الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

Air Accident Investigation Sector

Serious Incident

- Final Report -

AAIS Case Nº: AIFN/0006/2023

Tail Strike

Operator:	Wizz Air Abu Dhabi
Make and Model:	Airbus A321-271NX
Nationality and Registration:	The United Arab Emirates, A6-WZG
Place of Occurrence:	Abu Dhabi International Airport (OMAA)
State of Occurrence:	The United Arab Emirates
Date of Occurrence:	29 April 2023

This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to Civil Aviation Law No. 20 of 1991, in compliance with Air Accident and Incident Investigation Regulation, and in conformance with the requirements of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector issued this Final Report in accordance with the national and international standards and practices. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Final Report is publicly available at:

http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx

Air Accident Investigation Sector
The United Arab Emirates

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Occurrence Brief

AAIS Case Nº:	AIFN/0006/2023
Operator:	Wizz Air Abu Dhabi
Aircraft make and model:	Airbus A321-271NX
Registration mark:	A6-WZG
Manufacturer serial number:	11030
Number and type of engines:	Two, Pratt & Whitney PW1133GA-JM high-bypass geared turbofan engines
Date and time (UTC):	29 April 2023, at 0845 UTC
Place:	Abu Dhabi International Airport, the United Arab Emirates
Category:	Transport (Passenger)
Persons on-board:	208
Injuries:	Nil

Investigation Process

The occurrence, involving Airbus A321-271NX aircraft, registration marks A6-WZG, was notified by the operator to the Air Accident Investigation Sector (AAIS) by phone call to the Duty Investigator Hotline number +971 50 641 4667.

The AAIS opened an investigation in line with the State's obligations in accordance with Annex 13 as the United Arab Emirates being the State of Occurrence, Registry, and the Operator.

Following the Classification, Decision-making, and Scoping (CDMS) session, the AAIS classified the occurrence as a 'serious incident' and appointed an investigator-in-charge to conduct a single-investigator investigation. The scope of this investigation is limited to the events leading up to this occurrence. No in-depth analysis of non-contributing factors or non-safety-related issues was undertaken.

The Bureau d'Enquêtes et d'Analyses (BEA) of France, being the State of Design and Manufacture of the Aircraft, and the National Transportation Safety Board (NTSB) of the United States, being the State of Manufacture of the engines, were notified of the occurrence.

Notes:

[1] Whenever the following words are mentioned in this Final Report with the first letter capitalized, they shall mean the following:

- (Aircraft) – the aircraft involved in this serious incident
- (Commander) – the commander of the serious incident flight
- (Copilot) – the copilot of the serious incident flight
- (Incident) – this investigated serious incident referred to on the title page of this Report
- (Investigation) – the investigation into this serious incident
- (Operator) – Wizz Air Abu Dhabi

- (Report) – this serious incident investigation Final Report.

2 Unless otherwise mentioned, all times in this Report are 24-hour clock in Coordinated Universal Time (UTC) (United Arab Emirates local time minus 4 hours).

3 Photos and figures used in this Report are taken from different sources and are adjusted from the original for the sole purpose of improving the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or insertion of text boxes, arrows, or lines.

Abbreviations

AAIS	The Air Accident Investigation Sector of the United Arab Emirates
AOC	Air operator certificate
A-OCC	Adapted operator conversion course
AP	Autopilot
ARC	Airworthiness review certificate
ATC	Air traffic control
A/THR	Autothrust
ATIS	Automatic terminal information service
ATPL	Air transport pilot license
CAR	*Civil Aviation Regulations* of the United Arab Emirates
CAT	Category
CG	Center of gravity
CLB	Climb
COA	Certificate of airworthiness
CONF	Configuration
COR	Certificate of registration
CPL	Commercial pilot license
CRM	Crew resources management
CVDR	Cockpit voice and data recorder
DEC	Direct entry captains
DN	Down
ELP	English language proficiency
E/WD	Engine/warning display
FCOM	*Flight crew operating manual*
FCTM	*Flight crew techniques manual*
FE	Flaps extension
FFS	Full flight simulator
FL	Flight level
FLX	Flex takeoff
FMS	Flight management system
FSTD	Flight simulation training device
GA	Go-around
GCAA	The General Civil Aviation Authority of the United Arab Emirates
GND	Ground
G/S	Glideslope

hPa	Hectopascal
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
kg	Kilograms
km	Kilometers
KT	Knots
L/G	Landing gear
LOC	Localizer
LOC-I	Loss of control in-flight
LOFT	Line-oriented flight training
LPC	license proficiency check
MAC	Mean aerodynamic chord
MAX	Maximum
mbar	millibar
MCT	Maximum continuous thrust
METAR	Meteorological aerodrome report
MHz	Megahertz
NAV	Navigation
No.	Number
OAT	Outside air temperature
OCC	Operation conversion course
OM	*Operations manual*
OMAA	Abu Dhabi International Airport
OP	Open
OPC	Operator proficiency check
PAPI	Precision approach path indicator
PF	Pilot flying
PFD	Primary flight display
PM	Pilot monitoring
QAR	Quick access recorder
R	Right
REV (Rev)	Reverse
RHS	Right hand seat
RNAV	Area navigation
RPM	Revolutions per minute
SOP	Standard operating procedures

TO	Takeoff
TOGA	Takeoff - Go-around
UAE	The United Arab Emirates
UBBB	Heydar Aliyev International Airport
UPRT	Upset prevention and recovery training
UTC	Coordinated Universal Time
V	Airspeed
V_{FE}	Maximum speed for each flap configuration
V_{LO}	Maximum speed for landing gear operation
V_{LS}	Lowest selectable speed
V/S	Vertical speed

Synopsis

On April 29, 2023, a Wizz Air Abu Dhabi Airbus A321-271NX, registration marks A6-WZG, conducted a scheduled passenger flight WAZ25GR, departing from Heydar Aliyev International Airport in Baku, Azerbaijan, destined for Abu Dhabi International Airport in the United Arab Emirates. The Aircraft carried a total of 215 persons, including 208 passengers, 2 flight crewmembers, and 5 cabin crewmembers.

On landing with gusty wind conditions, the main gears remained on the ground for about 17 seconds whereas the nose gear wheel remained airborne. Fluctuation of the Aircraft's heading and drift was experienced, subsequently, the flight crew initiated a go-around and a tail strike occurred for about three seconds until the Aircraft lifted off.

The Air Accident Investigation Sector determines that the cause of the tail strike Incident was the improper high pitch control application when initiating the go-around while the airspeed was still low.

The AAIS identifies the following contributing factors to the Incident:

- The gusty wind conditions during landing.
- The Commander, in the PM role, did not witness the final portion of the radio altimeter and retard auto-callouts, along with the Copilot's action of adjusting to idle thrust before touchdown which was not noticed by both flight crewmembers.
- Following the touchdown, the Copilot, in the role of PF, inadvertently moved the thrust levers into reverse position, remaining unaware of the action, while the Commander did not notice the movement of the thrust levers.
- The fluctuations from the runway centerline in terms of heading and drift were caused by the Copilot's slight overuse of the rudder inputs.
- The lack of clear communication between the flight crewmembers, particularly the Copilot's omission to announce the initiation of a go-around and the Commander's subsequent cancellation, along with the Commander taking control, adversely affected the CRM.
- The Commander mistakenly perceived that the Aircraft had excess energy without verifying the actual low airspeed before deciding to commence the go-around.

The AAIS issued three safety recommendations addressed to the Operator. The recommendations were to: include go-around techniques on low-energy rejected landing close to the ground in the flight crew training program, and practice this in simulator training for the pilots; emphasize the importance of the monitoring role to the pilots as pilot monitoring including the callouts; and emphasize the CRM requirements and identify CRM issues during the pilot checks to address any necessary improvements in individual CRM skills and the overall efficiency of the CRM.

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1. Factual Information

1.1 History of the Flight

On 29 April 2023, a Wizz Air Abu Dhabi Airbus A321-271NX, registration marks A6-WZG, was scheduled to operate passenger flight WAZ25GR from Heydar Aliyev International Airport (UBBB[1]), Baku, Azerbaijan, to Abu Dhabi International Airport (OMAA[2]), the United Arab Emirates. A total of 215 persons were onboard the Aircraft, comprising 208 passengers, 2 flight crewmembers, and 5 cabin crewmembers. The Commander was the pilot monitoring (PM) and the Copilot was the pilot flying (PF).

The Aircraft took off from runway 17 at 0615 and climbed to cruise flight level (FL) 350 which continued for about 1 hour 27 minutes. The Aircraft then descended and cruised at FL270 for approximately nine minutes.

At 0820, the Aircraft commenced to descend and then proceeded with area navigation (RNAV) standard arrival for runways 31L/R.

The Aircraft approached on the profile with an instrument landing system (ILS) to runway 31L at OMAA (figure 1).

At 0839:58, the Aircraft was fully established on the ILS approach runway 31L, at a distance of 12.65 nautical miles from the threshold while descending through 4,160 feet indicated altitude with the correct QNH setting at 1007 hPa (mbar). The glideslope track (G/S) and localizer track (LOC) modes were active on the flight directors. Approach Controller instructed the flight crew to contact Abu Dhabi Tower South (Tower Control) on 119.2 MHz frequency.

Both autopilots and flight directors were engaged. NAV mode was active, and vertical speed (V/S) mode was selected at 300 feet per minute. The heading selection was set to magnetic at 280 degrees. The autothrust was active in SPEED mode. The auto brake was not armed.

At 0840:30, the flight crew contacted Tower Control and reported the Aircraft was fully established on the ILS approach to runway 31L. The Aircraft was about 11 nautical miles from the threshold, descending through 3,630 feet indicated altitude. Tower controller responded and issued clearance to land. The controller provided surface wind information indicating a direction of 300 degrees at a speed of 11 knots, alongside the QNH setting of 1007. The controller also instructed the flight crew to vacate via taxiway Echo 8 when possible, and the flight crew read back the instructions correctly.

At 0842:02, the landing gears lever was lowered.

At 0842:05, the 180 knots initially selected speed target on the SPEED mode changed to a managed speed target of 137 knots[3]. Two seconds later, the ground spoilers were set armed.

At 0842:27, the flaps lever was moved from position 2 to 3, which was moved to FULL position 15 seconds later when the Aircraft was descending through 1,780 feet, about five nautical miles from the threshold. [4]

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1 UBBB is the ICAO four letter airport code for Heydar Aliyev International Airport, Azerbaijan.

2 OMAA is the ICAO four letter airport code for Abu Dhabi International Airport, United Arab Emirates.

3 Selected speed means the pilot chooses the target speed overriding the flight management computer, while Managed mode means the autopilot follows the flight management system plan.

4 Flaps lever at position 2 has 22 degrees of slats and 14 degrees of flaps, while position 3 has 22 degrees of slats and 21 degrees of flaps, and FULL position has 27 degrees of slats and 34 degrees of flaps.

At 0843:54, both autopilots (AP1 and AP2) were disengaged when the Aircraft was descending through 770 feet indicated altitude (540 feet radio altitude), at about 1.6 nautical miles from the threshold.

At 0844:05, the tail strike pitch limit indicator appeared on the primary flight display (PFD) with a value of 9.67 degrees, while the Aircraft was descending through 635 feet indicated altitude (410 feet radio altitude). Three seconds later, the glideslope track and localizer track modes deactivated, and landing track (LAND) mode activated, when the radio altitude was 375 feet.

The Aircraft was on profile during the short final approach, except for a short glide excursion (below the path) at 300 feet radio altitude with a 0.5 dot (approximately 20 feet)[5] below.

At 0844:14, as the Aircraft was descending through 530 feet indicated altitude (265 feet radio altitude), at about 0.85 nautical miles from the threshold, Tower controller provided the surface wind information as 310 degrees at 12 knots. The flight crew did not reply back, but there was an unidentified double click heard on the cockpit voice and data recorder (CVDR).

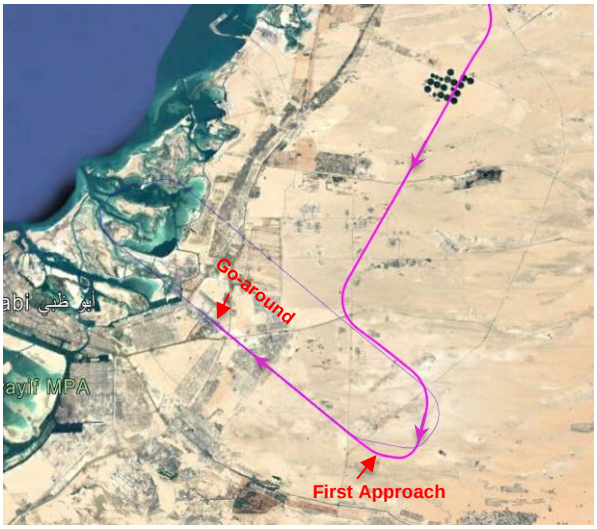

Figure 1. WAZ25GR flight path of first approach and go-around (purple thick-line) following instrument approach chart of OMAA ILS Runway 31L

As per the Commander's statement, prior to reaching the threshold, the Aircraft experienced “thermals[6]”.

At 0844:31, the radio altimeter announced auto callout ‘100’ feet. At 60 feet radio altitude, the localizer started to slightly deviate to the left indicating that the Aircraft was drifting slightly towards the right side of the runway centerline. At 45 feet radio altitude, the flare mode engaged and the drift angle started to increase to the right as a result of brief left rudder input. The drift angle reached 6 degrees at 0844:41.

Between 0844:35 and 0844:43, the Copilot made multiple control stick nose-down and nose-up inputs, causing the pitch angle to fluctuate between +1.9 and +3.9 degrees and the descent rate to decrease from 770 to 210 feet per minute. The descent rate then remained at about 240 feet per minute for the final four seconds of this period.

At 0844:37, the Aircraft passed over the threshold at about 25 feet radio altitude. Two seconds later, the cockpit loudspeaker announced ‘retard’ three times, while the thrust levers were simultaneously retarded to Idle (0) stop, causing the autothrust to disengage automatically.

At 0844:40, the roll angle was 3.4 degrees to the right. The Copilot then made a maximum left control stick input, which brought the Aircraft’s roll to change to the left. One second later, the radio altitude auto callout ‘5’ feet appeared. The pitch-up angle was at 3.1 degrees, while the localizer drift angle reached 6.1 degrees, and shortly thereafter, a right rudder pedal input was applied.

At 0844:43, both main landing gears touched the runway, with the left gear touching down first, while the pitch-up was at about 3.8 degrees decreasing to 2.5 degrees when the

[5] One dot represents ± 0.4 degrees on the glideslope scale.

