Islamic Republic of IRAN

Civil Aviation Organization

Aircraft Accident Investigation Board

Final Report

State File Number: A961129EPATS

Type of Occurrence: Accident

Date of Occurrence: Feb 18th 2018

Place of Occurrence: Near Yasouj Airport IR of IRAN

Aircraft Type: ATR 72-212

Registration: EP-ATS

Date of Issue: 15 Jun 2020

"In the name of God"

Basic Information:

State File Number:	A961129EPATS
Operator:	Iran Aseman Airlines
Flight Number:	IRC 3704
Aircraft Model:	ATR 72-212
Registration:	EP-ATS
Type of Accident:	Fatal Accident
Total Injuries:	66 Fatalities / 66 Occupants
Date of Occurrence:	Feb. 18, 2018
Time of Accident:	06:01 UTC (09:31 local time)
Place of occurrence:	Near Yasouj Airport, IR of Iran GEO; 30 49 25 N, 51 36 56 E
Flight Nature:	Domestic Scheduled Passenger Flight

Investigation Authority:

Civil Aviation Organization
Accident & Incident Investigation Board (AAIB)
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Abbreviations

A/C	Aircraft
AD	Airworthiness Directive
ADC	Air Data Computer
A/P	Autopilot
AAIB	Aircraft Accident & Incident Investigation Board
AAS	Anti-icing Advisory System
AAIC	Air Accident Investigation Commission
ACC	Area Control Center
AFM	Aircraft Flight Manual
AIP	Aeronautical Information Publication
RA	Radio Altimeter
AMM	Aircraft Maintenance Manual
AOA	Angle of Attack
APP	Approach
APU	Auxiliary Power Unit
ARP	Aerodrome Reference Point
ASL	Above Sea Level
ATC	Air Traffic Control
ATM	Air Traffic Management
ATPL	Airline Transport Pilot License
ATR	Avions De Transport Régional
ATS	Air Traffic Service
BEA	Bureau d'Enquête Et d'Analyses
CAOIRI	Civil Aviation Organization of the Islamic Republic Of IRAN
CABG	Coronary Artery Bypass Grafting
CB	Cumulonimbus
CG	Center of Gravity
COSPAS-SARSAT	International Satellite System For Search And Rescue
CL	Condition Lever
CPL	Commercial Pilot License
CRM	Cockpit Resource Management
C_X	Drag Coefficient
CVR	Cockpit Voice Recorder
DAF	De-icing / Anti-icing Fluid
DFDR	Digital Flight Data Recorder

DH/A	Decision Height/Altitude
EIS	Entry Into Service
F/O	First Officer
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FD	Flight Director
FDAU	Flight Data Acquisition Unit
FDA	Flight Data Analysis
FH	Flight Hours
FI	Flight Idle
FIR	Flight Information Region
FLTA	Forward Looking Terrain Avoidance
FMS	Flight Management System
Ft.	Feet
GI	Ground Idle
GPS	Global Positioning System
GRD	Ground
HP	High Pressure
Hpa	Hectopascals
HR	Radio Height
IATA	International Air Transport Association
IMC	Instrument Meteorological Conditions
KIAS	Knots Indicated Air Speed
Km/h	Kilometers Per Hour
Kts	Knots
LH	Left Hand
LMT	Local Mean Time
MEA	Minimum Enroute Altitude
M/s	Meters Per Second
Mbar	Millibar
METAR	Aerodrome Routine Meteorological Report
MH	Magnetic Heading
MOC	Minimum Obstacle Clearance
MOE	Maintenance Organization Exposition
MSA	Minimum Sector Altitude
MSN	Manufacturer Serial Number
N/A	Not Applicable
NAV	(Navigation) FMS Mode

