民航意外調查機構
AAIA
Air Accident Investigation Authority

Abnormal Runway Contact (ARC)

Accident Investigation Final Report

Boeing 777-333ER, C-FITW,
Hong Kong International Airport,
Hong Kong
11 December 2018

05-2021

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 Final 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 accident in accordance with the provision in CAP. 448B.

This accident investigation Final Report contains information of an occurrence involving a Boeing 777-333ER aircraft, registration C-FITW, operated by Air Canada, which occurred at Hong Kong International Airport on 11 December 2018.

The Transportation Safety Board of Canada (TSB), being the State of Registry and the Operator and the aircraft operator provided assistance to the investigation.

Unless otherwise indicated, recommendations in this Final 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 Final Report supersedes any previous Preliminary Report and Interim Statement concerning this accident investigation.

All times in this Final Report are in Hong Kong Local Times (HKT) unless otherwise stated.

Hong Kong Local Time is Coordinated Universal Time + 8 hours.

Chief Accident and Safety Investigator

Air Accident Investigation Authority

Transport and Housing Bureau

Hong Kong

December 2021

Synopsis

On 10 December 2018, at 1041 hrs Toronto local time, an Air Canada Boeing 777-333ER (registration C-FITW) operating as AC15 departed Toronto Pearson International Airport (CYYZ), Canada, for Hong Kong International Airport (VHHH), on a scheduled passenger flight. As the aircraft approached Hong Kong on 11 December 2018, the crew briefed for the approach and landing.

The approach was routine and the pilot flying disengaged the autopilot after descending through 500 ft above aerodrome (airport) elevation (AAE). Following the reversion to manual flight, the approach profile became slightly high above the glideslope. At approximately 200 ft AAE the aircraft entered into series of minor lateral roll deviations followed by a pronounced roll, first to the left and then to the right in response to the pilot's control inputs.

At the runway contact point, the aircraft, rolling left and right with a high rate of descent and a nose high pitch attitude, experienced a hard landing, with the right main landing gear contacting the runway followed by the left main gear and the aft lower fuselage contacting the runway surface. The aircraft bounced, touched down, bounced again, landing on the nose gear followed by both main gears. The aircraft then completed the landing roll and continued to the parking stand.

There were no injuries.

The investigation team has made seven safety recommendations.

Contents

1. Factual Information

1.1. History of the Flight

(1) On 10 December 2018, at 1041 hrs Toronto local time, an Air Canada Boeing 777-333ER (registration C-FITW) operating as AC15 departed Toronto Pearson International Airport (CYYZ), Canada, for Hong Kong International Airport (VHHH), on a scheduled passenger flight with 4 crew members, 13 cabin crew and 376 passengers on board. As the aircraft approached Hong Kong on 11 December 2018, the crew briefed for the approach and landing as normal.

(2) The crew consisted of a Captain, two First Officers (FO), of which one was assigned as an Augment Pilot, and one Cruise Relief Pilot. One of the FOs was the Pilot Flying (PF) from the Top of Descent (ToD). The Captain was the Pilot Monitoring (PM) and the Initial Operating Experience Training Captain (IOETC) for the FO. The other FO and the Cruise Relief Pilot were also in the cockpit.

(3) The crew anticipated an arrival and landing on Runway (RWY) 07L as indicated on the Automatic Terminal Information Service (ATIS), however, there was a runway change from RWY 07L to RWY 07R.

(4) The arrival meteorological conditions, including the forecast and actual weather, was as expected. The wind velocity was from 350 degrees at 12 knots.

(5) The aircraft intercepted the Instrument Landing System (ILS)[1] and was stabilised on the approach to RWY 07R, on the correct descent profile with the autopilot engaged through 1,000 ft AAE. The FO disengaged the autopilot after descending through 500 ft AAE. Following the reversion to manual flight, the approach profile became approximately half a dot above the glideslope.

(6) At approximately 200 ft AAE the aircraft entered into series of minor lateral roll deviations followed by a pronounced roll, first to the left and then to the right in response to the pilot’s control inputs.

(7) In response to the increasing unstable oscillations neither pilot called for or initiated a go around, nor did the other two crew members in the cockpit.

(8) At the runway contact point, the aircraft was rolling left and then right with a high rate of descent and a nose high pitch attitude. This resulted in a hard

[1] 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.

landing with the right main landing gear contacting the runway followed by the left main gear while the aft lower fuselage contacted the runway surface. The aircraft bounced with the right-hand main landing gear contacting the runway first. The aircraft bounced again, landing on the nose gear followed by both main gears.

(9) After the runway contact and initial bounce there was no call for a go around and after touch down from the subsequent bounce the PM removed the PF's hand from the thrust levers and selected reverse thrust. There was no formal transfer of control and there was a further distraction when a beverage container was dislodged from the PF's holder and dropped on to the floor and the PF bent forward to retrieve it.

(10) The aircraft then completed the landing roll and continued to the parking stand. The aircraft landed at 0653 UTC (1453 HKT).

(11) The crew initially informed Air Traffic Control (ATC) that there had been a tail strike but on being queried about the message this was not repeated or confirmed by the crew who then reported severe turbulence on final. There were no injuries.

Photo 1: Last Stage of the Approach and Runway Contact

1.2. Injuries to Persons

The crew was composed of 4 pilots and 13 cabin crew. The crew and passengers were uninjured during the occurrence.

Injuries to Persons						
Persons on board:	Crew	17	Passengers	376	Others	0
Injuries	Crew	0	Passengers	0		

Table 1: Injuries to Persons

1.3. Damage – Aircraft

1.3.1. Boeing 777-333ER Aft Fuselage Damage (Section 47)

(1) Subsequent inspection of the underside of the rear fuselage indicated the aircraft sustained damage to the rear lower fuselage requiring major repair or replacement of the affected components. The aircraft was declared unserviceable and underwent a major repair process to rectify the lower fuselage damage prior to a return to operational service.

(2) The aircraft rear aft fuselage sustained significant impact damage to the aft fuselage and various internal structural deformation. This model was fitted with a tail skid which assisted in absorbing the impact.

Figure 1: Lower Fuselage Damaged Area

Photo 2: Tail Skid Damage

Photo 3: Lower Aft Fuselage Damage (1)

Photo 4: Lower Aft Fuselage Damage (2)

1.3.2. Boeing Airplanes Damage Assessment/Survey Report

1.3.2.1. Damage Assessment Survey

A damage assessment survey was conducted by the aircraft manufacturer. A comprehensive damage assessment report detailed the structural repair and modification requirements.

1.4. Other Damage

Examination of the runway surface for damage and checking for foreign object debris (FOD)[2] did not detect any damage or debris on the runway. Examination of the runway was delayed as the crew initially communicated to ATC that they had a tail strike but when the controller asked them to repeat the message the crew stated that they had experienced severe turbulence on final.

[2] FOD - this relates to various objects (fallen from aircraft or vehicles, broken ground equipment, birds, etc.) that are present on a runway that may adversely affect fast-moving aircraft (during take-off and landing). Runway FOD has the greatest potential of causing damage. https://www.skybrary.aero/index.php/Foreign_Object_Debris_(FOD)

1.5. Personnel Information

1.5.1. Flight Crew

The flight crew were licensed, medically certified in accordance with the requirements of the State of Registry's licensing requirements, and adequately rested to operate the flight. Crew licence information is located in Section 7: General Details.