[6] A relatively small-scale, rising air current produced when the Earth's surface is heated. Thermals are a common source of low-level turbulence for aircraft.

right gear touched down. Both main gears remained on the ground for about 17 seconds whereas the nose gear wheel remained airborne, subsequently the ground spoilers deployed. The vertical acceleration was 1.09G at the touchdown, and the localizer deviation was at -0.11341 dots (about 8 meters right from the centerline).

At 0844:44, the pitch reduced to 2.1 degrees simultaneous to the right rudder pedal input reaching 8.1 degrees, and held for about 1 second, which then started to be released and transformed to left rudder input. The thrust levers were pulled back from the Idle stop to Rev Max (FULL) stop in 1 second when the right rudder pedal input started to be released and the lateral acceleration was increasing towards 0.1G to the right.

At 0844:45, the pitch reached 0.4 degrees, which then continuously increased up to 5.1 degrees for the next 3 seconds.

At 0844:46, the lateral acceleration reached 0.1G to the right, and that was the point when the thrust levers started to be pushed forward from Rev Max stop to Rev Idle (REV) detent which lasted for 1 second. Shortly thereafter, the left rudder pedal input reached 14.2 degrees at the same time when the thrust levers reached the Rev Idle stop, while the lateral acceleration was going back towards zero. The left rudder pedal input was then released.

At 0844:47, a right rudder pedal input started to be applied increasingly. The right engine thrust reverser deployed which lasted for 2 seconds. One second later, the left engine thrust reverser deployed for 1 second. At the same time, the Commander shouted “Wo” five times. The lateral acceleration reached 0.1G to the left. Shortly thereafter, the right rudder pedal input reached 9.9 degrees, before release.

At 0844:49, the Commander began to use his pitch control stick while the Copilot continued with his stick input[7]. Simultaneously, the thrust levers were pushed further forward to the Takeoff - Go-around (TOGA) stop position, causing spoilers to retract, while the pitch reached 5.1 degrees. The N1 of both engines started to increase from approximately 30% revolutions per minute (RPM). Shortly after, the Commander said, “Keep it… keep it like this.”

Between 0844:49 and 0844:51, the Commander made a slight nose-up control stick input up to 4.2 degrees, followed by a slight nose-down stick input up to 6.2 degrees within one second. While the Copilot applied nose-up control stick input between 3.8 and 10.9 degrees. The Commander shouted “No” five times and the autothrust became active. The Aircraft deviated to the right of the runway centerline reaching 0.14 dot[8]. Shortly afterward, thrust levers were pulled back from TOGA to IDLE position, and consequently, the spoilers started to deploy again.

Thereafter, the Commander continuously applied nose-up stick input that reached 13.7 degrees 3 seconds later, while, the Copilot maintained a slight nose-up pitch stick input between 2.9 and 3.6 degrees. These inputs resulted in an increased pitch in the next 3 seconds.

At 0844:53, the Commander initiated a go-around by pushing the thrust levers from IDLE to TOGA and the ground spoilers started to retract accordingly. The Copilot was heard asking the Commander, “Are we on the ground[?]”. The autothrust disengaged, and the pitch reached 4.4 degrees.

At 0844:55, the spoilers fully retracted while the pitch started to increase beyond the 4.4 degrees. The airspeed reached its minimum value of 108 knots.

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[7] As per the *flight crew operating manual* (*FCOM)*, at all times, only one flight crewmember should fly the aircraft. However, if both flight crewmembers use their sidesticks simultaneously, their orders are algebraically added. The flight control laws limit the combined order to the equivalent of the full deflection of one sidestick.

[8] One dot represents ±0.8 degrees on the localizer scale.

At 0844:56, the cockpit loudspeaker announced “Dual input”, while the pitch reached 8 degrees. The Commander’s pitch-up control stick input reached up to 13.7 degrees, and almost at the same time, the Copilot released his stick. The dual input was applied for about seven seconds, from 0844:49 to 0844:56[9].

At 0844:57, the Commander called out “Go around”. The pitch increased to 9.84 degrees and the airspeed was 111 knots. The roll angle was fluctuating between 0.79 and 1.41 degrees to the right.

At 0844:58, the master warning triggered for 5 seconds, due to the full flaps and slats setting which was inconsistent with the take-off configuration. The pitch increased to 10.55 degrees and the airspeed was at 112 knots. The roll angle was fluctuating between 1.23 and 1.49 degrees to the right.

At 0845:00, the Aircraft became airborne at an airspeed of 118 knots with a pitch angle of 10.81 degrees, proceeding to an uneventful go-around.

At 0845:38, another aircraft (callsign GFA543), which was on taxiway Echo, notified Ground Movement Control South about a potential tail strike incident involving WAZ25GR.

At 0845:52, Tower controller asked the WAZ25GR flight crew about the reason for initiating the go-around. The flight crew responded that it was due to an unstable approach. Subsequently, Tower controller directed the flight crew to contact Approach Control.

At 0846:18, the flight crew contacted Approach Control reporting the go-around. The controller issued instruction for climb to 4,000 feet. The instruction was correctly read back by the flight crew.

At 0846:55, Approach controller asked why the go-around was initiated, and the flight crew explained that it was due to unstable low altitude over the runway.

From 0847:57 onwards, Approach controller directed WAZ25GR by providing vectors for an ILS approach to runway 31L (figure 2).

At 0855:22, the flight crew of GFA543 established communication with WAZ25GR, notifying them about their observation that WAZ25GR's tail appeared very close to the ground during the go-around. However, GFA543's flight crew were uncertain whether this proximity resulted in a tail strike or not.

The Commander checked the pressurization of the Aircraft thereafter, and the indication showed normal functioning.

At 0859:11, Approach controller instructed the flight crew to contact Tower Control. Subsequently, the flight crew contacted Tower Control and informed that ILS approach runway 31L was established, and the Tower controller cleared to land at 0859:31.

Figure 2. WAZ25GR flight path after go-around, second approach, and landing (blue thick-line) following instrument approach chart of OMAA ILS Runway 31L

[9] In this case, both inputs were added by the flight control laws as per the design.

At 0902:55, the Aircraft landed uneventfully.

Figure 3 illustrates the main events that took place during the first landing attempt.

Figure 3. The main events during the first landing attempt

1.2 Injuries to Persons

There was no injury to any of the occupants.

1.3 Damage to Aircraft

The maintenance personnel inspected the Aircraft and reported minor damage to the aft lower fuselage skin.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

The qualifications and experience of the Commander and Copilot at the time of the Incident were as shown in table 1.

Table1. Flight crewmembers' data

	Commander	Copilot
Age	45	26

Type of license	ATPL-A[10]	CPL-A[11]
Valid to	23 November 2023	11 May 2025
Rating	IR/MPA[12], A320, A380	IR/MPA, A320
Total flying time (hours)	10,100	1,280
Total command on all types (hours)	686	0
Total on this type (hours)	2,112	903
Total command on this type (hours)	427	0
Total twelve months (hours)	678:16	405:00
Total on type for the last 28 days (hours)	70:02	62:00
Total on type for the last 14 days (hours)	33:17	33:00
Total for the last 7 days (hours)	11:40	20:00
Total on type for the last 7 days (hours)	11:40	20:00
Total for the last 24 hours (hours)	06:08	06:00
Last operator proficiency check (OPC)	27 December 2022	9 April 2023
Last annual line check	1 March 2023	28 January 2023
Medical class	Class 1	Class 1
Valid to	2 January 2024	7 September 2023
Medical limitation	VDL[13]	None
English language proficiency (ELP)	Level 5	Level 4

The Commander stated that he had about six and a half hours of sleep in the night before. His first flight on the following day was from Abu Dhabi to Baku, and the Incident flight was the return from Baku, making it the second flight of the day. The Commander was involved in an eight-hour office duty the day before the flight, assisting the Operator's flight operations department. According to him, he did not feel fatigued or tired during the flight.

The Copilot stated that he was on a two-hour (08:00 to 10:00 local time) standby in the day before. He had six hours of sleep the night before and, according to him, he did not feel tired during the flight.

1.5.1 The Commander's training

According to the Commander's training records, he received the required training and evaluations essential for fulfilling his role. According to the evaluators' documented comments, his overall performance was good, and demonstrated adherence to standards. He was granted the final status of 'competent'.

The Commander engaged in his command upgrade training from 17 to 24 July 2022. He completed five simulator sessions as part of the process. Some notes during the training were stated as the following:

[10] ATPL-A: Air transport pilot license - aeroplane

[11] CPL: Commercial pilot license - aeroplane

[12] IR/MPA: Instrument rating/Multi-pilot aircraft

[13] VDL is a medical limitation code of correction for defective distant vision, which means that the licence holder should have readily available spectacles that correct for defective distant vision as examined and approved by the aero-medical centre or aero-medical examiners.

- On 22 July 2022, during his third command upgrade simulator session, the instructor commented that he needs to react faster concerning the autoland warning (flashed light) appearance and to reject the condition. During his fourth session on the same day, the instructor commented that the Commander performed memory items (immediate action items that must be taken in response to a non-routine event quickly) not only for the required ones, therefore, it is recommended by the instructor to perform only the required memory items for the actual event. In addition, it is recommended "not to rush" when performing the memory items.
- On 24 July 2022, during his fifth command upgrade simulator session, the evaluator provided comments about his DODAR[14]. The instructor documented in the evaluation log that it is recommended "For DODAR, do not settle with only one immediate good option -- there might be better ones." However, overall his progress was good and he was ready (for the next step).

The Commander underwent his operator proficiency check (OPC) cycle 1 on 27 July 2022, followed by simulator training cycle 1 on the next day. There were no notes provided by the instructor for the OPC or simulator training.

On 27 December 2022, the Commander completed his license proficiency check (LPC) cycle 2 in the simulator, receiving positive feedback from the examiner on his "good" performance, "adept" workload management, and adherence to procedures. On 28 December, the Commander completed simulator training cycle 2 and received "good" performance comment.

1.5.2 The Copilot's training

The Copilot joined the Operator in mid-August 2022. According to the training records, he was provided with the required training for his role. The Copilot demonstrated overall good performance as documented by the evaluators who granted him a final status of 'competent'.

The Copilot completed his standard operating procedures (SOP) introduction 1, 2, and 3 simulator training during the period 4 to 7 November 2022, with overall good marks as per the comments given by the instructor.

The records showed that during the LPC cycle 2 in the simulator, conducted on 12 November 2022, the examiner commented that the Copilot needs to adapt to a more collaborative decision-making style. It was visible of cultural differences in communication. On the simulator training cycle 2 conducted on 13 November 2022, the instructor commented that the Copilot showed visible progress in terms of crew cooperation and communication.

The Copilot was evaluated for his OPC cycle 2 on 13 April 2023 with no notes from the instructor. On 15 April 2023, during his simulator training cycle 2, the instructor commented that the Copilot needs to work a bit on his crew resources management (CRM) skills, he could sometimes be "overbearing and needs to take a step back."

1.6 Aircraft Information

1.6.1 Aircraft data

Table 2 illustrates the general Aircraft data.

Table 2. Aircraft data

Manufacturer:	Airbus
Model:	A321-271NX

[14] DODAR stands for diagnose, options, decide, act, review which is a term used as memory aids to assist pilots in dealing with uncertain situations, problem solving, and decision-making.

Manufacturer serial number:	11030
Nationality and registration mark:	United Arab Emirates, A6-WZG
Name of the Operator:	Wizz Air Abu Dhabi
Certificate of airworthiness	
Number: Original issue date:	UAE-COA-0737 30 September 2022 *Airworthiness Review Certificate ARC-WAZ-WZG-1* , valid until 29 September 2023
Certificate of registration	
Number: Original issue date:	UAE-COR-1322 30 September 2022
Date of production/delivery:	September 2022 / 30 September 2022
Time since new (flight hours):	2,332:26
Cycles since new:	759
Last major inspection, type, date and hours/cycle:	No major check performed (new aircraft)
Time since last major inspection (hours):	No major inspection performed
Cycles since last major inspection:	No major inspection performed
Last inspection, type, date, and hours/cycle:	29 April 2023 (Daily-Check), 5,540.23 hours, 1,021 cycles
Maximum take-off weight:	89,000 kg
Maximum landing weight:	77,300 kg
Maximum zero fuel weight:	73,300 kg
Actual take-off weight and CG:	81,846 kg and 26.75 %MAC
Weight and CG at time of occurrence:	75,623 kg and 19.7% MAC

1.6.2 Engine data

Table 3 illustrates the general engines' data.

Table 3. Engines' data

Manufacturer:	Pratt & Whitney	
	No. 1 engine	No. 2 engine
Model:	PW1133GA-JM	PW1133GA-JM
Manufacturer serial number:	P772984	P800000
Date installed on Aircraft:	1 July 2022	1 July 2022
Time since new (hours):	2,332:26	2,332:26
Cycles since new:	759	759
Time/cycles since last overhaul/inspection (hours/cycles):	No overhaul performed (new engine)	No overhaul performed (new engine)

1.6.3 Maintenance records

The Aircraft's technical logbook showed seven previously deferred defects, and none of these had relevance to the Incident. There were no reported discrepancies on the Incident

flight's log page prior to departure.

1.6.4 Thrust levers

The thrust levers can only be moved manually. The lever's sector of motion is divided into four operational segments:

- A/THR (Autothrust) operating range 1 engine;
- Autothrust operating range 2 engines;
- Rev (Reverse) idle; and
- Reverse.

The sector has six positions separated by mechanical detents or stops as shown in figure 4.

