DIRECTORATE GENERAL OF CIVIL AVIATION

FINAL INVESTIGATION REPORT OF RUNWAY EXCURSION INCIDENT TO M/S JET AIRWAYS PVT LTD, AIRBUS-330 AIR CRAFT VT-JWV ON 29.08.2017 AT CHATRAPATHI SHIVAJI INTERNATIONAL AIRPORT, MUMBAI

Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 13(1) of Aircraft (Investigation of Accidents and Incidents), Rules 2012, the sole objective of the investigation of an incident shall be the prevention of accidents and incidents and not apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts, etc., The opportunitywas accorded to all the parties to participate during the course of investigation. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

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FINAL INVESTIGATION REPORT ON LATERAL RWY EXCURSION TO M/s. JET AIRWAYS PVT. LIMITED, AIRBUS-330 AICRAFT VT-JWV AT CHATRAPATI SHIVAJI INTERNATIONAL AIRPORT, MUMBAI ON 29.08.2017

1.	Aircraft	Type	Airbus 330-202
		Nationality	Indian
		Registration	VT-JWV
2.	Owner		Jet Airways(India) limited
3.	Operator		Jet Airways(India) limited
4.	Pilot- in- command		ATPL holder
	Extent of Injuries		NIL
5.	Co-Pilot		ATPL holder
	Extent of Injuries		NIL
6.	Date and Time of Incident		29/08/2017 & 10:00:43 UTC
7.	Place of serious incident		RWY 27, Mumbai Airport
8.	Last point of Departure		Chennai (VOMM)
9.	Point of intended landing		Mumbai (VABB)
10.	No. of Persons on board		240 (passengers) + 9 (crew)
	Extent of Injuries		NIL
11.	Type of operation		Scheduled passenger flight
12.	Phase of operation		Landing
13.	Type of incident		Runway Excursion
14.	Geographical location of site		19.0886° N, 72.8681° E

(All times in the report are in UTC unless specified)

SYNOPSIS:

M/s Jet Airways,(India) Ltd., Airbus 330-202, VT-JWV, while operating sector VOMM-VABB,was involved in a Runway excursion, after landing at Chatrapathi Shivaji International Airport, Mumbai on 29.08.2017. The flight was operated by ATPL holder on type as PIC and a ATPL holder on type as Co-Pilot. There were total 249 persons on board including 09 crew.

The aircraft took off from Chennai at 08:32:43 UTC and the flight was uneventful till landing phase; During final approach at Mumbai, the aircraft was stabilized & Auto Pilot was 'ON' till 163 ft Radio altitude (RA however the Aircraft landed to the right of the center line with right main wheels touching down outside the RWY edge marking and skidded further to the right. The right main wheels subsequently departed the RWY surface and entered the soft ground to the right. In the process, no RWY edge lights got damaged. After rolling for approx. 250 m on the unpaved surface, the crew controlled the aircraft and was taxied to parking bay safely.

The DGCA instituted investigation by appointing inquiry officer under Rule 13(1) as Aircraft (Investigation of Accident and Incidents) Rules,2012.

During investigation, it has been observed that the loss of situational awareness (due crew's impaired visual cues) under bad weather condition (heavy rains) and improper crosswind landing technique adopted by the crew to land the aircraft was the probable cause of the Runway excursion incident.

1. FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 29.08.2017, M/s Jet Airways, (India) Ltd., Airbus 330-202 aircraft VT-JWV was operating scheduled flight from Chennai to Mumbai. The time of takeoff from Chennai was 08:32:43 hrs UTC and the time of landing at Mumbai was 10:00:43 hrs UTC. The aircraft was cleared by qualified AME/ maintenance personal at Chennai. The aircraft was released with the following MEL: MEL 30-81-01Ice Detection System.

The takeoff & landing was carried out by PIC but handed over the controls to FO at 1000 ft RA after take-off and took over the controls at 1000 ft RA during the approach at Mumbai. There were no abnormalities observed on the flight from Chennai, Enroute and till final approach (1000 ft RA). Between 1000 ft RA and 500 ft RA, flight parameter deviations (CAS and pitch angle) briefly exceeded several times the callout values.

From 500 ft RA, all available weather information sources highlighted high headwind component about 35 Knots with some gusts, a left crosswind of 12 Knots and turbulent weather conditions. Mumbai tower reported visibility of400m/RVR600min heavy rain and winds at260/26G36 and cleared the aircraft to land on RWY27.

After APs disengagement at 163 ft RA, due to heavy rain showers over the airfield and other environmental factors(crosswind of 12 Knots), the PIC got disoriented, which impaired the crew's awareness about aircraft position with respect to RWY centre line . Consequently the PIC mistook the Right RWY edge lights as centre line & applied Right rudder inputs at 131 ft RA for 04 seconds which initiated the aircraft to bank to the right of the RWY centerline. Further just before 100 ft RA the aircraft began to swerve to the right of the RWY.

Just before the 50ft RA callout the first officer appraised about the lateral deviation and informed the PIC to bring the aircraft to left towards the center line.

Then in response to FO callout to rectify to left, the PIC applied leftward rudder pedal to try to return on the centerline of the RWY, but this input did not change the aircraft trajectory to avoid the lateral deviation. This action led the aircraft nose to move towards the left of the track and the heading to decrease to 256°(QFU271°).

During the initial touchdown, the right main landing gear touches first with a crab angle outside the Right RWY edge marking in the shoulder area despite of the attempts by PIC from ~70 ft RA by application of left rudder input in an attempt to return the aircraft onto the RWY centerline.

The aircraft touched down with a heading of 256 degrees on the wet RWY skidded further to the right. The reverse thrust was initially set to idle (03 seconds after touchdown) and differential braking (predominantly full left brake application) was used along with appropriate directional controls (full left rudder) to turn to left and come out of unpaved/uneven surface and align with the RWY centerline.

Aircraft Trajectory

Despite of the efforts, the right main landing gear left the paved shoulder area of the RWY and entered the grass portion on the right side of the RWY. This further caused the aircraft to continue skidding. The PIC continuously applied full left rudder and left braking to bring the aircraft back to the RWY centerline.

The right main wheel after travelling for approx. 250 m in the unpaved/uneven surface continued to roll forward while the right main wheels came in contact with a paved surface of taxiway N5 and steered to the RWY centerline.

Once the directional control was attained, a differential manual braking a rightward rudder pedal order were applied to realign the aircraft heading with the RWY.

Then, when aircraft was on the RWY and aligned, thrust reversers were pulled to "MAX". At the same time asymmetrical manual braking was applied and slowed the aircraft ontheRWY27to vacate via N8.

While taxiing for vacating the RWY, the following ECAM triggered "HYD G RESERVOIR LOW LEVEL and HYDGRESERVOIRLOWAIRPRESSURE"CrewthencarriedouttheHYDRAULLICGREENRESERVOIRLOW AIRPRESSURE ECAM action.

Aircraft was brought to full stop on the taxiway, as nose wheel steering ability was lost consequent to loss of Green Hydraulic system.

Maintenance Control Centre was informed and in co-ordination, the aircraft was towed to the bay. Normal disembarkation of passengers was carried out .On reaching the bay, during the walk around inspection by AME, the damage to the main wheel assembles and brake wheel assembles were identified , therefore confirming that the RH main landing gear had left the RWY and entered the uneven/unpaved surface.

The crew had made a PDR entry for the loss of HYDSYSG. The crew did not report the RWY Excursion.

There was no injuries to any person onboard and no evidence of fire.

1.2 INJURIES TO PERSONS

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
NONE	2+ 7	240	Nil

1.3 DAMAGE TO AIRCRAFT

- Heavy leak from RH Landing gear pitch trimmer.
- Brakes and tires having abrasion, Found cuts on all 4 tires of RH boogie and rubber chunks missing.

1.4 OTHER DAMAGE

Nil

1.5 PERSONNEL INFORMATION

1.5.1 Pilot – in – Command (PIC)

Details	PIC	FO
Age(as on date of incident)	46 years	34 years
Licence	ATPL Holder	ATPL Holder
Validity	14.03.2022	06.09.2020
Category	Aeroplane	Aeroplane
Date of Medical Examination	15.05.2017	31.07.2017
Validity of Medical	14.05.2018	30.07.2018
Endorsement as PIC	18.07.13	Not Applicable
Experience as PIC on type	2397 Hours	Not Applicable
Experience on type	2556 Hours	218:43 Hours
Flying experience in last 24 hrs	03:02 Hours	08:04 Hours
Flying experience in last 7 days	16:15 Hours	08:04 Hours
Flying experience in last 30 days	61:43 Hours	57:09 Hours
Flying experience in last 365 days	611:15 Hours	440:58 Hours
Rest period before incident flight	38:05 Hours	16:30 Hours

As ***on the date of incident*** ratings of both the flight crew were current and valid.

1.6 AIRCRAFT INFORMATION

Airbus A330-202 is a subsonic, medium-range, civil transport aircraft. The Aircraft was manufactured by M/s Airbus Industries, Toulouse, France in 2008 having MSN 923. Aircraft is powered with two high bypass turbofan engines LH Engine-PN: CF6-80E1A4B SN: 811498, RH Engine-PN: CF6-80E1A4B SN: 811497. The Aircraft has a total fueling capacity of around 109186 Liters. The aircraft is designed for operation with two pilots and has passenger seating capacity of 254(Business: 18 Economy: 236).

The aircraft is certified in Normal (Passenger) category, for day and night operation under VFR & IFR. The maximum operating altitude is 41,450 feet (12634 m) and maximum take-off weight is 233000.00 Kg. The Maximum Landing weight is 182000.00 kg.