NM	Nautical Mile
NOTAM	Notice To Airman
NSC	No Significant Clouds
OAT	Outside Air Temperature
OCC	Operation Coordination Center
OM	Operations Manual of Airline
OML	Operational multi-pilot limitation
NSW	No Significant Weather
PIC	Pilot-In-Command
PL	Power Lever
QAR	Quick-Access Recorder
QFE	Atmospheric Pressure At Runway Threshold
QMS	Quality Management System
RH	Right Hand
SAT	Static Air Temperature
SB	Service Bulletin
SIGMET	Significant Meteorological Information
SMM	Safety Management Manual
SMS	Safety Management System
SOP	Standard Operating Procedures
TAT	Total Air Temperature
TAF	Terminal Aerodrome Forecast
TAWS	Terrain Awareness And Warning System
TLP	Throttle Lever Position
TCAS	Traffic Alert Collision Avoidance System
TL	Transition Level
TRE	Type Rated Examiner
TRI	Type Rated Instructor
TQ	Engine Torque
UTC	Coordinated Universal Time
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
V_2	Takeoff Safety Speed
V_R	Rotation Speed
V_Z	Rate-Of-Descent
WAFS	World Area Forecast System

Foreword:

The Civil Aviation Organization, in accordance with international obligations and domestic regulation of the Islamic Republic of Iran, is in charge of monitoring the proper implementation of the laws and regulations and standards of flight in the civil aviation industry of the country. In order to identify the sources of threats on flight safety , based on the Regulations on the Investigation of Accidents and Civil Aviation Accidents, adopted in 2011 by the government and the International Regulations of the International Civil Aviation Organization (ICAO) Annex 13, the Aircraft Accident Investigation Board (AAIB) institutes the investigation of the civil Aircraft Accidents/Incidents, and after determination of the main cause and the contributing factors , will issue safety recommendations to prevent similar accidents and events in the future.

According to Civil Aircraft Accident Investigation Regulation of IR of Iran:
"*Accident investigation shall be conducted separately from any judicial proceeding and it is not the purpose of this activity to apportion blame or criminal liability*".

Based on Annex 13 to the Convention on International Civil Aviation, Chapter 3, Paragraph 3.1, and Chapter 5, Paragraph 5.4.1; it is stipulated and recommended as follows;

"The sole objective of the investigation of an incident or accident shall be the prevention of incidents and accidents. It is not the purpose of this activity to apportion blame or liability."

In the case of accident on Feb. 18, 2018, involving ATR72 aircraft with registration EP-ATS operated by Iran Aseman Airlines, the CAOIRI Aircraft Accident Investigation Board (AAIB) gathered whole information with coordination of related entities and approached the investigation as the representative of State of Occurrence.

According to international rules and Annex 13 to the Chicago Convention, the "Notification" was sent to the ICAO and the French National Accident Investigation Bureau (BEA), as the state of aircraft manufacture and design, as well as the Canadian Transport Safety Board (TSB) as representing of manufacturing state of engine. Both states have appointed their accredited representatives accordingly. BEA in response to the announcement of the accident sent a team consisting of three investigators from the BEA and four advisers from ATR Company to Iran, and in order to conclude the accident investigation again, the French 3-member team attended CAOIRI again the meetings in May 2018 to present their findings of the accident. The Canadian representative also announced that requested information is available from TSB and further cooperation will be based on effect of engine problem on the accident. No official coordination report from TSB was received based on acceptable engine performance on accident scenario. Subsequently, the accident investigation team, in concluding various accidental meetings with aviation industry experts, and interviewing relevant stakeholders, identified the main cause and contributing factors of the accident, and initiated the issuance of immediate five safety recommendations in the preliminary report and new recommendations in this report to prevent similar occurrences.

The interim report was issued publicly on Feb. 17, 2019. Related authorities were requested to send their comments to the report as draft of the final report. Comments from EASA, BEA and ATR were received on Apr. 19, 2019. The report was reviewed and upgraded accordingly and the final report was published.

Synopsis:

On 18.02.2018, at 06:01 UTC (09:31 local time), the aircraft ATR72-212 , EP-ATS operated by Iran Aseman Airlines during flight from Mehrabad (Tehran) to Yasouj Airport crashed while performing the scheduled passenger flight IRC3704.