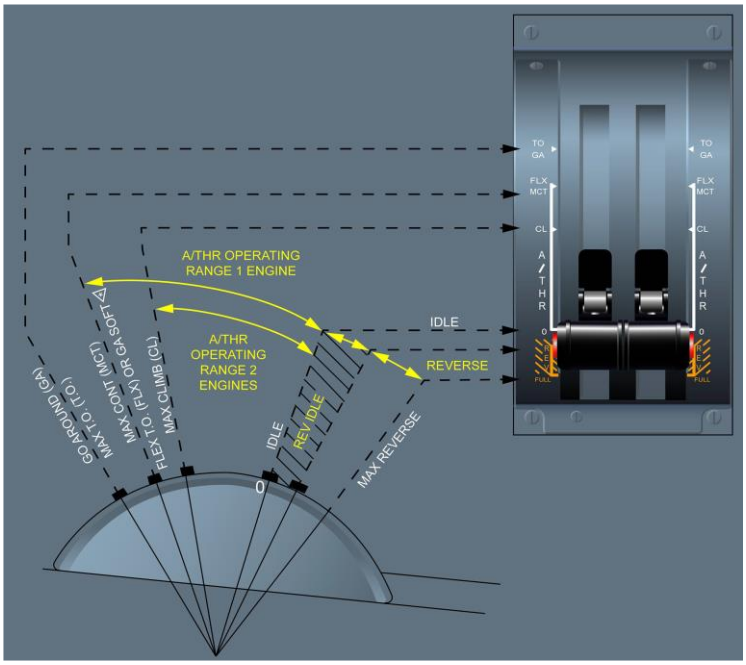


Figure 4. Thrust levers

1.6.5 Tail Strike Protection

Tail strike protection systems were installed on the Aircraft which consist of pitch rate limitation, aural warnings, and pitch limit indicator. The design philosophy and safety considerations that prevail for the tail strike protections systems are the following:

- These protections are inhibited during a go-around in order to provide the crew with full authority on flight controls, in particular on the pitch axis;
- The underlying safety principle is that a go-around is an emergency situation, whose criticality cannot be assessed by aircraft systems. This assessment can only be made by the crew combining all information regarding the aircraft, but also the operational situation and its anticipated evolution;
- The safety risk associated with a runway collision is much more important than for a tail strike.

These considerations are the reason why, when TOGA mode is activated, the manufacturer's design philosophy is to provide full authority to the crew in pitch and to inhibit all unnecessary warnings to help the crew focus on and handle the go-around actions, during

this very dynamic and critical phase of flight. It is up to the crew to apply adequate inputs on the flight controls to manage this critical situation, even if this leads to a tail strike. In some critical situations, keeping the pitch rate limiter and the « Pitch-Pitch » aural warning during a go-around could ultimately prevent the crew from achieving the rotation rates necessary for the intended maneuver and go against safety. The state-of-the-art technology does not allow to design of a tail strike protection in the go-around phase without affecting negatively the trajectory of the aircraft in case of an avoidance maneuver.

1.7 Meteorological Information

The meteorological aerodrome report (METAR) for OMAA on 29 April 2023, during the period from 0800 to 0900 stated:

METAR OMAA 290800Z 28006KT 250V310 CAVOK 34/03 Q1007 NOSIG

METAR OMAA 290900Z 29012KT 260V320 CAVOK 35/06 Q1007 NOSIG

METAR indicated that at 0800, the wind speed was 280 degrees, varying between 250 and 310 degrees, at 6 knots. The visibility was 10 kilometers or more. There were no clouds below 5,000 feet. The outside air temperature (OAT) was 34 degrees Celsius, and the dew point was 3 degrees Celsius. The atmosphere pressure was at 1007 hectopascal (millibars), and no significant weather change was expected within the next 2 hours.

At 0900, the wind speed was 290 degrees, varying between 260 and 320 degrees, at 12 knots. The visibility was 10 kilometers or more. There were no clouds below 5,000 feet. The OAT was 35 degrees Celsius, and the dew point was 6 degrees Celsius. The atmosphere pressure was at 1007 millibars, and no significant weather change was expected within the next 2 hours.

The automatic terminal information service (ATIS) was available to the flight crew, reported good visibility (CAVOK), light to moderate winds of 290 degrees at 12 knots, temperature of 35 degrees Celsius, and atmospheric pressure of 1007 hectopascal (millibars).

The flight crew received the wind surface conditions as 300 degrees at 11 knots. The atmospheric pressure was 1007 millibars for runway 31L when the landing clearance was granted by Tower Control. The Aircraft was on final about 11 nautical miles from the threshold of runway 31L when this information was received.

At the time the Aircraft was approximately 0.85 nautical miles (1.57 kilometers) away from runway 31L threshold, the controller provided the last updated wind surface information, 310 degrees at 12 knots.

1.8 Aids to Navigation

The onboard and ground navigation aids were functioning normally.

1.9 Communications

All communication between the flight crew and Abu Dhabi air traffic control (ATC) was generally clear and normal. The relevant ATC voice recording was provided to the Investigation. The flight deck communication was normal throughout the flight.

During the approach, from 0828:48 to 0840:07, the flight crew was in communication with Approach Control (Abu Dhabi Approach Central/West combined) on the primary frequency of 124.400 megahertz (MHz). Subsequently, the communication was switched to Tower Control (Abu Dhabi Tower South) on 119.200 MHz, from 0840:30 to 0846:10.

During the go-around and the second approach, the flight crew was in communication with Approach Control on frequency 128,100 MHz from 0846:18 to 0859:19 before switching to Tower frequency at 0859:23 until landing.

1.10 Aerodrome Information

Abu Dhabi International Airport (OMAA) is located 16.5 kilometers east of Abu Dhabi city and equipped with two asphalt runways: 13R/31L; and 13L/31R. The coordinates of the centerline mid-point of runway 13R/31L is 24°25'59"N 54°39'04"E, with an elevation of 83 feet.

Runway 31L has a landing distance available of 4,106 meters. The distance between both runways' centerlines is 2,000 meters.

Runway 31L is equipped with an ILS International Civil Aviation Organization Category (ILS ICAO CAT) II/III precision approach[15] lighting system, and precision approach path indicator (PAPI) lights set for a 3.0-degree glide path. The runway 31L heading is 306 degrees.

1.11 Flight Recorders

The Aircraft was equipped with two L3 cockpit voice and data recorders (CVDRs), part number: 7100-0200-00. Both the cockpit voice and flight data recordings were successfully downloaded. The Investigation was also provided with the quick access recorder (QAR) data.

The data of the CVDR and ATC transcript were examined and synchronized. Appendix 2 of this Report provides details about the flight and crew's actions.

1.12 Wreckage and Impact Information

The tail strike caused minor damage to the underside of the rear fuselage. Figure 5 illustrates the damage and its dimensions.

The aft lower fuselage skin was abraded, between frames 65 - 67 and stringers 42L to 42R. Drain mast assembly was required to be replaced prior to the next flight.

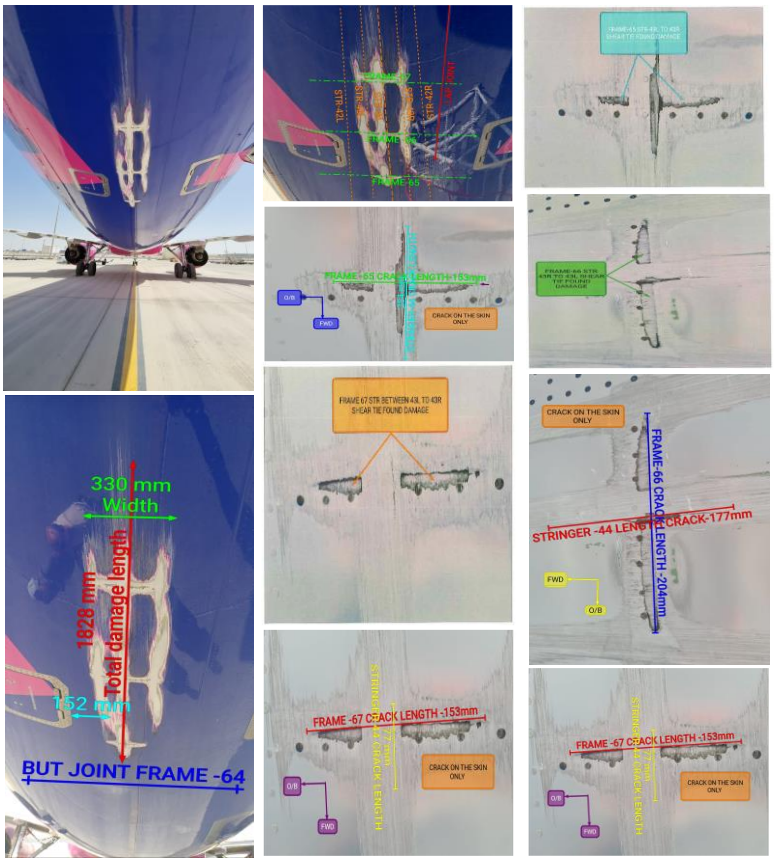


Figure 5. Skin abrasion on the aft lower

[15] A category II approach is a precision instrument approach and landing with decision height lower than 60m (200ft) but not less than 30m (100ft), and a runway visual range not less than 350m (1200ft).
A category III allows aircraft to land safely in low visibility conditions, minimizing the need for diversions or cancellations due to weather-related factors.

1.13 Medical and Pathological Information

No medical tests were made.

1.14 Fire

There was no sign of fire.

1.15 Survival Aspects

None of the persons onboard sustained any injury.

1.16 Tests and Research

No tests or research were required to be conducted as a result of this Incident.

1.17 Organizational and Management Information

1.17.1 General information

The Operator commenced its scheduled commercial flight operations in January 2021 in compliance with an air operator certificate (AOC) issued by the General Civil Aviation Authority of the United Arab Emirates (GCAA).

1.17.2 Training

All required training for the pilots as per the regulatory requirements, was described in the *operations manual − part D (OM-D)*.

In the initial ground training, the effect of high temperature on go-around performance is included as one of the emphasized hot weather operations procedures.

Practice on go-around maneuvers in various conditions (degraded automation, high energy, rejected landings) is included in the simulator training in order to regularly review and practice pilots' fundamental knowledge and skills, which is one of the practices of the Operator's continuous development of pilots' competencies.

1.17.2.1 A320 conversion course modules

Pilots are required to complete the Operator's conversion training course before commencing unsupervised line flying, whenever one of the following conditions require:

- joining Wizz Air Abu Dhabi; or
- changing to an aircraft for which a new type or class rating is required.

Upset prevention and recovery training (UPRT) is one of the A320 conversion course modules. Its objective is to provide pilots with the training necessary to mitigate loss of control in-flight (LOC-I). The UPRT training consists of ground training and flight training in a flight simulation training device (FSTD).

One of the elements under flight path management and manual handling skills in the UPRT is the management of go-arounds from various stages during approach (above/from platform altitude, high energy, soft go-around, from and below [minimum] decision altitude, in low visibility operations). In the ground training, the go-around includes discontinued approach, high-energy, and rejected landing. Using of side stick and the relationship between the two side sticks, and the transfer/takeover of control, are given during ground training.

The required elements of the UPRT flight training are performed in a level D full flight simulator (FFS)[16] qualified for the task. The level D FFS used by the Operator is qualified for

[16] Level D FFS is a full-motion flight simulator that provides a realistic representation of the flight deck, cockpit and visual environment. It is the most advanced type of simulator and provides the closest experience to actual flight conditions.

UPRT.

The required simulator sessions for initial flight simulator training/checking are as follows: SOP intro 1; SOP intro 2; SOP intro 3; recurrent OPC/LPC check (including low visibility operations); recurrent training session; simulator events implemented into type rating course; direct entry captains (DEC) new on type; adapted operator conversion course (A-OCC) FFS 1 session; A-OCC FFS 2 session; and SOP intro 3 right-hand seat qualification (RHS). Go-around management is provided during the SOP intro 3 session under normal procedures, A-OCC FFS 2 session, and DEC (not type-rated) extra training.

1.17.2.2 Crew resources management (CRM) training

The CRM training is part of the conversion training course. The Operator shall ensure that applicable elements of CRM training are integrated into all appropriate phases of the conversion training.

Furthermore, elements of CRM are integrated into all appropriate phases of the recurrent training. Each pilot undergoes specific modular CRM training. All major topics of CRM training shall be covered by distributing modular training sessions as evenly as possible over a three-year cycle.

1.17.2.3 Command upgrade course

As per the *OM-D*, the Operator's command course shall include at least the following elements:

- CRM
- command responsibilities training
- FSTD, which includes line-oriented flight training (LOFT)
- OPC, operating as commander
- line training as commander under supervision
- completion of a line check as commander and demonstration of adequate knowledge of the route or area to be flown and of the aerodromes, including alternate aerodromes, facilities and procedures to be used.

1.17.2.4 Rejected landing and go-around

As a part of the UPRT training, the rejected landing subject was included in the Operator's recurrent training and standard checking program, and in addition, in the supplementary simulator training only for the Operator's management pilots.

Beyond the minimum requirements, as a continuous development of pilots' competencies, the Operator provided simulator training programs which included the practice of go-around maneuvers in various conditions (degraded automation, high energy, rejected-landings), and positive transfer of flight controls (take-over exercises either due to unstable trajectory or after incapacitation of one pilot).

The flight simulator training encompassed practicing rejected landings below 100 feet, though not specifically addressing scenarios after touchdown.

1.17.3 Procedures

1.17.3.1 Manual landing procedures

According to the *flight crew operating manual (FCOM)*, the manual landing procedures are as illustrated in figure 6.

MANUAL LANDING

Applicable to: ALL

Ident.: PRO-NOR-SOP-19-A-00025032.0001001 / 09 NOV 21

FOR MANUAL LANDING

AP.....OFF | PF

Ident.: PRO-NOR-SOP-19-A-00010351.0011001 / 29 JUN 22

FLARE

- **AROUND 30 ft RA :**
  In stabilized approach, the flare height is approximately 30 ft.

FLARE.....PERFORM | PF
ATTITUDE.....MONITOR | PM
THRUST LEVERS.....IDLE | PF

L2 *Move the thrust levers to idle, and begin a gentle progressive flare to enable the aircraft to touch down without a prolonged float.*

If autothrust is engaged, it automatically disconnects when the flight crew sets both thrust levers to the IDLE detent.

At 20 ft, an automatic "RETARD " callout will trigger, as a reminder.

L1 *Note: Ground spoilers extension is inhibited if one or more thrust levers remain above the IDLE detent.*

AT TOUCHDOWN

- **As soon as the main landing gear touches down:**
  DEROTATION.....INITIATE | PF

ALL THRUST LEVERS.....REV MAX or REV IDLE | PF

The flight crew must select REV MAX immediately after landing gear touchdown and then set to idle if appropriate.

L2 *Reverse thrust above idle should be considered on short turnarounds and in high summer temperatures to reduce brake temperatures for subsequent dispatch.*

The flight crew must immediately select and use REV MAX, if any of the following occurs at any time during the landing:
- *An emergency*
- *The deceleration is not as expected*
- *A failure affects the landing performance*
- *A long flare or a long touchdown*
- *An unexpected tailwind.*

A small pitch up may occur during thrust reversers deployment before nose landing gear touchdown. However, the flight crew can easily control this pitch up.

As soon as the flight crew selects reverse thrust, they must perform a full-stop landing.

