FINAL REPORT OF ACCIDENT

INVOLVING

M/s JET AIRWAYS ATR 72-600 AIRCRAFT

VT-JCX

AT INDORE

ON 07TH MAY 2016

Jasbir Singh Larhga
Chairman, Committee of Inquiry

Capt. Rajiv Yadav
Member, Committee of Inquiry

Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2012, the sole objective of the investigation of an accident 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 and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

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Summary

ATR 72-600 aircraft VT-JCX was schedule to operate Flight 9W2793 from Delhi to Indore on 07.05.2016. The fight was operated by an ATPL holder on type as PIC and another ATPL holder on type as Co-Pilot. There were 66 passengers on board and 04 crew on board including the two pilots.

The flight took off from Delhi and was uneventful until landing at Indore. Aircraft landed at Indore Runway 25 at 1408 UTC and veered out of runway to the left. Aircraft travelled around 180meters on unpaved surface, rolling over uneven surface and pits. Aircraft crossed taxiway F and came to halt 78 meters from the runway centre line near isolation bay.

Occurrence was classified as Accident as per the Aircraft (Investigation of Accident and Incidents) Rules, 2012. Committee of Inquiry was appointed by Ministry of Civil Aviation vide its notification Ref AV.15013/1/2016-DG appointing Mr. Jasbir Singh Larhga, Assistant Director AAIB as Chairman and Capt Rajiv Yadav as Member.

Initial notification of the occurrence was sent to ICAO, Transport Safety Board of Canada and Bureau d'Enquêtes et d'Analyses (BEA), France on 09th May 2016 as per requirement of ICAO Annex 13. Mr. Emmanuel Delbarre was appointed as accredited representative by BEA, France under ICAO Annex 13.

FINAL REPORT ON ACCIDENT TO M/s JETAIRWAYS ATR 72-600 AIRCRAFT VT-JCX AT INDORE ON 07/05/2016

1.	Aircraft Type	: ATR 72-600 (ATR 72-212A)
	Nationality	: INDIAN
	Registration	: VT - JCX
2.	Owner	: M/s Celestial Aviation Trading 71Limited
3.	Operator	: Jet Airways.
4.	Pilot – in –Command	: ATPL holder on type
	Extent of injuries	: Nil
5.	First Officer	: ATPL Holder on type
	Extent of injuries	: Nil
6.	Place of Accident	: Indore Airport
7.	Date & Time of Accident	: 07th May 2016, 1411 UTC
8.	Last point of Departure	: Delhi
9.	Point of intended landing	: Indore
10.	Type of operation	: Schedule Operation
11.	Crew on Board	: 02 Pilot and 02 Cabin Crew
	Extent of injuries	: Nil
12.	Passengers on Board	: 66
	Extent of injuries	: Nil
13.	Phase of operation	: Landing
14.	Type of Accident	: Runway Excursion

(ALL TIMINGS IN THE REPORT ARE IN UTC)

1. FACTUAL INFORMATION

1.1 History of the flight

ATR 72-600 aircraft VT-JCX was schedule to operate flight 9W2793 from Delhi to Indore on 07.05.2016. The fight was operated by an ATPL holder on type as PIC and another ATPL holder on type as Co-Pilot. There were 66 passengers on board and 04 crew on board including the two pilots.

Crew reported for duty on time and proceeded to aircraft after breath analyser test and briefing. The crew decided to take 100 Kgs of extra fuel based on the weather reports. Departure clearance was obtained and the chocks were off 05 minutes ahead of schedule time at 1210 UTC approx. After pushback all checklists were carried out and flight took off from Runway 29 at 1210 UTC. Crew asked for left deviation while climbing to avoid weather and were 12 NM left of track.

ATIS was obtained by the crew approximately at 115 NM from Indore and arrival briefing was completed at 100 NM from Indore. Crew asked ATC for permission to descend at 1340 UTC, much before their descent point, so as to keep clear of weather and avoid turbulence. The winds reported by ATC were 130º and 08 Knots. As the winds were favourable for Rwy 07 the crew decided for VOR approach to Rwy 07 via DME arc.

At 1353 UTC crew reported commencing ARC. While on final approach crew asked for winds, ATC informed crew that the winds were 320º and 12 Knots. The crew also saw tail winds on PFD and decided to discontinue the approach. ATC then cleared the aircraft for ILS approach to Rwy 25 from overhead. Crew requested for ILS approach to Rwy 25 via DME arc, as there was weather overhead and same was acceded to by the ATC at 1401UTC. At the same time ATC also informed crew that winds were then 100º and 12 knots. Aircraft climbed 4000 feet and was kept left of Rwy keeping runway in visual contact.

Crew continued with the approach and went out for 15 NM to avoid weather before turning right to intercept the ILS. Crew reported established on localizer at 1407

UTC and was informed by ATC of moderate rain on airfield. At 1408 UTC crew reported intercepting ILS and was cleared to land with reported winds of 13 Knots at 160º. As per the statement of crew the approach was clear and runway lights could be seen from 13 NM. The runway lights and PAPI lights appeared bright and hence crew requested ATC to reduce the intensity of lights.

As the aircraft descended through 600 feet, auto pilot was disconnected. After the aircraft touched down, it veered to the right. The PIC tried to control the aircraft using rudder to turn it to the left. However aircraft went excessively to the left. PIC was also warned by the co-pilot about the aircraft heading. The aircraft continued going left even after application of full right rudder by the PIC.

The aircraft subsequently went out of the runway into the unpaved surface on left, damaging runway edge lights, runway marking light and taxiway edge light. Aircraft travelled approximately 180 meters on the unpaved surface while jumping a pit and crossing taxiway F near isolation bay before coming to halt 78 meters away from runway centre line, with heading 204°.

Co-Pilot gave the call "Crew to your stations" and responded with request for assistance when ATC called at 1412 UTC. Cabin crew was briefed of the situation by the PIC. Cabin crew confirmed to PIC that all passengers were OK. Pilots discussed regarding evacuation and decided to deplane normally once assistance arrives. After the propeller stopped rotating, PIC instructed cabin crew to open the door and deplane. All passengers disembarked and were taken to terminal building in buses. There was no injury to any of the passengers or crew.

1.2 Injuries to persons

INJURIES	**CREW**	**PASSENGERS**	**OTHERS**
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil

1.3 Damage to Aircraft :

Aircraft sustained substantial damage while moving over uneven and unpaved surface and was grounded for necessary repairs and maintenance. Deep scratch and dent was observed near Standby pitot probe SEC 11.

Fig 1

Lower fuselage belly skin was scratched, buckled and dented ahead of SEC 16.