Till the day of incident, the aircraft had done 38209 airframe hrs since new. The engines had logged 6243 hrs since new. The highest inspection schedule on this Aircraft is 'C6' Check which was completed on the Aircraft on 20.01.2017 at 35772.16/5428 FH/FC. The Aircraft was issued with Indian Certificate of Registration (C of R) no. 4499 under category 'A'. The last Certificate of Airworthiness(C of A) No.6608 issued on 12.05.2014 and "Pursuant to amendment in the Rule 50 of the Aircraft Rule 1937, C of A No.6790 remain valid until unless suspended/cancelled and ARC remain valid. The aircraft weight and CG were within limits.

On the day of incident, the aircraft was released with the following MEL: MEL 30-81-01 Ice Detection System.

1.7 METEOROLOGICAL INFORMATION

Landing data for Airport VABB at 1000 UTC for the VT-JWV

RWY	27
Winds	240, 24 knots gusting 38 knots
WX	RA
Visibility	400 m, and for RWY 27 RVR 600m in heavy rain
Temp	25^0C
Dew point	25^0C
QNH	995
Weather Phenomena	Heavy rain showers

It may be noted that Aircraft RVR was 550 m which was within limit for landing as the RWY 27 RVR was 600 m in heavy rain showers.

Mumbai tower reported visibility of 400m/RVR600m in heavy rain and winds at 260/26 G36 and cleared the aircraft to land on RWY 27.

1.8 AIDS TO NAVIGATION

Not Applicable.

1.9 COMMUNICATIONS

CVR Data reveals that Standard VHF communication was established between the aircraft and the Mumbai ATC. Further the incident was communicated to tower for further assistance.

1.10 AERODROME INFORMATION

Mumbai International Airport Limited is operated by M/s MIAL. Airport has two cross RWY 09/27 and 14/32 with ARP location 190530 N 0725158 E. RWY 27 was in use at the time of incident and its dimension is 2965m x60m. (There is a displaced threshold of 483m. In the whole report, the distance to the threshold refers to the distance to the displaced threshold).The course of RWY 27 is 271^o and has an elevation of 23 ft. The precision approach of RWY 27 is catered by ILS DME CAT I with a glideslope angle of 3^o.

Airport is equipped with ATS communication facilities .Mumbai is Class 'D' airspace with vertical limits from surface to FL 70 and lateral limits of 40 nm from DVOR, VFR/IFR operations and traffic separation are permitted.

Aerodrome is equipped with facilities like fueling, Cargo-handling, Hangar space and Repair facilities for visiting aircraft. Aerodrome is equipped with Category 10 type of firefighting facilities. Pushback facility is available. SID, STAR and Radar Vectoring Facilities as published are available. Both RWYs are equipped with PAPI lights with 3 degree glide path.

Meteorological Information can be availed for 24 hours.
On the day of the incident, the RWY 27 was wet due to heavy rains.

1.11 FLIGHT RECORDERS

The aircraft was fitted with SSCVR & SSFDR. After the incident, both were replaced. The CVR-DFDR downloading was carried out for the incident flight. Correlation of the Flight data and CVR transcript was carried out. The Flight data analysis has been substantiated with the Airbus findings. The findings and deductions arrived at has been used in the analysis part. The Parameters, sign convention and list of abbreviations (used for Flight data analysis) are available at the end of report as Annexure 1.

1.11.1 Flight data readouts

A) INITIAL CONDITION

At 1000 ft RA(09:59:21 UTC), the aircraft was in the following configurations	
Aircraft configuration	- Gross weight was 170.9T < MLW (= 182T). - CG was 26.6%. - Aircraft was in CONF FULL (Slats/Flaps 24°/32°). - Landing gear was selected down. - Ground spoilers were armed. - Autobrake "LOW" mode was armed.
AP/FD engagement status	- Both APs and Flight Directors (FDs) were engaged in "G/S"

	(Vertical) and "LOC" (lateral) modes.
Speed	- Auto thrust (A/THR) was engaged and active in "SPEED" mode. - VLS was 132kt. - Speed target was managed at 150kt (VAPP=VLS+18kt). - CAS was 150kt (=VAPP).
Attitude and trajectory	- Rate of descent was approximately 650ft/min. - Pitch angle was +1° (nose up). - Heading was 268° (QFU 271°). - Drift angle was +2° (aircraft nose toward the left of the track). - The aircraft was on the glide slope and the localizer (ILS).

The Automatic Flight System correctly tracked the ILS and the speed target (PA).

Due to the headwind value, the speed target was managed at 150kt (=VLS+18kt), highlighting the activation of the "Ground Speed Mini" function.

Note:
As described in the **FCOM DSC–22–30–90**, *when the aircraft flies an approach in managed speed, the speed target displayed on the Primary Flight Display (PFD) in magenta is variable during approach. This managed speed target is computed in the Flight Management Guidance Computer (FMGC), using the "Ground Speed Mini" function.*
The purpose of the "Ground Speed Mini" function is to take advantage of the aircraft inertia when the wind conditions vary during approach.
During approach, the FMGC continuously computes the speed target using the wind experienced by the aircraft in order to keep the ground speed at, or above, the "Ground Speed Mini".
If the A/THR is active in SPEED mode, it will automatically follow the speed target, ensuring efficient thrust management during approach.

B) FINAL APPROACH

From 1000ft RA(09:59:21 UTC) to APs disengagement at 163 ft RA(10:00:27 UTC)	
Aircraft configuration	- At ~250ft RA, Auto brake was changed from "LOW" to "MED"mode.
On the longitudinal axis	- Pitch angle varied between -2° (nose down) and +3° (nose up). - Speed target (VAPP) varied between 160kt and 142kt. - CAS varied between 169kt (=VAPP+13kt) and 148kt (=VAPP-8kt). - Rate of descent varied between 1100ft/min and 200ft/min. - Vertical load factor varied between +1.3g and +0.6g. - Aircraft was on the glide slope. - Between ~1000ft RA and ~500ft RA, the head wind component varied between 24 kt and 40 kt. - Between ~500ft RA and ~200ft RA, the mean headwind component was around 35 kt with some gusts.
On the lateral axis	- Roll angle varied between -5° (left wing down) and +5° (right wing down). - Heading varied between 268° and 265° (QFU 271°). - Drift angle varied between +1° and +6° (aircraft nose toward the left of the track). - Lateral load factor varied between -0.05g and +0.05g. - Aircraft was on the localizer. - Between ~500ft RA to AP disengagement, the left crosswind component was around ~12kt.
On the vertical axis	-Significant vertical load factor variations (between +0.6g and +1.3g) were recorded between ~1000ft RA and ~500ft RA highlighting vertical gusts.
Wind evolution during final approach	

Mean wind	Between 500ft RA (09:59:55 UTC) and 200ft RA (10:00:23 UTC), the average wind recorded by the DFDR came from 248° at 37kt (headwind component around 35kt and Left crosswind component around 12kt).
Wind trend	With AP ON, significant parameters variations (CAS, pitch angle, vertical load factor) were recorded in the flight raw data between ~1000ft RA and ~500ft RA and highlight turbulent weather conditions on longitudinal and vertical axes.

Significant parameters variations were recorded between ~1000ft RA and ~500ft RA and highlight turbulent weather conditions on longitudinal and vertical axes:

- CAS varied between speed target-8 knots and speed target+13kt (briefly exceeded their callout values: CAS lower than speed target-5 knots or higher than speed target+10 knots).
- Rate of descent varied between 1100ft/min and 200ft/min.
- Pitch angle varied between -2° and +3° (briefly exceeded several times its callout value: pitch lower than 0°).

The autopilot correctly controlled the exceeded parameters back into the defined stabilized conditions:

- The A/THR countered the CAS exceedances by thrust adjustments to maintain the speed target. Due to the wind variations, the speed target varied between 160 knots (=VLS+28 knots) and 142 knots (=VLS+10 knots), highlighting again the activation of the "Ground Speed Mini" function.
- The autopilot countered the vertical gusts with elevators deflections.

Between 1000ft RA and 500ft RA:
- The aircraft was on the correct lateral and vertical flight path.
- The aircraft was in landing configuration.
- Flight parameter deviations briefly exceeded several times their callout values.

As recommended in **FCOM–PRO–NOR–SOP–18– STABILIZATION CRITERIA** and **FCTM-PR-NP-SOP-190-CONF-FINAL APPROACH-TRAJECTORY STABILIZATION**, if one of the above-mentioned conditions is not satisfied, the flight crew must initiate a go-around, unless they estimate that only small corrections are required to recover stabilized approach conditions.
With regards to the gusty wind conditions and considering the brief exceedances above callout values (as per FCOM), final approach can still be considered as stabilized. However to be on safer side, the Captain should have opted for a Go-Around.

C) <u>FROM 163FT RA</u>

From APs disengagement at 163ft RA(10:00:27 UTC) to touchdown(10:00:43 UTC)	
Aircraft configuration	- At ~250ft RA, Auto brake was changed from "LOW" to "MED" mode
On the longitudinal axis	- A/THR was engaged and active in "SPEED" mode. - Side stick input varied between ~3/5 of full nose up and ~2/5 of fullnose down. - Pitch angle varied between +2° and +0.5° before gradually increasing from +0.5° to +5.5° (nose up). - CAS varied between 154kt (=VAPP+12kt) and 131kt (=VAPP-6kt). - Rate of descent varied between 700ft/min and 900ft/min before reaching 500ft/min. - Vertical load factor varied between +0.9g and +1.1g. - Aircraft was on the glide slope. - At ~10ft RA, thrust levers were retarded to the "IDLE" detent leading to A/THR disengagement as expected.

On the lateral axis	- Right rudder input is seen 03 seconds after AP disengagement and lasted for 04 seconds and left side stick input is seen 05 seconds after the AP disengagement. - The aircraft experienced a left crosswind component around 12kt. - From ~70ft (10:00:34 UTC), there is an abrupt increase in left crosswind. - Just before 100ft RA, several rightward side stick orders were applied up to ~3/4 of full side stick deflection. - Between 100ft RA and touchdown, side stick input varied between full right and ~4/5 of full left. - Roll angle varied between -2° (left wing down) and +7° (right wing down). - Leftward rudder pedal input was applied up to ~4/5 of full input at touchdown from ~70ft RA. - From 70ft RA, drift angle increased from +4° and +14° (aircraft nose toward the left of the track) and heading decreased from 268° to 256° (QFU 271°). - No significant lateral load factor variation was recorded. - Localizer deviation reaches 4/5DOT to the right of the localizer around 0ft RA.

