GOVERNMENT OF INDIA
MINISTRY OF CIVIL AVIATION
AIRCRAFT ACCIDENT INVESTIGATION BUREAU

FINAL INVESTIGATION REPORT ON SERIOUS INCIDENT TO M/S SPICEJET LTD. BOEING B-737-800 AIRCRAFT VT-SGZ AT MUMBAI ON 19.09.2017

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INVESTIGATION REPORT ON SERIOUS INCIDENT TO M/S SPICEJET LTD. BOEING B-737-800 AIRCRAFT VT-SGZ AT MUMBAI ON 19.09.2017

1.	Aircraft		Boeing
		Type	B737-800
		Nationality	Indian
		Registration	VT-SGZ
2.	Operator		M/s Spicejet Ltd.
3.	Pilot – in –Command		ATPL Holder (FATA)
	Extent of Injuries		Nil
4.	Co-pilot		CPL Holder
	Extent of Injuries		Nil
5.	No. of Passengers on board		183
	Extent of Injuries		Minor
6.	Last point of Departure		Varanasi
7.	Intended landing place		Mumbai
8.	Place of incident/ Co-ordinates		Runway 09/27, 19^{o} 5' 17.916 '' N 72^{o} 50' 51.72'' E
9.	Date & Time of incident		19.09.2017/ 2155Hrs IST
10.	Phase of operation		Landing Roll
11.	Type of incident		Runway excursion

1 FACTUAL INFORMATION

1.1 History of the flight

On 19.09.2017 a Boeing 737-800 aircraft was involved in a serious incident of runway excursion at Mumbai while operating a scheduled flight from Varanasi to Mumbai. The flight was under the command of an ATPL holder pilot (Pilot Flying) and a CPL holder pilot as Co-Pilot (Pilot Monitoring). The Pilot Flying (PF) is a foreign national and was holding Indian FATA (Foreign Aircrew Temporary Authorization). There were 183 passengers and 06 crew members on board.

It was raining heavily at the time of landing. After landing on runway 27 the aircraft went 42 meters beyond runway 27 end and approximately 19 meters left of runway extended line.

Final position of the aircraft (nose wheels)

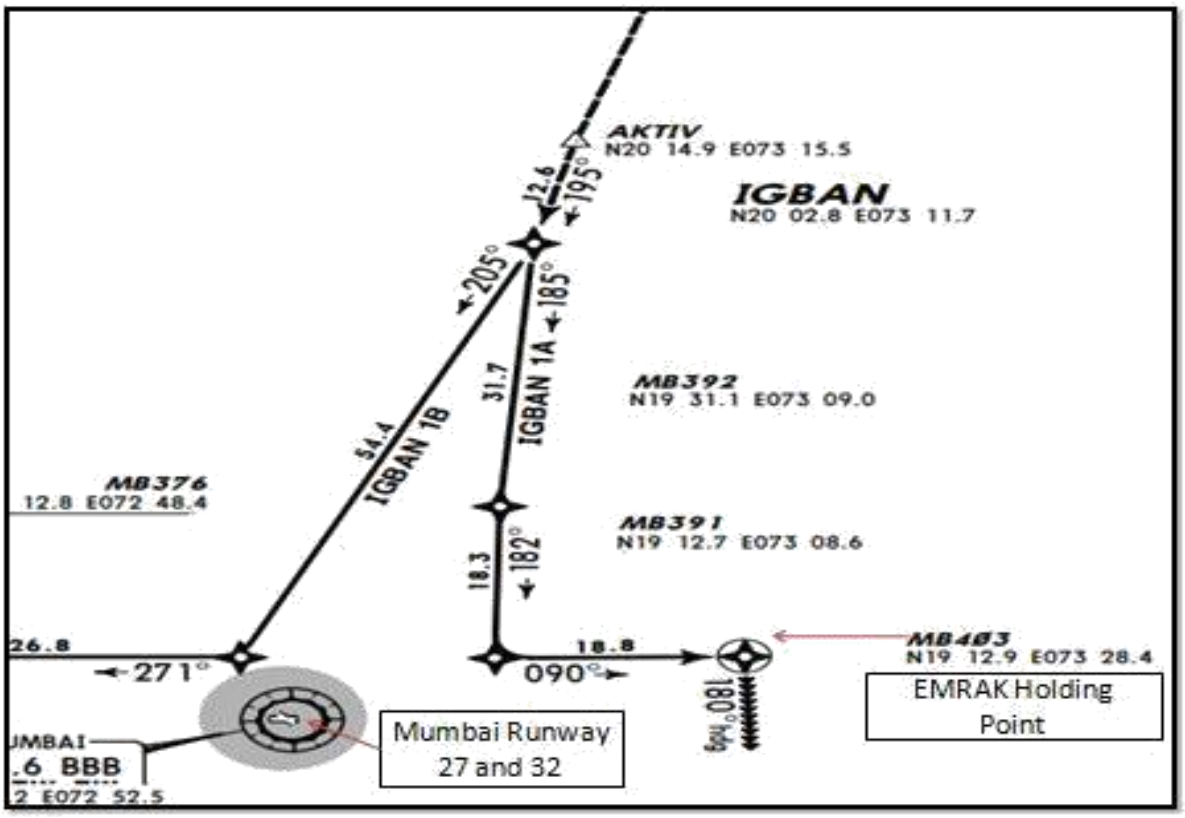
LH main wheels

RH main wheels

As it got stuck in the unpaved area, emergency escape slide chutes were deployed to evacuate the passengers. After evacuation 19 passengers and 5 crew members were attended by airport doctors out of which few were found to have sustained injuries and given first aid.

Before commencing the flight from Varanasi, the flight crew had carried out self briefing with the help of the folder provided by the flight dispatcher. The flight crew carried out detailed discussions among themselves about the weather, fuel uplifted (it was a tankering sector), runway in use, and NOTAMs issued for Varanasi, Mumbai and the alternate. In view of bad weather at Mumbai and anticipated traffic congestion, the briefing discussion also included go-around procedure, wind shear escape manoeuvre and stall recovery during approach.

At the time of take off all up weight of the aircraft was 69,000 kgs which included 11,500 kgs of fuel. The 1st alternate airport filed for the flight was Ahmedabad with a MDF (Minimum Diversion Fuel) of 3,374 kgs. The ETA for Mumbai was 2122 hrs (1552 UTC).