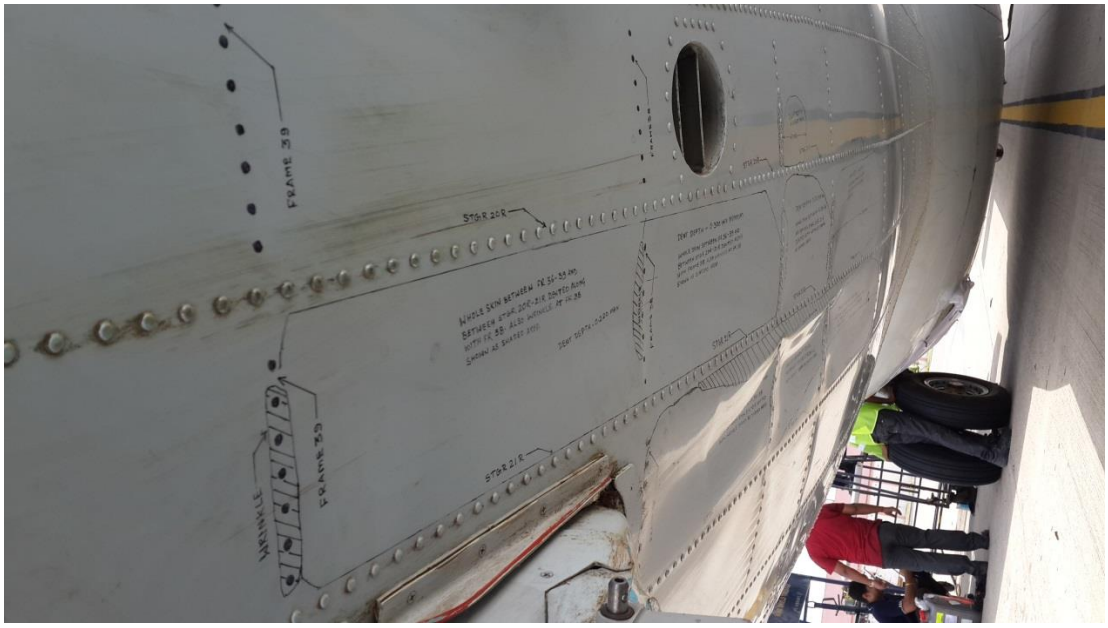

Fig 2

Bulkhead frame aft of wheel well was damaged. Damage was also observed on the drain mast, LH Hydraulic Bay access fairing as and the LH engine propeller blades.

Fig 3

All three landing gears were subjected to inspection due to suspected overload. Upper support and Shock absorber of NLG was damaged. On the RH MLG; Barrel, Trailing Arm, Universal Joint Hinge Pin of trailing arm and Shock Absorber Hinge Pin were damaged and had to be scrapped. On the LH MLG; Barrel, Trailing Arm, After Attachment Hinge Pin, Universal Joint Hinge pin of trailing arm and shock absorber,

Barrel Hinge Pin, Shock Absorber hinge pin and side brace hinge pin were damaged and had to be scrapped. In addition following damages were also noticed.

- The propeller blade no 3 of No. 1 Engine had FOD Damage.
- Bracket of primary WOW sensor was found loose.
- LH Main Landing Gear door was damaged at aft portion.
- Attachment fitting of RH MLG door was damaged.
- Link assembly joining LH MLG door to landing gear was sheared off.
- WEB attaching hydraulic bay panel on frame 27 found punctured at one point
- Inter coastal joining web of hydraulic fairing and web attaching LH MLG door aft fitting got sheared off
- Hydraulic bay access panel was damaged
- Skid marks observed on tail skid.
- Skin buckled at 5 inch aft of frame 34 to frame 40 with damage to four Frames.
- Dent and deep scratch observed at Section 11on LH Fuselage skin
- LH MLG Cantid Rib was found buckled and twisted.
- LH MLG door aft attachment fitting was damaged.

1.4 Other damage: Aircraft hit a runway edge light, runway marking light and a taxiway edge light, on its way to final halting position near isolation bay.

1.5 Personnel information

1.5.1 Pilot – in – Command

AGE	: 41 years
License	: ATPL Holder
Category	: Aeroplane
Validity	: 23.03.2018
Endorsements as PIC	: Cessna 152, ATR 72-500, ATR 72-600

Date of Medical Exam	:	18.03.2016
Medical Exam validity	:	17.09.2016
FRTO License validity	:	05.05.2017
Total flying experience	:	3943 Hrs
Experience as PIC on type	:	189 Hrs
Total flying experience during last 180 days	:	255:45Hrs
Total flying experience during last 90 days	:	192:00 hrs
Total flying experience during last 30 days	:	76:20 Hrs
Total flying experience during last 07 Days	:	13.00 Hrs
Total flying experience during last 24 Hours	:	02.05 Hrs

1.5.2 Co-Pilot

AGE	:	33 years
License	:	ATPLHolder
Category	:	Aeroplane
Validity	:	09.12.2016
Endorsements as PIC	:	Cessna 152, Piper Seneca PA34, SKA B200
Endorsements as F/O	:	ATR 72-500, ATR 72-600
Date of Medical Exam	:	19.01.2016
Medical Exam validity	:	18.01.2017
FRTOL validity	:	02.02.2019
Total flying experience	:	2693 Hrs
Experience as PIC on type	:	Nil
Total flying experience during last 180 days	:	379:30 Hrs
Total flying experience during last 90 days	:	171:34 Hrs
Total flying experience during last 30 days	:	52:46 Hrs
Total flying experience during last 07 days	:	17:51 Hrs
Total flying experience during last 24 Hours	:	02:05 Hrs

1.6 Aircraft Information:

1.6.1 Aircraft History:

ATR 72-600 (ATR 72-212-A), aircraft registration VT-JCX (MSN 1056) was manufactured in year 2012. The aircraft is registered with DGCA under the ownership of M/s Constellation Aircraft Leasing Limited. The aircraft is registered under Category 'A' and issued Certificate of registration No. 4379.

The Certificate of Airworthiness Number 6488 under "Normal category" and subdivision “Passenger / Mail / Goods” was initially issued by DGCA on 30.11.2012. The certificate of airworthiness specifies the maximum all up weight as “23000 Kgs”. The validity of the Certificate of Airworthiness is subject to the valid Airworthiness Review Certificate or unless suspended/cancelled by DGCA. The Airworthiness Review Certificate was valid up to 07.12.2016.

The Aircraft had a valid Aero Mobile License No A-006/068/WRLO-2014 at the time of accident. This aircraft was operated under Air Operator Permit No S-6A which was issued on 29.05.2015. As on 07.05.2016 a month prior to day of accident the aircraft had logged 9664:29 Airframe Hours.

The aircraft and its Engines are being maintained as per the maintenance program consisting of calendar period/ flying Hours or Cycles based maintenance as per maintenance program approved by DGCA. The last major inspection, C2 check was carried out in Mar 2016. Subsequently all lower inspections (Pre-flight checks, Service Checks, Weekly Checks) were carried out as and when due before the accident.

The aircraft was last weighed on 20.11.2012. As per the approved weight schedule the Empty weight of the aircraft is 13297.00 Kgs. Maximum Usable fuel Quantity is 5000.00 Kgs. Maximum pay load with fuel tanks full is 4315.00 Kgs. Empty weight CG is 14.043 meters aft of datum. The next weighing was due on 19.11.2017. Prior to the accident flight the weight and balance of the aircraft was well within the operating limits.

All the applicable Airworthiness Directive, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine has been complied with as on date of event.

The aircraft is equipped with PWC Engine PW127M. The left engine S/N ED0036 was manufactured on 24.04.2008 and had logged 19012 Hrs as on 07.05.2016. The last overhaul of engine was carried out on 21.08.2014.

The right Engine S/N ED0119 was manufactured on 03.11.2008 and had logged 17810 Hrs. as on 07.05.2016. The Right engine was overhauled on 01.05.2015.