According to the load sheet the A/C takeoff weight was 20963 kg and was within the aircraft operation limits. There were 6 crew members on board (PIC, F/O, two flight attendants and two security men) and 60 passengers. All on-board persons were Iranian citizens.

The aircraft was cleared to descend to FL170, and to continue to the destination. The aircraft started descending and prepared for landing in Yasouj Airport. Finally, the aircraft lost altitude and impacted mountain with a significant left bank. The collision first led to the complete destruction of aircraft. All 66 persons on board were fatally injured.

The information of the accident was received by the IR of Iran Aircraft Accident Investigation Board (AAIB) on the same date at 09:40 by contact of ACC as a part of Iranian Airport & ANS Company.

The Investigation Team was assigned by Iran Civil Aviation Organization (CAO) president and a supervision team by Minster of Road and Urban development. .

In accordance with Annex 13 to the ICAO Chicago Convention the Notification was sent to ICAO and the BEA, France (as a State of Design and Manufacturer), TSB, Canada (as a State of Engine Design and Manufacturer). In accordance with Annex 13 items 4.5 and 4.6 these States assigned their Accredited Representatives to support the investigation. The BEA sent accredited representative accompanying their advisors from ATR Company for onsite investigation.

The investigation team requested laboratory analysis on ELT and EGPWS of the aircraft. These components were picked up from wreckage and sent to France laboratories and related conclusions were sent to the investigation team.

No criminal investigation has been conducted due to the fact no sign of criminal act on the accident scenario was found.

1. FACTUAL INFORMATION:

1.1 History of Flight:

Iranian ATR72 aircraft registered EP-ATS operated by Iran Aseman Airlines was assigned to perform a domestic scheduled passenger flight from Tehran to Yasouj at 07:55 local time.

The aircraft took off from Tehran Mehrabad International Airport (0III) at 04:35 UTC. (08:05 LMT) and the flight was the first flight of the day for aircraft and the crew. The cruise flight was conducted at FL210 on airway W144 and no abnormal situation was reported by the crew and the flight was continued on Tehran ACC frequency till the time the first officer requested the latest weather information of the destination by contact to Yasouj tower, then requested to leave FL210 to FL170 from Tehran ACC. When the aircraft was descending to FL170 and crew calling YSJ tower the aircraft descending was continued to altitude of 15000 ft. The aircraft was expected to join overhead of the airport and perform "circling NDB approach "to land on RWY 31 at the destination aerodrome.

Finally, the aircraft collided with a peak lee of Dena Mountains about 8.5 miles at north far from the airport and involved accident at 06:01 UTC. The aircraft was completely destroyed as a result of collision with the mountain at the altitude of approximately 13300 ft.

The last 15 minutes of radio communications between the pilots and Yasouj Tower are as follows:

<u>The time frame in UTC (Z)</u>

At 05:49, the flight while still in contact with Teheran ACC, the crew contacted Yasouj tower to get meteorological information. Yasouj tower informed them about meteorological information at 05:30 and also mentioned that final approach path is clear.

At 05:52, the crew reported OBTUX position and aircraft was cleared to descend to FL170 by Teheran ACC.

At 05:53, the aircraft contacted Yasouj ATS unit and released to join the approach according to the approach chart. The crew answered "continues to overhead on FL150 and we will get out of clouds"

At 05:55, the aircraft disappeared from the Tehran ACC radar coverage due to limit of coverage in mountainous area .The latest recorded radar altitude was FL186. Then, the pilot began to speak with new AFIS operator (Aeronautical Deputy of Airport) about the weather and navigational aids of the airport and reported "NDB is not working based on NOTAM". ATC continued to describe the situation of DME on NDB, DVOR systems.

At 05:55:33, the crew reported 25 NM from destination.

At 05:56, the crew reported their plan to join overhead.

At 05:59, the crew reported 14 NM Yasouj DME and not receiving DME from NDB. Yasouj tower controller indicated that LH downwind and base leg were mostly clear of clouds.
At 06:00, Yasouj tower communicated corrected QNH 1021, which was acknowledged by the Captain.
This was the last communication between flight and airport tower.