As per the crew departure from Varanasi and flight en-route Mumbai was normal barring some deviations carried out to avoid weather. Though the direct routing was given to the aircraft and was required to follow 'IGBAN1A', it diverted towards left due weather. The aircraft was then radar vectored and instructed to proceed to 'EMRAK'.

The aircraft was holding over 'EMRAK for around 20 minutes and thereafter it descended (radar vectored) to intercept localiser ILS runway 27. At 162107 UTC tower had transmitted the weather information to crew, viz. "continue approach runway 27 wind 310/12 knots, gusting upto 22 knots and heavy rain over the field".

At the time when the aircraft was established on approach there was wide body aircraft ahead and the ATC instructed the subject flight crew to maintain a lower speed of 180 kts., which was further reduced to 160 kts. in order to maintain the separation. The weather at that time (on approach) was gusty with heavy precipitation. The crew felt that automation system of the aircraft will not be possibly able to maintain speed as instructed by ATC. The PF therefore disconnected the autopilot and took over the controls manually at 2000 feet so as to sustain the desired separation with the traffic ahead.

Meanwhile, ATC gave clearance to other aircraft to line up on runway 27 when the traffic ahead of subject aircraft had landed safely. As per the flight crew the runway was visible when it was around 4 nm from the airport. At 162350 UTC the other aircraft had taken off from the runway 27 and thereafter clearance was given to the subject aircraft to land when it was about 2 nm from the runway. As per the PM, the aircraft was high during approach and PF made corrections for deviation in speed, path and rate of descent throughout, due to prevalent gusty conditions.

The aircraft had touched down beyond the touchdown zone, with flaps 30, speed brake up and auto brake 3. Subsequently, the PF pulled the thrust reverser and as per the crew the auto brakes were not that effective. Crew therefore applied brakes manually but were not able to stop the aircraft on the runway. The aircraft exited the runway 27 end, went into the unpaved area (RESA of RWY 27). As the ground was soft and it was raining heavily, the tyres of landing gears got stuck in soft ground. After following the checklist and confirmation by the ATC that there was no fire, evacuation was initiated

using L1 and L2 doors after deployment of the emergency escape chutes, as per the procedure. There was panic in the cabin, though evacuation was completed without any major injuries.

Due to aircraft being stuck on runway 09/27 and due bad weather (low visibility and tail winds) for runway 14/32 both runways were not available for operations and flight operations were severely affected. The aircraft was retrieved from the site only on 20.09.2017 at around 1530 hrs IST and the runway 09/27 was cleared for operations at around 1900 hrs IST on 21.09.2017.

1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	Nil	Nil	Nil
SERIOUS	Nil	Nil	Nil
MINOR/ NIL	06	183	Nil

1.3 Damage to Aircraft

The aircraft exited the runway end and got stuck into the unpaved surface. The damages suffered were consequential damages suffered while rolling on the soft ground and are given below:

- Both MLGs lower bracket found deformed.
- RH side air conditioning composite panel found punctured (3.5 by 4.5 inches).
- ATC Antenna found cracked.
- RH MLG tacho generator cable was found damaged.
- Inboard and outboard fan cowls damaged at 6 O'clock position just forward to thrust reverser cowl.
- Inboard thrust reverser sleeve found with extensive honeycomb damage.
- Inboard thrust reverser assembly corner buckled on leading edge at mating portion of fan cowl at 7 O'clock position
- Minor dents on inlet cowl acoustic panel of RH engine at 4, 8 & 12 O' Clock position.

- 17 fan blades of RH engine had damages. Engine fan
- cowl latch bracket was found broken. (Photographs indicating damages are at Annexure I)

1.4 Other damages

NIL

1.5 Personnel information

1.5.1 Pilot – in – Command

AGE	: 40 Yrs 10 Month
Licence	: ATPL (and FATA)
Category	: Multi Engine
Date of Issue	: 30-MAY-14
Validity of Licence	: 31-DEC-17
Endorsements as PIC	: B 737 variants
Date of Medical Exam	: 05-JUN-17
Med. Exam valid upto	: 31-DEC-17
FRTO Licence No.	: 5264
Date of issue	: 30-MAY-14
Total flying experience	: 7113:37 Hrs
Experience on type	: 4340 Hrs
Experience as PIC on type	: 3140 Hrs
Total flying experience during last	
180 days	: 144:51 Hrs
90 days	: 144:51 Hrs
30 days	: 95:02 Hrs
07 Days	: 26:12 Hrs
24 Hours	: 04:32 Hrs

The FATA in favour of the PF was issued on 12.7.2017 for a period of 3 months and was valid till 12.10.2017. He had undergone ground and simulator training(s) for monsoon flying.

1.5.2 Co-Pilot

AGE	: 32 Yrs
License	: CPL
Category	: Multi Engine
Date of Issue	: 01-Sep-11
Validity of Licence	: 31-Aug-21
Endorsements as Co-Pilot	: B 737 700/800/900
Date of Medical Exam	: 21-FEB-17
Med. Exam valid upto	: 28-FEB-18
FRTO	: 16502
Total flying experience	: 1163 Hrs
Experience on type	: 839:03 Hrs
Last flown on type	: 19-SEP-17
Total flying experience during last	
180 days	: 410:40 Hrs
90 days	: 231:31 Hrs
30 days	: 81:55 Hrs
07 Days	: 30:10 Hrs
24 Hours	: 04:32 Hrs