L1 GND SPLRS.....CHECK/ANNOUNCE | PM

L2 *Check that the WHEEL SD page displays the ground spoilers extended after touchdown.*

If no ground spoilers are extended:
- *Check that all thrust levers are set to IDLE detent.*
- *Set both thrust reverser levers to MAX REV, and fully press the brake pedals.*

L1 *Note: If ground spoilers are not armed, ground spoilers extend at reverser thrust selection.*

REVERSERS.....CHECK/ANNOUNCE | PM

L2
- *Check that the ECAM E/WD displays the expected reverser deployment (i.e. REV).*
- *If reverser(s) do not deploy as expected, one of the main deceleration means is lost. The flight crew should consider adapting the available deceleration means to stop the aircraft.*

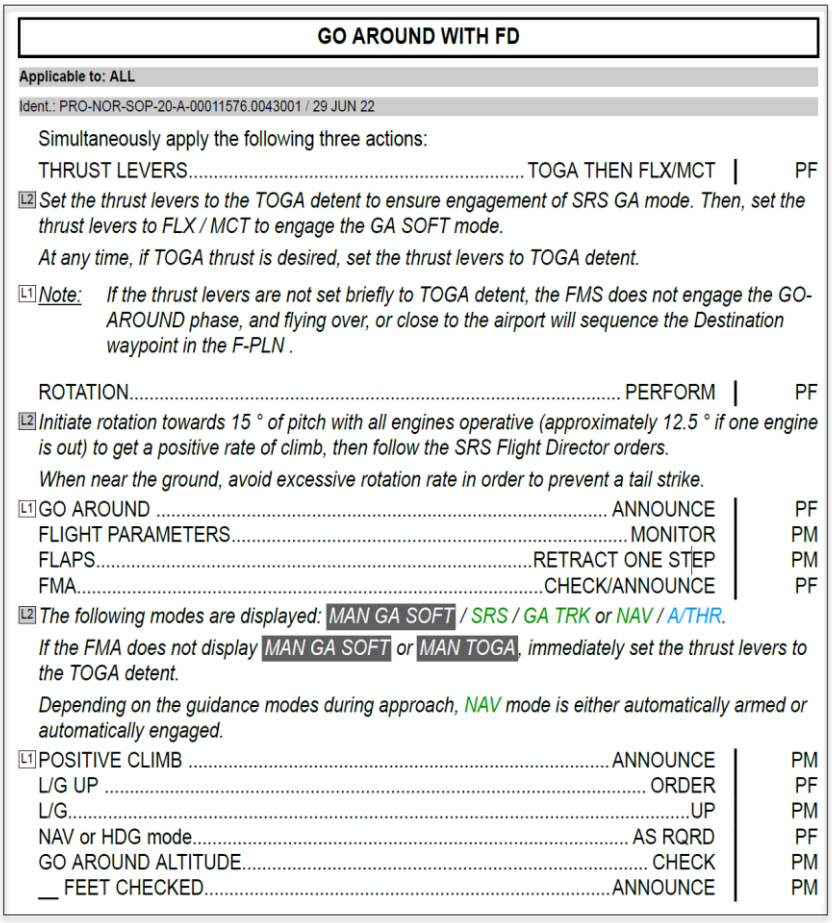
L1 DIRECTIONAL CONTROL.....MONITOR/ENSURE | PF

L2 - *Ensure directional control. Use the rudder pedals for directional control.*

Figure 6. *FCOM* manual landing procedures

1.17.3.2 Go-around procedures

The go-around with flight director procedures is illustrated in figure 7.



GO AROUND WITH FD

Applicable to: ALL

Ident.: PRO-NOR-SOP-20-A-00011576.0043001 / 29 JUN 22

Simultaneously apply the following three actions:

THRUST LEVERS ..... TOGA THEN FLX/MCT | PF

L2 *Set the thrust levers to the TOGA detent to ensure engagement of SRS GA mode. Then, set the thrust levers to FLX / MCT to engage the GA SOFT mode.*

At any time, if TOGA thrust is desired, set the thrust levers to TOGA detent.

L1 *Note: If the thrust levers are not set briefly to TOGA detent, the FMS does not engage the GO-AROUND phase, and flying over, or close to the airport will sequence the Destination waypoint in the F-PLN .*

ROTATION ..... PERFORM | PF

L2 *Initiate rotation towards 15 ° of pitch with all engines operative (approximately 12.5 ° if one engine is out) to get a positive rate of climb, then follow the SRS Flight Director orders.*

When near the ground, avoid excessive rotation rate in order to prevent a tail strike.

L1 GO AROUND	ANNOUNCE	PF
FLIGHT PARAMETERS	MONITOR	PM
FLAPS	RETRACT ONE STEP	PM
FMA	CHECK/ANNOUNCE	PF

L2 *The following modes are displayed: MAN GA SOFT / SRS / GA TRK or NAV / A/THR.*

If the FMA does not display MAN GA SOFT or MAN TOGA, immediately set the thrust levers to the TOGA detent.

Depending on the guidance modes during approach, NAV mode is either automatically armed or automatically engaged.

L1 POSITIVE CLIMB	ANNOUNCE	PM
L/G UP	ORDER	PF
L/G	UP	PM
NAV or HDG mode	AS RQRD	PF
GO AROUND ALTITUDE	CHECK	PM
__ FEET CHECKED	ANNOUNCE	PM

Figure 7. *FCOM* go-around with flight director procedures

1.17.3.3 Go-around near the ground

According to the *flight crew techniques manual (FCTM)*, the “The PF must not initiate a go-around after the selection of the thrust reversers.”

The *FCOM* also states that "As soon as the flight crew selects reverse thrust, they must perform a full-stop landing." For go-arounds near the ground, the *FCOM* states that "When near the ground, avoid excessive rotation rate to prevent a tail strike."

1.18 Additional Information

Several instances of tail strikes have occurred in the past. From these, three occurrences involving A321 aircraft were selected due to their similarity to the current Incident.

1.18.1 Ural Airlines A321

On 28 February 2013, at 02:13:59 UTC, a Ural Airlines A321 was involved in a tail strike during a bounced landing at runway 34 of Hurghada, Egypt. Consequently, the flight crew performed a go-around and landed uneventfully.

The Egyptian Aircraft Incident Investigation Central Directorate investigation revealed deviation from normal technique. The copilot (who was the PF) did not handle the landing properly, and the commander did not intervene at the proper time to prevent the pitch limit from exceeding the aircraft's geometric limit upon touchdown.

The investigation report concluded the following contributing factors:

- The commander did not intervene at the proper time in order to prevent the pitch from exceeding its limits;

- Both flight crewmembers were possibly affected by fatigue induced by the long duty period and early flight time, but still within the duty time regulations;
- The copilot was suffering from light intensity though he did not announce or inform the commander;
- Since the copilot had more flying experience than the commander, the commander might have felt high confidence in the copilot resulting in his relaxed feeling that the probability of his error is low;
- Both flight crewmembers did not sense the touchdown possibly because the bounce was very little, the touchdown was smooth, and abnormal pitch attitude at the time of the landing;
- The copilot was holding the aircraft nose high to prevent hard landing which was against the *FCTM* and operator's SOP for the case of bouncing at landing;
- The commander failed to properly conduct his duties as a PM for aircraft pitch monitoring at landing and timely announcing exceeding of this parameter; and
- The communication between the commander and the copilot throughout the event was not efficient.

1.18.2 Asiana Airlines A321

On 16 April 2013, at about 17:37, an Asiana Airlines A321-200, operating a scheduled international passenger flight, took off from Harbin Taiping International Airport, China, for Incheon International Airport, the Republic of Korea.

The aircraft experienced a tail strike while touching down on runway 16 at Incheon International Airport causing injuries to three flight attendants and substantial damage to the pressure bulkhead and stringers. Accordingly, the occurrence was classified as an 'accident'.

The Aviation and Railway Accident Investigation Board (ARAIB) of the Republic of Korea, concluded the following causes:

- The PF failed to maintain the proper approach speed until the flare just before touchdown, and the airplane bounced on touchdown since higher-than-normal vertical gravity was applied due to a high sink rate and increased thrust and speed just before touchdown; and
- The airplane made a second touchdown at the pitch attitude exceeding an A321 airplane's limitation and sustained a tail strike since the PF failed to keep thrust at idle and establish the proper pitch attitude during the bounce.

The following contributing factors were also concluded:

- Inadequate training program dealing with the recovery from the bounce;
- Lack of pre-landing preparation due to a failure to conduct an approach briefing on pitch attitude;
- The PF's failure to properly allocate his attention due to his delegation of flight control to the PM who failed to meet flight control requirements;
- The PM's inadequate advice and monitoring due to the PF's failure to make standard callouts;
- The disconnection of the autothrust and a failure to manually control thrust and speed; and
- Failure to execute a go-around when stabilized approach criteria are not met.

1.18.3 IndiGo Airlines A321 Neo

On 2 January 2023, an IndiGo Airlines A321 Neo, was involved in a tail strike incident upon landing at Kolkata Airport. The copilot was the PF.

The aircraft slightly bounced after touching down, followed by a high nose pitch attitude that led to a tail strike. 'PITCH PITCH' annunciation was heard coming from the commander who reported the tail strike in the technical logbook. There were no injuries reported.

The Indian Directorate General of Civil Aviation (DGCA) conducted an investigation and concluded that the cause of the tail strike was the continuous high pitch-up input by the copilot (PF) while landing and after touchdown. The lack of the commanders' (PM) role in monitoring the flight parameters and his passive involvement in corrective input have contributed to the incident.

1.19 Useful or Effective Investigation Techniques

This Investigation was conducted in accordance with the *Air Accident and Incident Investigation Regulation* of the United Arab Emirates, and the AAIS-approved policies and procedures, and in conformity with the Standards and Recommended Practices of Annex 13 to the Chicago Convention.

2. Analysis

2.1 General

The Investigation collected data from various sources for the purpose of determining the causes and contributing factors that led to the Incident.

This analysis covers the flying technique, the weather conditions, the relevant Operator's procedures, flight operations, and flight crew performance.

This part of the Report provides analysis of aspects that have contributed to the Incident. The analysis also contains safety issues that may not be contributory to the Incident but are significant in adversely affecting safety.

2.2 The First Approach, Go-around, and Tail Strike

During the first approach to runway 31L, the flight crew carried out all required briefings and actions as per the SOP. The Aircraft was on profile during the short final approach, except for a short time glide excursion 20 feet below the path, which happened when the Aircraft was at about 300 feet radio altitude.

The slats and flaps were fully extended. The autobrake was not armed, and the ground spoilers were armed. Autothrust was active in SPEED mode with a managed speed target at 137/138 knots.

Prior to reaching the threshold, the Aircraft experienced thermals as stated by the Commander, which was confirmed from the data of the cockpit voice and data recorder (CVDR) that showed fluctuation of the airspeed between 144 and 133 knots, and vertical acceleration between 0.78G and 1.1G. The fluctuation was experienced from the point when the Aircraft was about 1.2 nautical miles before the threshold to the point when it passed over the threshold. The Commander recalled that the airspeed and glide fluctuations were within limits.

The wind variations were between 305 degrees and 248 degrees in direction, at speeds from 6 to 20 knots, starting when the Aircraft descended through 70 feet radio altitude until the touchdown.

As the Aircraft approached about 140 meters before the threshold while descending through 50 feet, the Copilot, acting as the pilot flying (PF), started applying left rudder inputs to counteract the left gusty crosswind. These rudder inputs continued for about 18 seconds.

The Aircraft passed over the threshold at a height of approximately 25 feet. From the radio altimeter auto-callout, the Commander stated that he heard the '40' call-out as the last, and could not recall the rest of the radio altimeter call-outs.

The thrust levers were set to the IDLE position when the auto-callouts "Retard, retard, retard" triggered. Hence, the Copilot set the thrust levers to IDLE detent, as per the *flight crew techniques manual* (*FCTM)*.

The first 'retard' auto-callout was triggered when the Aircraft reached a radio altitude of 20 feet. The Commander stated that he did not hear this callout as he was focused on maintaining the Aircraft on profile. Therefore, the Commander anticipated the unheard 'retard' call-outs before the automated system activated, which led him to independently call out 'retard' simultaneously with the first auto-callout, coincidentally causing him to miss the subsequent two 'retard' auto-callouts. The Aircraft was already over the runway (about 150 meters after past the threshold) when the auto-callouts triggered, with the wind direction still changing, now coming from the west, resulting in increased crosswind components.

Two seconds before both main landing gears touched the ground, the wind direction shifted to 248 degrees at 20 knots, generating a peak crosswind component of approximately

17 knots that lasted for two seconds. The Aircraft's heading was 299 degrees with a drift of approximately 6.1 degrees to the right of the centerline, which led the PF to reduce the left rudder input to zero for about two seconds in order to bring back the Aircraft's heading parallel to the runway centerline (de-crab) accompanied by roll command inputs to adjust the angle (about 3.4 degrees) to zero. The wind direction then started to shift to be more northerly, which reduced the crosswind component.

About one second before the main gears touched the ground, the Aircraft reached to three degrees left roll. The Copilot (PF) then corrected this by making the required right roll inputs to level the wings. The left main landing gear touched down first with the Aircraft was at a one-degree left roll. The right main landing gear touched down about 430 meters after the threshold. The touchdown occurred before the aiming point marking of runway 31L, which was located 530 meters from the threshold and within the touchdown zone marking. The Aircraft's heading was 302 degrees, drifting about 3.5 degrees to the right, about 8 meters off the runway centerline. The airspeed was about 135 knots at the time of touchdown.

After the touchdown, the Copilot made continual adjustments to manage the drift and keep the Aircraft in line with the runway centerline. After maintaining a right rudder input (between 7° and 8°) for about one second, the right drift was adjusted to zero, then switched to the left, consequently, the Copilot released the right rudder input and made left rudder input in less than two seconds, which caused an increase in the lateral acceleration to the right by approximately 0.1G. A right drift emerged, prompting the Copilot to release the left rudder input and to make thereafter a right rudder input for approximately one second to reduce the right drift. This corrective action led to a slight increase in lateral acceleration to the left by about 0.1G. However, the Investigation believes the rudder inputs applied by the Copilot were slightly disproportionate contributing to the fluctuations of the drift.