1.6. Aircraft Information

1.6.1. Aircraft

The Boeing 777-333ER is the largest and extended-range variant of the Boeing 777 which is a long range, twin aisle, wide-body twin-engine jet airliner developed and manufactured by the Boeing Company. The aircraft concerned is powered by two General Electric GE90-115B engines.

1.6.2. Maintenance History

A review of the aircraft's maintenance history did not identify any defects or recent maintenance actions that could contribute to the occurrence. The aircraft had a valid Certificate of Airworthiness.

1.7. Meteorological Factors

1.7.1. ATIS

The relevant ATIS information for arrival at RWY 07L is as follows.

ATIS Information "F", at 0607 UTC (1407 HKT), 11 December 2018 – 0654 UTC (1454 HKT)

HONG KONG ARRIVAL INFORMATION F AT TIME 0607

ARRIVAL RUNWAY 07L

WIND 350 DEG 12 KT

VISIBILITY 10 KM

CLOUD FEW 2800 FT

TEMPERATURE 18 DEWPOINT 10

QNH 1020 HPA

ACKNOWLEDGE INFORMATION F ON FIRST CONTACT WITH APPROACH

1.7.2. Windshear and Turbulence

Following the landing the crew informed the Air Traffic Controller that they had experienced severe turbulence right on landing. The investigation reviewed the conditions at the time of the occurrence for low level windshear and turbulence.

1.7.2.1. Windshear Alerts on the Day of the Accident Flight

The windshear alert provided by the Windshear and Turbulence Warning System nearest the time of arrival of the aircraft was issued at 0641 hrs UTC (1441 HKT) with the aircraft landing twelve minutes later at 0653 UTC (1453 HKT).

- ISSUE TIME: 11/12/2018 0641 (UTC): 07RA WSA -25K RWY

Following the date and time, this refers to RWY 07R (A) Caution (WSA) Windshear (-25K) Minus 25 knots (RWY) on the Runway.

1.8. Navigation Aids

There were no reports of abnormal operation of any ground-based navigation aids or aerodrome visual ground aids at the time of approach and landing of the aircraft on RWY 07R.

1.9. Communications

The aircraft was equipped with VHF radio communication systems which were serviceable. Communication between Hong Kong ATC and the aircraft were recorded by the Digital Recording System[3] (DRS) of the Air Traffic Management System which supported Hong Kong ATC in the provision of air navigation services. There was no interruption to such communications.

1.10. Aerodrome Information

Information on Hong Kong International Airport is listed in Section 7.4.

[3] Digital Recording System is an ATC system that provides recording, playback and real time monitoring functions for radio transmissions, intercom and audio reception at controller workstations from the headset microphone and the surrounding area.

1.11. Flight Recorders

1.11.1. Flight Data Recorder

The flight data recorder (FDR)[4] was functional and recording data. The download captured all of the flight parameters required for the analysis of this occurrence.

1.11.2. Cockpit Voice Recorder

The cockpit voice recorder (CVR)[5] was functional and recording. The 120-minute closed-loop cockpit voice recorder was of inadequate duration to be useful for the investigation of this accident as the CVR was not isolated and recorded over the relevant cockpit conversations during the descent and approach to Hong Kong.

1.11.3. Airborne Image Recorder inside the Cockpit

(1) The investigation was advised that a portable Airborne Image Recorder (AIR) mounted on the left hand cockpit side window (adjacent to the Captain's position) was operating during the descent into Hong Kong. This provided video and audio capture of the activities including the descent and the approach into Hong Kong, the landing sequence, and the subsequent taxi to the stand for passenger disembarkation.

(2) The crew submitted this recording to Air Canada who provided a copy to the AAIA. The recording has been referred to during the investigation. The AAIA would like to acknowledge that the crew provided this voluntarily and it has only been used in the interest of safety to prevent recurrences.

(3) Air Canada's Operational Procedures do not permit the use of such AIR devices, there was no authorization for such a device to be employed by the crew for any purpose on this flight and Air Canada was not aware that such a device was in use.

1.12. Wreckage and Impact

The damage to the aircraft is detailed in Section 1.3 Damage – Aircraft.

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[4] FDR - device used to record specific aircraft performance parameters. The purpose of an FDR is to collect and record data from a variety of aircraft sensors onto a medium designed to survive an accident.

[5] CVR - a device used to record the audio environment in the flight deck for accidents and incident investigation purposes. The CVR records and stores the audio signals of the microphones and earphones of the pilots' headsets and of an area microphone installed in the cockpit.

1.13. Medical/Pathological Information

No medical or pathological investigations were conducted as a result of this occurrence.

1.14. Smoke, Fire, and Fumes

There was no smoke or fire in the aircraft after the occurrence.

1.15. Survival Aspects

Not applicable.

1.16. Tests and Research

Not applicable.

1.17. Organisation, Management, System Safety

1.17.1. Air Canada

Air Canada holds an air operator certificate issued by Transport Canada[6]. It provides domestic and international scheduled and charter air transport for passengers and cargo. It operates a fleet of Boeing 777 aircraft as well as the Boeing 787 and Airbus A330 on long-haul routes.

1.18. Additional Information

1.18.1. Pilot Induced Oscillation

(1) Pilot Induced Oscillations (PIO) are rare, unexpected, and unintended excursions in aircraft attitude and flight path caused by anomalous interactions between the pilot and the aircraft.[7]

(2) PIOs are sustained or uncontrollable oscillations resulting from the effort of the pilot to control the aircraft and occur when the pilot of an aircraft inadvertently commands an often increasing series of corrections in opposite directions; each one is an attempt to control the aircraft's reaction to the previous input with an overcorrection in the opposite direction. PIO events include a broad set of undesirable, and sometimes hazardous,

[6] Transport Canada is the department within the Government of Canada responsible for developing regulations, policies and services of road, rail, marine and air transportation in Canada.
[7] Source: https://www.skybrary.aero/index.php/Pilot_Induced_Oscillation

phenomena that are associated with less than ideal interactions between pilots and aircraft.

1.18.2. Exiting PIO – Pilot / Control Input Loop

(1) By definition, PIO is a function of pilot input; these inputs are sustaining the oscillation, that is, the pilot is "in the loop" that caused and is maintaining the condition.

(2) Consequently, the first and most critical step for exiting PIO is to exit the loop. This presents three primary possibilities:

- The pilot freezes the controls;
- The pilot releases the controls;
- The pilot significantly reduces the aggressiveness of control input.

1.18.3. 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[8] 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.

(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 feet above the airport runway) a go around was required. The majority of operators now have included instructions in their standard operating procedures (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*[9] states the need for operators to publish a go around policy.

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8 Flight Safety Foundation Briefing Note 7.1

9 The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations. It reviews the principles and techniques of international air navigation and fosters the planning and development of international air transport to ensure safe and orderly growth.

“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”.

1.18.3.1. Stabilised / Unstabilised Approaches

(1) The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Briefing Note 7.1[10] suggests that:

"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:

1. The aircraft is on the correct flight path;

2. Only small changes in heading/pitch are required to maintain the correct flight path;

3. The aircraft speed is not more than V_{REF} + 20 kt indicated airspeed and not less than V_{REF};

4. The aircraft is in the correct landing configuration;

5. 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;

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

7. All briefings and checklists have been conducted;

8. 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

[10] Source: Flight Safety Foundation - The FSF Approach-and-landing Accident Reduction (ALAR) Briefing Note 7-1.pdf

9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

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."

(2) "*Continuation of an unstabilised 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.*"[11]

1.18.3.2. Strategies to Ensure Go Around Decision Making[12]

Strategy 1 – Enhance crew dynamic situational awareness.