1.6.2 Aircraft Description and Systems:

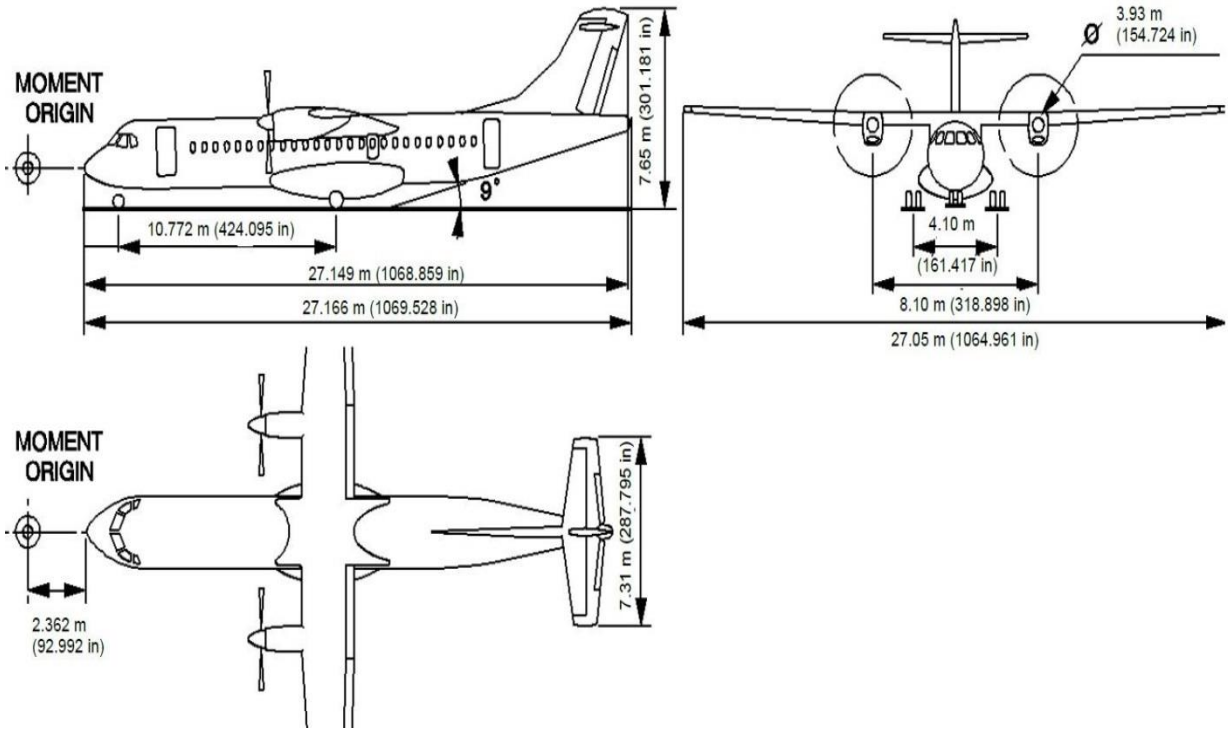

Fig 4

ATR-72-212A aircraft is certified in the Transport Category, JAR25 and ICAO annex 16 for day and night operations, in the following conditions when the appropriate equipment and instruments required by the airworthiness and operating regulations are approved, installed and in an operable condition :

- VFR and IFR
- Flight in icing conditions.
- Reverse thrust taxi (single or twin engine)

As per the Airframe Manual Minimum flight crew requirement is two. It can seat a maximum of 74 passengers as limited by emergency exit configuration. It has a length of 27.16 m and wingspan of 27.05 m. Wing reference area is 61m^2. Maximum permissible Take-off weight is 22500 Kgs and maximum permissible landing weight is 22350 Kgs.

1.6.2.1 Aircraft Braking

Main Landing gears are equipped with hydraulically operated multidisc brakes. The normal braking is provided with hydraulic pressure from the green system and is equipped with antiskid mechanism.

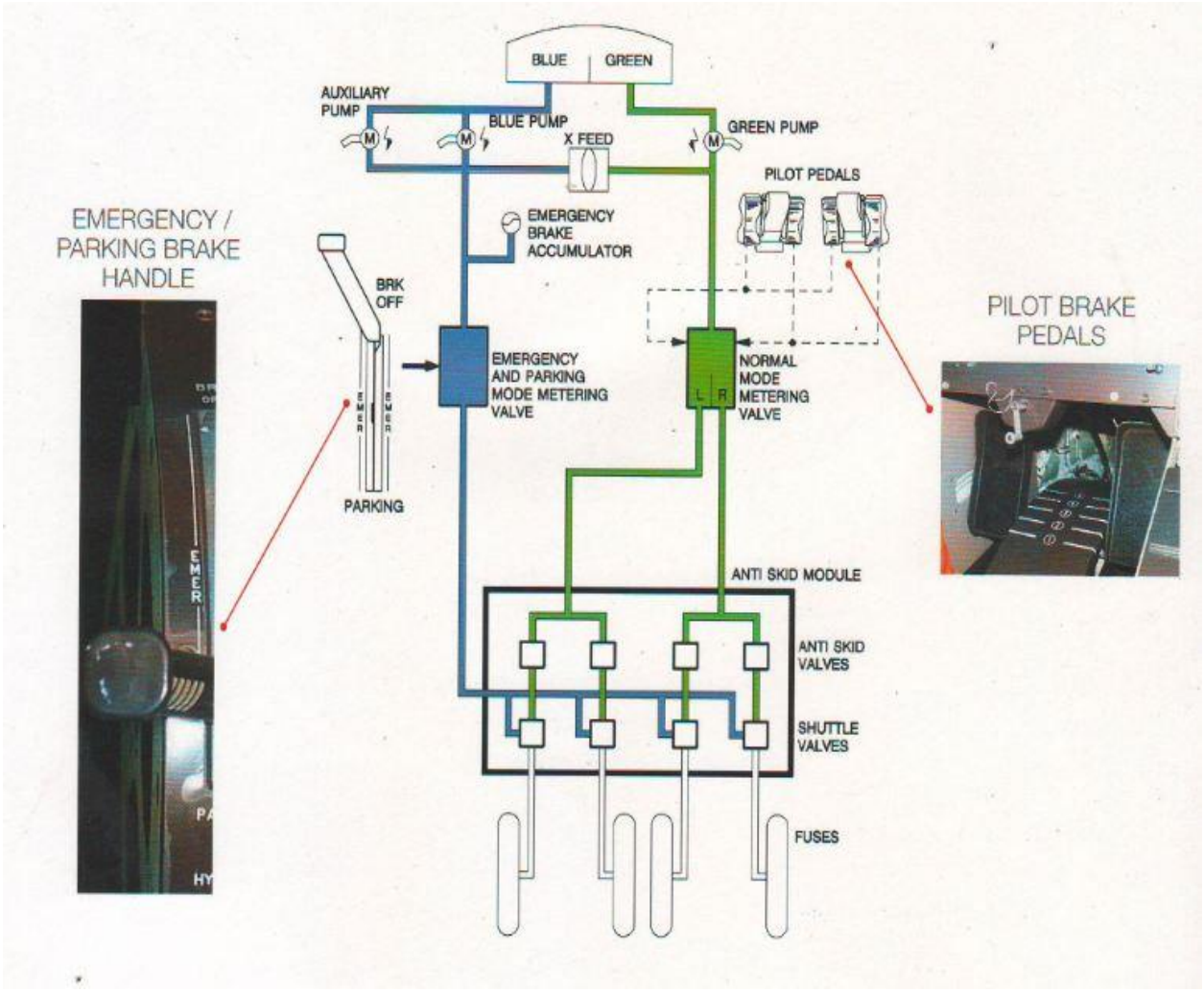

Fig 5 : Normal and Emergency Braking Schematic and controls

In case of failure of normal braking, emergency braking is obtained by pulling the brake handle on flight compartment pedestal. The hydraulic pressure to the emergency

braking is supplied by the blue system through an accumulator capable of six complete braking action.

1.6.2.2 Steering System

The steering system allows the Nose wheels to be steered during taxiing or parking to enable aircraft maneuverer on ground. Maximum angle of deflection to right or left is 60 degree from centre. Nose wheel steering system is controlled through the nose wheel steering switch and a hand wheel located on left side of cockpit. The Hydraulic supply to operate the system comes from Blue Hydraulic System.