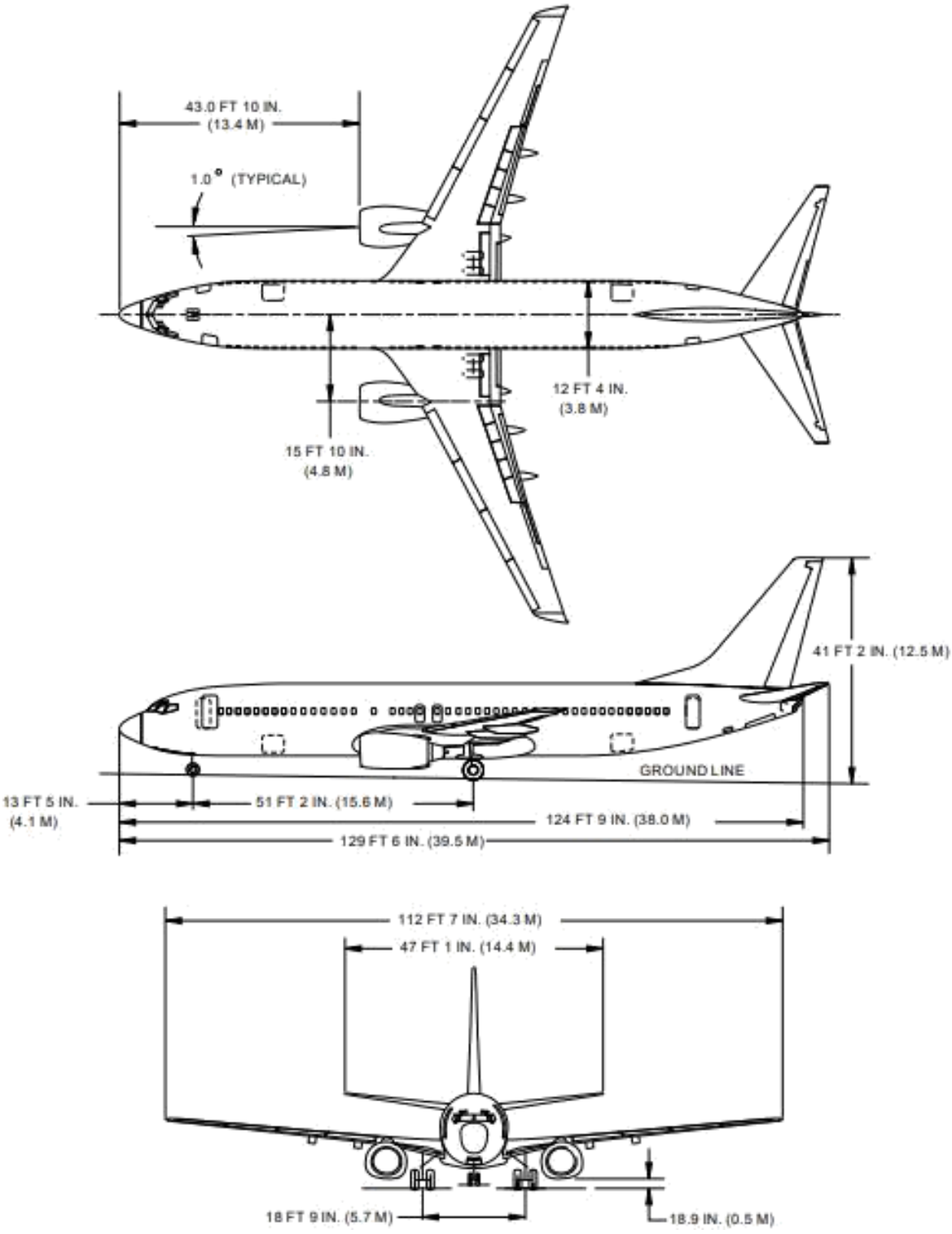
None of the operating crew was involved in any serious incident/ accident in past.

1.6 Aircraft Information

Boeing B737-800 is a subsonic, medium-range, civil transport aircraft. The aircraft is installed with two high bypass turbofan engines manufactured by International Aero Engines. The aircraft is designed for operation with two pilots and has passenger seating capacity of 189. The aircraft is certified in Normal (Passenger) category, for day and night operation under VFR & IFR. The maximum all up weight authorised is 70987 Kg. The Maximum Landing weight is 65770 Kg.

The subject aircraft bearing MSN 39423 was manufactured in the year 2012. The aircraft was registered with DGCA, India under the ownership of

M/S CIT Aerospace Ltd. Ireland. The aircraft is registered under Category 'A' with Certificate of registration No. 4325.



The Certificate of Airworthiness Number 6434 under "Normal category" subdivision Passenger / Mail / Goods was issued by DGCA on 10th May 2012. At the time of incident the Airworthiness Review Certificate was current

and was valid up to 11th May 2018. The aircraft was powered with two CFM Engines. The details of the Engines are as below:

	Engine # 1	Engine # 2
Engine Model	CFM56-7B	CFM56-7B
Serial Number	892690	960814
TSN	37404:50	20774:09
CSN	24962	12806

The aircraft and its engines were being maintained as per the maintenance program consisting of calendar period/ flying hours based maintenance program approved by DGCA India. As per the airframe log book, as on 19th Sep 2017 the aircraft had logged 20774:09 hrs and 12806 landings since new. The aircraft was last weighed on 18th Aug 2016 and as there was no major modification affecting weight & balance since then.

Brake System

For the purposes of operation of various systems and controls including brakes there are three hydraulic systems viz main, alternate and standby. The standby system can be used in emergency, if main and alternate system pressure is lost. Either main or alternate hydraulic system can power all flight controls with no decrease in aircraft controllability.

Each main gear wheel has a multi–disc hydraulic powered brake. The brake pedals provide independent control of the left and right brakes. The nose wheels have no brakes. The normal brake system is powered by main hydraulic system and the alternate brake system is powered by alternate hydraulic system. If main hydraulic system is low or fails, alternate hydraulic system automatically supplies pressure to the alternate brake system. The brake accumulator is pressurized by main hydraulic system. If both normal and alternate brake system pressure is lost, trapped hydraulic pressure in the brake accumulator can still provide several braking applications or parking brake application.

The autobrake system uses main hydraulic system pressure to provide maximum deceleration for rejected takeoff and automatic braking at preselected deceleration rates immediately after touchdown. The system operates only when the normal brake system is functioning.

Antiskid protection is provided in the normal and alternate brake systems. The normal brake hydraulic system provides each main gear wheel with individual antiskid protection. When the system detects a skid, the associated antiskid valve reduces brake pressure until skidding stops. The alternate brake hydraulic system works similar to the normal system however antiskid protection is applied to main gear wheel pairs instead of individual wheels. Both normal and alternate brake systems provide skid, locked wheel, touch-down and aquaplane protection. Antiskid protection is provided during autobrake operation and is available even with loss of both hydraulic systems.