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

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

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

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

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.

1.18.3.3. Air Canada Stabilised Approach Policy

The Air Canada Stabilised Approach Policy is built around two arrival gates with specific requirements for each gate. Guidance for crew is published in the Flight Operations Manual (FOM)[13]. Section 8.11.7.1 – 1,000 Foot Arrival Gate, Section

[11] https://www.skybrary.aero/index.php/Stabilised_Approach

[12] Source: Flight Safety Foundation – (Go-around Safety Forum 18 June 2013 Brussels Findings and Conclusions.pdf)

[13] 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.

8.11.7.2 – 500 Foot Arrival Gate, and Section 8.11.7.3 Stable Approach Requirements below 500 Feet AAE are extracted below.

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23 OCT 2018		FLIGHT OPERATIONS	

2. The difference between the charted (temperature corrected as required) and actual altitude is greater than 100 feet.

NOTE: Charted altitude is based on ISA conditions where the temperature at MSL is 15°C and the lapse rate of the airmass is 1.98°C/1000'. When uncorrected, lower than standard temperatures cause an aircraft to fly below the charted altitude; higher than standard temperatures cause an aircraft to fly above the charted altitude. A general "Rule-of-thumb" to use: the error equals 4ft/°C of ISA deviation for every 1000 ft of altitude.

The PM checks that the appropriate missed approach altitude is set in the altitude selector and/or FMA.

For some approaches outside Canada, the FAF may be too far back from the runway threshold to be useful or appropriate as a point for an altitude crosscheck. In this case an appropriate waypoint closer to the runway may be used if there is adequate charted information to conduct the crosscheck at this point. If an alternative waypoint is being used, it shall be included in the approach briefing. Waypoints shall not be modified or inserted into the FMC/FMGC approach between the FAF and the runway.

8.11.6 Monitoring and Announcing Deviations During Approach

Monitoring and feedback are key to a stable approach. The PF may be too task saturated during an unstable approach and fail to recognize that tolerances are being exceeded, so the role of the PM is crucial.

The PM shall monitor approach tolerances as defined by the AOM and alert the PF when a significant deviation is observed during an approach (e.g., "Localizer" or "Airspeed") or when a flag or warning is observed (e.g., "Glideslope Flag").

Throughout the approach, the PM should make informative callouts to assist the PF to achieve stabilized approach conditions (e.g., "Airspeed, target plus 15"). Momentary deviations of glidepath, course, airspeed, and sink rate do not require an immediate go-around. The PM shall make required deviation callouts and monitor for corrections. The PF shall acknowledge any deviation callouts and correct as appropriate.

For the purposes of stable approach requirements, flightpath deviations are defined as deviations from tolerances described in the AOM for:

- Instrument approaches - Localizer and Glideslope tracking; NPA tracking of lateral and vertical path; or
- Deviations from the intended visual approach path when 1,000 feet AAE and below.

8.11.7 Stabilized Approach Policy

Air Canada's Stable Approach Policy is built around two Arrival Gates with specific requirements for each gate. These requirements apply at all times to all approaches in all weather conditions, including visual approaches. A Go-around shall be conducted if the requirements for each Arrival Gate are not met, or at any time on approach if conditions warrant. This will be initiated when either flight crew member calls "unstabilized".

Tolerances for the flightpath, speed, and rate of descent during approach are as established in the aircraft AOM.

Figure 2: Stabilised Approach Policy in FOM

Flight Operations	FLIGHT OPERATIONS MANUAL	8	P 97
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1. There are two Arrival Gates for every approach:
   a) 1,000 feet AAE; and
   b) 500 feet AAE.

   NOTE: The radio altimeter is an acceptable means to determine height over relatively level terrain.

2. There are five requirements that shall be established and maintained within tolerance at specific gates during the approach:
   a) Flightpath; and
   b) Configuration; and
   c) Airspeed; and
   d) Thrust; and
   e) Rate of Descent.

8.11.7.1 1,000 Foot Arrival Gate

No flight shall continue an approach and landing past the 1,000 foot AAE Arrival Gate unless the following requirements are met:

1. The aircraft is on the correct lateral and vertical flightpath in accordance with the AOM; and
2. Final landing configuration (gear and flap) has been selected.

8.11.7.2 500 Foot Arrival Gate

No flight shall continue an approach and landing past the 500 foot AAE Arrival Gate unless the 1,000 foot gate requirements continue to be met, and;

1. Airspeed is stabilized on target (+10/-5 knots); and
2. Thrust stabilized, usually above idle, to maintain the target airspeed; and
3. Rate of descent is stabilized not in excess of 1,000 fpm; and
4. Final landing checks completed.

8.11.7.3 Stable Approach Requirements Below 500 Feet AAE

The aircraft shall continue to meet the Stable Approach requirements below 500 feet and be in a position over the runway threshold to make a normal landing within the Touchdown Zone. The PM shall monitor flight instrument indications for Stable Approach compliance throughout the approach.

If these requirements are not maintained below 500 feet AAE, a verbal call of "Unstabilized" shall be made, even if a "Stable" call had been made earlier. A Go-around shall be carried out anytime an "Unstabilized" call is made.

Figure 3: Stabilised Approach Policy in FOM (Cont'd)

1.18.4. Bounced Landing Recovery

According to the Air Canada Boeing 777 AOM[14], if the airplane should bounce the technique for recovery is:

(1) "*Hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate a go-around. Apply go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.*"

(2) "*If higher than idle thrust is maintained through initial touchdown, the automatic speed brake deployment may be disabled even when the speed brakes are armed. This can result in a bounced landing.*"

(3) "*If the speedbrakes started to extend on the initial touchdown, they will retract once the airplane becomes airborne again on a bounce, even if thrust is not increased. The speed brakes must then be manually extended after the airplane returns to the runway.*"

1.18.5. Sterile Flight Deck

(1) ICAO defines a Sterile Flight Deck as "any period of time when the flight crew should not be disturbed, except for matters critical to the safe operation of the aircraft".[15]

(2) The sterile cockpit policy was adopted after a series of accidents in which it was thought extraneous conversation relating to non-operational matters resulted in a loss of situational awareness during critical parts of the flight. The Federal Aviation Administration (FAA) of the United States have a formal rule concerning it and most other regulators have encouraged operators to have a policy.

(3) In 2018 Air Canada did not specifically define it, considering that the principles were listed under the Critical Phase of Flight policy promulgated in their FOM 7.1.7.

"*Critical phases of flight includes all flight below 10,000 feet AAE, and all ground operations when the aircraft is in motion. During critical phases of flight the Pilot-in-Command shall enforce the critical phase of flight policy …*". This includes that "*only required operational conversation shall be conducted*" and "*The Pilot-In-Command shall manage the flight deck to*

[14] Aircraft Operating Manual B777 1.04.13 P7 Dec17/14
[15] ICAO Doc 9870 *Manual on the Prevention of Runway Incursions*

ensure distractions do not interfere with safe and accurate aircraft operation."

1.18.6. Windshear and Turbulence Warning System

The Hong Kong Observatory (HKO), the aviation weather forecaster, has been operating a Windshear and Turbulence Warning System (WTWS) since the opening of the airport in July 1998 to alert pilots of significant windshear over and in the vicinity of VHHH. It has continuously been enhanced, with the latest addition being the implementation of the Light Detection and Ranging (LIDAR) Windshear Alerting System (LIWAS). HKO also issues warnings of windshear for broadcast to aircraft-in-flight via the ATIS of the airport, when windshear and/or turbulence are detected.