The flight crew voluntarily disengaged both APs at 163 RA (10:00:27 UTC) via the side stick instinctive pushbutton, then final approach was manually handled by CM1with the A/THR engaged and active in "SPEED" mode. The speed target was managed.

Note:
Airbus refers to two different types of AP disengagement:
'Voluntarily' means disengagement:
- Through the instinctive side stick push button (by SOP)
'Involuntarily' means disengagement:
- By FCU push button OR With side stick input OR Due to a failure

On the longitudinal axis:
From 90ft RA to touchdown, several pitch up orders (up to ~3/5 of full nose up input) were applied.
Consequently:

- The pitch angle increased from +0.5° to +5.5°.
- The rate of descent increased from ~700ft/min to ~900ft/min for 4 seconds before reaching~500ft/min.

On the lateral axis:

Just after 03 seconds of AP disengagement, a small right rudder input is seen for 04 seconds and the aircraft is observed banking to the right.

Just before 100ft RA, several rightward side stick orders (up to ~3/4 of full side stick deflection) were applied. Consequently, the roll angle increased up to ~7° on the right.

This right roll angle led the aircraft to swerve to the right of the RWY: the lateral deviation increase from ~ 1/5DOT to ~4/5DOT to the right of the RWY.

Then at ~70ft RA, a leftward rudder pedal order was applied up to ~4/5 of full deflection, most probably to try to return on the centerline of the RWY, but this input did not change the aircraft trajectory to avoid the lateral deviation. This action led the drift angle to increase from +4° to +14° (aircraft nose toward the left of the track) and the heading to decrease to 256° (QFU 271°).

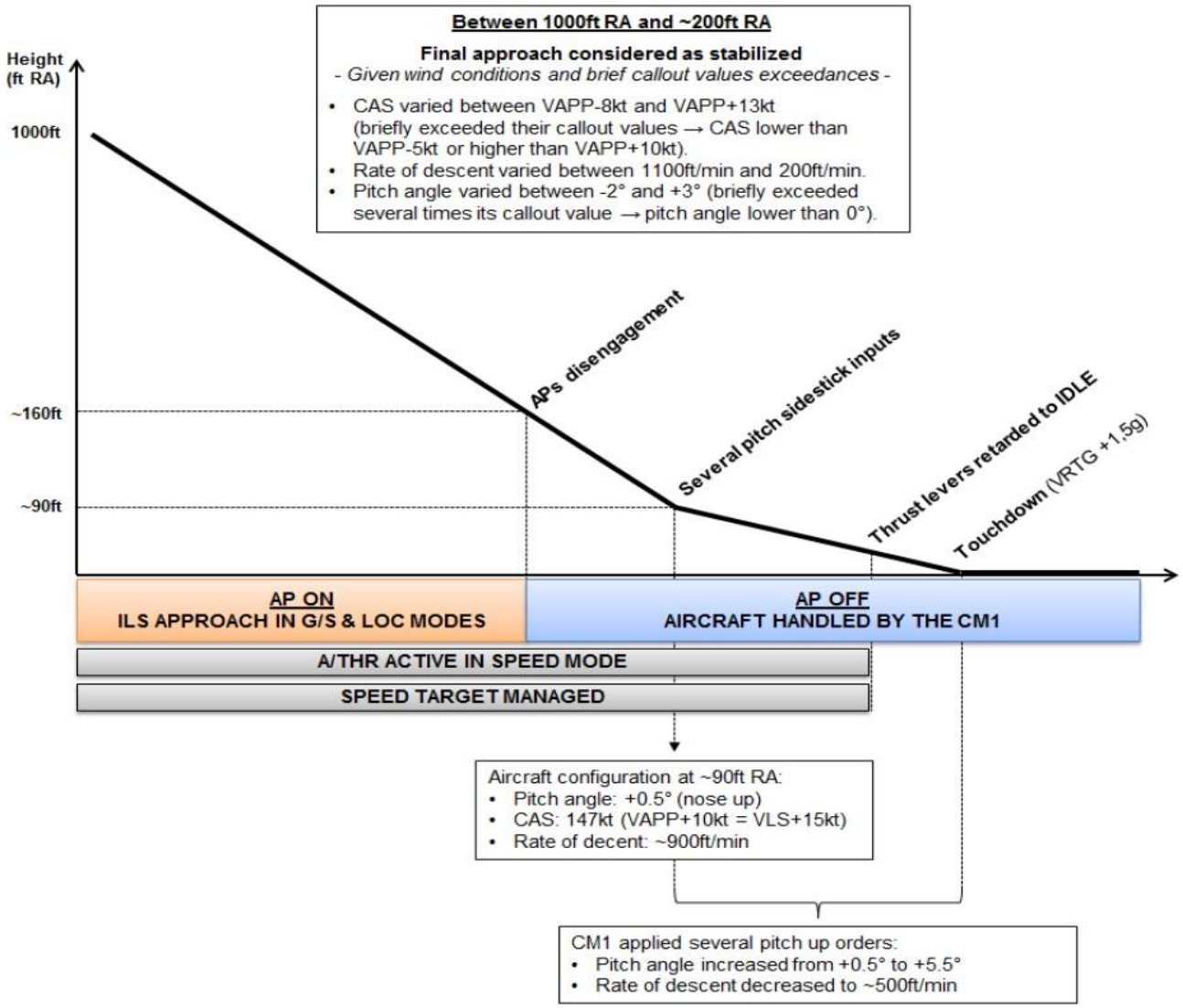
As recommended in the following **FCTM-NORMAL PROCEDURES-SOP-LANDING-FLARE & TOUCH DOWN extract**, the objective of the lateral and directional control of the aircraft during the flare are to land on the centerline, and to minimize the lateral loads on the main landing gear. The recommended de-crab technique is:

- First to use the rudder to align the aircraft nose with the RWY heading.
- Then, if needed, to maintain the aircraft on the RWY centerline with roll control.

D) TOUCHDOWN

At 10:00:43 UTC, The aircraft touched down with:	
On the longitudinal axis:	- +5.5° of pitch angle. - -7ft/s (±2ft/s) of recalculated aircraft vertical speed. - +1.5g of vertical load factor. - CAS 131kt (Ground Speed 125kt).
On the lateral axis:	- +1.5° of roll angle (right wing down). - 256° of heading (QFU 271°). - +14° of drift angle (nose toward the left of the track). - +0.15g of lateral load factor.

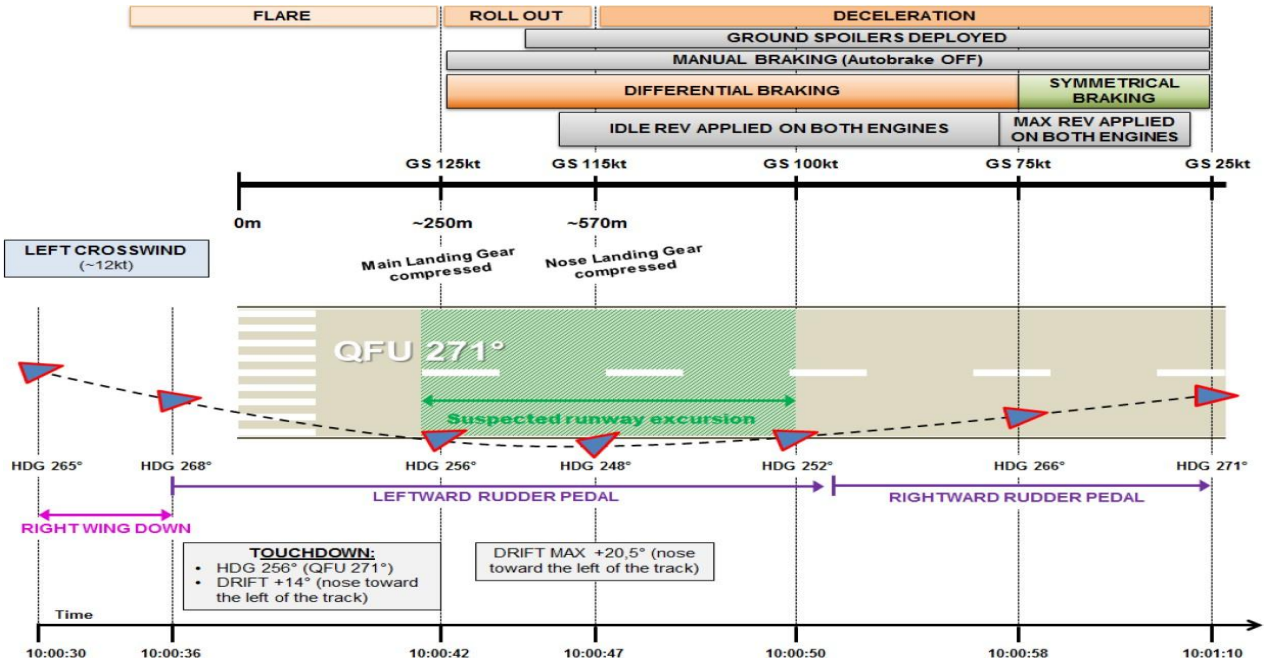
According to the roll angle recorded at touchdown (+1.5°), the right main landing gear touched down first followed by the left main landing gear.
The touchdown occurred out of the RWY on the right side.