1.7 Meteorological information

The incident occurred at 1625 UTC (21:55 IST) and the METAR of 1600 hours UTC (after sunset) was valid at the time of incident. Weather information prior to and after the incident was as follows:

Time in UTC	Wind Direct-ion	Speed (K)	Vis (m)	Weather	Clouds	Temp (°)	Dew Point	QFE hPa	QNH hPa
1500	280	17	1500	FBLSHRA	SCT, OVC & FEW CB	26	25	29.70	29.68
1530	300	12	1000	FBLSHRA	SCT, OVC & FEW CB	26	25	29.73	29.72
1600	300	12	0700	FBLTSRA	SCT, OVC & FEW CB	26	25	29.71	29.70
1630	300	16	0800	FBLTSRA	SCT, OVC & FEW CB	25	24	29.72	29.70
1700	300	08	0900	FBLTSRA	SCT, OVC & FEW CB	25	25	29.74	29.72
1730	290	15	1200	MODRA	SCT, OVC & FEW CB	26	25	29.70	29.67

1.8 Aids to navigation

Mumbai airport is equipped with VOR (frequency 116.60 MHz), DME (frequency 1200/1137 MHz), NDB (frequencies 396 kHz), ASDE (frequency 9375 MHz). PAPI & ILS Cat- II is installed on Runway 27. PAPI &ILS Cat-I is installed at 09 & 14 and SALS (Short Approach Lighting System) is installed at Runway 32.

1.9 Communications

At the time of incident the aircraft was in contact with Mumbai ATC on frequency118.1 MHz. There was always positive two way communications between the Flight Crew & ATC throughout the flight. The Communication was also satisfactory between aircraft and SMC Controller Mumbai Ground (121.9 MHz).

1.10 Aerodrome information

The CSIA (Reference point 19° 05' 30" N 072° 51' 58" E) is a licensed airport both for IFR and VFR traffic with IATA location Identifier code as BOM and ICAO location Indicator code is VABB. The elevation (AMSL) is 12.13 m (40 ft) with reference code as 4F. The airport has two cross runways made of Asphalt. The details of these runways are as given below:

- Rwy 27 -- 3448m × 60m
- Rwy 09 -- 3188m × 60m
- Rwy 14/32 -- 2871m × 45m

Runway	TORA (M)	TODA (M)	ASDA (M)	LDA (M)	RESA (M)
09	3188	3188	3188	3048	240 X 120
27	3448	3448	3448	2965	240 X 120

1.11 Flight recorders

The aircraft was equipped with both SSCVR and SSFDR. The data from both these recorders was downloaded and analysed for the investigation purposes.

1.12 Wreckage and impact information

The aircraft had flared for a long duration and touched almost at the end of touch down zone and overshot the runway. After travelling for around 42 m in the soft ground, both the main landing gears and nose landing gear got stuck into the soft ground. The incident occurred in night conditions and

the aircraft has stopped in the RESA area. (Photographs are attached as Annexure I)

Defueling was carried out (2.3 tons) along with off loading of baggage (1161 kgs.) and cargo (473 kgs.) prior to recovery/ removal of the aircraft using the IATP kit provided by Air India. After recovery and removal of the aircraft, the runway was handed over to ATC during early morning hours of 21.9.2017.

1.13 Medical and pathological Information:

The crew had undergone pre-flight medical at Hyderabad before departure as per requirement of CAR Section 5, Series F, Part III. The test was satisfactory and the breath analyser test was negative.

1.14 Fire

There was no fire either before or after the incident.

1.15 Survival aspects

The incident was survivable.

1.16 Tests and research

After the incident all the wheels and all the four Brake assembly along with the nose wheel assembly were removed. Brake assemblies were sent to an approved facility for inspection and to carry out bench check.

During functional check on brake assemblies, no leak was found from piston assembly, inlet fittings or bleeder assembly. Adjuster assembly parts were found satisfactory, running clearance between each insulator assembly and the pressure plate assembly was found within the limits.

Pressure check and visual inspection was carried out for all the wheel assemblies installed on the aircraft and initial inspection showed signs of water ingress. There was reddish colour grease in bearings which was indicative of corrosion. Mud was also found in inner and outer hub of every wheel assembly. In addition to this a deep cut was observed on the shoulder area of the tire of no. 1 main wheel.

The nose wheel assembly no. 1 & 2 was visually inspected and pressure check was carried out. Condition of no. 2 wheel assembly bearing was found satisfactory. However no. 1 wheel assembly bearing had the sign of water ingress and mud.

1.17 Organisation and Management information

The aircraft was operated by a DGCA approved aircraft operator holding AOP (S-16) in Passenger and Cargo Category which was valid till 16.5.2018. The operator carries out its own maintenance as CAR 145 approved organisation. On the day of incident it had 34 Boeing 737 variants and 20 Bombardier Q-400 aircraft. There is in house training facility for the pilots, cabin crew, airport services and Engineering. The operator hires foreign nationals (pilots) to meet its operational requirements and utilise them after issue of FATA by the DGCA.

1.18 Additional Information

1.18.1 Aquaplaning

Aquaplaning, also known as hydroplaning is a condition in which standing water, slush or snow, causes the moving wheel of an aircraft to lose contact with the load bearing surface (runway) on which it is rolling. As a result of that braking action on the wheel is not effective in reducing the ground speed of the aircraft.

A layer of water builds up beneath the tyre which eventually results in the formation of a wedge between the runway and the tyre. This resistance to water displacement has a vertical component which progressively lifts the tyre and reduces the area in contact with the runway until the aircraft is completely water-borne. In this condition, the tyre is no longer capable of providing effective braking because the drag forces are low.

If such a runway surface state prevails, then flight crew are required to make their aircraft runway performance calculations using "slippery runway" data; this specifically allows for poor deceleration. They must also take account of crosswind component limits in the AFM which make allowance for less assured directional control.

Aquaplaning on runway surfaces with normal friction characteristics is unlikely to begin in water depths of 3mm or less. For this reason, a depth of 3mm has been adopted in Europe as the means to determine whether a runway surface is contaminated with water to the extent that aircraft performance assumptions are liable to be significantly affected. Once

aquaplaning has commenced, it can be sustained over surfaces and in water depths which would not have led to its initiation.

In the case of dynamic aquaplaning, minimum groundspeed for initiation of aquaplaning on a sufficiently wet runway is dependent on tyre pressure. With a typical tyre pressure of about 150 psi, aquaplaning is possible even at about 70 knots. It leaves no physical evidence on tyre or runway surface. Viscous aquaplaning arises on abnormally smooth surfaces (contaminated with excessive rubber deposits) where it may begin and continue at any ground speed.