1.18.7. Windshear[16]

(1) Windshear refers to a sustained change (i.e. lasting more than a few seconds as experienced by an aircraft) in the wind direction and/or speed, resulting in a change in the headwind or tailwind encountered by an aircraft.

(a) A decrease in lift will cause the aircraft to go below the intended flight path.

(b) Conversely an increase in lift will cause the aircraft to fly above the intended flight path.

(2) Pilots should be aware that significant windshear at low levels in approach and departure zones may cause difficulty in control, thus requiring timely and appropriate corrective actions to ensure aircraft safety.

(3) Alerts for Windshear are classified into two levels: "Microburst Alert" and "Windshear Alert". This follows the same terminology adopted by the FAA in classifying Windshear alerts issued by the Terminal Doppler Weather Radar (TDWR) installed at major aerodromes throughout the USA.

(4) Microburst Alert (MBA) is for windshear with headwind loss of 30 knots or greater and when precipitation is present. This can only be generated by the TDWR.

(5) Windshear Alert (WSA) is for windshear with headwind loss or gain of 15 knots or greater (except microburst). The following will be issued as a

[16] *Windshear and Turbulence in Hong Kong - information for pilots*, Hong Kong Observatory,4th edition 2019

WSA, not MBA: (i) a headwind gain of 30 knots or greater; and (ii) a headwind loss of 30 knots or greater but with NO precipitation present.

(6) These parameters assume no unusual circumstances or conditions and may require allowances for momentary variations due to weather and turbulence.

1.18.8. Training - Flight Operations

1.18.8.1. Pilot Flying B777 Conversion

The PF had completed the Air Canada Boeing 777 transition course. This includes 11 sessions totalling 44 hours in a Level D full flight simulator. Both the course and the simulator are approved and certified by Transport Canada.

1.18.8.2. PIO Recognition as Risk Factor for Pilots under Conversion Training

There is no requirement for PIO onset recognition or recovery actions in the operator's training procedures.

1.18.8.3. Initial Operating Experience (IOE)

Pilots transitioning to a new aircraft type have a minimum of six sectors and 25 hours flight time to complete during the training phase. This transition is with an IOETC. The PF was completing the first flight of this phase.

1.18.8.4. Crew Resource Management (CRM)

(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 encompasses a wide range of knowledge, skills and attitudes including communications, loss of situational awareness, problem solving, decision making, and teamwork; together with all the attendant sub-disciplines which each of these areas entails.[17]

(3) Generally, all flight crew members are required to complete CRM training at various stages of their careers, including initial and recurrent training and on appointment to command. Training must be carried out by approved instructors and must follow approved syllabi, which must be detailed in the company flight operations manual.

[17] Crew Resource Management (CRM) https://www.skybrary.aero/index.php/

(4) Air Canada has a CRM training course and conducts refreshers for all crew members.

1.18.9. Human Factor and Behaviour Considerations

1.18.9.1. Startle Effect[18]

(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.

1.18.9.2. 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 sources, so

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

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.[19]

(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.

[19] 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 support the findings, contributing factors and the safety recommendations.

2.1. Introduction

(1) The event occurred as the crew were completing a routine flight from Toronto to Hong Kong. The four crew members were on the flight deck for the approach and landing. Prior to the descent the crew had briefed and prepared for the approach on RWY 07L. The runway was later changed to RWY 07R which was also briefed and programmed in the Flight Management System (FMS).

(2) The flight up to this stage had been routine but after flying the approach to RWY 07R at VHHH, the aircraft experienced an abnormal runway contact event. Prior to the event the landing configuration, airspeed, and descent rate were normal. There were no aircraft serviceability issues.

(3) The abnormal runway contact was due to loss of control after the aircraft experienced rapidly escalating PIO. This analysis will discuss the cause of the PIO, flight operations and a range of other factors identified during the investigation.

2.2. Flight Operations

2.2.1. First Officer (the PF)

(1) The FO had recently been qualified on the Boeing 777, following eight weeks on a type conversion course from the narrow-body Embraer E190 to the wide-body Boeing B777. The Air Canada simulator conversion course which is approved by Transport Canada where the aircraft type rating is completed in the simulator before commencing the on-line training with an IOETC.

(2) The FO completed the B777 aircraft type rating on the 6th December 2018.

(3) This flight was the first B777 operating flight for the FO and the first actual landing of a Boeing 777. It was also the FO’s first arrival into Hong Kong as an operating crew member.

2.2.2. Training Captain (Pilot Monitoring - PM)

The IOETC was the pilot in command and training the FO as part of his line training. Although the FO was the PF the IOETC has overall responsibility for the safe conduct of the flight. The IOETC had operated into Hong Kong on previous occasions.

2.2.3. Flight Data Analysis

The data obtained from the Digital Flight Data Recorder was analysed for the last stage of the approach and runway contact. The aircraft had become slightly high above the glideslope but overall the approach was stable until the oscillations commenced.