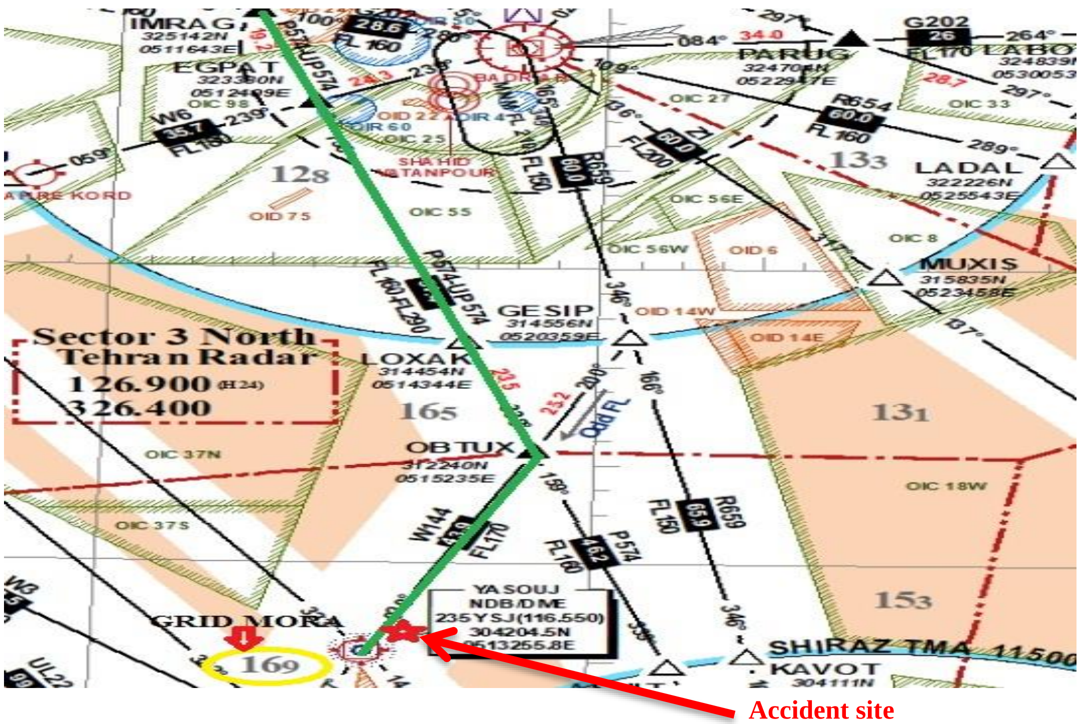


Figure 1 – Flight En-Route

1.2 Injuries to Persons:

Unfortunately, all on-board crew and passengers were fatally injured. The passengers included 59 adults and one child. The crew included 6 persons (two pilots- two flight attendants- two security men).

Injuries	Crew	Passenger	Others	Total
Fatal	6	60	0	66
Serious	0	0	0	0
Minor/ None	0	0	0	0
Total	6	60	0	66

1.3 Damage to Aircraft:

The aircraft fuselage was destroyed by collision with the mountain.

1.4 Other Damage:

The accident, except for the aircraft, has not caused any damage to the public or any personal properties.

1.5 Personnel Information:

1.5.1 The Pilot:

The pilot was male 62 years old with an ATPL Certificate No;. 1122 with the expiry date: 16/09/2020. The operational records of him are as follows:

License Number	**ATPL.1122**
Total Flying Time	**17926 h**
Flying Time in last 6 Months on ATR	**530 h**
Flying Time In last 3 Months	**271 h**
Flying Time In last Month	**88 h**
Flying Time In last 72 hours	**09 h**
Flying Time In last 24 hours	**00 h**
Flying Time In Current Type	**12519 h**
Last Proficiency Check (Validity)	**21/08/2018**
Last Medical Exam	**25/09/2017**
Last Simulator	**11/12/2017**

He was also the training pilot of the Company and a CAO examiner (TRI/TRE) and had experience of flights in India from 2002 to 2007 and returned to Aseman Airlines again.