1.18.2 Runway Friction Checks

The friction status of a dry runway surface must be assessed periodically under the terms of ICAO TPN 13. It should also be re-assessed after any maintenance which might have affected the surface smoothness. Dry runway friction is directly related to the lesser friction when a runway is wet and this affects the braking coefficient.

If during regular inspections or a planned maintenance work, low friction is noticed particularly in TDZ, unless rectification can be immediately achieved, NOTAM action to the effect that the runway is liable to be slippery when wet should be taken. Any such low friction condition is conducive to viscous aquaplaning beginning below the 'aquaplaning speed' and therefore 'slippery runway' landing performance data should be used.

The airport operator has issued an SOP to formalise the friction testing of the runways and to ensure that the standard friction co-efficient is maintained. As per the SOP the periodicity for the inspection shall not exceed 7 days. As per the information available with the airport operator, the friction test was carried out on 19.9.2017 and the friction level was found to be more than 0.64 against a minimum of 0.50.

1.18.3 Runway Surface State – information to the pilot

The surface state of a wet runway can be assessed by either:

- the depth of water in the touchdown zone, or
- the measured or observed braking action.

It is unlikely that the actual depth of water on a runway will be passed to an aircraft by ATC; at present, equipment which takes tactical friction measurement on wet runways is rarely authorised for use, so the best information a pilot is likely to get prior to landing is an informal braking action comment made to ATC by a previously landed aircraft. This should be passed by ATC with the time of the report, the aircraft type which made it and any significant change in precipitation since it was received.

1.18.4 Monsoon Operations - Requirements

To enhance the operational safety during adverse weather particularly in the monsoon season which is prevalent in India are laid down in Annexure to the CAR Section 8 Series C Part I. As per these procedures, the operator is accountable and has to ensure that pilots are qualified and efficiently trained before undertaking flights into adverse weather. The crew who is roistered to fly during monsoon should

- have undergone annual adverse weather ground training even if the crew have flown during previous adverse weather. Ground training may be combined with the annual recurrent training programme of pilots, and should invariably cover Aircraft Performance during Take-off and Landing with specific emphasis on wet and contaminated runway conditions, calculation of take-off and landing field lengths and impact of individual failure events, Use of weather radar, Techniques of weather avoidance, Indian monsoon climatology and ALAR and Adverse Weather Tool Kit.
- PF should have acted as PM on commercial transport aircraft during a minimum of one monsoon season prior to obtaining PIC rating for the first time.
- PF should have at least 100 hours experience on type to operate the flight as PIC during adverse weather conditions unless the PF has a minimum of three monsoon seasons as PM on type prior to obtaining PIC rating for the first time. In cases where a PIC is short of the 100 hours requirement or his endorsement has been obtained prior to or during adverse weather, the pilot may continue to fly as PIC during adverse weather conditions till PF achieves 100 hours provided the PM has a minimum of 1000 hours on type and a minimum of two monsoon seasons on type.

- During simulator training, one hour training for adverse weather operations covering all aspects of adverse weather conditions likely to be encountered en-route and in terminal areas covering aircraft performance related to wet/ contaminated runway conditions combined with MEL dispatch should be the part of the simulator training wherein increased emphasis on landing performance should be given including assessment of landing distance required in reduced braking effectiveness vs. actual Landing Distance Available (Safety Margins).

In addition to the above specific requirements, general conditions are also laid down which are as follows:

(i) Minimum total cockpit experience level of the crew as PF and PM should not be less than 500 hours on type.

(ii) No supervised take-offs and landings in actual adverse weather conditions.

(iii) Approach briefing prior to Top of Descent shall include wet/contaminated Actual Landing Distance calculation. Scheduled Operators shall prepare a quick analysis table for use during normal operations for wet/contaminated ALD and 1.15*ALD in view of the high cockpit work-load environment. For aircrafts where the ALD is factored by at least 15% to derive an Operational Landing Distance, this figure may be used.

(iv) ILS approaches are to be preferred to non-precision approaches. In case of non-precision approaches, emphasis must be given on CDFA (Continuous Descent Final Approach).

(v) Greater emphasis given on stabilized approaches.

(vi) Go around is encouraged in case the pilot is not comfortable.

(vii) Full flap landing and adequate usage of reverse thrust and consideration of extra en-route/ terminal fuel computation shall be adhered to. (Type specific manufacturer's guidance accepted)

Windshield wipers and weather radar shall be fully serviceable for flights to or from aerodromes with forecast or actual adverse weather conditions and in any case aircraft cannot be released under MEL if the aforesaid items are unserviceable.

1.18.5 Avoiding Aquaplaning

- If there is any doubt as to the probable extent of water of depth greater than 3mm on the landing runway, then an alternative runway should be chosen, if possible.
- If the flight crew become aware, just before landing, that the depth of water on the runway, especially in the touchdown zone, has increased to an extent that aquaplaning is likely, then a go-around should be flown. If this circumstance is not apparent until touchdown, then, provided it is permitted by the AFM, the landing should be promptly rejected from the runway.
- If it is decided to continue an approach to a landing, a stabilised approach is required which results in the aircraft crossing the runway threshold at the correct airspeed and height so as to achieve a touchdown within the TDZ.
- Careful attention should be paid to the appearance of the tyres during the pre-flight external check, as far as is possible, especially the depth of tread.
- The main gear touchdown on a wet runway should always be firm and made without any bounce in order to break through the surface water film and make effective contact with the runway surface to spin-up the wheels.
- A significant crosswind component may result in a difference between the amounts of weight transferred onto each main gear assembly. This is because, even with the wings being held level by into-wind aileron, fuselage shielding partly blanks the downwind wing. This increases the likelihood of difficulties with directional control in a situation where the possibility of transient differential aquaplaning may also exist.
- Where available, full reverse thrust or reverse pitch should be selected whilst the ground speed is still high in order to gain maximum effect. Full ground spoiler deployment should also be made as soon as all wheels are on the ground if manual selection is necessary.
- In very slippery conditions the Autobrake may appear to fail under heavy antiskid operation. Disconnecting the Autobrake prematurely is likely to increase stopping distance. Crew should be familiar with the

indications of correct Autobrake / Anti-skid functioning, which is best learnt in the simulator.