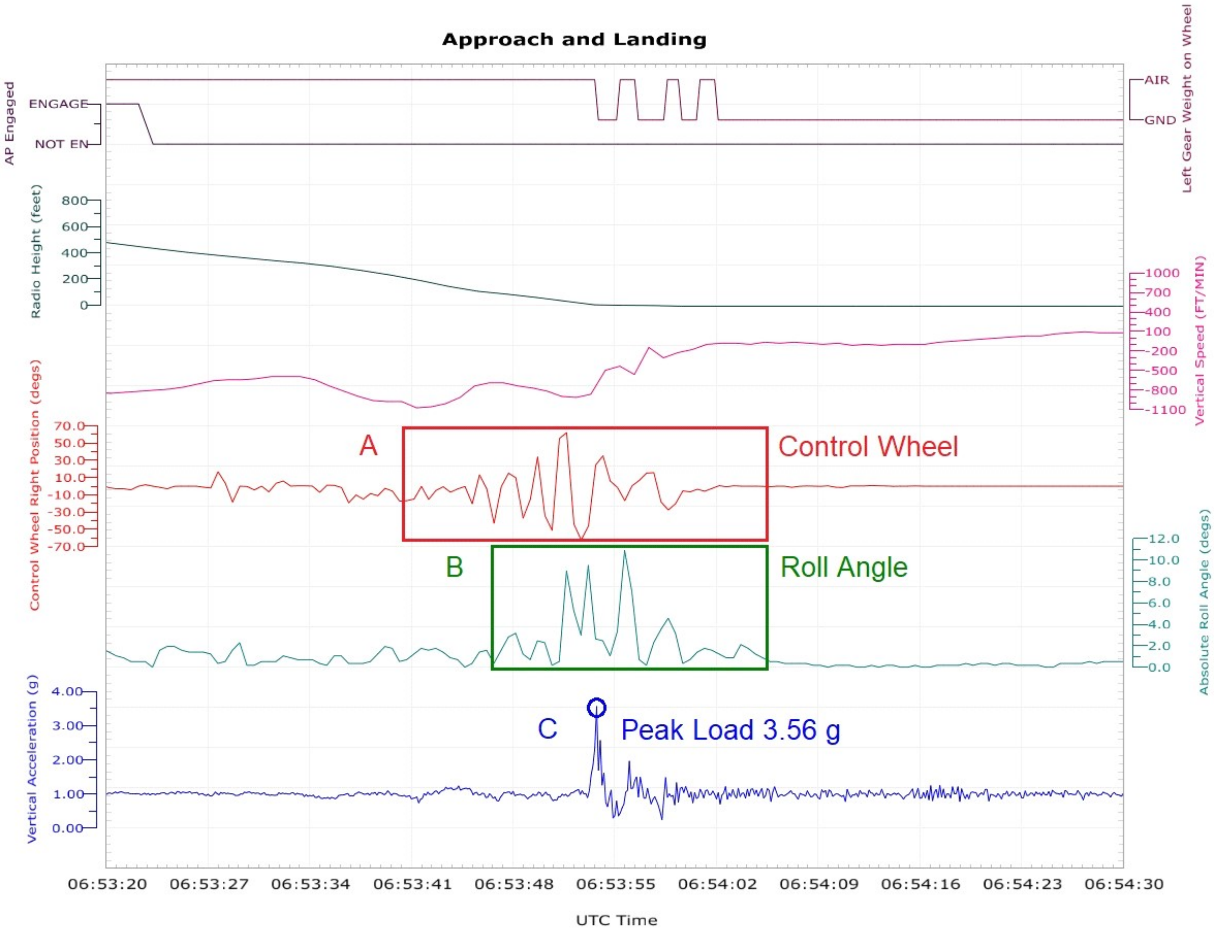

Figure 4: Flight Data Recorder Parameters

2.2.3.1. Pilot Flying Control Wheel Displacement (A)

There was minimal control wheel movement until the aircraft descended through approximately 200 feet radio altitude (RA) where the inputs start to increase in magnitude. Starting from approximately 80 feet RA the control wheel gain becomes full deflection to the left and right with increasingly rapid inputs. The PIO onset and the related control wheel movements exhibit high gain as the oscillation increases.

2.2.3.2. The Aircraft Roll Angle (B)

(1) Area “B” demonstrates the onset and continuation of the roll condition and PIO. The aileron inputs produce excessive roll rates which leads to the PF overcorrecting as they increase in magnitude.

(2) The oscillation increases resulting in a roll angle on touchdown of 10° right.

2.2.3.3. Peak Loading – “g” Load (C)

(1) Peak loading at the initial contact with the runway was 3.56 g.

(2) The aircraft rate of descent remained constant throughout with no attempt to check the rate of descent prior to the runway contact.

2.2.3.4. Flight Data Assessment

(1) Due to the PIO, at the runway contact point, the aircraft was rolling 10° right with a rate of descent of 723 ft/min and a nose high pitch attitude of 6.8° which resulted in the right main landing gear contacting the runway followed by the left main gear concurrent with the rear fuselage contacting the runway surface.

(2) This was followed by a high bounce, a marked bank to the right with runway contact occurring with the right main gear, another smaller magnitude bounce and eventual touch down initially on the nose wheel followed by the main gears.

2.3. Operational Procedures

2.3.1. Oscillation Onset

In this occurrence the oscillation onset was rapid, the high gain appeared in direct correlation to the roll oscillation as the PF countered the aircraft lateral deviations with the high gain control movements as the oscillation increases.

2.3.2. Ground Contact

(1) The increasing roll control deviation distracted the PF from flaring the aircraft and arresting the high descent rate prior to the runway contact. It appears that just before the initial runway contact the PF made an abrupt back input on the control column but this was ineffective in arresting the rate of descent.

(2) The high descent rate, combined with the pitch angle and the lateral aircraft movements resulted in the tail strike.

2.3.3. Bounced Landing Recovery

During this occurrence a bounced landing recovery in the form of a go around was an option. The aircraft deceleration was normal, with no additional longitudinal stability issues contributing to an unstable landing recovery. The Air Canada AOM states that a go around should be performed after a hard, high bounce. The conduct of a go around after the bounce was an option but no call or action was taken by the PM or the PF to initiate one nor from the other two crew members in the cockpit.

2.3.4. Pilot Monitoring and Announcing Deviations during Approach

(1) A high degree of discipline is required by both pilots during an approach. The PM (the IOETC) 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 within all the stable approach criteria and following the second arrival gate at 500 ft the autopilot was disconnected at 420 ft AAE.

(3) After the PF disconnected the autopilot and flew manually the aircraft became slightly high on the glideslope.

(4) Taking into account that this was the PF’s first landing on type, this was possibly an opportunity for the PM to provide some training input. Being aware that the aircraft was approaching the stable limits would also be a trigger to alert the PM that a go around might be imminent.

(5) The stable approach criteria tolerances were reached in the event sequence when the oscillations started, which according to the operators operating manual[20] required the PM (the IOETC) to alert the PF when a significant deviation is observed.

(6) The PM (the IOETC) did not call for a go around when the onset of the oscillation was detectable. There was also an opportunity to take control at the recognition of the PIO.

(7) Air Canada has advised that following this accident their procedures now require the first landing for transitioning pilots to be conducted by the IOETC unless the candidate is experienced on the aircraft type.

[20] Flight Operations Manual 8.11.6 23 Oct 2018

2.3.5. Air Canada Unstabilised Approach Criteria

(1) At the time of the accident the operator's criteria was contained in the FOM which set out the requirements at 1,000 ft AAE and 500 ft AAE. A verbal call of "unstabilised" was required to be made under 500 ft AAE if the requirements were no longer being met even if a "stable" call had been made earlier.

(2) There is no reference to a "Stable" call being required in the preceding "Arrival Gate" requirements. For important SOP there should be no potential confusion and the procedures as written could possibly be confusing to crew and might benefit with the requirements and crew response required be presented in an easier to read format. A "boxed checklist" would be beneficial and Air Canada have adopted this format since the accident.

2.3.6. Go Around Decision

(1) The stabilised approach criteria tolerances are not subjective, the call for a go around should have occurred after the second 500 ft AAE arrival gate tolerances at the onset of the PIO lateral deviations.

(2) Just prior to touchdown, with no flare initiation, when it became apparent that the approach had become unstable a decision could have been made to go around then. This could have been instigated either by the PF initiating it or the PM, or either of the relief pilots (RP) saying go around, or the PM taking control and conducting the manoeuvre.

(3) Air Canada policy on go arounds is non-punitive and also the RP is encouraged to monitor both the PF and PM calling out any deviations and ultimately can call for a go around.

(4) A go around is possible at any stage even after touch down as long as reverse thrust has not been selected on the engines.

2.3.7. Crew Actions during the Landing Roll

(1) After the first runway contact it appears the PM took control at some stage during or after the first bounce.

(2) Following the final bounce the PM moved the PF's hand from the thrust levers and selected reverse thrust. There was no statement of intention from the PM or formal handover of control. Air Canada FOM 7.1.4 advises that the acceptable method of transferring control is *"You have control / I have control"* but there is no guidance for this situation when the PM took control where the method could include "I have control/you have control" which may have avoided any potential confusion.

2.3.8. Stowage of Articles

(1) After the first touchdown a beverage container from the holder on the FO's side become dislodged and fell on to the cockpit floor. This created an added distraction when the PF bent forward to retrieve it.

(2) Loose items in a cockpit environment can easily place a crew into a hazardous, and yet easily preventable operational situation. Pilots need to be vigilant and adopt a clean and tidy cockpit philosophy from preflight through to landing and arrival at the gate as loose objects can get jammed in the controls, typically the rudder pedals, when they fall on the floor and move during flight.

(3) Operators should have guidelines in their manual suite for any loose objects like culinary utensils and crockery to be removed and stowed before descent and collected as soon as possible.

2.3.9. Sterile Flight Deck

(1) ICAO defines a Sterile Flight Deck as "any period of time when the flight crew should not be disturbed, except for matters critical to the safe operation of the aircraft."