Final Approach from 1000 ft to touchdown

E) DECELERATION AND RWY EXCURSION

From touchdown (10:00:43 UTC) to aircraft at ~20kt (10:01:15 UTC),	
On the longitudinal axis:	- Nose up side stick order was progressively released: • Pitch angle decreased toward 0°. - Manual braking input was applied on pedals (up to ~3/4 of full pedal deflection) leading to auto brake disengagement as expected: differential braking was applied (higher braking pedal order on the left then on the right). - Nose landing gear was recorded compressed ~4s after touchdown. - 3 seconds after touchdown, ground spoilers started to extend. - Ground spoilers fully extended. "IDLE REV" thrust was applied on both engines for 12 seconds, then "MAX REV" for 10 seconds, then "IDLE REV" again for 8 seconds. - Ground Speed decreased regularly from ~125kt to ~20kt.
On the lateral axis:	- Aircraft was on the right of the RWY. - Left side stick order was recorded up to ~4/5 of full deflection just after touchdown then no significant roll side stick order was recorded: • Roll angle decreased and remained around 0° (wings level). - Leftward rudder pedal orders were applied (up to full deflection) then rightward rudder pedal orders were applied (up to full deflection). • Heading decreased to 248° then increased up to 272° (QFU 271°). - After the lateral RWY excursion, the aircraft returned on the RWY centerline.



Rollout and Deceleration

After touchdown, pitch up order was progressively released. Consequently the pitch angle slowly decreasedtoward 0°

and the nose wheel was recorded compressed ~4 seconds after touchdown.
Between touchdown (10:00:43 UTC) and 10:00:50 UTC, a differential manual braking (with a higher braking order on the left pedal) and a leftward rudder pedal order (up to full deflection) were applied to correct the trajectory and return on the RWY. Then, between 10:00:50 UTC and 10:00:58 UTC, a differential manual braking (with a higher braking order on the right pedal) and a rightward rudder pedal order (up to full deflection) were applied to realign the aircraft heading with the RWY.
Then, when aircraft was on the RWY and aligned, thrust levers were pulled to "MAX REV". At the same time, a symmetrical manual braking was applied.

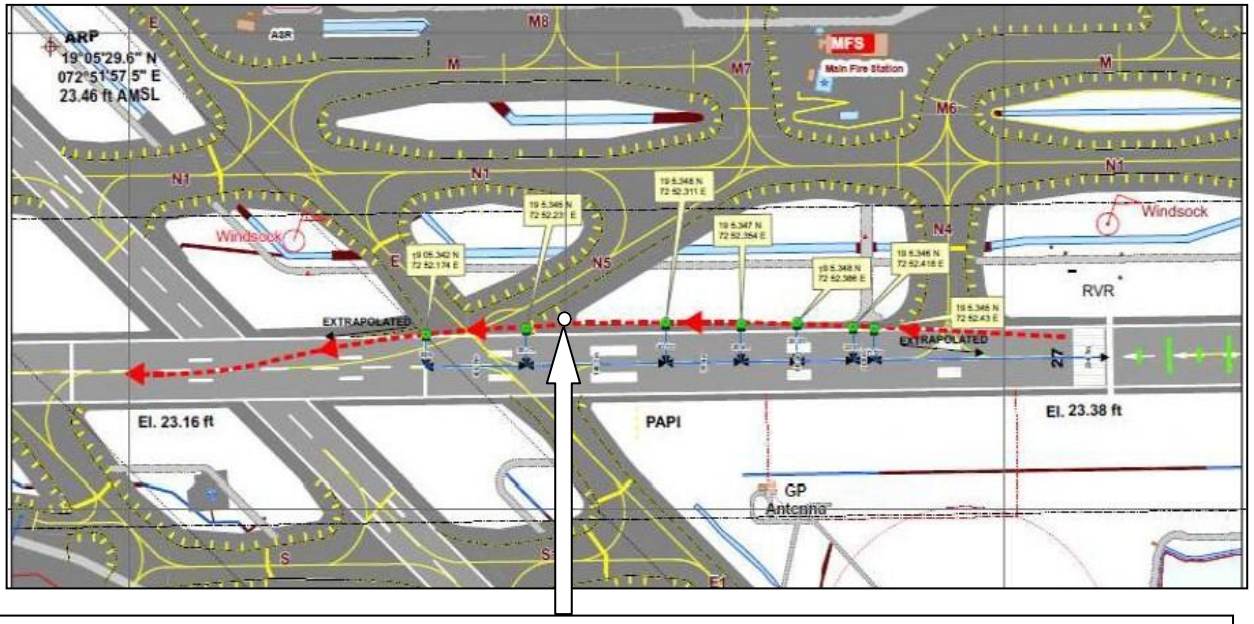
1.11.2 CVR extract:

From the CVR recording, following relevant observations have been observed:

- From the CVR read out abstract, it is observed that the take-off & landing was carried out by PIC but handed over the controls to FO at 1000 ft RA after take-off and took over the controls at 1000 ft. RA during the approach at Mumbai. The climb, cruise, descent and approach phases for the incident sector MAA-BOM were uneventful and flight was stabilized at 1000 ft. However when correlated with DFDR readouts, it was observed that there were brief exceedances above callout values (CAS and pitch angle) but still can be considered stabilized considering the gusty wind conditions.
- Mumbai towers reported winds at 260/26 Knots gusting 36 Knots, & cleared the aircraft to land on RWY 27. Further FO confirmed aircraft stabilized at 1000 ft followed by PIC disconnecting the AP below 500 ft. RA.
- At 50 ft RA auto callout, it is observed that FO realized the aircraft going towards right of RWY centerline & immediately at 30 ft. RA he cautioned/alerts the PIC to move towards left to align with the RWY centerline. However FO did not use any standard callouts, i.e. Go-Around.
- On touch down PIC realized that something went wrong with the landing. On touchdown the FO has not made proper callouts for Landing checklists,i.e ground spoilers callouts have not been announced & there is delay in "Reversers" callouts.
- 17 seconds after touchdown, there is a "Reversers" callout by FO and later there is a conversation by PIC pertaining tothe Reversers.
- It is evident from the conversation of PIC & FO that there is some deviation in usage of reversers from the usual technique & PIC explains that he did this to avoid weather cock effect so as to avoid the aircraft veering outside RWY towards unpaved/uneven surface(kutcha).
- From CVR-DFDR correlation was done by taking a primary reference point of AP disengagement and time calculation was done to find out that the Max thrust reversers were applied on both engines 17 seconds after touchdown when the FO calls out for reversers. Initially 03 seconds after touchdown, Idle Reversers were applied on both engines. This delay in applying the Max thrust reversers has reduced the reverse thrust side force component and restricted the aircraft from skidding completely into the uneven surface(only right main landing gear entered uneven/unpaved surface).
- While taxing for vacating the RWY, the ECAM is triggered for Hydraulic series Master Caution Hydraulics. Further another thud is heard for which the PIC confirms that is due to the aircraft hit the centerline. Then the FO guides the PIC to vacate Via N8. Then FO confirmed the loss of hydraulics. Aircraft was bought to a full stop (shutting down the engines) on the taxiway consequent to loss of Green Hydraulic system.
- From the conversation of PIC & FO, it is evident that the crew was well aware that their aircraft had Lateral Runway excursion.

1.12 WRECKAGE AND IMPACT INFORMATION

During site visit, it was observed from marks, that the aircraft touchdown was in the touchdown zone approximately 1585 m from the threshold to right of the RWY center line such that the right main landing gear touched down outside the RWY edge marking, in the paved shoulder area.
Due to the surface of the RWY being wet, the aircraft skidded due to Viscous Hydroplaning & continued to move further laterally.



Point where aircraft exited unpaved/uneven surface and enters paved surface

The Right main landing gear left the paved shoulder area of the RWY and enters the grass portion on the right side of the RWY. This further caused the aircraft to continue skidding. In the process, no RWY edge lights got damaged as the Right main wheels missed the lights.

The right main wheel after travelling for approx. 250 m in the unpaved/uneven surface continued to roll forward while the right main wheels came in contact with a paved surface of taxiway N5 and steered to the RWY centerline.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Both the PIC & FO had undergone preflight medical check prior to the flight and was found satisfactory. After the incident the breath analyzer test was carried out and same was found to be negative.

1.14 FIRE

There was no fire at any stage..

1.15 SURVIVAL ASPECTS

The incident was survivable

1.16 TESTS AND RESEARCH

Nil

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

M/s Jet Airways (India) Ltd. is a Scheduled Airline having DGCA Schedule Operator Permit No. S-6A in "Passenger and Cargo" category. The Airline Head Quarter is located at Mumbai.

The Company is headed by CEO assisted by a management team. The Flight Safety Department is headed by Chief of Flight Safety approved by DGCA. The Chief of Safety reports directly to the Chairman.

Jet Airways currently operates a fleet of 111 aircrafts, which include 10 Boeing 777-300 ER aircrafts, 08 Airbus A330/-202-302 aircrafts, 75 next generation Boeing 737-700/800/900/900-ER aircraft and 18 modern ATR 72-212A turboprop aircraft. With an average fleet age of 6.06 years, the airline has one of the youngest aircraft fleets in the world. Flights to 73 destinations span the length and breadth of India and beyond, including Abu Dhabi, Bahrain, Bangkok, Brussels, Colombo, Dammam, Dhaka, Doha, Dubai, Hong Kong, Jeddah, Kathmandu, Kuwait, London (Heathrow), Milan, Muscat, New York (Newark), Riyadh, Sharjah, Singapore and Toronto.

1.18 ADDITIONAL INFORMATION

1.18.1 Relevant Extract from FCOM-Normal procedures-Standard callouts-Flight parameters

Approach

During approach, the PM announces:

- "SPEED" if the speed decreases below the speed target -5 knots, or increases above the speed target + 10 knots.
- "SINK RATE" when the descent rate exceeds 1200 ft/min
- "BANK "when bank angle becomes greater than 7^0
- "PITCH" when pitch attitude becomes lower than 0^0 or higher than $+10^0$
-"LOC" or "Glide" when either localizer or glide slope deviation is:
    - ½ dot LOC
    - ½ dot GS

The PM announces the attitude deviations until landing.