- If there is a significant crosswind component, a landing on a potentially slippery runway should not be attempted.

1.18.6 Aircraft Removal/ Recovery Plan

The Aircraft Manufacturer provides an Aircraft Recovery Manual (ARM) which provides useful information, general procedures and equipment to effectively recover the type of aircraft being manufactured by them. The airlines and airport authorities use this information for planning aircraft recovery operations. The airline is required to prepare in advance for occurrences where recovery of the aircraft is required by establishing an aircraft recovery team, training, listing available recovery equipment and developing an internal aircraft recovery process document. The aircraft recovery strongly depends on the type of incident and the equipment available. A standard procedure for all the aircraft recovery incidents cannot be proposed, but the ARM provides general indications which can be useful to carry out an efficient operation and act as a guide to assist an aircraft recovery. It is also recommended that the record of all the data and actions related to the aircraft recovery process and specify the necessary corrective actions before the aircraft is returned to service.

DGCA India has laid down requirements in CAR Section 4 Series F Part I for the issue of aerodrome license wherein it is required that airport operator should have SOP on disabled aircraft removal. It is also mandatory for the airport operator to include the disabled aircraft removal plan in their aerodrome manual.

To comply with the above requirement, MIAL (Mumbai International Airport Limited) has prepared an SOP to recover the aircraft from the occurrence site and has made an agreement with all the operators to render it services during removal of their disabled aircraft at CSIA.

The main objective of this plan is to make all the Aircraft Operators, MIAL, the IATP custodian aware about the recommended procedures and practices on the removal of disabled aircraft and to restore normal operations

at the airport ASAP and with minimum secondary damage to the aircraft. The operator has an agreement to use International Airline Technical Pool (IATP) and the same was utilised for recovery of the aircraft from the soft ground. The equipment includes items such as pneumatic lifting airbags, recovery jacks, and slings to lift the airplane. MIAL in all such cases assume the role of "Aerodrome Coordinator" and at the same time supervise the process when a disabled aircraft recovery operation is in progress at CSIA.

All the Operations on runway 09/27 were suspended by ATC from 2155 IST (1625 UTC) until further notice. Disabled Aircraft recovery plan was activated and Air India was informed at 2207 hrs IST (1637 UTC) which is the custodian of IATP kit at Mumbai airport. Initially aircraft de-fuelling was carried out and baggage removed at the site.

1.18.7 Validation of Foreign Licences of Flight Crew

Under the provisions of Rule 45 of the Aircraft Rules, 1937, the Central Government may, subject to such conditions and limitations and for such periods as it shall think fit, render licence granted by the competent authority in a foreign State and is for the time being in force such licence valid by an authorization for flying aircraft registered in India and a licence so validated shall be subject to the provisions of rules 19 and 19A and such validation of a licence shall cease if the licence is revoked or suspended. Rendering (a licence) valid means; the action taken by a Contracting State, as an alternative to issuing its own licence, in accepting a licence issued by any other Contracting State as the equivalent of its own licence.

DGCA has issued Civil Aviation Requirement Section 7 Series G Part II which lays down the requirements for validation of foreign licences (Foreign Aircrew Temporary Authorization - FATA) under the above mentioned rule of the Aircraft Rules, 1937. A foreign licence may be validated for a specific purpose and for a limited period of time. The FATA is ordinarily issued to overcome the shortage of trained Indian Pilot-in-Command and as authorized by the central Government from time to time.

The requirements laid down are prescriptive in nature and some of the relevant requirements are given below:

- After arrival of the foreign pilot to India, operator will provide appropriate training on company operations/operations manual for a minimum period of three days, prior to the conduct of the oral examination in DGCA and the operator will submit the certificate to this effect. Further during oral examination by the board, authorized representative of the operator may also be present.
- Applicant during the oral examination shall be assessed for his knowledge of air regulation, Operator's Operations manual in general. The applicant shall be required to produce original documents like licence, medical assessment, log book etc. at the time of examination.
- The foreign pilots, whose licence and ratings are validated under the provisions of this CAR shall be released after passing an assessment check on simulator / aircraft by DGCA approved examiner/Instructor/FOI/DGCA authorized pilot. In case of non-availability of DGCA approved examiner/Instructor/FOI then DGCA may be depute an authorized pilot for the assessment check. Further if FOI is nominated for assessment check then fees under rule 48 of Aircraft Rule 1937 shall be applicable.

1.19 Useful or effective investigation techniques

NIL

2 ANALYSIS

2.1 Serviceability of the aircraft.

The aircraft has a valid Certificate of Airworthiness and a Valid Certificate of Registration at the time of incident. Scrutiny of the aircraft records has not indicated any snag or system malfunction pending rectification. None of the system or component was under MEL requirements. All the mandatory modifications were found to be complied with on the aircraft. The aircraft weight & balance was well within the operating limits. The aircraft and its Engines were maintained as per the approved maintenance program.

From the above it is inferred that serviceability of the aircraft was not a contributory factor to the accident.

2.2 Crew Qualification

Both the cockpit crew i.e. PF and PM were qualified to operate the type of aircraft. After undergoing the ground training and simulator check as per the requirements of DGCA and the Operator, the PF was issued with FATA by DGCA. Both the flight crew members had valid medicals and had undergone all refresher and other training requirements to operate in monsoon.

2.3 Weather

Prior to commencing descent; the Mumbai airport weather noted by the crew was (1510 UTC):

Rwy 27; Rwy Wet; ILS approaches /Transition Level FL 55/ Surface wind 280-17 kts gusting 27kts; visibility 1500 m in SHRA/ Clouds Sct 1000 ft/ Sct 150 ft/ Few Cb 3000 ft/ Overcast 8000 ft/ 26/25, QNH 1005 hPa,

Subsequently (at 1535 UTC) weather information noted was:

Rwy 27; Rwy wet; ILS approaches; Transition Level FL 55; Surface wind 300-12 kts gusting 22 kts; visibility 700m-800m in SHRA

Mumbai weather observations as per METARs of 2130 IST (1600 UTC) and 2200 IST (1630 UTC) was:

191600Z 33012G22KT 0700 R27/0800 -TSRA SCT010 SCT015 FEW030CB OVC080 26/25 Q1006 NOSIG=

191630Z 30016G26KT 0800 R27/0900 -TSRA SCT010 SCT015 FEW030CB OVC080 25/24 Q1006 NOSIG=

From the DFDR data it could be seen that there were gusting cross winds of around 25 knots. With the above weather scenario, the flight crew should have considered discontinuing the approach and going around.