As both main landing gears touched down, the ground spoilers automatically deployed and the airspeed decreased. Both flight crewmembers did not notice the spoilers deploying. About one second after touchdown, the thrust levers were pulled from idle (IDLE/0) to maximum reverse (MAX REVERSE/FULL) and then pushed back to reverse idle (REV IDLE). The Copilot stated that the Aircraft never touched down, so he did not set the thrust levers to reverse position as per the standard operating procedure (SOP) for landing. However, the CVDR data showed that the thrust levers were indeed moved to the reverse position. This discrepancy indicated that the Copilot was unaware of moving the thrust levers to reverse position after the touchdown. The IDLE detent is a physical stop that prevents the thrust levers from being moved below the idle position during flight (in the air) and can only be overridden on the ground, as per the *certification specifications*. Since the Copilot perceived that the Aircraft was still airborne, the movement of the thrust levers below the idle position was not noticed.

The lateral acceleration variations after reaching 0.1G to the right, then continuously changed and reached 0.1G to the left within two seconds, and reduced again thereafter to zero. In the meantime, the thrust levers were moved to reverse position (MAX REVERSE position and then to the REV IDLE stop position). The changes in the lateral acceleration probably affected the Copilot, such that he moved inadvertently the thrust levers (without his awareness/undetected) to the reverse position, and lasted for approximately four seconds. It is possible that, as per his natural physical reaction, the Copilot was inadvertently using the thrust levers to steady himself against these lateral load factor acceleration variations and this caused the movement of the thrust levers.

During the period from nine seconds before touchdown to six seconds after, the Copilot made several attempts to align the Aircraft with the runway centerline because of changes in wind direction and speed. The Copilot was focused on crabbing before reaching the threshold and de-crabbing before and after touchdown. This Investigation finds that it is

probable that the intense focus affected the Copilot's awareness of the Aircraft's touchdown and the movements of the thrust levers.

After moving the thrust levers from MAX REVERSE to the REV IDLE stop position, the Aircraft's heading started to change from 307.1 to 303.6 degrees, causing a slight deviation off track due to increased left rudder input. A right lateral acceleration of 0.1G was experienced as the heading changed. The initial left drift decreased, transitioning to a right drift.

The Copilot adjusted by reducing the left rudder input and introducing a slight right rudder input, halting the increase in right drift and heading change. A left lateral acceleration of 0.1G was experienced as the heading change concluded at 303.6 degrees. This prompted the Commander, who was the PM, to express his surprise with five times repeated "wo" utterances. The heading of 303.6 degrees was maintained for about one second. Meanwhile, the Copilot applied additional right rudder input to realign the Aircraft's heading with the runway centerline (right drift reduced).

Afterward, the Commander loudly said, "Keep it… keep it like this", indicating the need to keep the Aircraft heading and track around 305 degrees. Following this, the Commander repetitively loudly said, "No" five times upon observing the Copilot pushing the thrust levers forward toward TOGA. Just before reaching TOGA, the Commander pulled the thrust levers back to the idle, where stayed for two seconds. As stated by the Copilot, he removed his hand from the thrust levers when the Commander took over controls.

Since the Commander believed the Aircraft was still airborne, but it had already touched down, he expected the Copilot to reduce the thrust after his repetitive loud cues, but the Copilot increased it to TOGA instead. This showed the Commander's expectation bias about the thrust settings and his surprise when the Copilot did not follow his expectations. The Commander's confusion about the thrust levers being above idle, even after his instruction retard, indicated his lack of awareness that the thrust had already been shifted to idle and then to reverse.

On the touchdown, the Aircraft's pitch was about 3.5 degrees, which then decreased to 0.4 degrees within two seconds. As the pitch angle decreased, the Copilot, without being noticed, moved the thrust levers to the maximum reverse position. This caused the pitch to increase. The sustained nose-up control stick control, along with the deployment of the ground spoilers and no application of braking pressure on the pedals, led to an increase in the pitch up to 5.1 degrees. When the pitch started to increase, the Copilot, without being noticed, moved the thrust levers from maximum reverse to the reverse idle position.

The Investigation believes that the Copilot maintained a nose-up position on the control stick, believing that the Aircraft was still in a flare and expecting it to touch down soon. However, he then decided to initiate a go-around by applying TOGA thrust. The Commander, realizing the Copilot's actions, began adjusting the pitch control. There was no evidence supporting the Copilot's statement that he called for a go-around. Relying solely on memory to recall completed tasks can lead to source memory confusion, as individuals may conflate the current situation with past experiences where that task was successfully carried out[17].

The Copilot chose to initiate a go-around by applying TOGA thrust because he believed the Aircraft was still airborne, had concerns about the remaining distance before reaching the end of the touchdown zone, and was worried about the possibility of landing on the edge of the runway, as per his statement. His decision was influenced by the fluctuations of drift and heading. This indicates that the Copilot lacked awareness of the Aircraft's state and position.

[17] R. Key Dismukes, Benjamin A. Berman, Loukia Loukopoulos, *'The limits of expertise: Rethinking pilot error and the causes of airline accidents*', Ashgate Aldershot UK, 2007.

The Copilot responded to the Commander's warning about the TOGA setting, following the Commander's exclamation and action of pulling back the thrust levers, by asking "Are we on the ground[?]". As he stated, the Copilot question was a way to confirm the Aircraft's status. He understood the last Commander's previous callout as indicating that they could still attempt a landing, which was also the Commander's intention at that moment. The Commander did not respond to the Copilot's question. This situation highlighted that both flight crewmembers believed the Aircraft was still airborne and had not yet touched down.

After the Commander cautioned the Copilot about the TOGA setting, he took over controls by pulling back the thrust levers to the idle and making adjustments on his control stick. During this process, the Commander slightly decreased the Aircraft's pitch for about two seconds by applying nose-down stick input, as he intended to proceed with the landing at that moment. The Commander did not follow the SOP PF/PM duties transfer by announcing "I have control" when taking over controls, and the Copilot did not acknowledge this transfer of control by stating "You have control".

As per the Commander's statement, his mental model was tuned at that moment that the Aircraft had already passed the threshold and experienced some floating. He did not hear the height callouts "30, 20, …", and thought that the Copilot had not yet set the thrust levers to idle (including to reverse position), making it difficult for him to accurately assess the Aircraft's position on the runway. He also assumed that the airspeed was similar to when the Aircraft passed over the threshold (138 knots) without verifying it, leading him to believe there was excess energy for a normal landing. Expectations play a significant role in determining where a person seeks information and the type of information he looks for[18], shaping how he perceives and interprets incoming information[19]. This influenced his decision to initiate a go-around and increase thrust to TOGA about four seconds after taking over controls.

When the thrust levers started moving forward towards the TOGA position, the Aircraft pitched up to about 4 degrees, and the airspeed was 115 knots. Two seconds later, the thrust levers reached the TOGA detent, and a "Dual input" callout was heard while the thrust levers were still being moved. As a result, the Copilot released his hands from the controls. Shortly thereafter, within one second, the Commander called for a go-around. The warning message CONFIG FLAPS NOT IN TO CONFIG or CONFIG SLATS NOT IN TO CONFIG probably appeared on the Engine/Warning Display (E/WD) since the flaps/slats were still fully extended whereas the Aircraft was in the take-off roll phase (phase 4) as computed by the flight warning computer (FWC). The master warning was also activated due to this incorrect take-off configuration, which lasted for five seconds.

The airspeed decreased to a minimum of 108 knots while the pitch reached 5 degrees, about three seconds after the thrust levers were moved to TOGA. As the engine started to spool up, the airspeed and pitch gradually increased.

Two seconds later, the pitch reached about 10 degrees, which was about two seconds before the Aircraft lifted off. Based on the ground clearance diagram (Appendix 2, figure 8) and the appearance of the tail strike pitch limit indicator on the PDF, the Investigation believes that the tail strike occurred when the pitch reached the limit of 9.7 degrees. At this point, both main landing gears were on the ground (compressed shock absorber condition) with a low airspeed of 112 knots. The tail strike condition lasted for about three seconds and ended when the Aircraft lifted off (extended shock absorber condition) with an airspeed of 118 knots and a pitch of 10.8 degrees.

During liftoff, the Aircraft's roll angle varied between 0.9 and 1.8 degrees to the right. According to the Aircraft's ground clearance diagram, the tail strike pitch limit changed from

[18] Christopher D. Wickens, Jason S. McCarley, *Applied attention theory*, CRC Press, Boca Raton, 2019.

[19] Christopher D. Wickens, Justin G. Hollands, Simon Banbury, Raja Parasuraman, '*Engineering psychology and human performance*', 4th edition, Pearson Boston, MA, 2013.

10.1 degrees (on the main landing shock absorber compressed) to 11.8 degrees (uncompressed). The engines were still spooling up, and both N1 values reached a maximum value of 93%. The Aircraft rolled on the runway for about 17 seconds with the nosewheel remaining airborne throughout.

The Commander stated that when he initiated the go-around, he made a slight pull on the control stick, which was confirmed by the data. Later on, he checked the primary flight display (PFD) and noticed that the pitch was between 9 and 10 degrees, prompting him to adjust the pitch slightly. This indicates that the Commander was aware of the 9.7 degrees pitch limitation for the takeoff. However, based on the data, the Commander made a slight adjustment to the pitch at the moment of liftoff, meaning he adjusted the pitch when it had already reached 10.8 degrees. This suggests that the Commander was slightly delayed in recognizing the pitch information displayed on the PFD.

As mentioned, the decision to go around was influenced by the Commander's perception of the Aircraft's excess energy. The Investigation believes that the Commander's perception of high energy was due to his assumption that the Aircraft was still airborne. Furthermore, he did not check or verify the airspeed displayed on the PFD. Therefore, the Investigation concludes that the Commander was not aware of the Aircraft's low airspeed, indicating that the Aircraft had low energy at that moment, contradicting the Commander's perception.

The Commander assumed that the Aircraft had excess energy and was still airborne, leading him to focus on increasing the pitch, resulting in a maximum pitch rate of about 3.5 degrees per second. The Aircraft had tail strike protection for landing to reduce the tail strike risk by restricting the commanded pitch rate after touchdown, which becomes active once the ground spoilers are deployed. In this case, a go-around was initiated by setting the thrust levers to TOGA, causing the ground spoilers to retract deactivating the tail strike protection.

Despite having commands for nose-up pitch, including a full back stick command for two seconds with dual inputs from both flight crewmembers, the pitch remained steady before TOGA selection, attributed to the effectiveness of the tail strike protection system. After the Commander selected TOGA, the tail strike protection deactivated, and the elevators quickly deflected upwards as both pilots sustained nose-up inputs. This upward deflection of the elevators, along with the pitch-up induced by the thrust increase from engaging TOGA, resulted in a significant increase in the pitch angle, reaching up to 10.8 degrees, and exceeding the tail strike limit.

The Commander initiated the go-around ten seconds after the Aircraft touched down while it was decelerating through 108 knots, which was 24 knots less than the lowest selectable speed (V_{LS}) of the CONF FULL configuration (132 knots). Because of the Aircraft's very low speed, the main landing gears were decompressed about six seconds after the full-back control stick input, and when the airspeed reached sufficient 118 knots for this full configuration, the Aircraft lifted off approximately 2,600 meters before the end of the runway. As per the design, take-off performances are not computed or tested, whether in the landing full configuration or when thrust reversers are activated, which was the case in this Incident. The Aircraft's center of gravity (CG) was at a forward position at the time of the Incident.

As per the design, the twice "Pitch" automatic callout is available to prevent excessive pitch attitude during the flare and landing, activating when conducting manual landings below 50 feet radio altitude. The alert activates when the pitch approaches an excessive level, including a phase advance term that predicts the pitch angle one second ahead. This timing is finely tuned to give pilots enough time to adjust their sidestick input while keeping the alert unobtrusive. In this case, the pitch angle becomes excessive whereas the thrust levers were on TOGA. Therefore, the Pitch automatic callout, inhibited during the go-around phase, did not trigger.

Once the Copilot initiated reverse thrust, he should have executed a full-stop landing as soon as possible according to SOP which also stated in the *FCTM* for a go-around near the ground. Due to the unnoticed activation of the reverse thrust setting by both pilots, the execution of the go-around deviated from the SOP.

Following the Aircraft's liftoff, the Commander, acting as the PF, called out "Positive climb", a responsibility that should have been carried out by the Copilot. Subsequently, the Copilot, in the role of PM at that moment, called out "Gear up", a command which should have been given by the PF to retract the landing gear.

These actions indicated that despite the Commander taking control from the Copilot, both flight crewmembers continued to act as if they were in their original positions (Commander as PM and Copilot as PF). Furthermore, the selection of flaps for the go-around was delayed. The flaps selection from FULL to position 3 occurred after retracting the landing gears, contrary to the correct sequence where it should have been set after the go-around announcement by the Commander. This indicates that the go-around procedure, including its sequence, was not carried out in accordance with the SOP.

2.3 Flight Crew Performance

The Investigation believes that if both pilots had identified the low airspeed condition, they might have recognized that the Aircraft was already on the ground, and therefore, they might have continued the landing without any issue.

The changes in wind direction and speed resulted in an increase in the left crosswind as the Aircraft was passing over the threshold, peaking at 17 knots before decreasing rapidly during the flare (as depicted in figure 11). This most probably affected the Copilot's workload, necessitating increased focus on maintaining the Aircraft on track and heading, by applying directional and lateral control inputs, and adjusting its pitch for the flare, as the Copilot perceived the Aircraft had not yet touched down.

These demanding adjustments most probably impacted the Copilot's focus and attention, increasing the likelihood of fixating on his actions and the Aircraft's response. As a result, he could not notice the Aircraft's touchdown, compounded by the smooth landing indicated by almost no change in vertical acceleration. Furthermore, inadvertently moving the thrust levers to the reverse position was another slip error made by him which degraded his situational awareness of the Aircraft's state, prompting him to initiate a go-around by pushing the thrust levers forward. However, he omitted the required go-around callout, leading the Commander to take control. Apart from the wind variations, there was no evidence that the Copilot was distracted from landing duties.

The Investigation believes that the Commander focused his attention on the Aircraft's maneuvers and most probably became fixated on them when the Copilot was trying to land the Aircraft and align with the runway centerline. This condition affected the function of his monitoring role, as the PM. As a result, the Commander did not observe:

- some last radio altimeter auto-callouts;
- the 'retard' auto-callouts;
- the thrust setting to idle and reverse positions moved by the Copilot;
- the Aircraft had already touched down;
- the position of the Aircraft along the runway; and
- the low energy of the Aircraft (low airspeed).

All these slip errors of the Commander started when the Aircraft passed over the threshold. One of the prevailing types of errors involves the omission of a step or action, frequently linked with interruptions, distractions, or the diversion of attention to other tasks[20].