Meanwhile, in the past three months before this accident, he had two flights to Yasouj airport.

The medical certificate was valid until April 14, 2018, and the Instrument Rating credit date was April 14, 2018. The English Language Proficiency Level (IV) was valid until July 19, 2018.

The pilot is in accordance with the medical regulations set out in Chapters one and six of the ICAO DOC 8984, as well as the Air Crew -Part MED regulations, with the age limit of 60 years old and had the limitation of Class 1 medical limitation (OML). In the year 2009, the CABG was performed for him and for a period of nine months, his flight was suspended. Then based on the medical regulations of CAOIRI, the supplementary specialist evaluations were carried out by Cardiologist. As resulted conclusion from the Aviation Medical Commission of CAOIRI on May 24, 2010, the following limitations were issued for him:

1- Medical Certification validity is 6 months

2. Shall fly with or as Qualified Co-pilot without medical and operational limitation

3. In each air-medical assessment, a specialist cardiovascular assessment shall also be performed.

This limitation was prior to the age of 60 years, and after this age, his medical situation was evaluated for eye, cardiovascular, neurological, and neuropsychiatric systems. Finally, his pilot certification was also subjected to six months of validity and each air-medical evaluation shall be done by a special medical cardiovascular clinic. At the time of the accident, the following limitation was stated in the pilot's license.

(Shall fly with another pilot who is younger than 60 years and has no medical and operational limitations)

1.5.2 First Officer: as pilot flying (Right Hand Seat):

The first officer was male, 36 years old; the holder of CPL-IR certificate No; 3584 / valid till 16/09/2020. His class 1 medical certificate has been in accordance with the current regulations of the Civil Aviation Organization, with limitation of using corrective glass during flight. His operational records are as follows**:**

License Number	CPL.3584
Total Flying Time	1880 h
Flying Time in last 6 Months on ATR	197 h
Flying Time in last 3 Months	185:15 h
Flying Time in last Month	99:15 h
Flying Time in last 72 hours	10:20 h
Flying Time in last 24 hours	00 h
Flying Time in Current Type	197 h
Last Proficiency Check (Validity)	19.03.2018
Last Medical Exam	19.10.2017
Last Simulator	19.09.2017

The medical certificate was valid until April 19, 2018, and the validity of his Instrument Rating was valid until 19.09.2018. The English Language Proficiency Level (IV) was valid until 19/07/2018.

Note: using corrective glass is defined as a medical limitation based on CAOIRI regulation.

1.5.3 Yasouj Tower Air Traffic personnel (AFIS Officer):

He is 37 years old holding flight control controller certificate No; 1374 with a history of working at the control tower in Bandar Abbas and Shiraz Airport Tower. His medical qualification certificate is valid until May 20, 2018. He has been working in Yasouj airport since 2015. Yasouj airport is located in class G Aerospace (uncontrolled aerospace) and according to local regulations; he acted as a flight information service officer. It is not required for him to have a rating of Yasouj airport because this airport is handled as a Flight Information Service Airport.

1.5.4 Flight attendants:

The flight service was conducted with two male flight attendants aged 46 and 30. They had a valid ATR72 type certification.

They had passed initial training for rescue and first aid process, as well as continuing education in training center of the airlines.

1.6 Aircraft information:

Aircraft Type: Turbo Prop ATR 72-212 with Serial Number: 391 and manufactured in 1993.

The aircraft was a tricycle type with two main landing gears on right / left hand side and a nose landing gear. The landing gear system was retractable.

All necessary certifications for this aircraft were obtained and validated as follows:

- Aircraft Registration Certificate (C.of.R): Date Issued on 10/12/1993
- Airworthiness Certification (C.of.A) has been valid to 31/10/2018.
- The Airworthiness Review Certificate (ARC) was valid to 31/10/2018.
- The Aircraft Radio Certificate (ARSL) had been validated to 31/10/2018.