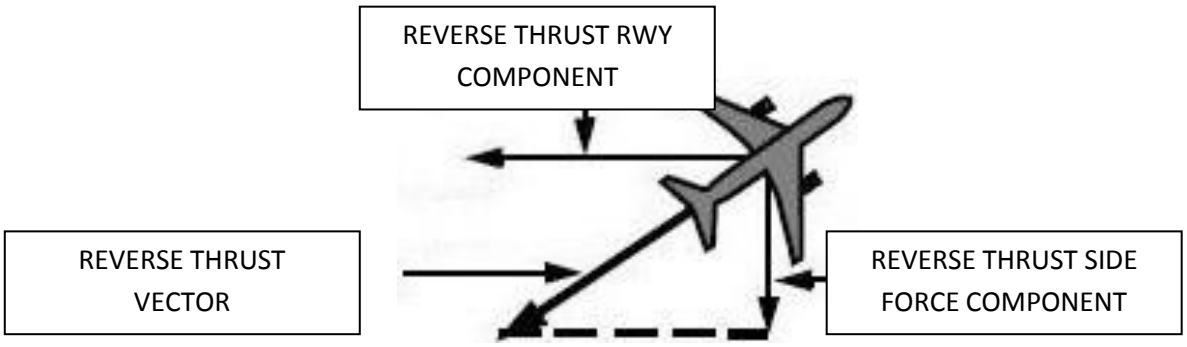
1.18.2 Factors Contributing to the Airplane Skid on Wet RWY

a) Dynamic Aquaplaning

For Dynamic Aquaplaning, a simple formula (**Horne's formula**) exists for calculating the minimum groundspeed for initiation of this type of aquaplaning on a sufficiently wet RWY based upon tyre pressure where V = groundspeed in knots and P = tyre inflation pressure in psi:

$V = 9 \times \sqrt{P}$

b) REVERSE THRUST SIDE FORCE COMPONENT (SKIDDING SIDEWAYS)



The tendency of Aircraft skidding sideways on a wet RWY is increased by reverse thrust side force component when the aircraft lands in crosswinds.

The reversers have a destabilizing effect on the airflow around the rudder and thus decrease the efficiency of the rudder. Furthermore they create a side force, in case of a remaining crab angle, which increases the lateral skidding tendency of the aircraft. This adverse effect is quite noticeable in case of wet RWYs in crosswind. To reduce the sideways skidding tendency, the reverse thrust should be set to idle. At low speeds the directional control of aircraft becomes problematic, more specifically on wet RWYs. In such case differential braking is to be used by releasing the pedal on the opposite side to expected turn direction. Once the aircraft is bought back to directional control, the reverse thrust may be set to Max.

1.18.3 Relevant Extract from FCTM- Normal procedures -SOP-Landing-Flare & Touch Down

LATERAL AND DIRECTIONAL CONTROL

Final Approach

In crosswind conditions, a crabbed-approach wings-level should be flown with the aircraft (cockpit) positioned on the extended RWY centerline until the flare.

FLARE

The objectives of the lateral and directional control of the aircraft during the flare are:
-To land on the centerline, and
-to minimize the lateral loads on the main landing gear.
The recommended de-crab technique is to use all of the following:
-The rudder to align the aircraft with the RWY heading during the flare
-The roll control, if needed to maintain the aircraft on the RWY centerline. Any tendency to drift downwind should be counteracted by an appropriate lateral (roll) input on the side stick.
In the case of strong crosswind, in the de-crab phase, the PF should be prepared to add small bank angle into the wind in order to maintain the aircraft on the RWY centerline. The aircraft may be landed with a partial de-crab (residual crab angle up to about $5^{0)}$ to prevent excessive bank. This technique prevents wingtip (or engine nacelle) strike caused by an excessive bank angle.

As a consequence, this may result in touching down with some bank angle into the wind (hence with the upwind landing gear first).

1.18.4 Information about Tyre pressure post incident on individual wheels confirmed by Engineering

- The arrival check by AME does not include checking of tyre pressure with an instrument. The range of permitted tyre pressure is 206 PSI-215 PSI. A330 has Tyre Pressure Indication System (TPIS). The TPIS computers monitors the tyre pressure electrically by converting analog into digital signal. The system check for low pressure on individual wheels and additional even compares the tyre pressure on the same axle wheels for any abnormality. On the day of event there was no abnormal warning or caution in the subject incident.

1.18.5 Relevant excerpts from crew statements/discussions

The landing technique used was de-crab method where the winds were from left and the PIC gave input to right rudder & left aileron. Just after AP disengagement, Right rudder was applied because at lower height the PIC was momentarily disoriented due to heavy rain & the RWY edge light was thought to be as RWY centerline for that moment. Just before touch down the wind direction and speed changed to 190/40 approx. and the RWY was in flooded condition due to heavy downpour. Initially the reversers were used in idle and when the speed dropped the full reversers were applied. The PIC explains that this procedure was followed to avoid weather cock effect due to crosswinds. The PIC was firm in his belief that there was no RWY excursion and did not report the same.

1.18.6 Information from Apron

On 29th Aug. 2017, while carrying out RWY 27-09 Inspection (between 17:59 IST to 18:04 IST), "Follow-Me" Jeep observed tyre marks on the unpaved area on the edge of shoulder North of RWY 27, between TWY N4 and RET N5.

However, no report from any aircraft was received regarding any RWY Excursion earlier or thereafter. Since it was raining heavily at that time and due to flowing water, it could not be confirmed if the marks were that of any aircraft or vehicle.

On closer inspection, between 09:34 - 09:36 IST, it was suspected that the tyre marks were that of a Code E aircraft. On further investigation it was found out that Jet Airways aircraft JAI-429, Regn. VT-JWV, Type: A330-200, Sector: VOMM-VABB, POB: 259, ATA: 15:30 IST and parked on Stand S3 had grass and loose soil entrapped in the right hand side main landing gears / tyres. It is thus suspected that the above aircraft might have had a RWY excursion. Earlier, on 29th Aug. 2017, the aircraft after landing and vacating RWY 27 via TWY N9, had reported suspected hydraulic leakage and was holding on TWY N abeam TWY L4. The aircraft was then towed and parked on Stand S3 at 16:50 IST (On-Chocks).

2 ANALYSIS

2.1 SERVICEABILITY OF THE AIRCRAFT

The maintenance document of the incident aircraft VT-JWV were scrutinized and observed to be valid on the date of incident. On the day of incident, the aircraft was released with Ice Detection System under MEL. However this did not have a bearing to this incident.

The review of aircraft techlog/snag register revealed that there was no defect pending to be rectified before operating the incident flight. The post Flight report also did not record any system failure that might have been involved in the RWY excursion. As such maintenance task post incident as per the Aircraft Maintenance Manual and as per OEM recommendations were carried out.

From the above it is evident that serviceability of the aircraft and maintenance aspect is not a contributory factor to the incident.

2.2 WEATHER

All available weather information sources are consistent and highlighted a high head wind component, a left cross wind component and turbulent weather conditions.

During Final approach, the aircraft experienced a high head wind and a left crosswind component, with turbulent weather conditions in longitudinal and vertical axis. Prior to landing the visibility reported was 400 m/RVR 600 m in heavy rains and winds at 260/26 Knots gusting at 36 Knots(Significant vertical load factor variations (between +0.6g and +1.3g) were recorded between ~1000ft RA and ~500ft RA highlighting vertical gusts).

From 500 ft RA to 200 ft, the headwind was 36 kt with some gusts, Further from 200 ft RA to touch down, there is a progressive diminution of head wind and left cross wind component was about 12 kt (Between ~500ft RA and ~100ft RA). A major part of the wind evolution (from ~70ft RA) observed during the rudder pedal action was artificial due to

the sudden commanded yaw dynamics of the aircraft. The crosswind trend is thus not valid anymore when rudder pedal orders started to be applied, from ~70ft RA (10:00:34 UTC. So it is evident that the winds are within the aircraft operation limitation.

However, heavy rains over the airfield and other environmental factors impaired the crew visual cues about the position of the aircraft with respect to the RWY centerline. Captain misjudged the Right RWY edge lights as center line & applied Right rudder inputs which caused the aircraft initiating a bank to the right of the RWY center line.

Therefore the weather is a contributory factor to the incident.

2.3 OPERATIONAL ASPECT

2.3.1 Pilot handling of aircraft

a. Prior to touchdown

The flight crew voluntarily disengaged both the APs at 163 ft(10:00:27 UTC) via the side stick instinctive pushbutton, then final approach was manually handled by PIC with A/THR engaged and active in "speed" mode. The speed target was managed.