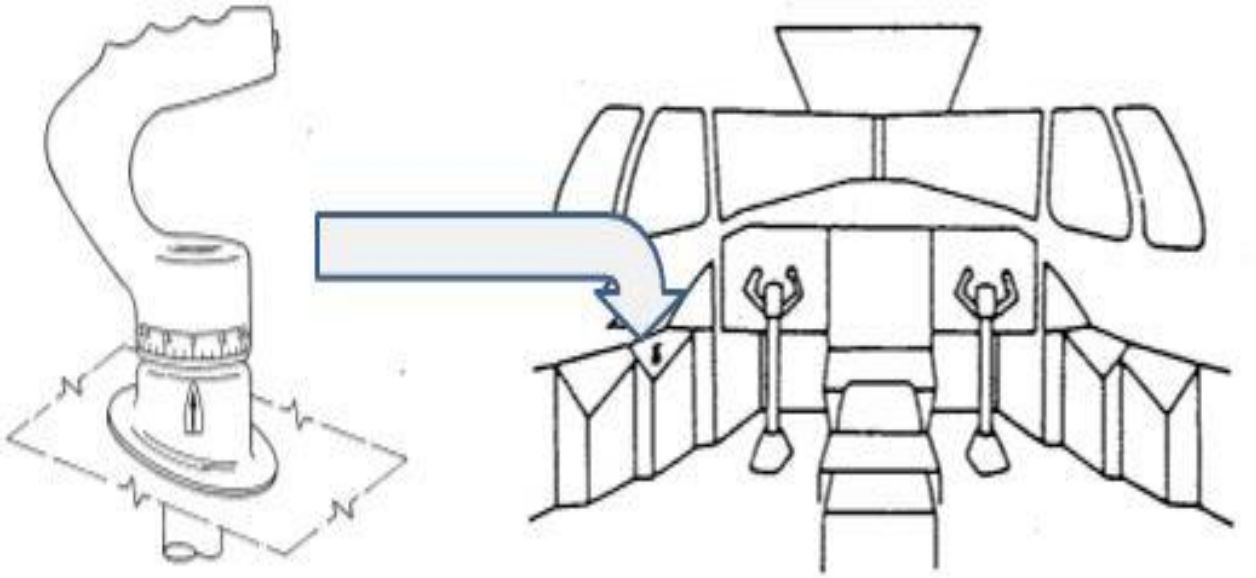

Fig 6: Nose Wheel Steering Handle and its position in cockpit

1.7 Meteorological information.

As per the met report for Indore, at 1400 UTC the winds were 340º and 14 Kt. The visibility was 5000m with feeble thunderstorm and rain. There were few clouds at 2000ft, scattered clouds at 2500 feet and CB clouds at 3000 feet. There were CB clouds in south west direction and overhead. No significant change was predicted.

The METAR at 1330 UTC indicated similar weather except for winds which blew from 120º at 07 Kt and CB clouds in South direction. No significant change was predicted.

Similar weather was also recorded at 1300 UTC with winds blowing from 100º at 09 Kt and CB clouds in South east direction and overhead. The visibility remained at 5000 m. There was no significant change predicted.

As per the ATC transcript the observed winds from tower at 1401 UTC was 100º and 12 Kt. The winds were varying between 330º and 120º and gusting upto14 Kt. The crew was also cautioned by the ATC about moderate rains on the airfield and wet runway surface with water patches on Runway.

1.8 Aids to navigation

Indore Airport is equipped with following Navigation Aids and Landing Aids.

Type of aid CAT of ILS/ MLS (for VOR /ILS/ MLS give VAR)	ID	Frequency	Hrs of operation	Site of transmitting antenna Coordinates	Elevation of DME trans-mitting antenna	Remarks
1	2	3	4	5	6	7
DVOR	**IID**	**116.7MHz**	**AS ATS**	**224238.2N 0754646.2E**	---	---
DME (VOR)	**IID**	**1138/1201MHz**	**DO**	**224322.1N 0754824.3E**	**561.7 MTS (1848 FT)**	**COLOCATED WITH VOR "IID"**
NDB	**ID**	**335 KHz**	**DO**	**224347.1N 0754836.3E**	---	---
LLZ 25 ILS Cat.I	**IIDR**	**110.9MHz**	**DO**	**224258.1N 0754719.3E**	---	**CW-TX1/TX2: 3.34/3.3°**
GP 25 ---		**330.08MHz**	**DO**	**224329.1N 0754835.3E**	---	**GP ANGLE – TX1/TX2 : 2.99° / 3° RDH 50FT**
DME (ILS)	**IDR**	**1070/1007MHz**	**DO**	**224329.1N 0754835.3E**	**559.5 Mts 1836 ft**	**COLOCATED WITH GP 25**

1.9 Communications

Details of ATS communication facilities available at Indore airport are as below.

Service Designation	Call Sign	Frequency		Hours of operation	Remarks
		Main	Alternate		
1	2	3		4	5
TWR	**INDORE TOWER**	**122.8 MHz**	**118.50 MHz**	**AS ATS**	**NIL**
APP	**INDORE APPROACH**	**122.8 MHz**	**118.50 MHz**	**AS ATS**	---
DATIS	----	**127.6 MHz**		**AS ATS**	---

1.10 Aerodrome information

The aerodrome at Indore is called Devi Ahilya Bai Holkar Airport. ICAO nomenclature for the airport is VAID and IATA nomenclature is IDR. The airport is maintained and managed by Airport Authority of India. The details of the airport are as below.

Co-ordinates

ARP : 22°43'24" N 75°48'19.7" E

Elevation : 1840 Ft.

Runway Orientation and dimension

Orientation: 07/25

Dimension: 2750MX45M

Threshold Elevation Runway 07: 1836 Feet

Threshold Elevation Runway 25: 1837 Feet

The declared distances are as below.

RWY	TORA	ASDA	TODA	LDA	REMARKS
07	2750m	2750m	2750m	2750m	NIL
25	2750m	2750m	2750m	2750m	NIL

R/W & Taxi Tracks Markings Standard as per Annex- 14

Details of Approach and Runway Lighting are as below:

RWY Designator	APCH LGT TYPE LEN INST	THR LGT COLOUR WBAR	VASIS (MEHT) PAPI	TDZ, LGT LEN	RWY Centre Line LGT Length, spacing Colour INTST	RWY edge LGT LEN spacing colour INTST	RWY End LGT Color WBAR	SWY LGT LEN(M) Colour	Remarks
1	2	3	4	5	6	7	8	9	10
07	SALS 420 Mt LIH	GREEN	PAPI LEFT/3° (15.43 M)	NIL	NIL	2750M / 60M, WHITE LIH	RED	NIL	NIL
25	SALS 420 Mt LIH	GREEN	PAPI LEFT/3° (15.186 M)	NIL	NIL	2750M / 60M, WHITE LIH	RED	NIL	NIL

Details of fire fighting facilities available are as below.

1	AD category for fire fighting	As per ATS HR, CAT VII
2	Rescue equipment	02 CFT & AMBULANCES +01STANDBY
3	Capability for removal of disabled aircraft	NIL(LOCALLY NOT AVAILABLE BUT EVERY AIRLINES AT INDORE has an arrangement with AIR INDIA, MUMBAI Which has IATP Disabled Aircraft Removal Kit available with it at Mumbai Airport)
4	Remarks	NIL

As per the statement of both the crew the runway condition apart from being wet was not very good. DGCA had conducted surveillance of Indore airport for aerodrome licensing in August 2012 as per the non-compliance report *"The runway was re-surfaced in 2008. The top layer of aggregate is loosening and spreading on entire runway thereby generating hazard of FOD on the runway, taxiway and apron"*.