(2) Air Canada defines it as all flight below 10,000 ft AAE. It is effectively a period of flight with the crew not engaging in non-essential conversations that do not pertain to operational matters. If flight crews do not adhere to sterile flight deck procedures they may be distracted during critical phases of flight.

(3) During the approach there was some distraction when the PM pointed out some recently completed construction and geographical features. As a result some extraneous flight crew member conversation occurred regarding this which potentially could have been distracting to the PF.

(4) The sterile flight deck policy of the operator at the time was that it was covered under the critical phrases of flight criteria and although sterile flight deck was mentioned there was no definition of it.

2.3.10. Aircraft State - Monitoring

(1) It was apparent that during the approach there appeared to be no tactile ("Hands-on") monitoring of the flight controls or thrust levers until around 1,000 ft AAE. Selections were being made on the Mode Control Panel

(MCP)[21] panel for required speeds and altitude settings but no following through on control movement was evident.

(2) This is subjective and most operators do not cover this in their manuals but it is generally accepted as an aid to be aware of the aircraft configuration and associated handling before disengaging the autopilot and continuing manually. This is more noticeable on approach where the aircraft configuration is changing with flap being extended with trim changes coupled with changes in the engine thrust required resulting in large variations of movement of the thrust lever positions.

2.3.11. Crew Actions after Landing

(1) After an event such as this the runway would normally be inspected and cleared of any FOD which may have separated from the aircraft. The FOD has the potential of causing damage as, for example, it can be ingested into the engines or damage the tyres of a following aircraft.

(2) During the roll out the IOETC mentioned to the crew that a tail strike check would be required and the FO advised ATC as an addition to the read back of taxi instructions. ATC did not understand the message and asked for it to be repeated. The IOETC then requested the FO to reply with the statement that the aircraft experienced severe turbulence on final which was acknowledged by ATC.

(3) Due to this confusion safety defences were breached and a prompt opportunity to inspect the runway for damage or any FOD was lost.

(4) It was noted during the investigation that one aircraft waiting at the holding point for departure, decided to take off after observing the event.

2.4. Weather

The aircraft was landing with a crosswind component inside the aircraft operating limits.

2.4.1. Windshear

(1) Analysis of the existing conditions at the time of the landing did not indicate the factors necessary for windshear at this low altitude were present.

(2) The ATIS “F” issued at 0607 hrs UTC did not advise of windshear nor had the previous one at 0507 hrs UTC.

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[21] The MCP is located in the glare shield and is the human machine interface to the flight guidance system of the aircraft.

(3) The last windshear warning system alert was issued at 0642 hrs UTC indicating a shear of -25 knots which was eleven minutes before the accident. No other preceding aircraft had reported any windshear, including the aircraft that landed ahead of the accident aircraft at 1450 hrs.

(4) The investigation reviewed the FDR and determined that there were no factors that would suggest a windshear event had occurred. The wind velocity, aircraft speed, rate of descent and thrust remained constant prior to the first runway contact. The PF stated that there was no turbulence on the approach.

(5) The two preceding landing aircraft did not report the presence of windshear to ATC.

(6) It should be noted, although not apparent for this event, that windshear and turbulence events can be very small scale, sporadic and transient in nature and may affect successive aircraft differently. Therefore windshear or turbulence as experienced by an aircraft may at times differ from the conditions reported by the preceding aircraft and from the alerts provided.

2.5. Organisational Risk - Training

2.5.1. Automation Dependency

(1) As the use of automation increases in aircraft design, organisations standards and guidance should evolve to ensure that pilot training programmes align with technological advancements and the evolving change in skills requirements for automation in the aviation highly complex human machine interface environment.

(2) When consolidating on a new type and considering this was the PF’s first landing, some manual flying earlier in the approach phase may have been beneficial to give the PF a feel for the aircraft handling characteristics and prevailing meteorological conditions.

(3) The PF kept the autopilot engaged until below 500 ft AAE and this would probably not be enough time to recognise any significant variations to the approach profile considering it was the first actual landing on type.

(4) Air Canada has advised that this is now being promoted by Flight Operations and the IOETCs. The IOETC Manual has been reviewed to offer additional guidance on this matter.

2.5.2. Training - Pilot Induced Oscillations

(1) PIO is in general not a training requirement for most major operators.

(2) Recognition and recovery from PIO is not required in the training process or assessed as a risk in the training phase. Recognition of the potential risk, in particular the precursors for the onset of PIO with pilots unfamiliar with the aircraft handling and behaviour would benefit transitioning pilots.

2.6. Human Factors

2.6.1. Situational Awareness

(1) The flight from Toronto to Hong Kong is regarded as a "long haul" flight in which the crew were on duty for a long period. The crew was augmented by two other pilots to give the operating crew, the PF and PM, sufficient rest. The crew stated that they were sufficiently rested and the flight up to the time of the occurrence had been routine.

(2) There are no indications that the Crew Resource Management (CRM) during the flight was less than optimal.

(3) The initial approach was carried out in a relaxed manner with some extraneous conversation from the PM about the infrastructural changes in the area. The PF did not join in this but the potential for distraction was present.

(4) It was the events at the completion of the flight where several factors came into play. The sudden onset of the PIO and subsequent abnormal runway contact happened abruptly and took all crew members by surprise occurring as it did after a routine flight.

2.6.2. Go Around Decision

During the latter stages of the approach there were several opportunities to carry out a go around which included the onset of the PIO, the initial runway contact and subsequent bounced landing.

2.6.3. PIO Onset

(1) After the reversion to manual flying with the aircraft going slightly high on the glideslope the PM advised the PF that the aircraft was above the glideslope, recognising that the aircraft was still within the stable approach prescribed criteria.

(2) As the aircraft continued its descent the call by the PM for a Go Around should have occurred at the onset of the PIO lateral deviations as the stabilised approach criteria tolerances are not subjective.

(3) The sudden escalation of the unstable oscillations would have probably taken the PM by surprise, which is defined by the FAA as an “unexpected event that violates a pilot’s expectations and can affect the mental processes used to respond to the event”.[22] In these unexpected situations there may be a delayed response and reaction which delays corrective actions.

(4) As the PIO lateral oscillations increased in magnitude at the flare height a decision could still have been made to go around. This could have been instigated by anyone of the crew - either by the PF or the PM or the RP saying go-around or the PM taking control and conducting the manoeuvre but would have been still subject to the delayed response and reaction by the PM.

2.6.4. Runway Contact

Preoccupied with the unexpected roll control deviations which distracted the PF from flaring the aircraft and arresting the high descent rate prior to the runway contact suggest that the PF was most probably experiencing task saturation. It appears that just before the initial runway contact the PF realised that there had been no flare input and made an abrupt back input on the control column, but this was ineffective in arresting the rate of descent at this stage.

2.6.5. Bounced Landing Recovery

(1) During this occurrence a bounced landing recovery was achievable, the aircraft deceleration was normal, with no additional longitudinal stability issues contributing to an unstable landing recovery. The ability to conduct a go around after the bounce was an option but no call or action was taken by the PM or the PF to initiate one. There was no input from the other two crew members in the cockpit.

(2) The decision not to go around during the bounce was probably also due to the “startle effect”, which is a human factor condition which leads to a delayed response and action to an unexpected situation.

(3) To sum up, the sudden onset of the PIO at the end of a long haul flight took the crew by surprise due to recognised human factor behaviour when presented with an unexpected situation. The loss of situational awareness impeded the recovery of the event.