After the last "C" check, the aircraft had accumulated 700 hours and 732 cycles since October 25, 2017.

1.6.1 Information on the structure of the aircraft:

The aircraft has been certified by the DGAC and recognized by European Aviation Safety Agency with TCDS under the number EASA A.084 and by FAA with TCDS under the number A53EU at the same date (Dec. 15, 1992).

The service life of the aircraft is also 70000 flight cycles. (Limit of Validation-LOV: 70000 Cycles).

According to the latest information, the aircraft had 28857 hours flight time and 28497 flight cycles since new on accident time.

The aircraft was taken out of commercial service on February 2, 2011 in a hanger at Shiraz airport at the request of the company with replacement of two engines and some other components under preservation inspections. The aircraft was in the preservation condition for 6 years and the combination of periodic checks were done on the aircraft then after two flight tests, it had returned to normal operation on October 29, 2017.

Aircraft maintenance was carried out at Iran Aseman Airlines base at Shiraz airport according to the type of checks which were determined by approved maintenance program related to the manufacturer's latest instruction.

1.6.2 Periodic Checks:

- A: Every 500 hours of flight or 4 months.
- 1CC: Every 365 CA
- 2CC: Every 730 CA
- 1CF: Every 5,000 FH
- 2CF: Every 5,000 FH
- 4CF: Every 20,000 FH
- 4CC: Every 1460 CA
- 8CC: Every 2920 CA
- 12CC: Every 4380 CA

The last aircraft major inspection (combined C checks) was done after preservation period and according to related releasing certificate CRS No. EP-ATS / WO # 52057, this inspection was issued on 1.5.2017 in Shiraz, when the aircraft had total time of 28124 hours since new.

The aircraft accumulated a total of 700 hours of flight from this inspection. The last periodic check was "A" check and 233 hours flight had been done after the check.

1.6.3 Engine Information:

The engines are Pratt &Whitney of Canada PW 127 certified for a 2750SHP Max take-off rating. However, in normal operation, take-off rating will be 2475SHP with an Automatic power increase to 2750SHP (reserve take-off rating RTO) in case of other engine failures.

	Engine #1	**Engine #2**
Type	PW127	PW127
Serial number	127042	127049
Total time since new	25325	24899
Total cycles since new	25238	24027
Total time since overhaul	733 FH/696 FC	734 FH/ 695 FC
Remaining cycles to next overhaul	8355	3885

1.6.4 Propellers Information:

The engine comprises two spool gas generators driving a four-blade propeller via a free turbine/concentric shaft/reduction gearbox assembly. Propeller regulation is hydro-mechanically controlled. The propeller is a Hamilton Standard 247 F-1

- Diameter : 3.96 m (13 ft)
- Rotation : clockwise (looking forward)
- 100 % Np : 1200 RPM
- Weight : 147 kg

	Propeller #2	Propeller #1
Manufacturer	Hamilton Standard	
Type	247 F-1	
Serial number	FR930911	FR930717
Total time since new	40124	35999
Total time since overhaul	7874	*4364*

1.6.5 Aircraft technical log reports:

A review of the logbook was performed from the 14th of November 2017 until the date of the accident. Most recent remarks are the following which have already been rectified:

- On Feb 18, 2018 , the RH Side window was exchanged
- On Feb 17, 2018 a Brake Overheat was registered
- On Feb 14, 2018 the Overboard Valve was exchanged

The summary of the most significant items over the last 3 months were:

- Various Engine #2 De-icing operation malfunction

- Reports of heading on EHSI #2 were difficult to read and RMI#1 suspected wrong by pilots.

- Different reports about ADF#1 malfunction

- NP indications reflect differences between Engine #1 and Engine#2.

1.6.6 Airworthiness Directives:

The list of Airworthiness Directives (AD) status produced by Aseman Airlines related to this aircraft EP-ATS dated 22.02.2018 showed the following remarks:

- around 300 AD logged in totally, either from EASA, FAA and TCCA
- 78 AD stated as applicable; all of them were embodied or were planned to be embodied within the required compliance time.