The DGCA had conducted last surveillance of Indore Airport on 26.11.2014. As per the non-compliance report *"Surface condition of runway is very bad. Loose pebbles are observed throughout the runway. There are depression and pot holes at many places on the runway, It is safety hazard to aircraft."* The picture below shows the surface condition of runway near area where aircraft exited the runway

Fig 7

As per the Action Taken Report provided to the COI, both the non-compliances were still open, as on 31.03.2016. The tender for resurfacing was awarded, but the work was under progress, and in the meanwhile regular removal of gravels was being done through runway cleaning contract. The potholes were also being repaired as per operational requirement. The expected date of completion was stated as 30.11.2016.

1.11 Flight recorders:

The aircraft was equipped with DFDR and CVR units. The detail of the DFDR and CVR equipment is as below.

DFDR Details:	**CVR Details:**
Make: L3 Aviation Recorders Model: FA2100 Part No. : 2100-4045-00 S/N: 000849127	Make: L3 Communications Model: A200S Part No. : S200-0012-00 S/N: 000107175

1.11.1 CVR readout:

The CVR unit of the aircraft was downloaded at CVR laboratory of DGCA, India using digital audio playback unit. Using the Fleximusic software, 06 audio files were created during the download for different channels in different modes. Following were the output files and there durations.

1. CAM – HQ : 00:30:25 Hrs
2. CAM – SQ : 02:01:58 Hrs
3. CH 1 – HQ : 00:30:35 Hrs
4. CH 2 – HQ : 00:30:35 Hrs
5. CH 3 – HQ : 00:30:35 Hrs
6. COMB – SQ :02:02:03 Hrs

The quality of audio recording was good and recording was audible. Following are the extract from CVR recordings for some events;

Time(UTC)	Event
14:10:06	Autopilot disconnected
14:11:00	Radio Height Annunciation “TEN” is heard
14:11:17	Co-Pilot is heard shouting “RIGHT RIGHT”
14:11:24	Sound of aircraft hitting the uneven surface
14:11:31	PIC is heard Shouting “STOP”
14:11:52	ATC is requested for assistance
14:13:48	ATC is informed that all passengers are OK
14:15:39	Cabin crew is instructed to open doors for normal deplaning.
14:16:16	Cabin Crew requests passengers to deplane.

1.11.2 DFDR Read out

The raw data from DFDR was downloaded at CVR FDR Laboratory of DGCA, India using a portable interface unit. Partial download was carried out and file named *JCX.FDR* of 14340 KB size was created, containing data of last approximately 10 Hrs.

Main events vis-a-vis travel of aircraft on runway and off the runway after landing as per the report provided by BEA, France are appended below.

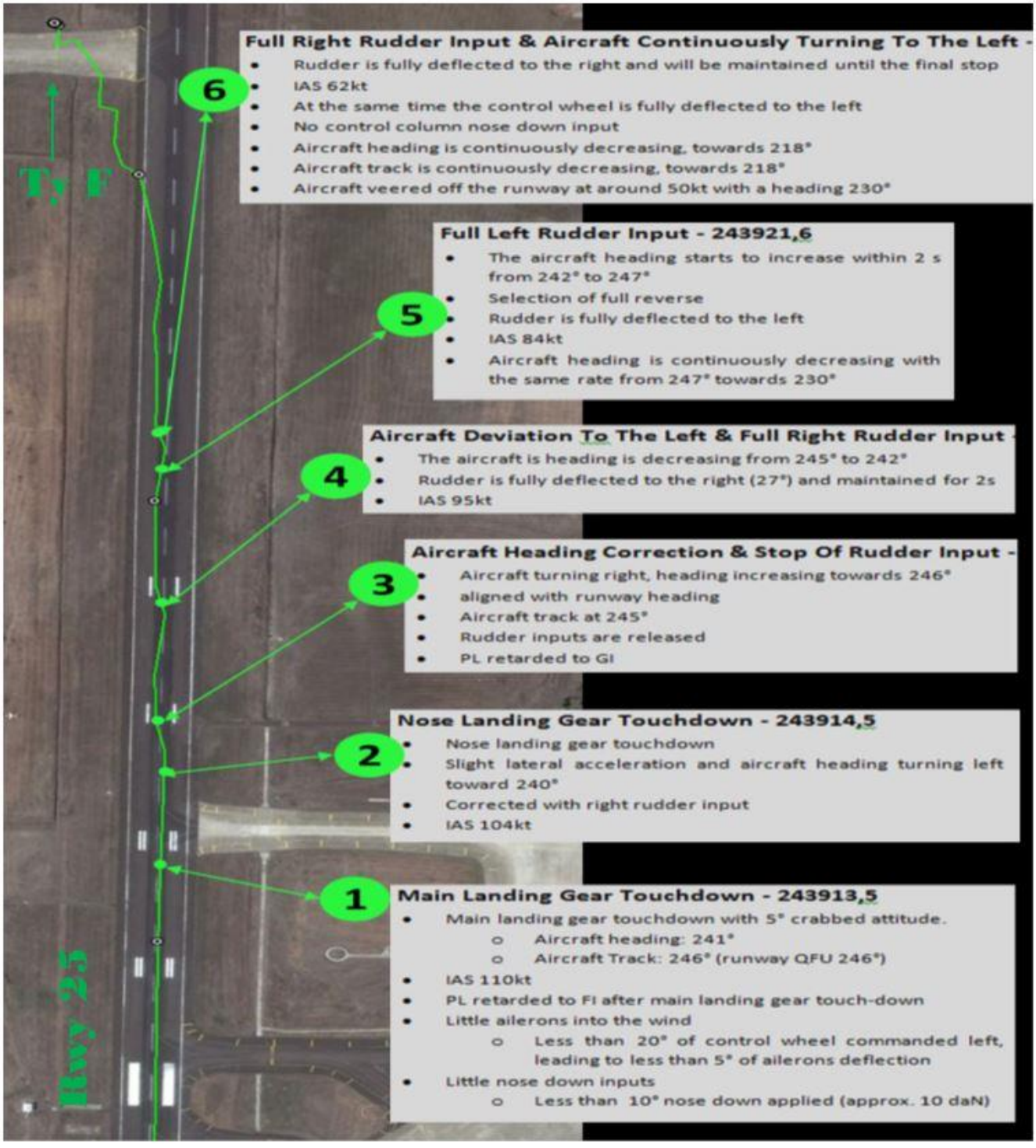

Fig 8

The data was sent to BEA, France for conversion into engineering parameters and plots. CSV file containing the engineering parameters for accident flight was also obtained from the operator and both the data were used for co-relation with CVR.

1.12 Wreckage and impact information:

The aircraft exited the runway on the right at a distance of approximately 1300m from Rwy 25 threshold.