2.4 Disabled Aircraft Removal

Immediately after the runway excursion, all the Operations on runway 09/27 were suspended by ATC from 2155 IST (1625 UTC) until further notice. Disabled Aircraft recovery plan was activated at 2207 hrs IST (1637 UTC) by requisitioning of IATP kit. Initially aircraft de-fuelling was carried out and baggage removed at the site. Due to heavy rains the recovery was delayed and runway was finally made operational after around 31 hours.

2.5 Sequence of Events

The SSFDR data was downloaded and analysed. Following is the sequence of relevant events:

V_{ref} for the approach was 145 kts.

TIME (UTC)	EVENT
16:21:00	Altitude 3100 ft, CAS 158 kts, Landing Gear Down, Flaps 15, aircraft on localiser and glide slope, autopilot not engaged
16:21:18	Altitude 3100 ft, CAS 160 kts, Flaps 30 selected
16:21:34	Altitude 3100 ft, aircraft established in descent, CAS 147 kts, ROD 800 ft/min, N1 59 %
16:22:02	Altitude 2500 ft, CAS 157 kts, ROD 1125 ft/min, N1 32 %
16:23:30	Radio Height 500 ft, CAS 158 kts, ROD 600 ft/min, on localiser and glide slope, N1 72 %
16:24:50	Radio Height 300 ft, CAS 158 kts, ROD 810 ft/min, Glide slope 1.86 dot Fly down (aircraft above the approach descent profile), N1 65 %

16:24:58	Radio Height 200 ft, CAS 169 kts, ROD 1004 ft/min, Glide slope 1.7 dot Fly Down, N1 72 %
16:25:04	Radio Height 100 ft, CAS 174 kts, ROD 765 ft/min, Glide slope 2.52 Fly down, N1 65 %
16:25:06	Radio Height 90 ft, CAS 172 kts, ROD 630 ft/min, Glide slope 2.89 dot Fly down, N1 72 %
16:25:10	Radio Height 50 ft, CAS 171 kts, ROD 360 ft/min, N1 73 %
16:25:14	Radio Height 40 ft, CAS 172 kts, ROD 150 ft/min, N1 70 %
16:25:18	Radio Height 30 ft, CAS 167 kts, ROD 375 ft/min, N1 67 %
16:25:20	Radio Height 20 ft, CAS 167 kts, ROD 315 ft/min, N1 67 %
16:25:24	Radio Height 10 ft, CAS 165 kts, ROD 315 ft/min, N1 67 %
16:25:32	Aircraft touch down CAS 150kts, N1 31 %
16:25:33	Auto brakes engage automatically, Thrust Reversers deployed, N1 84 %
16:25:37	Crew found Auto brakes ineffective and disengaged Auto brakes, applied full manual brakes (3000 psi)

2.5 Circumstances leading to the Incident

The incident flight was from Varanasi to Mumbai. Earlier the same crew had operated flight from Hyderabad to Varanasi and had undergone pre flight medical check at Hyderabad which was satisfactory. At Varanasi both the flight crew had all the information available viz. weather, fuel uplifted, runway in use etc. in the briefing folder which they discussed. The NOTAM provided for Mumbai indicated visibility, rain, winds etc. The crew also discussed the en-route weather and as they were given direct routing they also discussed "go around" procedure, wind shear escape maneuver, stall recovery procedure and about the diversions, if required.

Barring some diversions in the flight path due en-route weather, for which the ATC had Radar vectored the aircraft, the flight was uneventful till overhead Mumbai. As per the ATC instructions, the aircraft was holding over 'EMRAK for few minutes and thereafter it descended to intercept localiser ILS runway 27. At 162107 UTC tower had transmitted the weather information to crew, viz. "continue approach runway 27 wind 310/12 knots, gusting upto 22 knots and heavy rain over the field". As per the METARs the visibility reported was of 700m from 1600 UTC to 1630 UTC. The RVR reported for Runway 27

was 800m. At 162118 UTC flaps 30 were selected and the CAS at that time was 160 knots. (V_{ref} for the approach was 145 kts).

At 162330 UTC, the aircraft was at a height of 500 feet and was on localiser and glide slope. The rate of descent of the aircraft was 600 ft./ min. In view of the deteriorating and fast changing weather (gusty with heavy precipitation), the flight crew prior to initiation of final approach had discussed various options including slippery / wet runway and go around. As it was not possible to maintain the speeds instructed by ATC and maintain desired separation with the traffic ahead, PF disconnected the autopilot and took over the controls manually at 2000 feet. However from the perspective of crew at that moment, weather conditions were not a threat. The runway was visible when the aircraft was around 04 nm from the airport.

From the DFDR data in the previous section (2.4) it can be seen that in the last 200 ft of the approach, the aircraft was flying well above the planned approach descent profile with the crew maintaining high power settings. High power settings were maintained till close to touchdown. PF had made corrections for deviation in speed, path and rate of descent throughout, due to prevalent gusty conditions.

The landing checklist is performed as per the airline procedures. Though the go around procedure and actions required on the part of PF and PM were discussed from coordination point of view but configuration with flaps 40 was not discussed which would have given a lower approach speed, would have provided maximum aerodynamic drag after touchdown and shorter landing distance

As the aircraft was flying above the glide-slope and with high power settings, the aircraft touched down well past the touchdown zone, with flaps 30, speed brake up and auto brake 3. With this delayed touchdown, combined with the wet and waterlogged runway and flaps 30, it was not possible to stop the aircraft on the runway. The problem was further aggravated as the auto brakes were not effective immediately (because of rain) upon engagement due to which the PF shifted the braking to manual braking. Further during the landing roll, the tires aquaplaned on the wet runway which limited the effectiveness of the brakes to about one-third of that on a dry runway. Due to all of the above factors, the aircraft could not be stopped within the paved

surface. It left the paved surface of the runway at an approximate speed of 12 kts. and stopped in the slushy area approximately 10 metres beyond the paved surface. After following the checklist and confirmation by the ATC that there was no fire, evacuation was initiated using L1 and L2 doors after deployment of the emergency escape chutes, as per the procedure. There was panic in the cabin, though evacuation was completed without any major injuries.