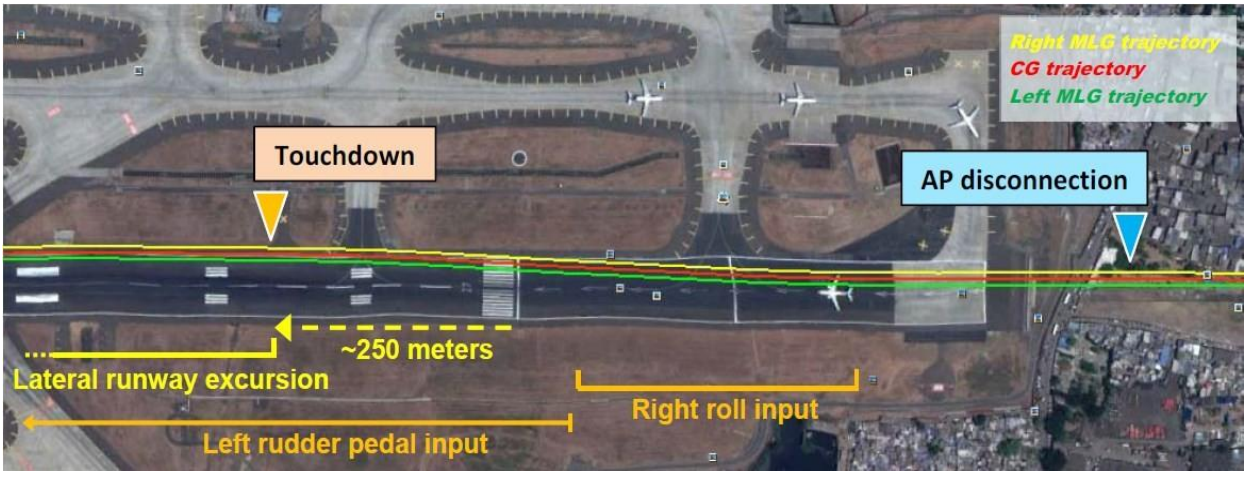
The aircraft experienced a left crosswind component around 12 Knots.
After the APs disengagement, the PIC got momentarily disoriented due to heavy rain & the RWY edge light was thought to be as RWY centerline for that moment. Therefore PIC applied right rudder pedal input (at 131 ft RA) for 04 seconds which initiated the aircraft to bank to the right. Alongside left side stick input was also applied.
Further to manage the cross winds of 12 kt, just before 100 ft RA, several rightward side stick orders (up to ~3/4 of the full side stick deflection) were applied. Consequently, the roll angle increased up to ~7^0 on the right. This right roll angle led the aircraft to swerve to the right of the RWY: the lateral deviation increase from ~1/5DOT to ~4/5 DOT to the right of the RWY.

The Lateral dynamics induced by the right roll commanded by the crew in the last 150 RA, predominantly led the aircraft to swerve/veer towards the right of the RWY.
From CVR-DFDR correlation, as a response to FO's callout to rectify to left, the PIC applied leftward rudder pedal order up to ~4/5 of full deflection, most probably to try to return on the centerline of the RWY, but this input did not change the aircraft trajectory to avoid the lateral deviation. This action led the drift angle to increase from +4° to +14° (aircraft nose toward the left of the track) and the heading to decrease to 256° (QFU 271°).

There was an artificial increasing crosswind trend which is observed due to the sudden commanded yaw dynamics of the aircraft. Therefore the crosswind trend is thus not valid anymore when rudder pedal orders started to be applied, from ~70ft RA. The improper de-crab technique using the roll control to align the aircraft with the RWY heading and the rudder to try to maintain the aircraft on the RWY center line.

b. On touchdown

As per DFDR readout, the aircraft touched down with a roll angle of +1.5^0, the right main landing gear touched down first followed by the left main landing gear. The touchdown occurred with a crab angle (heading 256 degree) out of the right RWY edge marking in the shoulder area.



Trajectory/Touchdown

The ground spoilers fully extended in 02 seconds after touchdown followed by "IDLE REV" thrust applied to both engines. However it may be noted that the FO had not properly announced the landing check callouts, i.e. Ground spoilers callouts & there is delay in reversers callout.

c. Rollout and deceleration

After touchdown, pitch up order was progressively released. Consequently the pitch angle slowly decreased toward 0° and the nose wheel was recorded compressed ~4 seconds after touchdown.
Between touchdown (10:00:43 UTC) and 10:00:50 UTC, a differential manual braking (with a higher braking order on the left pedal) and a leftward rudder pedal order (up to full deflection) were applied to correct the trajectory and return on the RWY.
From 10:00:46 UTC to 10:00:57 UTC, thrust levers were pulled to "IDLE REV"
Then, between 10:00:50 UTC and 10:00:58 UTC, a differential manual braking (with a higher braking order on the right pedal) and a rightward rudder pedal order (up to full deflection) were applied to realign the aircraft heading with the RWY.
Then, when aircraft was on the RWY and aligned, thrust levers were pulled to "MAX REV". At the same time, a symmetrical manual braking was applied.

2.3.2 CRM

The CVR/DFDR analysis shows that the flight crew followed company procedures till the point of incident and the final approach can be considered as stabilized considering the gusty wind conditions and brief exceedances above callout values(CAS and pitch angle). Just from 70 ft RA, the FO was aware of the aircraft heading towards the right edge and the PIC, though acknowledging his calls, was not able to manage with appropriate inputs. The FO could have played a more pro-active role by making standard PM Callouts i.e Go-Around to preclude the impending lateral runway excursion. Also the FO had not carried out the Landing checks callouts appropriately, i.e. ground spoilers callouts have not been announced & there is delay in "Reversers" callouts.

2.3.3 Discussions on possible scenarios

All the possibilities which could have resulted into the incident were explored and are detailed as below:

a. Rudder Jam and rudder pedal stiff:

DFDR data indicated that rudder movement was consistent with the rudder pedal inputs. This rules out Rudder Jam as a cause of the incident and there was no rudder stiffness experienced by the crew.

b. Nose Wheel steering fault:

No Nose Wheel Steering fault was recorded in flight and the nose wheel steering ability being lost due to loss of Green Hydraulic system was a consequential secondary damage caused by the Lateral RWY excursion incident.

d. Skidding on the wet RWY:

The surface of RWY was wet due to heavy rain showers. Skidding on wet RWY mainly happens due to Hydroplaning & lateral skidding occurs due to reverse thrust side force component when the aircraft heading is into wind and not aligned with RWY.
As per the Engineering, the tyre pressure was not checked with instrument post incident but the range of permitted tyre pressure is 206 PSI-215 PSI. On the day of event there was no abnormal warning or caution detected by the Tyre Pressure Indication System (TPIS) in the subject incident. Therefore considering the minimum permitted tyre pressure, i.e, P=206 PSI, the minimum ground speed is calculated by applying in Horne's formula.
$\mathbf{V_{calculated}=9 \times \sqrt{206}=129.1}$ Knots.
The actual touchdown groundspeed ($\mathbf{V_{actual\ touchdown}}$) on day of incident was 125 Knots as per DFDR.
Therefore, it is evident that the aircraft had not encountered dynamic hydroplaning and had momentarily skidded due to Viscous Hydroplaning. It can also be confirmed from the immediate effectivity of the brakes and regaining of directional control just after touchdown which would not be the scenario in case of Dynamic hydroplaning.

Lateral skidding due to reverse thrust side force component (03 seconds after touchdown) was restricted as the reverse thrust was initially set to idle and differential braking was used by releasing the right pedal to turn to left and come out of unpaved/uneven surface and align with the RWY centerline(as observed from DFDR).

e. Thrust Reverser asymmetry:

DFDR data revealed that there was no thrust reverser asymmetry and nor was any actual strong cross wind experienced during the landing roll to cause any yawing movement/ deviation.

Circumstances leading to the incident

A. Disorientation due to bad weather

Due to heavy rain showers over the airfield and other environmental factors (crosswinds of 12 Knots), impaired the crew visual cues about the position of the aircraft with respect to the RWY centerline. Captain misjudged/mistook the Right RWY edge lights as center line & applied Right rudder inputs which caused the aircraft initiating a bank towards the right of the RWYcenter line.

B. Improper crosswind landing technique

Further to encounter the cross winds of 12 kt, just before 100ft RA, the PIC had applied several rightward side stick orders (up to ~3/4 of full side stick deflection) increasing the roll angle up to ~7° on the right, predominantly causing the aircraft to swerve to the right of the RWY.
From ~70 ft RA, PIC applied leftward rudder pedal order up to ~4/5 of full deflection, most probably to try to return on the centerline of the RWY, but this input did not change the aircraft trajectory to avoid the lateral deviation resulting in runway excursion. This action led the drift angle to increase from +4° to +14° (aircraft nose toward the left of the track) and the heading to decrease to 256° (QFU 271°).
The aircraft had touched-down with a crab angle outside the Right RWY edge marking in the shoulder area despite of the attempts by PIC from ~70 ft RA to return the aircraft on the centerline of the RWY.

C. CRM-unassertiveness of the FO

The First officer should have played a more pro-active role by making standard PM Callouts or a Go-around callout to preclude the impending Lateral Runway excursion.

3. CONCLUSION

3.1 Findings

1. The aircraft was airworthy with all valid certifications. All maintenance schedules, mandatory modifications and checks were carried out as per the requirements. The maintenance aspect was not a contributory factor to the incident.
2. Both the flight crew were fit to fly with valid license/ratings.
3. No abnormalities were observed during entire flight till final approach (1000 ft RA). Between 1000 ft RA and 500 ft RA, flight parameter deviations (CAS and pitch angle) briefly exceeded several times their callout values. With regards to the gusty wind conditions and considering the brief exceedances above callout values, final approach can still be considered as stabilized. However, to be on the safer side, the PIC should have followed the FCOM and opted for a Go-around.
4. From 500 ft RA, all available weather information sources highlighted high headwind component about 36 Knots with some gusts, a left crosswind of 12 Knots and turbulent weather conditions. There was an artificial increasing crosswind trend which is observed due to the sudden commanded yaw dynamics of the aircraft. Therefore, the crosswind trend is thus not valid anymore when the rudder pedal orders started to be applied, from ~70 ft RA. Therefore the winds were within the aircraft operation limitation.
5. However due to heavy rain showers over the airfield and other environmental factors (crosswind of 12 Knots) subsequent to APs disengagement, the PIC got disoriented, which impaired the crew's visual cues about aircraft position with respect to RWY centre line. Consequently, the PIC mistook the Right RWY edge lights as centre line & applied Right rudder inputs which initiated the aircraft to bank to the right of the RWY center line. Weather therefore was a contributory factor to the incident.
6. Further to manage the cross winds, the improper de-crab technique adopted by the PIC caused the Lateral dynamics induced by the right roll commanded by the PIC in the last 150 RA, led the aircraft to swerve towards the right of the RWY.
7. During the initial touchdown, the right main landing gear touches first with a crab angle outside the Right RWY edge marking in the shoulder area despite of the attempts by PIC from ~70 ft RA to return the aircraft on the centerline of the RWY.
8. The aircraft touchdown with a heading of 256 degrees on the wet RWY skidded further to the right due to viscous hydroplaning and later due to reverse thrust side force component (03 seconds after touchdown). However the Lateral skidding due to reverse thrust side force component was restricted as the reverse thrust was initially set to idle and differential braking (full left brakes) was used along with appropriate directional controls(left rudder pedal full deflection) to turn to left and come out of unpaved/uneven surface and align with the RWY centerline.
9. The right main landing gear left the paved shoulder area of the RWY and entered the unpaved portion on the right side of the RWY. This further caused the aircraft to continue skidding. No RWY edge lights were

damaged in the process. The PIC continuously applied full left rudder and left braking to bring the aircraft back to the RWY centerline.