The Investigation believes that these slip errors degraded the Commander's situational awareness of the correct Aircraft's state states (position, configuration, and energy) and dynamics. Consequently, his decision to initiate the final go-around and its execution was based on an erroneous mental representation of the situation and was not in accordance with the SOP, which resulted in a tail strike. The ineffective communication between both flight crewmembers during this critical phase of flight and a brief period of high workload is believed to be one of the contributing factors to the Incident.

After the Commander's "Go-around" callout initiated, as the PF, the Copilot, acting as the PM, was supposed to retract the flaps from FULL to position 3. However, this action was not executed immediately in accordance with the SOP, resulting in a 28-second delay before the flaps were eventually retracted one step.

Additionally, the Copilot sought guidance from the Commander regarding the flaps setting before making the required adjustment. The "Positive climb" callout, which should have been initiated by the Copilot, was instead made by the Commander. Furthermore, the Commander was responsible for commanding the gear retraction, but this step was omitted (lapse), prompting the Copilot to call out "Gear up" while retracting the landing gear. These deviations from SOP during the go-around indicated a degradation in the crew coordination, probably influenced by the issues encountered before initiating the go-around.

Therefore, the Investigation concludes that the proficiency of crew resource management (CRM), which includes communication, decision-making, problem-solving, crew coordination, and situational awareness, decreased from the moment the Aircraft passed over the threshold until the go-around was initiated. The CRM deficiency was based on the erroneous mental representation of the situation by both flight crewmembers. The increased workload induced by handling wind variations, and unclear communication between the flight crewmembers, including the absence of announcements when the Copilot initiated the go-around and when the Commander assumed control, also played a role in their CRM deficiency.

2.4 Rejected Landing and Go-around Training

Go-arounds and rejected landings were part of the Operator's ground training as well as flight training conducted using level D full flight simulator (FFS).

All training maneuvers involving rejected landings and go-arounds were performed with the aircraft airborne, even below 100 feet above ground level. The training provided by the Operator for go-arounds and rejected landings primarily emphasized high-energy flying for aircraft in flight. There is no technique or procedure in the *FCOM* and *FCTM* for go-around after touchdown, and as per the Aircraft manufacturer which is agreed by the Investigation, this is deliberate with the safety rationale as follows:

- Such a technique or procedure would contradict the SOP for landing, which explicitly states that "The flight crew must select reverse thrust immediately after landing gear touchdown." and "As soon as the flight crew selects reverse thrust, they must perform a full stop landing."
- In certain extreme operational situations, such as an immediate risk of collision with a vehicle or another aircraft just after touchdown, it may be safer in specific circumstances to perform a go-around rather than a full-stop landing. However, differentiating between scenarios that require a full-stop landing as per the

[20] Reason J '*Combating omission errors through task analysis and good reminders*', BMJ Quality & Safety, Quality Safe Health Care 2002; 11:40–44.

landing SOP and those that necessitate a go-around after touchdown is difficult to determine in advance. This poses a significant risk of negative training if such training is implemented.

- In a situation when an immediate threat exists, like an immediate risk of collision just after touchdown, the safety essentially relies on the crew's situational awareness, basic skills, and airmanship.

In this Incident, it is evident that there was a lack of situational awareness and degradation of airmanship of both flight crewmembers during landing, including during the decisions for the go-arounds, one by the Copilot which then the execution was canceled, and the final go-around by the Commander which the go-around was executed.

2.5 Wind Condition

The Tower controller relayed information to the flight crew regarding the surface wind of 310 degrees at 12 knots when the Aircraft was 0.85 nautical miles away from the threshold. During the approach, the Commander raised the possibility of thermals above the runway and discussed with the Copilot whether to set the flaps to FULL or position 3, ultimately agreeing on using the flaps at the FULL position.

Thermal conditions can create wind variations around runways and are commonly encountered on short final and landing, which indeed occurred on short final and landing in this flight. In the subject Incident, both flight crewmembers were mindful of the potential sudden changes in wind speed and direction due to these thermal conditions.

However, the Copilot's application of rudder inputs was slightly excessive, contributing to fluctuations in heading and drift. In addition, the Copilot mentioned a prolonged flare due to thermals. The Investigation believes that if the Copilot had recognized the touchdown of the main landing gear and the reduction in airspeed, he would have continued the landing smoothly. It was determined that the Copilot's statement about the prolonged flare was not caused by the thermal condition.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes, and contributing factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the Conclusions heading:

- **Findings.** Are statements of all significant conditions, events, or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes.** Are actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors.** Are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided, or absent, would have reduced the probability of the Incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2 Findings

3.2.1 Findings relevant to the Aircraft

(a) The Aircraft was certificated, equipped, and maintained in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Aircraft was airworthy when dispatched for the flight, and there were no reported defects in the technical log before or during the flight.

(c) The Aircraft sustained minor damage to the lower surface of the rear fuselage due to the tail strike. However, no cabin depressurization was reported.

3.2.2 Findings relevant to the flight crew

(a) The flight crewmembers were licensed and qualified for the flight in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) Both flight crewmembers stated that they were well-rested and fit for the flight.

(c) The variation of wind conditions prompted the Copilot, as the pilot flying (PF), to focus attention on maintaining the Aircraft's track and heading, which most probably affected his situational awareness to observe that the Aircraft had touched down and he inadvertently moved the thrust levers into reverse position.

(d) The Commander was primarily focused on the Copilot’s efforts to align the Aircraft with the runway centerline. This probably led to the omission of certain tasks that are typically part of his role as the pilot monitoring (PM).

(e) The Commander was not sufficiently aware of the Aircraft's state from the time it passed over the runway threshold until the decision was made to perform the go-around. This included the Aircraft’s status whether in the air or on the ground, its position in relation to the runway, and the energy indicated by its airspeed.

3.2.3 Findings relevant to flight operations

(a) The Aircraft experienced a smooth touchdown with a negligible change in vertical acceleration.

(b) When the "retard" auto-callouts triggered and the Commander called “retard” at the same time as the auto callouts, the Copilot promptly moved the thrust levers to the idle position. Shortly after, he inadvertently shifted the thrust levers to reverse without being aware of it.

(c) The Copilot's slightly excessive rudder inputs contributed to the fluctuations in the Aircraft's heading and drift while on the runway.

(d) In the role of PM, the Commander did not observe several important cues, including the final radio altimeter auto-callouts, retard auto-callouts, and the Copilot’s adjustment of the thrust levers to idle and inadvertently to reverse positions. This led him to mistakenly assume that the thrust levers were still set above idle, even after his "retard" callout.

(e) Both flight crewmembers were unaware of the Aircraft's touchdown after completing the flare maneuver.

(f) The Copilot, as the pilot flying, struggled to align the Aircraft with the runway centerline due to the wind variations, which resulted in his unawareness of moving the thrust levers to reverse, and the Aircraft’s state and position.

(g) The Copilot decided to initiate a go-around since he was uncertain of the Aircraft’s state and position.

(h) The Copilot attempted to perform the go-around by pushing the thrust levers toward TOGA without making the necessary callouts. Following this, the Commander intervened by pulling the thrust levers back to idle to continue the landing.

(i) The Commander took over the controls without necessary callouts being made. Subsequently, he decided to perform a go-around because he was unable to accurately determine the Aircraft’s position along the runway.

(j) When determining and executing the go-around, the Commander based his decision on his perception of the Aircraft’s high energy levels. He was unaware of the actual low energy (low airspeed) due to overlooking to verify the airspeed from his instruments.

(k) The execution of the go-around by the Commander deviated from the SOP due to activating the reverse thrust, which went unnoticed by both flight crewmembers.

(l) During the go-around, there was confusion between both flight crewmembers regarding their communication and roles as PF and PM, probably influenced by preceding issues encountered before starting the go-around.

(m) There was a deficiency in the crew resource management (CRM) that began when the Aircraft passed over the threshold and persisted during the initial climb following the go-around.

(n) At TOGA selection, the tail strike protection system was deactivated, as intended during a go-around maneuver.

(o) The continuous nose-up inputs by both flight crewmembers led to a high rate pitch increase resulting in a pitch that exceeded the tail strike limit.

(p) As per design, the twice "pitch" automatic callout is provided to prevent excessive pitch attitude during the flare and landing. However, the callout was inhibited during the go-around phase as TOGA was engaged when the pitch began to increase.

3.2.4 Findings relevant to the Operator

(a) The Operator's training program outlined in the *flight crew techniques manual (FCTM)* and the guidance provided in the *flight crew operating manual (FCOM)* did not include specific training or procedures for managing a go-around after touchdown, since these would lead to a risk of negative training that implies asking pilots not to adhere to the SOP for landing and selecting reverse thrust immediately after main landing gear touchdown.

3.2.5 Findings relevant to Weather

(a) The Aircraft experienced thermal (gusty) conditions starting from approximately 1.2 nautical miles before the threshold and persisted until it reached a position on the runway approximately 1,200 meters past the threshold.

(b) The Aircraft encountered a peak crosswind component of 17 knots during the initial flare.

3.3 Cause

The Air Accident Investigation Sector determines that the cause of the tail strike Incident was the improper high pitch control application when initiating the go-around while the airspeed was still low.

3.4 Contributing Factors to the Incident

The Air Accident Investigation Sector identifies the following contributing factors to the Incident:

(a) The gusty wind conditions during landing.

(b) The Commander, in the PM role, did not witness the final portion of the radio altimeter and retard auto-callouts, along with the Copilot’s action of adjusting to idle thrust before touchdown which was not noticed by both flight crewmembers.

(c) Following the touchdown, the Copilot, in the role of PF, inadvertently moved the thrust levers into reverse position, remaining unaware of the action, while the Commander did not notice the movement of the thrust levers.

(d) The fluctuations from the runway centerline in terms of heading and drift were caused by the Copilot’s slight overuse of the rudder inputs.

(e) The lack of clear communication between the flight crewmembers, particularly the Copilot’s omission to announce the initiation of a go-around and the Commander’s subsequent cancellation, along with the Commander taking control, adversely affected the CRM.

(f) The Commander mistakenly perceived that the Aircraft had excess energy without verifying the actual low airspeed before deciding to commence the go-around.

4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in Part 3 of this Report; the Air Accident Investigation Sector expects that all safety issues identified by the Investigation are addressed by the concerned organizations.

4.2 Safety Actions Taken

4.2.1 Wizz Air Abu Dhabi

After the Incident, the Operator took the following safety actions:

- Necessary remedial training on competencies, which included knowledge, application of procedures, communication, observable behaviors, flight path management, leadership and teamwork, problem-solving and decision-making, situational awareness, and workload management, were provided for both pilots on the simulator, and the line check thereafter.
- The Commander was also provided simulator training to reinforce commander duties and assertiveness, including simulator training with TREs involving scenarios of control takeover combined with balk landings from a low altitude and low aircraft energy state, and carried out line flying under supervision (LIFUS) for 4 sectors.
- The Copilot was also provided simulator training to practice crosswind landings and to correct the airplane trajectory in case of an off-centre touchdown, and carried out LIFUS for 10 sectors with a minimum of two different TRIs.
- Additional policy about new pilots not being rostered together, was included in the *Operations Manual Part A (OM-A)*.
- Issuing Safety Alert and Safety Bulletin to its pilots which included the Operator's internal safety investigation on the occurrence with safety recommendations as follows:

> "The importance of standard callouts is paramount, especially during critical phases of flight. Using undocumented callouts may confuse the other crewmember, and lead to undesirable events.
>
> Keep in mind the **correct sequence and timing** for the intervention: "suggest – direct – take-over", and don't wait until the situation deteriorates to such a level that it cannot be corrected anymore.
>
> If not time limited, point out the deviation; if the deviation is large or the situation is time restricted, take-over and debrief the occurrence when convenient.
>
> **Remember: After selection of reverse thrust, a full stop landing is mandatory!**
>
> Note: be careful with the "direct" part because it might cause confusion on who is the PF. For example, directing someone to use the speed-brakes will take away their PF responsibility."

- Improvement in the recurrent simulator training and checking program which emphasizes on:

- Scenario based training (SBT), which focuses on the development of resilience through exposure to situations that develop and sustain a high level of competency;
- One of the upset prevention and recovery training (UPRT) topics, which covers approach to stall at low altitude and recovery in various configurations;
- Refresher training of standard missed approach procedure versus a rejected landing procedure in LQSA[21];
- Narrow runway/rejected takeoff/rejected landing; and
- First officers development which provides development opportunities depending on the first officers' experience level.

4.2.2 Airbus

Airbus took safety action after the Incident by publishing in the Annex of the *flight crew training standards (FCTS)*, training recommendations to support the operators in mitigating the risks associated with go-around maneuvers executed at very low height above the ground, applicable to A320, A330, A340, A350, and A380 aircraft. The training recommendations are the result of the analysis of go-around events reported to Airbus. This analysis has shown that some go-around maneuvers initiated at a very low height above the ground may lead to inappropriate aircraft attitude (high pitch) and may result in a tail strike event. Thus, the present training recommendations aim to improve the application of the go-around technique near the ground.

4.3 Safety Recommendations

4.3.1 Wizz Air Abu Dhabi

SR11/2024

As per the Operator's *Operations Manual − Part D (OM-D)*, simulator training included practice on go-around maneuvers in different conditions. The training involves practicing rejected landings below 100 feet for high-energy situations. In this Incident, the go-around was executed not in accordance with the standard operating procedures (SOP) as the activation of reverse thrust after the touchdown was made, which should have required a full stop-landing thereafter. The touchdown and reverse thrust activation went unnoticed by both flight crewmembers, and the Aircraft was in a low-energy state.

The Investigation recommends the Operator include go-around techniques on low-energy rejected landing close to the ground in the flight crew training program, and practice this in simulator training for the pilots.

SR12/2024

As pilot monitoring, the Commander focused his attention on the Aircraft's maneuvers before the flare, and most probably became fixated on them when the Copilot was trying to land the Aircraft and align with the runway centerline. Hence, the Commander's monitoring role function was affected, which led to missing callouts and a degradation of his situational awareness.

Therefore, to ensure effective crew resource management (CRM) during landing, the Investigation recommends that the Operator emphasize the importance of the monitoring role to the pilots as pilot monitoring including the callouts.