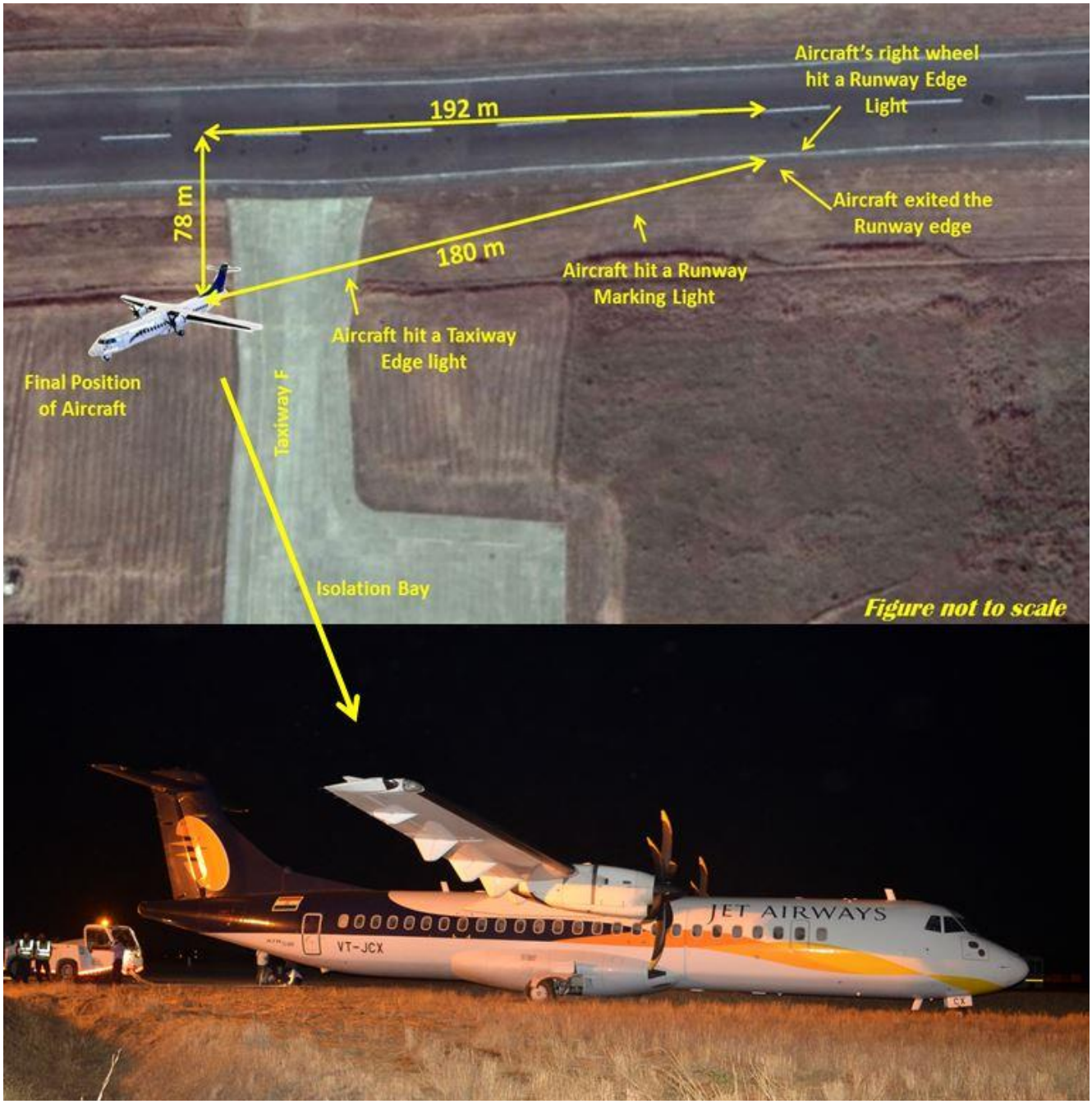

Fig 9

Its right wheel hit a Rwy edge light and aircraft travelled around 180 m in unpaved surface while hitting a Rwy marking sign and crossed over the taxiway F, hitting a Twy edge light and came to stop across the Twy. The final position was approximately 78 m from the Rwy edge.

Fig 10

1.13 Medical and pathological Information:

The crew had undergone breath analyser test at Delhi prior to flight as require by CAR Section 5, Series F, Part III which was satisfactory. Post flight medical examination was carried out at District Hospital, Indore and no injury to any of the crew was observed. Crew was not found to be under influence of alcohol in post flight medical examination.

1.14 Fire:

There was no fire reported on aircraft before or after the accident. Emergency evacuation was not carried out. The crew carried out normal deplaning of passengers on the taxiway and passengers were carried to terminal building in ambulance and buses.

1.15 Survival aspects:

The accident was survivable

1.16 Tests and research: NIL

1.17 Organizational 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 Air operator permit of the Airline is valid till 12/02/2018. The airline commenced its operations on 5th May 1993.

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 is a Senior Vice President in the company who reports directly to the Chairman

The airlines operate a fleet of aircraft, which includes 09 Airbus A330-200/300, 10 Boeing 777-300 ER aircraft, 76 Boeing 737-700/800/900/900ER aircraft and 18 ATR 72-500/600 turboprop aircraft.

1.17.1 Normal Procedures for Landing:

The PIC is seated on left seat and Co-Pilot is seated on right seat and function of PIC and Co-Pilot as Pilot Monitoring and Pilot Flying are defined in the Flight Crew Training Manual published by manufacturer and also in company's standard operating procedure.

The cockpit procedures during landing as per the company's standard operating procedure are quoted as below;

2.21.22 Landing

Flight Events	PM	PF
When PF disconnects Autopilot (press twice to cancel cavalry charge) Upto 160 ft (CAT I) and 80 ft (CAT II)		**Announce :** Autopilot OFF
RA Information at 10 ft	**Do :** FLARE.....PITCH MONITOR	**Do :** PL ..... FI
On RWY (Both Low Pitch Lights Illuminated)	**Check and Announce :** "2 Low Pitch"	**Do :** PL .....GI **Do :** PL ..... Reverse As Rqd
Reaching 70 kts	**Announce :** 70 KT	

Note: *Use reverse to full stop only if necessary, according to the local noise abatement regulation .It is recommended to return to GI position at 40 kt to avoid flight control shaking.*

Reverse Policy :

Engines	Lo Pitch Lights	PM Announces	PF Action on Reverse
2 Engines	Two Illuminated	"Two Low Pitch"	Normal Use
	Only One Illuminated	"No Reverse"	No Use, Maxi Yaw Effect
1 Engine	One Illuminated	"One Low Pitch"	Use With Care, Yaw Effect

Flight Events	CM1	CM2
When PM Calls 70 Kt	**Announce :** I Have Control	
Flight Control Transfer	**Do :** Steering Control ..... Hold Normal Brakes.....Applied	**Do :** Control Wheel.....Hold Into the Wind

Fig 11

The airline's operational procedures do not require crew to use differential braking and same is also not taught to crew during training. Only type rated instructors are permitted to use differential braking during take-over while imparting training.

1.18 Additional information

1.18.1 Crosswind Landing Techniques

Crosswind Landings require special methods for executing the landing. The two common methods generally used for landing in cross winds are crabbed approach method and sideslip approach method.

In crab approach method flight heading is adjusted so as to keep the aircraft track aligned with the runway center line. The nose of aircraft points into the wind and the aircraft is slightly skewed with respect to the runway. This method requires pilots to maintain crab into the flare and correct just as the aircraft touches so as to align with the runway. Upwind aileron input is required to keep the aircraft level as rudder is applied to maintain the track.

In sideslip approach method the nose of aircraft is aligned using rudder and aircraft is banked to stop sideways motion during final approach and touchdown.

In both the methods, the aileron input is required to be progressively increased up to full deflection during the landing roll as airspeed decreases.