10. The right main wheel after travelling for approx. 250 m in the unpaved/uneven surface continued to roll forward while the right main wheels came in contact with a paved surface of taxiway N5 and steered to the RWY centerline.
11. Once the directional control was attained, a differential manual braking (with a higher braking order on the right pedal) and a rightward rudder pedal order (up to full deflection) were applied to realign the aircraft heading with the RWY.
12. Then, when aircraft was on the RWY and aligned, thrust levers were pulled to "MAX". At the same time a symmetrical manual braking was applied and slowed the aircraft on the RWY to vacate via N8.
13. While taxiing for vacating the RWY, the nose wheel steering ability was lost due to loss of Green Hydraulic system (ECAM triggered) was a consequential secondary damage caused by the Lateral RWY excursion incident.
14. During the walk around inspection by AME, it was identified that the RH main landing gear had left the RWY and entered the uneven/unpaved surface. Thereafter, the incident was reported.
15. The crew had made a PDR entry for the loss of HYD SYS G. The crew did not report the Runway Excursion. It is evident from the CVR that the crew was well aware of the runway excursion by their aircraft. The crew had intentionally omitted reporting the crucial portion of occurrence which involved their mishandling and made an incomplete/inappropriate reporting of consequential damage caused by the Lateral Runway excursion.
16. The First officer should have played a more pro-active role by making standard PM Callouts or a Go-around callout to preclude the impending lateral runway excursion.

3.2 Probable Cause of the Incident

- Loss of situational awareness (due impaired visual cues) under prevailing bad weather conditions (heavy rains) combined with Pilot's improper crosswind landing technique was the probable cause of the Runway excursion.

4. SAFETY RECOMMENDATIONS

1. Necessary corrective action as deemed fit by DGCA, Hqrs.

Vipin Venu Varakoth
Digitally signed by Vipin Venu Varakoth
Date: 2022-07-26 12:24:41

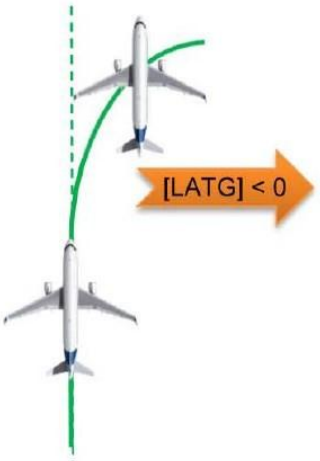
26.07.2022
MUMBAI – 99.

Vipin Venu Varakoth
Assistant Director Air Safety
Inquiry Officer VT-JWV

Annexure 1
SIGN AND CONVENTION

Load factor

Lateral load factor [LATG]

Positive lateral load	Negative lateral load
	
Positive [LATG] A/C goes to the **left** of the track (pilots bodies are attracted to the right or the airframe)	**Negative** [LATG] A/C goes to the **right** of the track (pilots bodies are attracted to the left of the airframe)

Longitudinal load factor [LONG]

Postive longitudinal load	Negative longitudinal load
	
Positive [LONG] A/C **decelerates** Ground speed decrease	**Negative** [LONG] A/C **accelerates** Ground speed increase

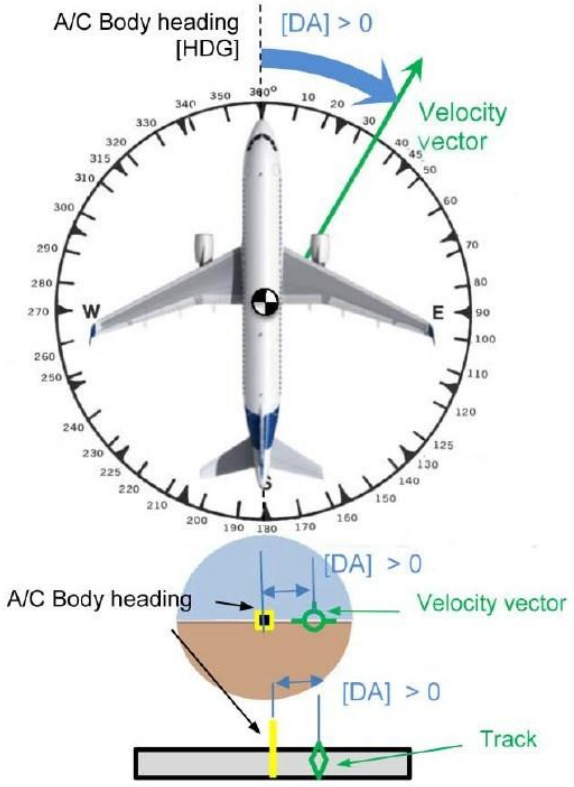
Vertical Load factor [VRTG]

Positive vertical load	Negative vertical load
	
[VRTG] **> 1** A/C goes towards the **sky** [VRTG] increase = more lift	[VRTG] **< 1** A/C goes towards the **ground** [VRTG] decrease = loss of lift

A/C movements

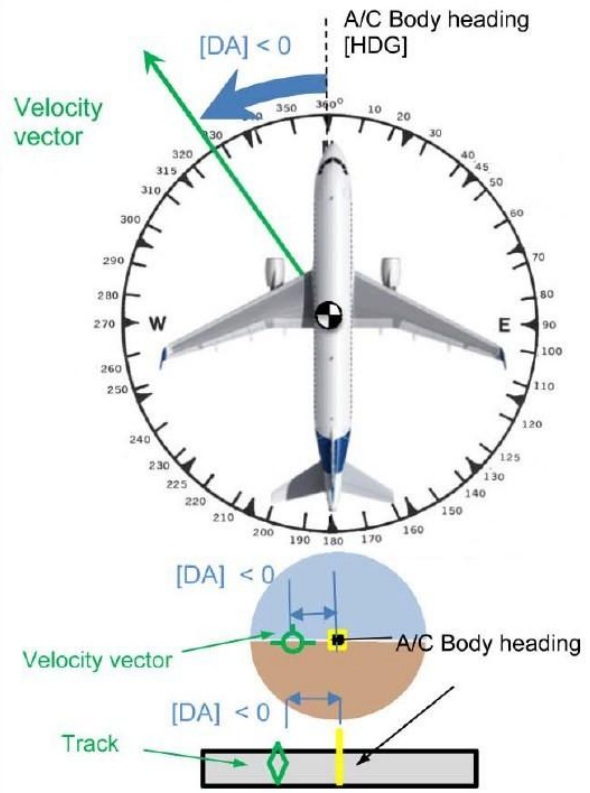
Drift angle [DA]

Positive drift angle



Positive Drift angle
A/C **nose** to the **left** of the track

Negative drift angle



Negative Drift angle
A/C **nose** to the **right** of the track

Lateral control via Rudder

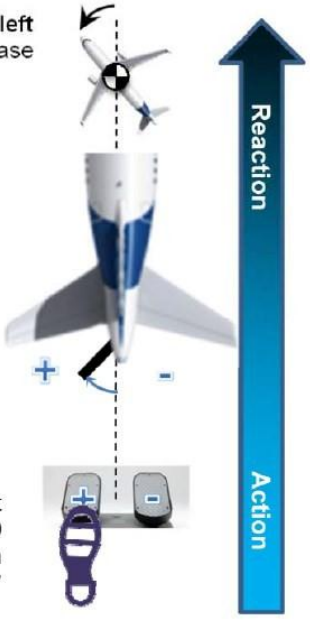
Right / Negative rudder pedal

A/C **nose** moves to the **right**
Heading increase

Rightward rudder
Negative deflection
Rudder [RUDD] < 0
Max $_{A330\text{-}200}$ = - 31.5
Max $_{A330\text{-}300}$ = - 35°

Right rudder pedal input
Negative deflection
[RUDP] < 0
Max = - 21°

Left / Postive rudder pedal



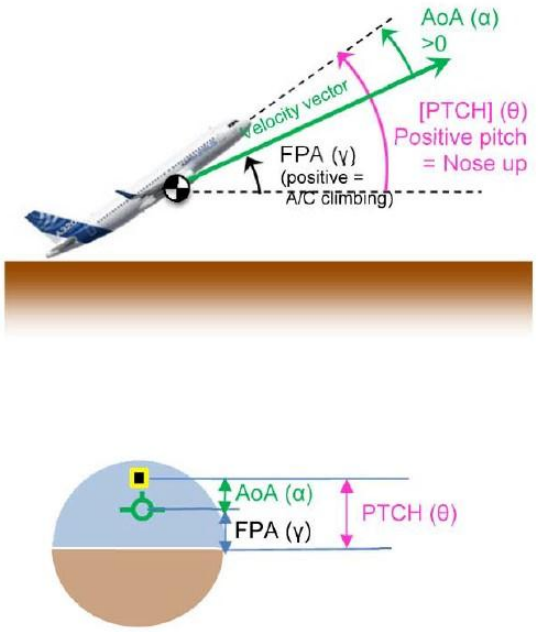
A/C **nose** moves to the **left**
Heading decrease

Leftward rudder
Positive deflection
Rudder [RUDD] > 0
Max $_{A330\text{-}200}$ = + 31.5
Max $_{A330\text{-}300}$ = + 35°