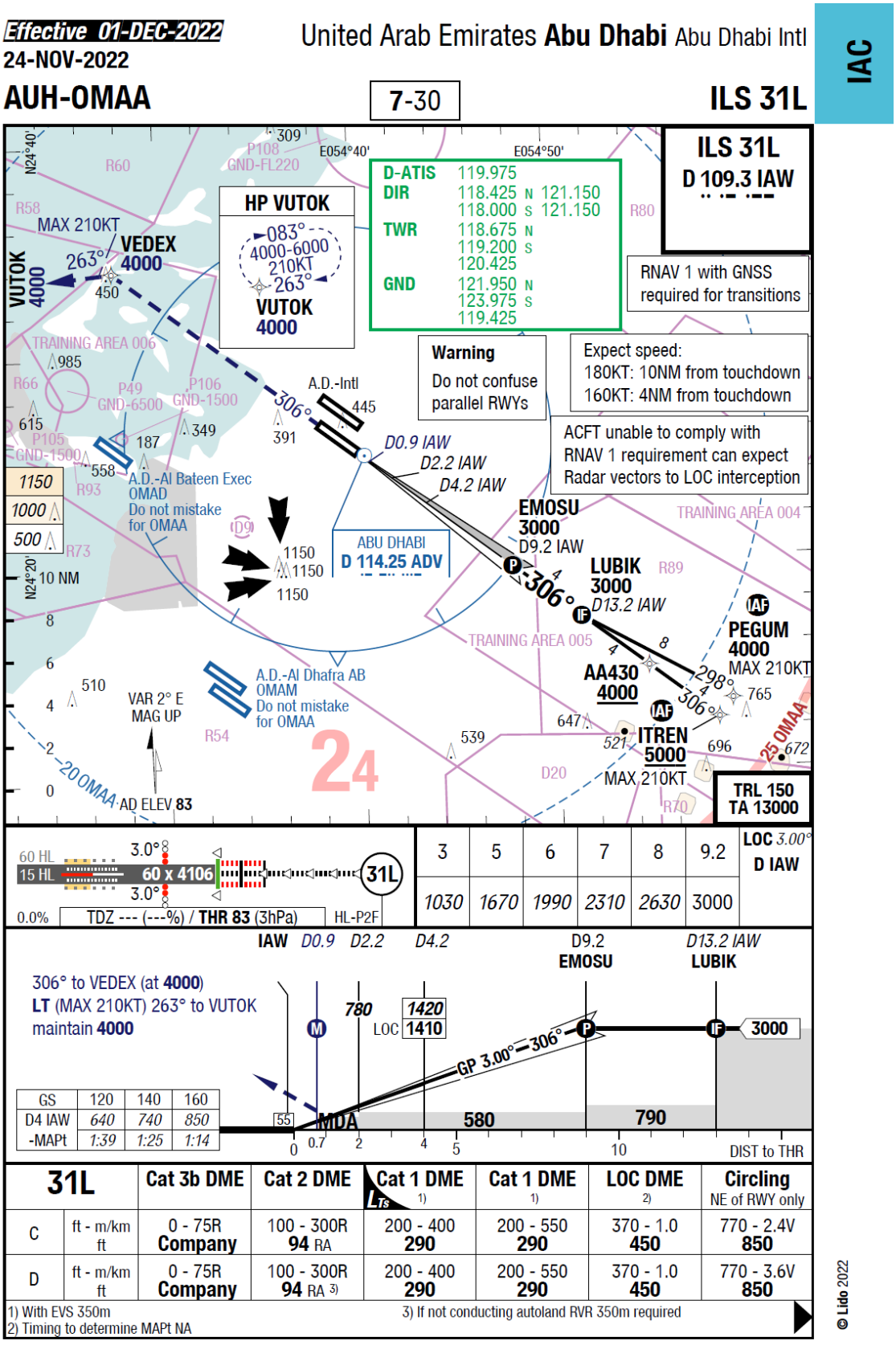
[21] LQSA is the ICAO four letter airport code for Sarajevo International Airport, Bosnia and Herzegovina.

SR13/2024

The deficiency of the CRM during landing, as one of the contributing factors in this Incident also impacted the flight crew coordination during the go-around after the liftoff.

Therefore, the Investigation recommends that the Operator continue to emphasize the CRM requirements outlined in *OM-D* to pilots. It is also recommended that the Operator identify any CRM issues during the pilot checks to address any necessary improvements in individual CRM skills and the overall effectiveness of the Operator's CRM system.

APPENDIX 1. APPROACH CHART – OMAA ILS 31L



Changes: APL

APPENDIX 2. DETAILED SEQUENCE OF EVENTS AS DERIVED FROM THE CVDR

The following details of the flight are based on the available data after time synchronization.

At 0839:58, WAZ25GR fully established on the ILS approach runway 31L at a distance of 12.65 nautical miles from the threshold while descending through 4,160 feet indicated altitude with the correct QNH setting at 1007 hPa (mbar), with the activation of glideslope track (G/S) and localizer track (LOC) modes on the flight directors. The approach controller instructed the flight crew to contact Tower Control (Abu Dhabi Tower South) on 119.2 MHz frequency.

Both autopilots and flight directors were engaged. NAV mode was active. V/S mode was activated with a selected vertical speed of -320 feet per minute. The heading selection was set to magnetic with a selected heading of 280 degrees. The autothrust was active in SPEED mode. The auto brake was not armed.

The flight crew commenced contacting Tower Control at 0840:30 and reported that WAZ25GR established on ILS 31L at a distance of 11 nautical miles from the threshold while descending through 3,630 feet indicated altitude. The Tower controller responded by granting clearance to land and provided surface wind information of 300 degrees at 11 knots, and the QNH setting of 1007. The controller also instructed to vacate via taxiway Echo 8 when possible. The flight crew read back correctly and mentioned that they would try to vacate the runway via taxiway Echo 8.

At 0842:02, the landing gear lever was selected to DOWN position. Ten seconds later, the flaps lever was moved from position 2 to 3 detent.

At 0842:05, the 180 knots selected speed target of the SPEED mode changed to a managed speed target of 137 knots.

At 0842:07, the ground spoilers were set armed.

At 0842:27, the flaps lever was moved from position 3 to FULL detent when WAZ25GR was descending through 1,780 feet indicated altitude, about five nautical miles from the threshold of runway 31L.

At 0842:41, the lowest selectable speed (V_{LS}) changed to 132 knots as computed by the flight management system (FMS) for landing full configuration (CONF FULL).

At 0843:54, both autopilots (AP1 and AP2) were disengaged when WAZ25GR was descending through 770 feet indicated altitude (540 feet radio altitude) at about 1.6 nautical miles from the threshold.

At 0843:56, master warnings appeared for about four seconds due to both autopilots disengagement.

At 0844:05, the tail strike pitch limit indicator appeared on the primary flight display (PFD) with a value of 9.67 degrees, while WAZ25GR was descending through 635 feet indicated altitude (410 feet radio altitude).

At 0844:08, glideslope track and localizer track modes deactivated, and landing track (LAND) mode activated, when the radio altitude showed 375 feet.

At 0844:14, as WAZ25GR descended to 530 feet indicated altitude (265 feet radio altitude) and neared a distance of 0.85 nautical miles from the threshold, the Tower controller informed the flight crew about surface wind 310 degrees at 12 knots. Based on the flight data,

the actual wind was 294 degrees at 9 knots at this time. The flight crew did not reply back, but there was an unknown double click heard.

At 0844:30, as WAZ25GR descended to 105 feet radio altitude and approached a distance of 0.25 nautical miles from the threshold, a small rudder input commenced to be applied. Concurrently, the recorded wind was 294 degrees at 13 knots at the Aircraft's position.

At about 0844:31, the cockpit altitude callout "100" annunciated. Subsequently "50, 40, 30, and 20" (in feet).

At 0844:34, the Aircraft was descending through 60 feet radio altitude and the localizer started to deviate to the left (Aircraft to the right of the runway centerline) and reached a maximum of 0.14 dot at 0845:00. (one dot represents a deviation of ± 0.8 ° on the localizer scale)

At 0844:35, the flare mode engaged when the radio altitude showed about 45 feet. The drift angle started to increase to the right as a result of an increment in the left rudder input. The drift angle reached 6 degrees at 0844:41.

From 0844:35 to 0844:43, the Copilot applied several nose-down and nose-up stick inputs resulting in the pitch angle varying between +1.9 and +3.9 degrees and the descent rate decreasing from -770 feet per minute to -210 feet per minute. The descent rate average was approximately -240 feet per minute which stayed stable on the last 4 seconds of the mentioned period.

At 0844:37, WAZ25GR flew over the threshold at approximately 25 feet radio altitude.

At 0844:39, the cockpit loudspeaker announced "Retard, retard, retard". At the same time, thrust levers were pulled back to IDLE. The autothrust was automatically disengaged.

At 0844:40, the roll angle reached 3.4 degrees to the right, and left side stick input by the Copilot was applied up to the maximum (15.6 degrees) which brought the Aircraft's roll to 3.3 degrees to the left at 2 feet radio altitude two seconds later.

At 0844:41, the automated altitude callout system in the cockpit announced "5" as the aircraft reached the specified altitude. The drift angle reached 6.1 degrees. The Aircraft's pitch was at about 3.1 degrees.

At 0844:42, a right rudder pedal input started to be applied.

At 0844:43, the left main gear touched first the runway with a left roll angle of 1.14 degrees, then the right main gear after 0.5 seconds. The Aircraft's pitch reached approximately 3.8 degrees upon the left gear contacting the ground, subsequently decreasing to 2.5 degrees as the right gear touched down. Consequently, the spoilers commenced deploying. The vertical acceleration was 1.09G on the touchdown. The localizer deviation at touchdown was at -0.11341 dots (about 8 meters right from the centerline).

At 0844:44, the Aircraft's pitch was reducing through 2.1 degrees. The input on the right rudder pedal reached 8.1 degrees and held for about one second, which then started to be released and continued applying a left rudder input. The thrust levers were pulled back from the IDLE stop to the MAX REVERSE (FULL) stop in one second starting when the right rudder pedal input started to be released and the lateral acceleration started increasing towards 0.1G to the right.

At 0844:45, the pitch reached a minimum of 0.4 degrees, which then continuously increased up to 5.1 degrees in the next 3 seconds.

At 0844:46, the lateral acceleration reached 0.1G to the right, and that was the point when the thrust levers started to be pushed forward from MAX REVERSE to REV IDLE detent which lasted for one second. Shortly thereafter the left rudder pedal input reached 14.2 degrees at the same time when the thrust levers reached the REV IDLE detent, while the

lateral acceleration was going back towards zero. The left rudder pedal input was then released.

At 0844:47, the right rudder pedal input started to be applied increasingly. The right engine thrust reverser deployed lasted for two seconds.

At 0844:48, the left engine thrust reverser deployed for one second. At the same time, the Commander mentioned “Wo wo wo wo wo”. The lateral acceleration reached 0.1G to the left. Shortly thereafter, the right rudder pedal input reached 9.9 degrees, and it was then released.

At 0844:49, the Commander started to apply input on his pitch sidestick while the Copilot was still applying his stick input. As per the Flight Crew Operating Manual (*FCOM)*, at all times, only one flight crew member should fly the aircraft. However, if both flight crewmembers use their sidesticks simultaneously, their orders are algebraically added. The flight control laws limit the combined order to the equivalent of the full deflection of one sidestick.

At the same time, the thrust levers were pushed further forward to the TOGA position, consequently, the spoilers started to retract, while the pitch reached 5.1 degrees. N1 of both engines started to increase from approximately 30% revolutions per minute (RPM). Shortly thereafter, the Commander said, “Keep it… keep it like this!”.

Between 0844:49 and 0844:51, the Commander applied a slight nose-up stick input up to -4.2 degrees (minus sign means nose-up input). Thereafter, he applied a slight nose-down stick input up to 6.2 degrees within one second.

0844:50, the Commander mentioned, “No no no no no!”. The autothrust became active. Short afterward, thrust levers were pulled back from TOGA to the IDLE stop position. Consequently, the spoilers started to deploy again. The pitch reduced to 3.3 degrees and then increased slowly in the next 3 seconds.

From 0844:52, the Commander started to apply nose-up stick input continuously and reached -13.7 degrees (nose-up input) at 0844:54.

Between 0844:52 and 0844:55, the Copilot maintained a slight nose-up pitch stick input between 2.9 and 3.6 degrees.

At about 0844:53, the thrust levers were commenced to be pushed forward from the IDLE stop to TOGA. The ground spoilers retracted accordingly.

At 0844:54, the Copilot asked the Commander “Are we on the ground?”. The autothrust disengaged. The Aircraft’s pitch reached 4.4 degrees.

At 0844:55, the spoilers fully retracted as a consequence of the TOGA setting. The Aircraft’s pitch started to increase from 4.4 degrees. The airspeed reached its minimum value of 108 knots.

At 0844:56, the cockpit loudspeaker announced “Dual input”, while the Aircraft’s pitch was continuously increasing from 5.8 to 8 degrees. The Commander’s pitch-up input reached up to 13.7 degrees of his stick, and almost at the same time, the Copilot released his stick.

Both sidestick inputs were applied for about seven seconds, from 0844:49 to 0844:56. In this case, both inputs were added by the flight control laws as per the design.

At 0844:57, the Commander called out “Go around”. The Aircraft’s pitch was increasing from 8.17 to 9.84 degrees and the airspeed was 111 knots. The roll angle was between 0.79 and 1.41 degrees to the right.

According to the Aircraft’s ground clearance diagram (figure 8), with the main landing gear compressed condition, the tail strike pitch limit is approximately 9.7 degrees at a roll angle of 0 degrees and 11 degrees at a roll angle of 4 degrees. As per the *FCOM*, the pitch limit

indicates the maximum pitch attitude to avoid the tail strike risk at landing. The indication is a fixed value corresponding to the main landing gear compressed. The indication appears at 400 ft radio height. The indication disappears when there is no longer a risk of tail strike.