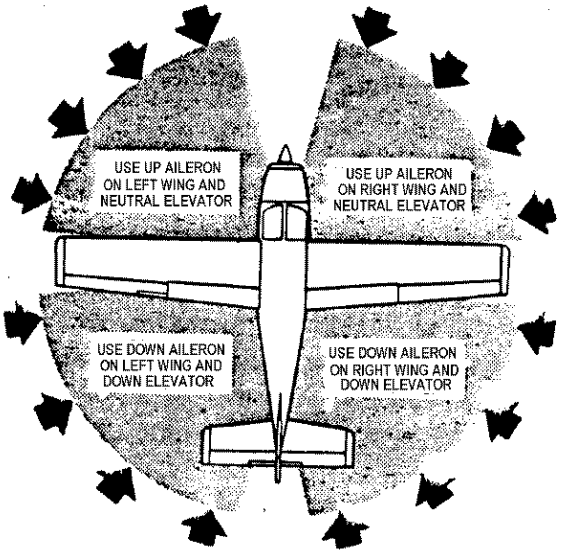

Fig 12

At lower speeds the nose down input helps in increasing directional stability by applying higher load on nose wheel if using nose wheel steering. The figure above depicts use of controls in different wind conditions.

1.18.2 Rudder Efficiency

The aerodynamic efficiency of the flight control surfaces such as rudder is related to with square of the speed and proportional to deflection; the graph below is plotted using data from the DFDR and represents the rudder deflections efficiency as a function of time during the event sequence. With the same deflection, the efficiency of the rudder between the first rudder deflection at 95Kt and the second at 62Kt, in 7 seconds, has been reduced by more than half. Below 60Kt the rudder efficiency drops quickly to null efficiency.

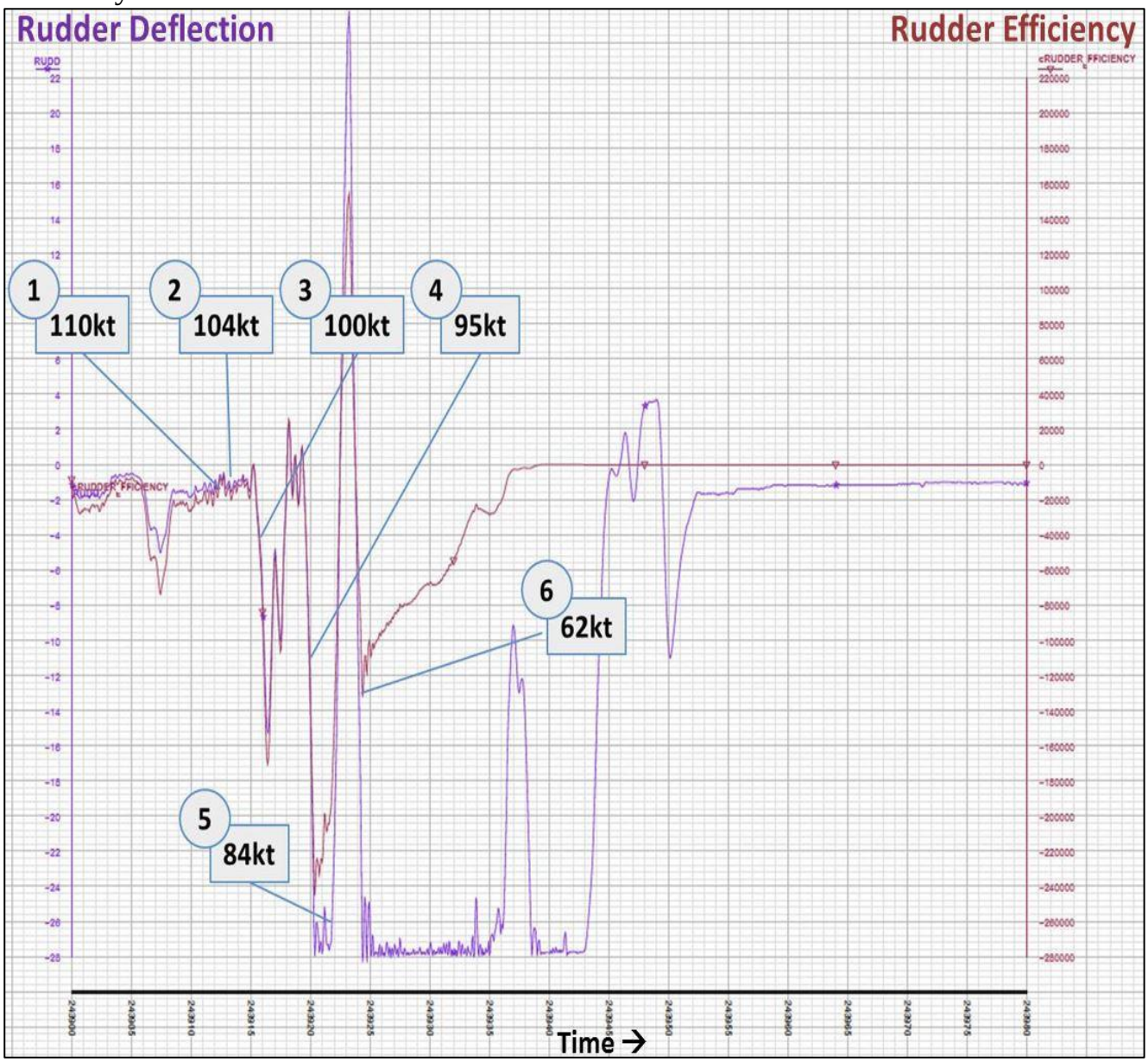

Fig 13

In addition, the graph attached also shows the effort applied on the rudder pedals, the diminution of the effort to maintain the mechanical stop of the rudder illustrates the rudder's decreasing effectiveness from the reducing force needed on the rudder pedals.

1.19 Useful or effective investigation techniques:

NIL

2. ANALYSIS

2.1 Serviceability of the aircraft:

The aircraft had a valid certificate of airworthiness on the date of accident. The last major inspection on the aircraft was carried out at in Mar 2016. Aircraft did not have any pending snag and was neither operating under any MEL.

Both the engines were serviceable and did not have any pending snags. Aircraft was maintained as per the approved program and was airworthy on the date of accident. The aircraft had clocked 9664:29 Hrs on the day of accident. Serviceability of the aircraft did not have any bearing on the accident.

2.2 Weather

As per the met report for Indore, the visibility was more than 5000 m at 1400 UTC. Feeble thunderstorm and rain were reported and there were few clouds at 2000ft, scattered clouds at 2500 feet and CB clouds at 3000 feet. There were CB clouds in south west direction and overhead. No significant change was predicted. The winds were 340º and 14 Kt.

However from the CVR and ATC recording it is observed that winds were varying between 330 degree and 120 degree and gusting up to 14 Kt.

With application of correct procedure weather could not possibly have been a contributory factor in accident.

2.3 Runway Condition:

It is evident from the CVR and ATC recording that crew was cautioned by the ATC about moderate rains on the airfield and wet runway surface with water patches on Runway.

DGCA had reported following non-compliances during the surveillances conducted in August 2012 and Nov 2014 respectively.

- *"The runway was re-surfaced in 2008. The top layer of aggregate is loosening and spreading on entire runway thereby generating hazard of FOD on the runway, taxiway and apron".*
- *"Surface condition of runway is very bad. Loose pebbles are observed throughout the runway. There are depression and pot holes at many places on the runway, It is safety hazard to aircraft."*

As per the last Action Taken Report dated 31.03.2016 before the accident, provided to COI, both the non-compliances were still open. The tender for resurfacing was awarded, but the work was under progress, and in the meanwhile regular removal of gravels was being done through runway cleaning contract. The potholes were also being repaired as per operational requirement. The expected date of completion was stated to be 30.11.2016.

It is evident that from the photographs, inspection report and statements of pilot that, condition of the runway had deteriorated and was a contributory factor in accident.