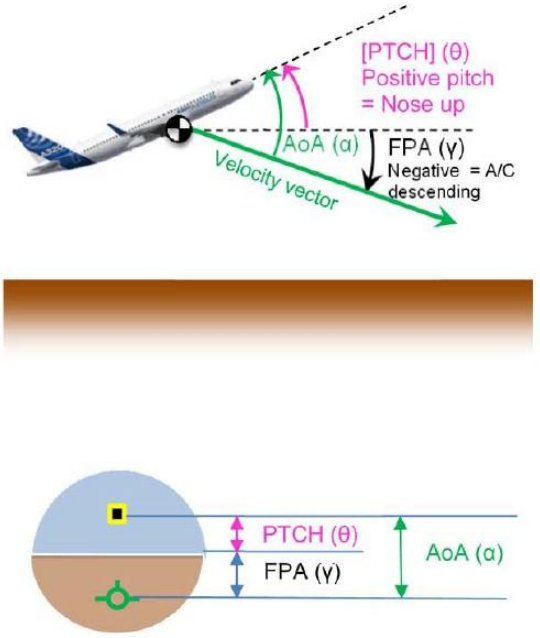
Left rudder pedal input
[RUDP] >0
Positive deflection
Max = 21°

A/C movements

Pitch angle A/C climbing



Pitch angle A/C in approach



Side stick longitudinal [STKP] negative

Negative
Side stick
[STKP] < 0
Max= -16°

Elevators upwards
Negative elevators
[ELV] Elevator < 0
Max -30°

Nose up
Pitch increase

Action → **Reaction**

Trimmable Horizontal Stabilizer (STAB)
Normal Take Off range is between -7° (nose down) and 0°.
Maximum STAB deflection is -14° (nose up) and +2° (nose down).

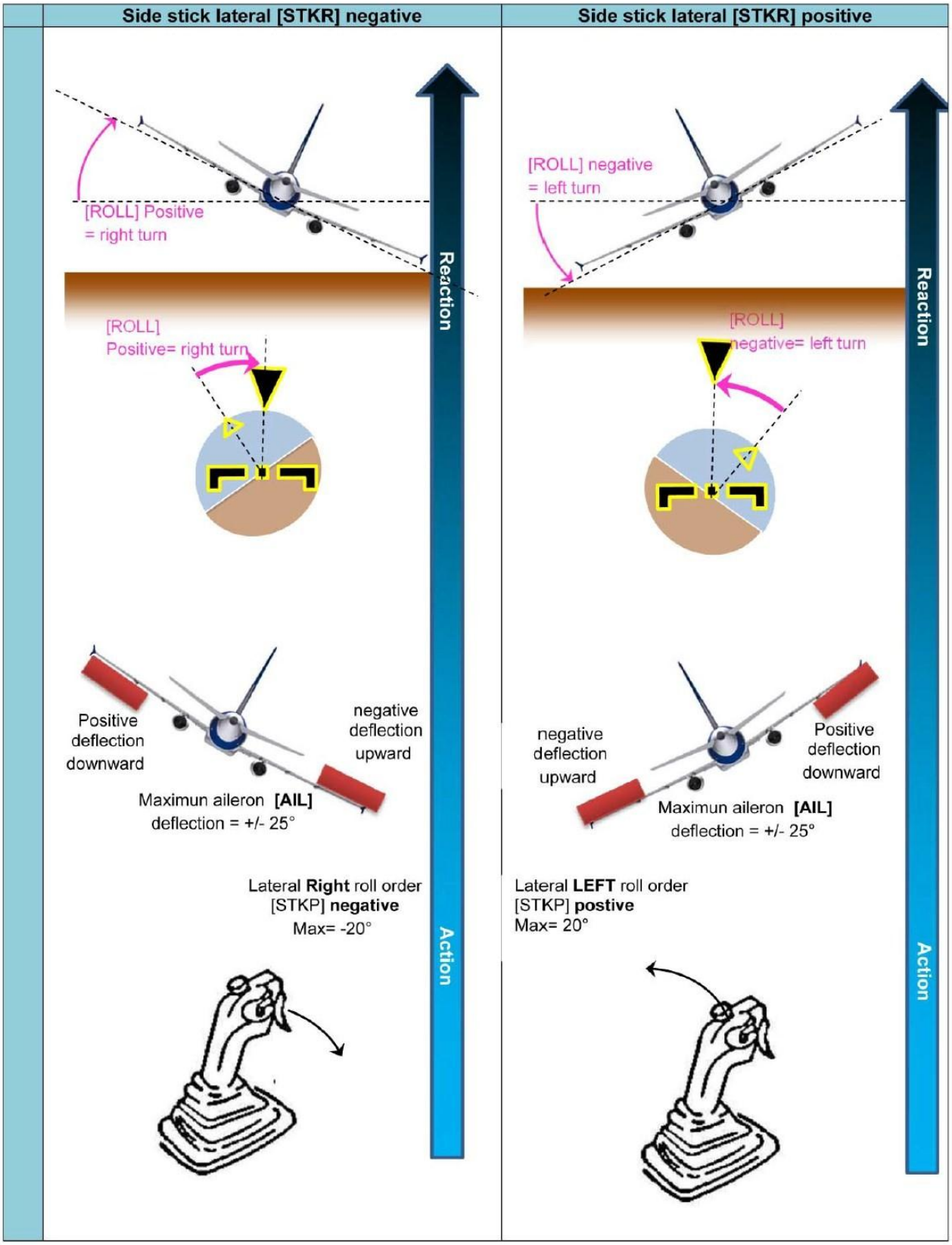
Side stick longitudinal [STKP] positive

Positive
side stick
[STKP] > 0
Max= +16°

Elevators downwards
[ELV] Elevator > 0
Max +15°

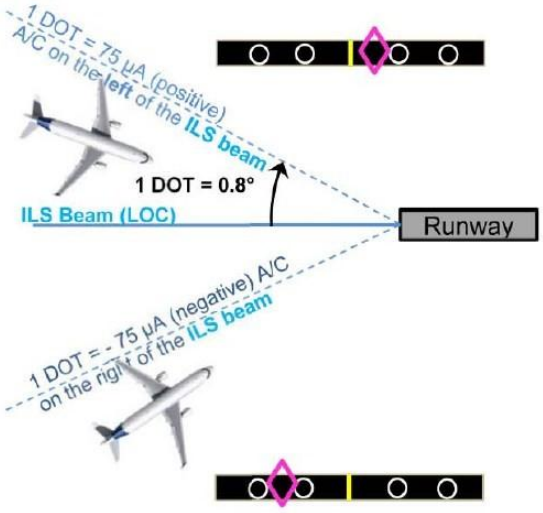
Nose down
Pitch decrease

Action → **Reaction**

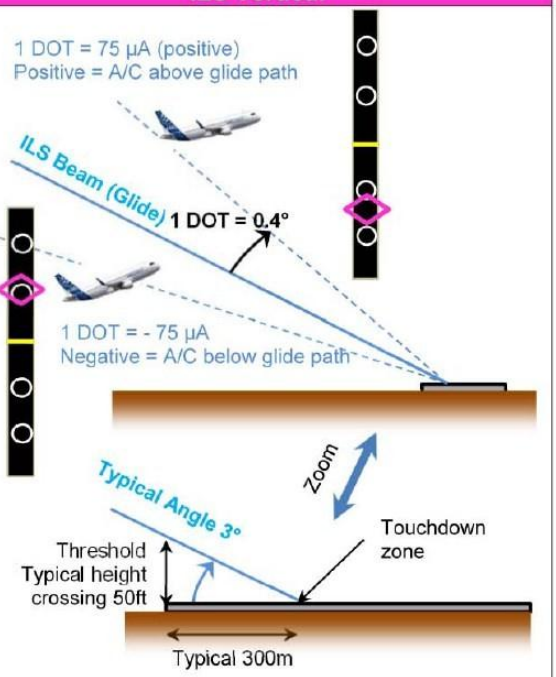

Side stick lateral [STKR] negative
Side stick lateral [STKR] positive
[ROLL] Positive
= right turn
[ROLL]
Positive= right turn
Reaction
Positive
deflection
downward
negative
deflection
upward
Maximun aileron [AIL]
deflection = +/- 25°
Lateral Right roll order
[STKP] negative
Max= -20°
Action
[ROLL] negative
= left turn
[ROLL]
negative= left turn
Reaction
negative
deflection
upward
Positive
deflection
downward
Maximun aileron [AIL]
deflection = +/- 25°
Lateral LEFT roll order
[STKP] postive
Max= 20°
Action

Approaches

ILS Lateral



ILS Vertical



Wind lateral

Wind speed lateral > 0 = Left Crosswind

Wind speed lateral < 0
= Right Crosswind

Wind longitudinal

TAS < GS
tailwind

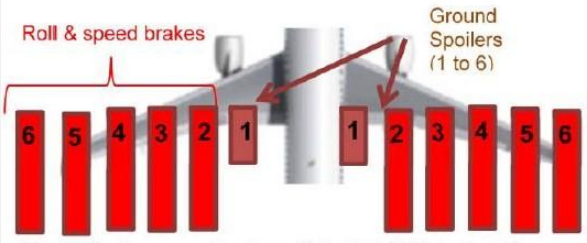
TAS > GS
headwind

CTAS = Corrected True AirSpeed
GS = Ground speed

Slats Flaps [LR]

Levers	Conf	Flaps [°]	Slats [°]
1	1	0	17
	1+F	8	17
2	2	14	21
3	3	22	24 A330-200 23 A330-300
4	Full	32	24 A330-200 23 A330-300

Spoilers



Max deflection speed brake : SP1 : 25° SP 2 to 6 : 30°
Spoiler Partial extension : SP1 : 14° SP 2 to 6 : 20°
Spoiler Full extension : SP1 : 20° SP 2 to 6 : 50°