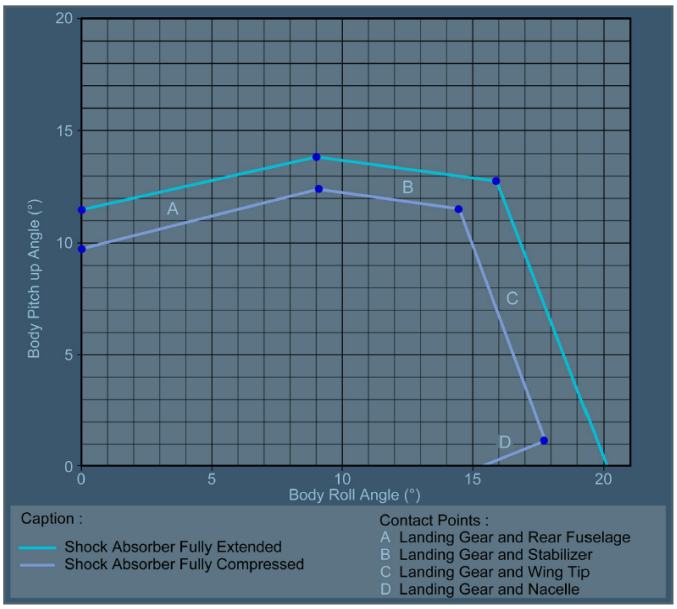


Figure 8. Ground clearance diagram

At 0844:58, the master warning triggered for five seconds, due to the full flaps and slats setting which was not for the takeoff configuration. The Aircraft's pitch was increasing from 10.02 to 10.55 degrees and the airspeed was at 112 knots. The roll angle was between 1.23 and 1.49 degrees to the right.

At 0844:59, the Aircraft's pitch was increasing from 10.46 to 10.72 degrees and the airspeed was at 114 knots. The roll angle was between 1.32 and 1.67 degrees to the right.

At 0845:00, the Aircraft's pitch reached up to a maximum of 10.81 degrees with a maximum right roll angle of 1.76 degrees. At this time, the left main gear lifted off first then followed by the right main gear, which means that the main landing gears were in an uncompressed condition. The airspeed was 118 knots, and N1 of both engines reached approximately 93% RPM shortly after liftoff.

At 0845:07, the Commander called out "Positive climb". The Copilot then repeated calling out "Positive climb".

At 0845:08, the thrust levers were pulled back from TOGA to maximum continuous thrust (MCT/FLEX) setting that gave 90% RPM N1 on both engines. Almost at the same time, the landing gear lever was raised to the UP position as the Aircraft reached 50 feet above the runway. The airspeed was 146 knots which did not exceed the maximum speed for retracting the landing gear ($V_{LO\ retraction}$ = 220 knots).

At 0845:09, the Copilot called out "Gear up".

At 0845:10, the navigation (NAV) mode activated when the radio altitude showed 130 feet.

The autopilot AP1 was engaged at 0845:12 when the Aircraft climbed passing 200 feet radio altitude and the airspeed was 149 knots.

At 0845:13, the Commander called out "AP one", to which the Copilot then replied by calling out "Checked".

At 0845:15, the thrust levers were pulled back to the maximum climb thrust (CLIMB) setting, resulting in approximately 82% RPM N1 on both engines. The Commander called out “Thrust Climb”, which the Copilot then replied by calling out “Checked”.

At 0845:16, the autothrust activated in THRUST mode, when the Aircraft climbed passing 330 feet radio altitude.

At 0845:22, the Copilot asked the Commander by calling out “Flaps?”. The Commander replied, “Yeah, flaps”.

At 0845:25, the flaps lever was moved from FULL to position 3. The airspeed was 133 knots which did not exceed the maximum speed for flap FULL configuration ($V_{FE\ FULL}$ = 186 knots). At the same time, the Copilot asked the Commander “Should I select flaps three?”, which replied “Yeah, flaps three” by the Commander. The Copilot then called out “Flaps three set”.

At 0845:32, the thrust levers were pushed from CLIMB to MCT/FLX setting. The autothrust deactivated, while the Aircraft was climbing passing 1,065 feet pressure altitude.

At 0845:39, the Aircraft flew over the threshold of the runway’s end and climbed passing 1,020 feet radio altitude.

At 0845:41, open climb (OP CLB) mode was activated with a selected altitude of 4,000 feet that had already been set before (at 0839:37).

At 0845:43, the thrust levers were pulled back from MCT/FLX to CLIMB setting. Consequently, the autothrust activated. The Aircraft was climbing through 1,400 feet pressure altitude.

At 0845:52, the Tower controller inquired about the reason behind the go-around. The flight crew replied, citing an unstable approach as the cause for the maneuver.

At 0846:02, the flaps lever was moved from position 3 to 1. The airspeed was 159 knots which did not exceed the maximum speed for flaps position 3 ($V_{FE\ position\ 3}$ = 195 knots). The Aircraft climbed passing 1,830 feet radio altitude.

At 0846:06, the Tower controller then instructed the flight crew to contact Approach Control on 128.100 MHz frequency, while the Aircraft climbed passing 1,980 feet indicated altitude (1,930 feet radio altitude). The flight crew correctly read back.

At 0846:42, the flaps lever was moved from position 1 to 0. The Aircraft climbed passing 2,750 feet indicated altitude with an airspeed of 206 knots which did not exceed the maximum speed for flaps position 1 ($V_{FE\ position\ 1}$ = 243 knots).

After the flight crew established communication with Approach Control, the controller queried the reason for the go-around at 8:46:55. In response, the flight crew stated that the Aircraft was at an unstable low altitude over the runway of the reason behind the go-around maneuver.

Afterward, the Approach controller provided vectors to the flight crew for an ILS approach of runway 31L.

At 0855:22, traffic with callsign GFA543 communicated with the Aircraft flight crew explaining that the Aircraft was very close to the ground when performing the go-around, however, the GFA543 flight crew was not sure whether it was a tail strike.

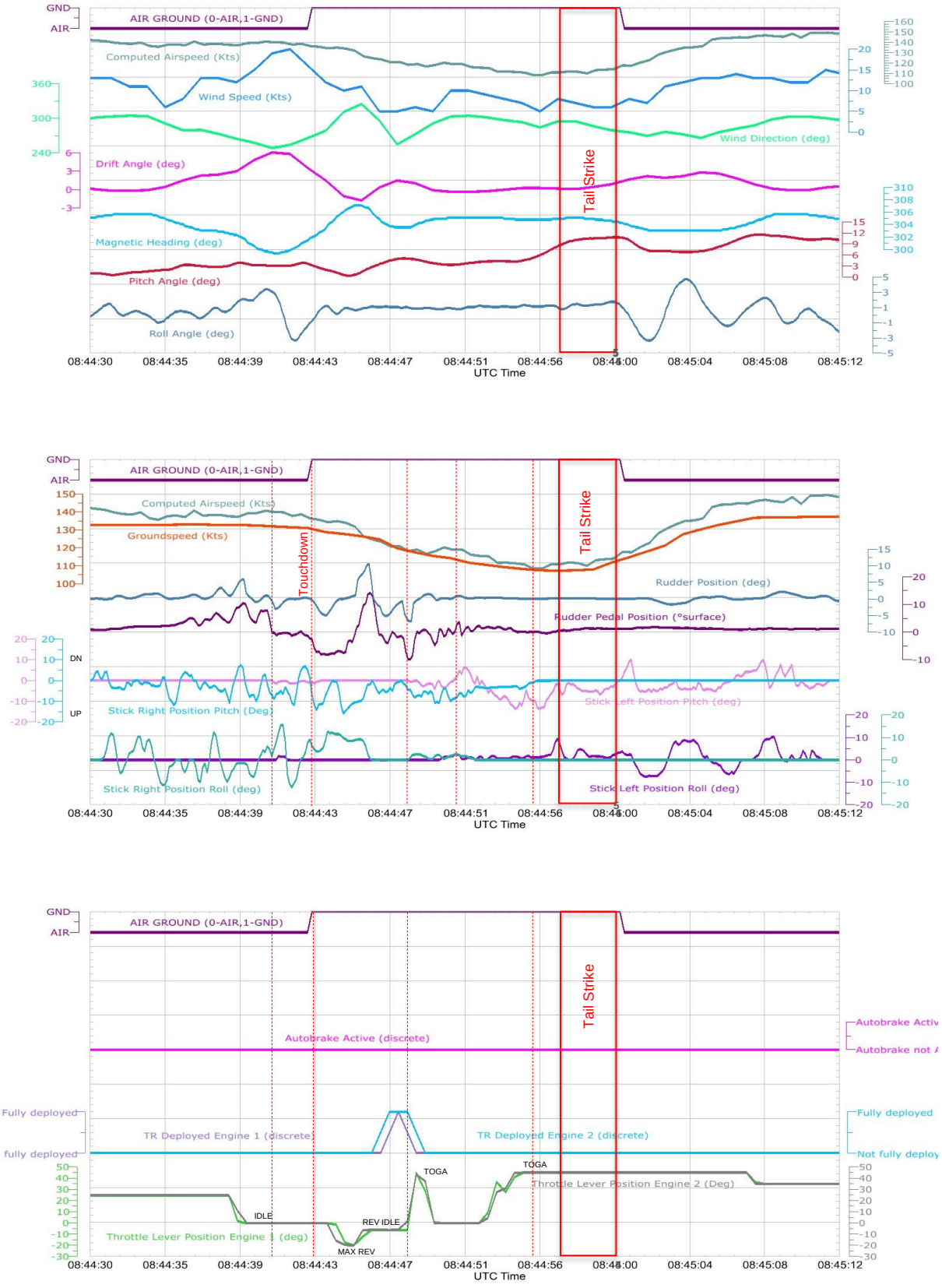


Figure 9. Flight data parameters

At 0859:11, Approach controller instructed the flight crew to contact Tower South Control on 119.2 MHz frequency. The flight crew correctly read back.

At 0859:23, the flight crew contacted Tower Control informing that ILS approach runway 31L is established. The Tower controller replied and cleared WAZ25GR to land.

The Aircraft landed uneventfully at 0902:55, vacated the runway via taxiway Echo 8, and continued taxiing through taxiways Echo 6, Foxtrot, and Echo 11 to parking stand 133. The engines were shut down at 0908:16.

Figure 9 shows the related flight data parameters around the Incident.

Figure 10 presents the Aircraft heading and track, capturing the span from just before touchdown to after liftoff.

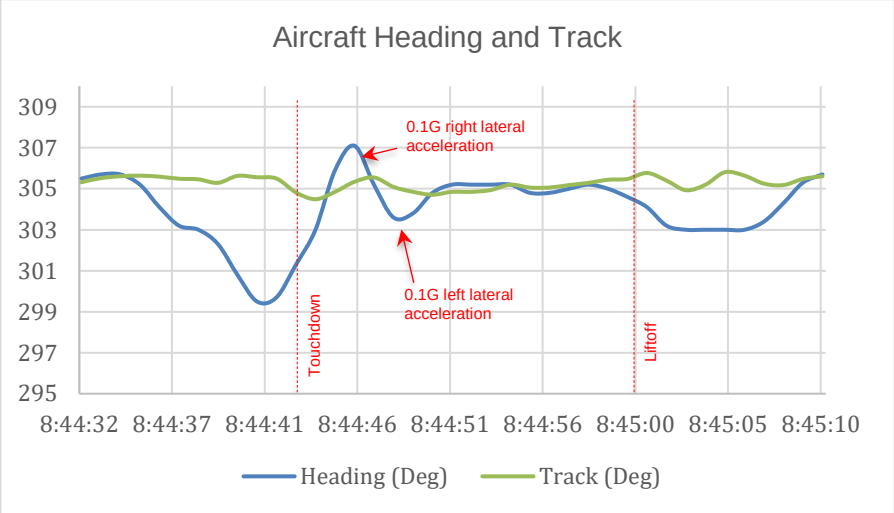


Figure 10. Aircraft heading and track on landing

Figure 11 shows the crosswind component experienced by the Aircraft, spanning from before the threshold to after liftoff.

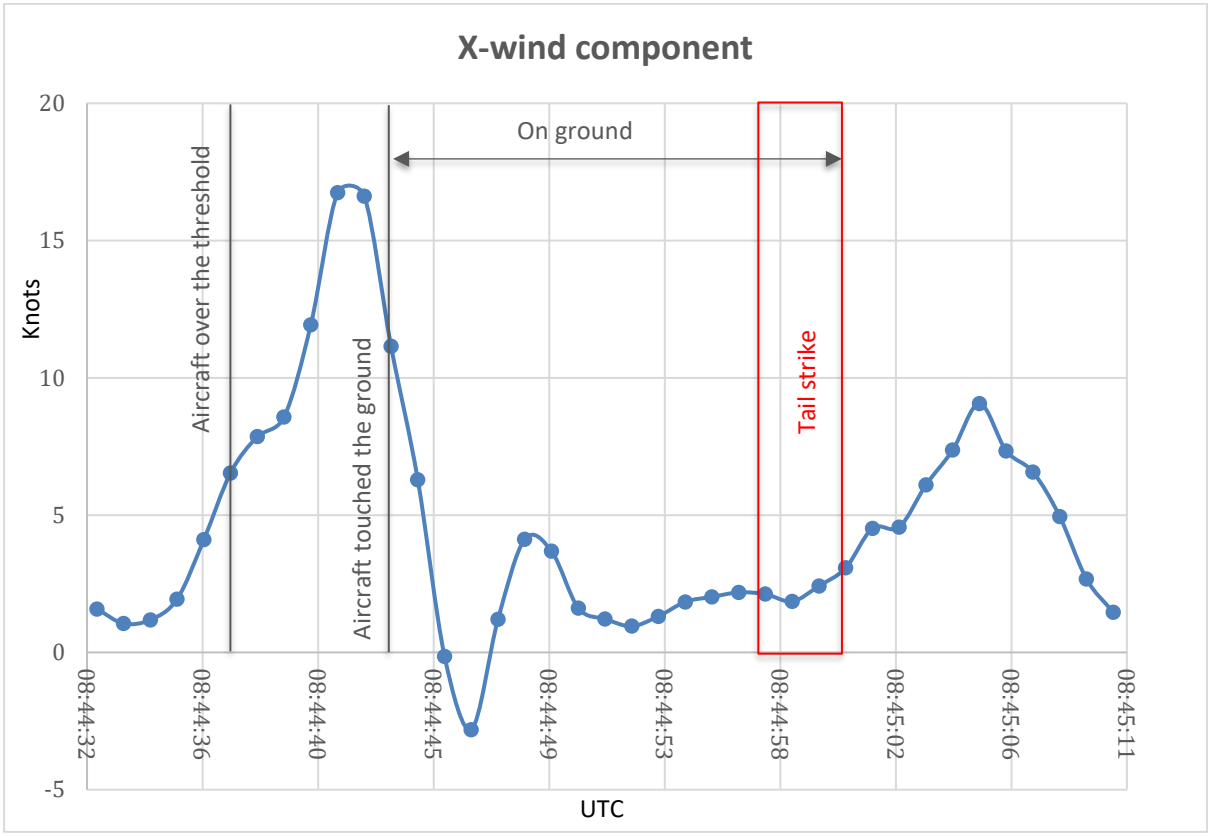


Figure 11. Crosswind Component on landing