[22] AC 120-111 CHG 1 - Upset Prevention and Recovery Training

3. Conclusions

3.1. Findings

From the evidence available, the following findings are made with respect to the abnormal runway contact of the Boeing 777-333ER registered C-FITW that occurred at Hong Kong International Airport 11 December 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

(1) The aircraft had a valid Certificate of Airworthiness and was maintained in accordance with the regulations. (1.6.2)

(2) The crew were licensed and qualified for the flight in accordance with existing regulations and the operator's requirements. (1.5.1)

(3) The approach under the 1,000 ft arrival gate was in accordance with the procedures in the operator's SOP and FOM. (1.18.3.3)

(4) The approach exceeded the tolerances for stabilised approach after the second (500 ft) arrival gate and should have resulted in a go around. (1.18.3.3)

(5) The PIO was a direct result of the over controlling of the aircraft by the PF. (2.2.3)

(6) The increasing roll control deviation distracted the PF from flaring the aircraft and arresting the high descent rate prior to the runway contact. The high descent rate, combined with the high pitch angle and the lateral aircraft movements resulted in the tail strike. (2.2.3.4)

(7) The PF did not execute a go around at the onset and development of the PIO or after the initial bounce after the first runway contact. (2.6.2 and 2.6.4)

(8) The PM did not call for or execute a go around at the onset and development of the PIO or after the initial bounce after the first runway contact. (2.6.2 and 2.6.4)

(9) The PF's training did not provide awareness training for PIO when converting from a narrow-body to wide-body type. (1.18.8.2 and 2.5.2)

(10) Sterile cockpit procedures during the approach were not observed with potential distractions affecting the PF's situational awareness. (1.18.5 and 2.3.9)

(11) Following the first touchdown there was an added distraction when the PF bent forward to retrieve a beverage container which had become dislodged and had fallen on to the cockpit floor. (2.3.8)

(12) The crew did not advise ATC of the suspected tail strike which delayed inspection of the runway. (2.3.11)

(13) There was an Airborne Image Recorder operating in the cockpit recording the actions of the PF, the pilot under training during the IOE process. Air Canada's Operational Procedures do not permit the use of such AIR devices, there was no authorization for such a device to be employed by the crew for any purpose on this flight and Air Canada was not aware that such a device was in use. (1.11.3)

3.2. Causes

An unstable approach developed due to pilot induced lateral rolling oscillations which coupled with a high rate of descent resulted in an abnormal runway contact. [2.2.3, and 3.1 (6)]

3.3. Contributing Factors

3.3.1. Stabilised Approach Criteria

The late recognition by the PM that the stabilised approach criteria after the second (500 ft) arrival gate was outside the required tolerances. [3.1 (4)]

3.3.2. Pilot Flying PIO Onset Recognition

The over controlling (high gain) by the PF resulted in PIO. [3.1 (5)] There is no requirement for PIO onset recognition or recovery actions in the operator's training procedures. [3.1 (9)]

3.3.3. Go Around Decision

(1) The late recognition by the PM that the aircraft was in an unstable flight condition that should have resulted in an "unstabilised" or a "go around" call from the PM and required an immediate go around. [3.1 (8)]

(2) The PF did not initiate a go around when the aircraft was in a PIO condition. [3.1 (4)]

3.3.4. Pilot Flying Loss of Situational Awareness

Task saturation with the lateral oscillation and high gain corrections resulted in the high descent rate up to the runway contact point. [3.1 (7)]

3.3.5. Pilot Monitoring Loss of Situational Awareness

Any decision to go around during the bounce was impeded due to the “startle effect”, which delayed any response or action. [3.1 (8)]

4. Safety Actions Already Implemented

Whether or not AAIA identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. AAIA has been advised of the following proactive safety action by the operator in response to this occurrence.

4.1.1. Revision of Advanced Qualification Program Volume 1 / IOETC Qualification

The Advanced Qualification Program (AQP) was revised with effective from September 01 2019.

- The minimum training to qualify an IOETC with no previous experience is increased as below:

Qualification of IOETC, AQP Volume 1

To qualify as an IOETC, the following must be completed:	
Day 1	AQP 101
Day 2	Fundamentals of Instruction & Crew Resource Management
Day 3	Inter Rater Reliability (IRR)
Complete Right Seat ground based and simulator training exercises	
Complete briefing with Chief-Pilot	
Conduct one leg in right seat as PF and one as PNF with Chief-Pilot (or delegate) as PNF and PF respectively.	
Observe at least 2 sectors of IOE conducted by a qualified IOETC	
Conduct at least 2 sectors of IOE under supervision of a Quality Assurance Instructor or Evaluator (QAI or QAE)	

Table 2: Qualification For Instructors with No Previous Air Canada AQP Experience

4.1.2. Policy Changes to IOETC Qualification

4.1.2.1. Related to Conduct

The IOETC shall act as the PF for the first sector of a candidate's IOE training.

4.1.2.2. Related to Training and Qualification

- A new IOETC shall conduct a minimum of six legs of an IOE from the left seat prior to conducting IOE from the right seat. This does not apply to IOETCs with previous IOE experience on another aircraft type.
- A new IOETC shall conduct a minimum of six legs prior to conducting IOE with a ZFTT candidate. This does not apply to IOETCs with previous experience on another type.
- Each fleet will designate IOETC's that are qualified to conduct IOE on command upgrade candidates.
- A minimum training to qualify an IOETC with no previous experience will be increased as noted in the AQP Volume 1.

5. Safety Recommendations

5.1. Safety Recommendation 12-2021

It is recommended that Air Canada consider recognition and awareness training for Pilot Induced Oscillation (PIO) during the training process, in particular as a component for pilots converting across type. [3.1 (9)]

Safety Recommendation Owner: Air Canada

5.2. Safety Recommendation 13-2021

It is recommended that Air Canada consider awareness training for crew qualifying as IOETC to emphasise the requirement to monitor and recognise situations where the control of the aircraft may be compromised. This should also include guidance when the trainee is new to the type. (3.3.4)

Safety Recommendation Owner: Air Canada

5.3. Safety Recommendation 14-2021

It is recommended that Air Canada consider reviewing and where necessary revise the unstabilised 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. [3.1 (4)]

Safety Recommendation Owner: Air Canada

5.4. Safety Recommendation 15-2021

It is recommended that Air Canada consider reviewing and where necessary revise the formal handover of control criteria contained in the FOM incorporating the method when a pilot takes over control "I have control/you have control" setting out the requirements in a clear and unambiguous format to avoid any confusion that flight crew may have in interpreting them. (2.3.7)

Safety Recommendation Owner: Air Canada

5.5. Safety Recommendation 16-2021

It is recommended that Air Canada consider reviewing and where necessary revise the Sterile Flight Deck criteria contained in the FOM incorporating setting out the requirements in a clear and unambiguous format to avoid any confusion that flight crew may have in interpreting them. [3.1 (10)]

Safety Recommendation Owner: Air Canada

5.6. Safety Recommendation 17-2021

It is recommended that Air Canada consider reviewing and where necessary revise the removal of loose objects from the flight deck policy, including eating utensils and beverage containers, before the top of descent setting out the requirements in a clear and unambiguous format to avoid any confusion that cabin and flight crew may have in interpreting them. (2.3.8)

Safety Recommendation Owner: Air Canada

5.7. Safety Recommendation 18-2021

It is recommended that Air Canada consider incorporating policy and guidelines in the company manual suite regarding the reporting of potentially hazardous occurrences, for example a tail strike, to the relevant Air Traffic Services 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. [3.1 (11)]

Safety Recommendation Owner: Air Canada

6. Safety Recommendations Already Implemented

On receipt of the draft report Air Canada proactively addressed all the Safety Recommendations made and after review by the AAIA they are considered closed.