The PF immediately after exiting the runway has uttered that they should have gone around. This was meekly agreed by the PM. Question then is why the flight crew has not carried out the go around at first place and secondly why flap 40 was not selected. The rough calculations made with flap 40 and all other parameters and actions by the flight crew remaining same indicate that the aircraft could have been stopped on the paved area. Further how normally any flight crew would have reacted to the situation and what decision he would have taken?

The subject approach and landing is a frequently encountered situation in which the flight crew has to adapt to rapidly changing weather conditions during landing and manage the flight. In the complex and dynamically evolving operational setting of a final approach, decision making is strongly linked to situational awareness and to the action taken. Going around in India and elsewhere is encouraged. However decisions are associated with a certain level of risk. There is no decision without some risk taking. The choice between alternatives is a choice based on the expected results for each alternative and the risk of failure to meet those results with the chosen alternative.

The appropriate approach-and-landing procedure was flaps 40 resulting into lower approach speed, which would have been easier to fly in terms of speed control and runway touch-down and providing maximum aerodynamic drag after touchdown when the effectiveness of the brakes was reduced because of aquaplaning. FATA is issued to the flight crew from other States under a CAR which is very prescriptive in nature. Throughout the industry, operational procedures and training (particularly pilots flying with FATA) is not designed around risk analysis and mitigation aspects. It appears, it is over-reliant on the decision-making ability of flight crew without placing

adequate emphasis on structured process for each and every individual concerned.

3 CONCLUSIONS

3.1 Findings

- Aircraft had a valid Certificate of Airworthiness and was certified and maintained in accordance with the approved maintenance schedule**.**
- Both the crew were current and qualified on type to operate the flight.
- The pre flight medical check of both the flight crew members was satisfactory.
- Prior to operation of the flight, the flight crew had all the information available viz. weather, fuel uplifted, runway in use, en-route weather.
- During pre-flight discussions the crew have discussed about, direct routing, “go around” procedure, wind shear escape maneuver, stall recovery procedure and about the diversions, if required.
- While instructing to continue approach, tower had transmitted, “continue approach runway 27 wind 310/12 knots, gusting upto 22 knots and heavy rain over the field”. As per the METARs the visibility reported was of 700m from 1600 UTC to 1630 UTC. The RVR reported for Runway 27 was 800m.
- Flaps 30 were selected for approach and landing at 160 knots. (V_{ref} for the approach was 145 kts).
- In view of the fast changing weather (gusty with heavy precipitation), the flight crew prior to initiation of final approach had discussed various options including slippery / wet runway and go around.
- PF disconnected the autopilot and took over the controls manually at 2000 feet. The runway was visible when the aircraft was around 04 nm from the airport.
- In the last 200 ft of the approach, the aircraft was flying well above the planned approach descent profile and the crew had maintained high power settings till close to touchdown.
- Though the go around procedure and actions required on the part of PF and PM were discussed from coordination point of view but configuration

with flaps 40 was not discussed which would have given a lower approach speed and would have provided maximum aerodynamic drag after touchdown.

- As the aircraft was flying above the glide-slope and with high power settings, the aircraft touched down well past the touchdown zone, with flaps 30, speed brake up and auto brake 3.
- With this delayed touchdown, combined with the wet and waterlogged runway and flaps 30, it was not possible to stop the aircraft on the runway.
- The problem was further aggravated as the auto brakes were not effective immediately (because of rain) upon engagement due to which the PF shifted the braking to manual braking.
- The aircraft left the paved surface of the runway at an approximate speed of 12 kts. and stopped in the slushy area approximately 10 metres beyond the paved surface.
- Post flight BA test was carried out for crew members and none of the crew members were found under the influence of alcohol.
- The runway 09/27 remained closed for operations for about 31 hrs.

The investigation also observed some effects which are not the causes of the incidents, but are required to be analyzed and improved upon. Following interactive latent and active failures exist across the stake holders including the DGCA, which has roots in the absence of practical implementation of the existing systems and procedures.

- Lack of adequate risk management strategy in following the prescriptive CAR by the stakeholders in selection and training of the flight crew (FATA) particularly for the peculiar Indian conditions.
- Surveillance on flights operated by pilots flying on FATA.
- Failure of CRM due to sharp gradient in the cockpit and lack of communication comfort.
- Though aware of the option of go-around available and discussed between the flight crew prior to approach but not taking a decision to go-around.
- Non selection of flap 40, as normal airline procedure is selecting flap 30.

- The airport license holder has procedure in place with the aircraft operators, for disabled aircraft removal plan but could not be effectively implemented by the involved stakeholders.
- There was disruption to smooth flow of Air Traffic. In present case the ATFM unit of AAI could have taken pro active action from the real time weather information available thereby avoiding huge diversions and disruption of Air Traffic.

3.2 Probable cause of the Incident:

- The aircraft left the runway end paved area and went into slush area as PF continuously flew well above the planned approach descent profile with flap 30 during the last segment of the approach, not going around after an unstable approach (due weather), maintaining high power settings till close to touchdown, which was well beyond the touchdown zone of the wet and waterlogged runway, changing the brakes to manual as auto brakes were not immediately effective upon engagement due aqua-planning.
- Failure of CRM particularly deciding on going around.

4. Recommendations:

➢ DGCA may ensure that the flight operations departments across the industry are carrying out risk identification and assessment training for the flight crew operating under FATA.

➢ Operators should carry out risk reduction processes in a structured proactive and systematic manner rather than relying on the crew's decision-making abilities when developing or updating procedures.

➢ Based on the available precursors e.g. analysis of real time weather and NOTAMs, ATFM unit of AAI should, develop pro active procedures to avoid diversions and disruption of Air Traffic and implement the same on day to day basis.

➢ The airport license holder(s) should develop procedures in association with the aircraft operators, for disabled aircraft removal plan and ensure availability of requisite infrastructure for the same. DGCA while carrying

out the renewal of the airport licence must ensure that all the stakeholders at the airport have effectively implemented the plan.

- ATIS (AAI) must inform flight crew on status of the runway braking conditions.

Rajinder Singh Passi 23/7/2018

(Rajinder Singh Passi)
Investigator-In-Charge

Date: 23.7.2018
Place: New Delhi