2.4 Pilot Handling

It is observed from the DFDR and CVR analysis that crew disconnected the auto pilot at 14:10:06 UTC while aircraft was little more than 600 feet radio altitude.

It is observed that, the crew carried out approach with a crabbed angle of about 5^{o}, in 10kt crosswind component. The aircraft was not de-crabbed during flare and aircraft touched down at approx14:11:08 UTC with a 5^{o} drift at 110Kt and, with power lever at Flight Idle and less than 5 degree aileron into air.

The aircraft continued in crab configuration as the nose landing gear touched down and aircraft started deviating to left. Right rudder was applied for correction and aircraft was brought back to track, however at no time during the landing phase the recordings showed more than a slight use of ailerons into the wind.

As the PIC struggled to bring power lever to ground idle, First officer tried to check if idle gate was locked and their hands obstructed each other. The power lever was later brought down to ground idle by PIC with some effort resulting in aircraft deceleration and Right rudder input was released.

Release of rudder, with insufficient or no aileron into air and nose down inputs, caused the aircraft to again deviate to left due to wind cock effect.

The crew applied right rudder again for approximately 02 seconds to correct the left heading deviation, and a rate of heading change of 3^{o}/s to the right was induced with heading reaching 248^{o}. Meanwhile full thrust reverser was applied. The airspeed had by then reached 95Kt.

This heading excursion was immediately followed by a full left rudder input from the crew, which induced a rate of heading change of 2^{o}/s to the left, while the aircraft speed dropped to 84Kt and continued to drop. This was followed immediately by another full right rudder input which will be maintained until the full stop of the aircraft. However, as the aircraft slowed down, the rudder became less and less effective.

Co-Pilot saw the aircraft veering towards left before the speed reached 70 Kt and is heard shouting "RIGHT RIGHT" at approx. 14:11:17 UTC in the CVR. The PIC did not use nose wheel steering to control the aircraft, as First officer had not called out "70 Knots" as per landing procedures. The aircraft left the runway and entered unpaved surface at approx. 14:11:24 UTC as evident from the CVR, while its speed was around 50Kt.

Crew continued to apply right rudder, none of the crew used use differential braking to steer the aircraft. Use of differential braking was neither part of airline's procedures and nor taught to crew during training. PIC is heard shouting "STOP" at 14:11:31 UTC and full brakes were applied at 14:11:33 UTC bringing the aircraft to a complete halt at 14:11:35 UTC.

2.5 CVR and DFDR Analysis:

CVR recording was played and heard to analyse the flight and co-relate the events with ATC recordings and DFDR data. Various non-standard call outs were used by both the crew. PIC is heard asking First officer to control the Power Lever immediately after Auto pilot is switched off. During Flare the Co-pilot is heard calling *"thoda sa neeche, thoda sa neeche aur neeche bas upar upar (Translated as: little down, little down, Enough, Up Up)"* during the final approach. However these calls did not seem to have caused any confusion and calls were clearly followed by both crew.

As per the analysis report of the DFDR received from BEA, France;

"The initial crabbed attitude of the aircraft at nose- wheel touchdown initiated a lateral deviation that was corrected. The aileron into the wind and nose down inputs were not of sufficient magnitude to ensure on-ground proper directional stability.

As the initial right rudder correction was released, the aircraft departed again to the left due to wind cock effect. In reaction, the rudder was fully deflected and input maintained for 2s which induced a high rate of heading change to the right. In reaction, the rudder was fully deflected to the left inducing a high rate of heading change in the opposite direction, to the left.

Although a last full deflection of the rudder to the right was applied, the rudder efficiency decreased as the speed continuously decreased and did not allow recovering the deviation of the aircraft to the left."

The events in the CVR recording could also corroborated the events in the DFDR analysis.

2.6 Sequence of Events

Sr. No	UTC Time (approx.)	Event
1	14:10:06	Autopilot disconnected
2	14:11:00	Radio Height "TEN" annunciation heard.
3	14:11:08	Touchdown Wind Direction 193/10Kts Aircraft Heading 241 IAS 110 LH aileron deflected up by less than 5 degree Little Nose down applied PL retarded to FI
4	14:11:09	Aircraft begins to turn left. Application of Right Rudder.
5	14:11:11	Right rudder is released, as aircraft heads right PL retarded to GI
6	14:11:12	Aircraft again begin heading to left
7	14:11:13	Right Rudder is pressed and maintained for another 2seconds
8	14:11:14	Aircraft begins to turns right, reaching heading 248º
9	14:11:15	Full reverser is selected.
10	14:11:16	Full left rudder is applied IAS drops to 84 Kt Aircraft heads to left and heading continue to decrease.
11	14:11:17	Rudder is deflected to the right IAS drops drastically Control Wheel deflected to left Aircraft heading continue to decrease
12	14:11:18	P2 heard shouting "RIGHT RIGHT"
13	14:11:24	Aircraft veers out of Runway at around 50kts IAS and heading 230º.
14	14:11:32	PIC calls out "STOP"
15	14:11:33	Brakes are applied.
16	14:11:35	Aircraft comes to halt
17	14:11:52	ATC requested for assistance
18	14:16:16	Deplaning of passengers starts

3 CONCLUSIONS

3.1 Findings

1. Aircraft had a valid certificate of airworthiness and was certified and maintained in accordance with the approved maintenance schedule**.**
2. Both crew had the necessary qualifications to operate the flight and were current on the date of accident.
3. The last two surveillances carried out by DGCA at Indore airport were in Aug 2008 and Oct 2014.
4. The findings related to poor condition of runway were still open on the date of accident and expected date for closure of the same was 30.11.2016.
5. There was moderate rain over the airfield at the time of accident, with wet patches on runway and crew was cautioned of the same by the ATC. Reported visibility was 5000M
6. Crew used some non-standard call outs during the approach and landing.
7. Crew landed using crab approach to land in the crosswinds, however did not give sufficient aileron input after landing.
8. Co-pilot who was Pilot Monitoring did not gave standard call out "70 Kt" as he was cautioning the PF about the aircraft going left.
9. Crew applied Left rudder to turn the aircraft to left when the heading was almost 248, and the aircraft heading sharply changed to left. Thrust Reverser was applied simultaneously causing quick drop in speed.
10. Aircraft continued heading left as speed and rudder efficiency drops, even though full right rudder input is given.
11. Aircraft exited the runway on the left, approximately 16 seconds after touchdown.
12. Nose Wheel Steering was not used to steer the aircraft after the speed dropped and rudder efficiency diminished.
13. The crew did not use differential braking to control the aircraft as it was not part of airline's procedures.
14. Brakes were applied to stop the aircraft after aircraft had gone out of runway**.**
15. Aircraft travelled 180m on unpaved surface and crossed taxiway F after veering off the runway and came to halt at 78m from the runway edge.

16. Passenger evacuation was not carried out, instead, normal deplaning of passengers was carried out which led to some delay in getting passengers off the aircraft.

17. There was no injury to any passengers or crew.

3.2 Probable cause of the Accident:

Improper cross wind landing technique and failure to use nose wheel steering or differential braking after rudder efficiency was diminished due to decreasing speed caused the aircraft to veer out of runway.

The runway condition was a contributory factor.

4. Recommendations

4.1 Operator should reiterate the crew about the use of correct procedures while landing in crosswinds and use of standard call-outs.

4.2 DGCA should ensure time bound closure of non-compliances reported in surveillances and audits.

Jasbir Singh Larhga
Chairman, Committee of Inquiry

Capt. Rajiv Yadav
Member, Committee of Inquiry

Date : 18.05.2018
Place : New Delhi