6.1. Safety Recommendation 12-2021

(1) Air Canada has designed a module on PIO in their Pilot Indoctrination Training course for new pilots, so that every new pilot is aware of this phenomenon. This will be implemented prior to their next course.

(2) Additionally, since currently some pilots may not be aware of this phenomenon information will be included on PIO in their next Annual Recurrent Training (ART) cycle to ensure all pilots will see this material over a 12-month period.

6.2. Safety Recommendation 13-2021

(1) Air Canada has amended their training manual with guidance for training captains on taking control early in appropriate situations and to be alert for students freezing in tense situations.

(2) The simulator training for training captains includes practical training on taking control from a student pilot. Scenarios are included where the student candidate (a check pilot or instructor in this case) will intentionally operate the aircraft in a manner that will necessitate the IOETC to take control of the aircraft.

6.3. Safety Recommendation 14-2021

Air Canada incorporated a new Stable Approach, Landing and Go-Around Policy into their FOM in September 2020 which defines crew tasks and responsibilities including guidance for the requirement of a go-around.

6.4. Safety Recommendation 15-2021

Air Canada has amended their procedures to incorporate both cases of control handover.

6.5. Safety Recommendation 16-2021

Air Canada has amended their use of “sterile cockpit principles” and how they are employed during critical phases of flight.

6.6. Safety Recommendation 17-2021

Air Canada has amended their procedures which now include the requirement to remove or secure loose objects for critical phases of flight.

6.7. Safety Recommendation 18-2021

Air Canada has amended their procedures which now include that in order to reduce the risk of potential safety risks to aircraft or flight operations, Flight Crews shall report as soon as possible any hazardous flight condition to ATC, such as any observed conditions or events that may cause Foreign Object Damage (FOD).

7. General Details

7.1. Occurrence Details

Date and time:	11 December 2018 – 1454 hrs HKT (0654 hrs UTC)	
Occurrence category:	Accident	
Primary occurrence type:	ARC: Abnormal Runway Contact	
Secondary occurrence type:	Hard landing	
Location:	Runway 07R, Hong Kong International Airport, Hong Kong	
	Latitude: 22°18'41.14"N	Longitude: 113°53'58.32"E

7.2. Pilot Information

7.2.1. Pilot-in-Command

Age:	64
Licence:	Transport Canada ATPL-A
Aircraft ratings:	B727, B767, B777, DC9, EA32, EA33, EA34
Date of first issue of aircraft rating on type:	29 July 2008
Instrument rating:	Group 1 Instrument Rating
Medical certificate:	Class 1 unrestricted
Date of last proficiency check on type:	12 July 2018
Date of last line check on type:	27 June 2018
Date of last emergency drills check:	27 June 2018
ICAO Language Proficiency:	English
Limitation:	Nil

Flying Experience:	
Total all types:	23 615 hours
Total on type (B777) :	6 440 hours
Total in last 90 days:	180 hours
Total in last 30 days :	60 hours
Total in last 7 days:	15:39 hours
Total in last 24 hours:	15:39 hours
Duty Time:	
Day up to the incident flight (Hours:Mins) :	17:14 hours
Day prior to incident (Hours:Mins) :	0

7.2.2. First Officer (the PF)

Age:	41
Licence:	Transport Canada ATPL-A
Aircraft ratings:	B777, DH8,E170, EA32 SW3, SW4,
Date of first issue of aircraft rating on type:	6 Dec 2018
Instrument rating:	Group 1
Medical certificate:	Class 1
Date of last proficiency check on type:	6 Dec 2018
Date of last line check on type:	Not yet completed- first sector on type
Date of last emergency drills check:	17 August 2017
ICAO Language Proficiency:	English
Limitation:	Nil
Flying Experience:	
Total all types:	8 426 hours
Total on type (B777) :	15:39 hours
Total in last 90 days:	35 hours
Total in last 30 days :	15:39 hours
Total in last 7 days:	15:39 hours
Total in last 24 hours:	15:39 hours

Duty Time:	
Day up to the incident flight (Hours:Mins) :	17:14 hours
Day prior to incident (Hours:Mins) :	0

7.3. Aircraft Details

Manufacturer and model:	Boeing 777-333ER	
Registration:	Canada, C-FITW	
Aircraft Serial number:	35298	
Year of Manufacture	2007	
Engine	Two General Electric GE90-115B engines	
Operator:	Air Canada (AC)	
Type of Operation:	Scheduled Passenger Service	
Certificate of Airworthiness	Valid	
Departure:	Toronto Pearson International Airport (CYYZ)	
Destination:	Hong Kong International Airport (VHHH)	
Maximum Take-off Weight	351 533 kg	
Total Airframe Hours	54 543 hours	
Total Airframe Cycles	6 815 cycles	
Persons on board:	Crew – 17	Passengers – 376
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

7.4. Aerodrome Information

7.4.1. 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	3,800 m
Runway Width	60 m
Stopway	Nil
Runway End Safety Area	240 m x 150 m
Azimuth	07L / 25R, 07R / 25L
Category for Rescue and Fire Fighting Services	CAT 10

8. Abbreviations

AAE	Above Aerodrome (Airport) Elevation
AAIA	Air Accident Investigation Authority
AIR	Airborne Image Recorder
ALAR	Approach-and-landing Accident Reduction
Annex 13	Annex 13 to the Convention on International Civil Aviation
AOM	Aircraft Operating Manual
APC	Aircraft Pilot Coupling
AQP	Advanced Qualification Program
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
CAP. 448B	Hong Kong Civil Aviation (Investigation of Accidents) Regulations
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
CYYZ	Toronto Pearson International Airport
EBT	Evidence Based Training
FAA	Federal Aviation Administration of the United States
FAR	Federal Aviation Regulations
FCOM	Flight Crew Operating Manual
FDR	Flight Data Recorder
FMS	Flight Management System
FO	First Officer
FOD	Foreign Object Debris
FOM	Flight Operation Manual
FSF	Flight Safety Foundation
ft	Feet
ft/min	Feet per minute
g	Normal acceleration
HKG	IATA code for Hong Kong International Airport
HKO	Hong Kong Observatory
HKT	Hong Kong Time

hrs	Hours
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IOE	Initial Operating Experience
IOETC	Initial Operating Experience Training Captain
kg	Kilograms
km	Kilometres
kt	Knots (nautical miles per hour)
LIDAR	Light Detection and Ranging
LIWAS	Windshear Alerting System
m	metres
MBA	Microburst Alert
MCP	Mode Control Panel
º	Degree
PF	Pilot Flying
PIO	Pilot Induced Oscillation
PM	Pilot Monitoring
QNH	Pressure setting to indicate elevation above mean sea level
RA	Radio Altitude
RP	Relief Pilot
RWY	Runway
s	Seconds
SOP	Standard Operating Procedures
TDWR	Terminal Doppler Weather Radar
ToD	Top of Descent
US	The United States
UTC	Coordinated Universal Time
VHF	Very High Frequency
VHHH	Hong Kong International Airport
VMC	Visual Meteorological Conditions
WSA	Windshear Alert
WTWS	Windshear and Turbulence Warning System

ZFTT	Zero Flight Time Training

9. Table of Figures, Photos, Tables