap.448B	Hong Kong Civil Aviation (Investigation of Accidents) Regulations
CFIT	Controlled Flight Into or Toward Terrain
CLK	Chek Lap Kok
CRD	Circadian Rhythm
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DCAS	Display Crew Alerting Systems
DFDAC	Digital Flight Data Acquisition Card
DME	Distance Measuring Equipment
EAFR	Enhanced Airborne Flight Recorder

EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine-Indicating and Crew-Alerting System
ENG	Engine
FAA	Federal Aviation Administration USA
FCOM	Flight Crew Operating Manuals
FDR	Flight Data Recorder
FO	First Officer
FSF	Flight Safety Foundation
ft	Feet
ft/min	Feet per Minute
GP	Glide Path
GPWS	Ground Proximity Warning System
GS	Glideslope
HKAIP	Hong Kong Aeronautical Information Publication
HP	Holding Point
hPa	Hectopascal
HUD	Head Up Display
ICAO	International Civil Aviation Organization
IIDS	Integrated Instrument Display System
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
INR	Integrated Navigation Receiver
kt	Knots
LOC	Localiser
METAR	Meteorological Terminal Air Report
NM	Nautical Miles

NTSB	National Transportation Safety Board USA
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PFD	Primary Flight Display
PIC	Pilot-in-command
PM	Pilot Monitoring
QNH	Barometric Altimeter Setting
QRH	Quick Reference Handbook
Rwy	Runway
SAR	Special Administrative Region
SOP	Standard Operating Procedures
TRM	Team Resource Management
TWR	ATC Control Tower
UTC	Coordinated Universal Time
VABB	ICAO Code of Mumbai International Airport
VFR	Visual flight rules
VHF	Very High Frequency
VHHH	ICAO Code of Hong Kong International Airport
VIDP	ICAO Code of Indira Gandhi International Airport
VMC	Visual Meteorological Conditions
VREF	Landing Reference Speed
WOCL	Window Of Circadian Low

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8. Table of Figures, Photos, Tables