Based on CAOIRI part-M regulation M.A.303, the applicable AD issued by the first state of design was applicable on this aircraft. One AD had not been applied and the compliance time was overdue from Aug. 24, 2015. The EASA AD No. 2009-0170 was related to the installation of Multi-Purpose Computer / Aircraft Performance Monitoring. The research/ investigation showed that the airline could not receive the required parts due to the sanctions imposed by the United States of America. The airlines had several attempts accordingly to solve the problem with cooperation of aircraft manufacturer, finally the ATR Company as the aircraft manufacturer provided supportive documentation for the customer to apply for an Alternative Method of Compliance (AMOC) in 2015 to receive approval from Iranian Authority to postpone the AD for a year. The request for the approval of AMOC was not sent to CAOIRI by the operator. The AMOC includes recommendations for training and operational procedures distributed to required/ involved departments accordingly.

Recommended context of AMOC was:

- Include recurring training course on aircraft icing for ATR crews,
- Reinforce the briefing to the flight crew regarding severe icing conditions and the remind the associated operational procedure for avoidance,
- Pending the MPC installation (and availability of the APM), instruct all pilots to use the IAS mode of the AP while in climb in icing conditions with monitoring of the vertical speed. For all other flight phases and in another AP mode, instruct the crew to monitor the IAS.
- The flight crew shall be provided with all available weather charts prior each flight. Detailed study of these weather charts during the preflight briefing will allow to better anticipating any icing encounter and freezing level along the route.

The airline used software to control the AD list on all its aircraft. Upon receiving supportive documentation to apply for an AMOC, the AD was deleted from applicable "AD" list of all ATR aircraft on the related software by the engineering department of the airline to follow it.

Based on CAOIRI Part-M regulation (M.B.902: Airworthiness review by CAO.IRI), when the CAOIRI carries out the airworthiness review and issues the airworthiness review certificate (ARC), an airworthiness review in accordance with point M.A.710 shall be carried out . To satisfy the requirement for the airworthiness review of an aircraft, full documented review of the aircraft records shall be carried out by the approved continuing airworthiness management organization in order to satisfy/approve that all applicable AD's have been applied and properly registered. CAOIRI airworthiness inspectors carry out document "sample checks" to issue ARC and C of A. During sample check of applied AD's, lack of implementation of AD No. 2009-0170 was not found.

1.6.7 Aircraft Systems:

The following chapter details the description of ATR aircraft systems.

Due to the fact that the aircraft was flying in icing condition in a short period before the end of the flight, therefore the ice protection system is also discussed in this report.

The system consists of two parts: "***Ice Detection and Ice Protection***".

1.6.7.1 Ice and rain protection systems:

The ATR 72 ice protection system is a combination of deicing and anti-icing systems. These systems are as follows:

A pneumatic system (leading edge inflatable boots) that permits deicing of critical airframe surfaces, i.e. outboard and inboard wing sections, the horizontal stabilizer leading edges, and the vertical stabilizer (optional);

1. A pneumatic system for de-icing the engine air intakes;
2. Electrical heating for anti-icing of the propeller blades, the windshield and forward portion of the side windows, the pitot tubes, static ports, TAT [total air temperature] probe, and the AOA vanes;
3. Electrical heating for anti-icing horns fitted on the ailerons, elevators and rudder;
4. And a windshield wiping system for the forward windows.

The ice protection systems are controlled and monitored from control panels located in the cockpit. In addition, there is an illuminated Ice Evidence Probe (IEP Mod.3632) located outside and below the captain's left side window. The IEP is visible to both pilots and provides visual information regarding ice accretion. The IEP is molded in the shape of an airfoil with span wise ridges to increase its ice accretion efficiency and is a good indicator of presence of ice on the airframe. The probe is designed to retain ice until sublimation or melting has occurred and is intended to provide the flight crew with a visual means of determining that other portions of the airframe are either accreting ice or are free of ice.

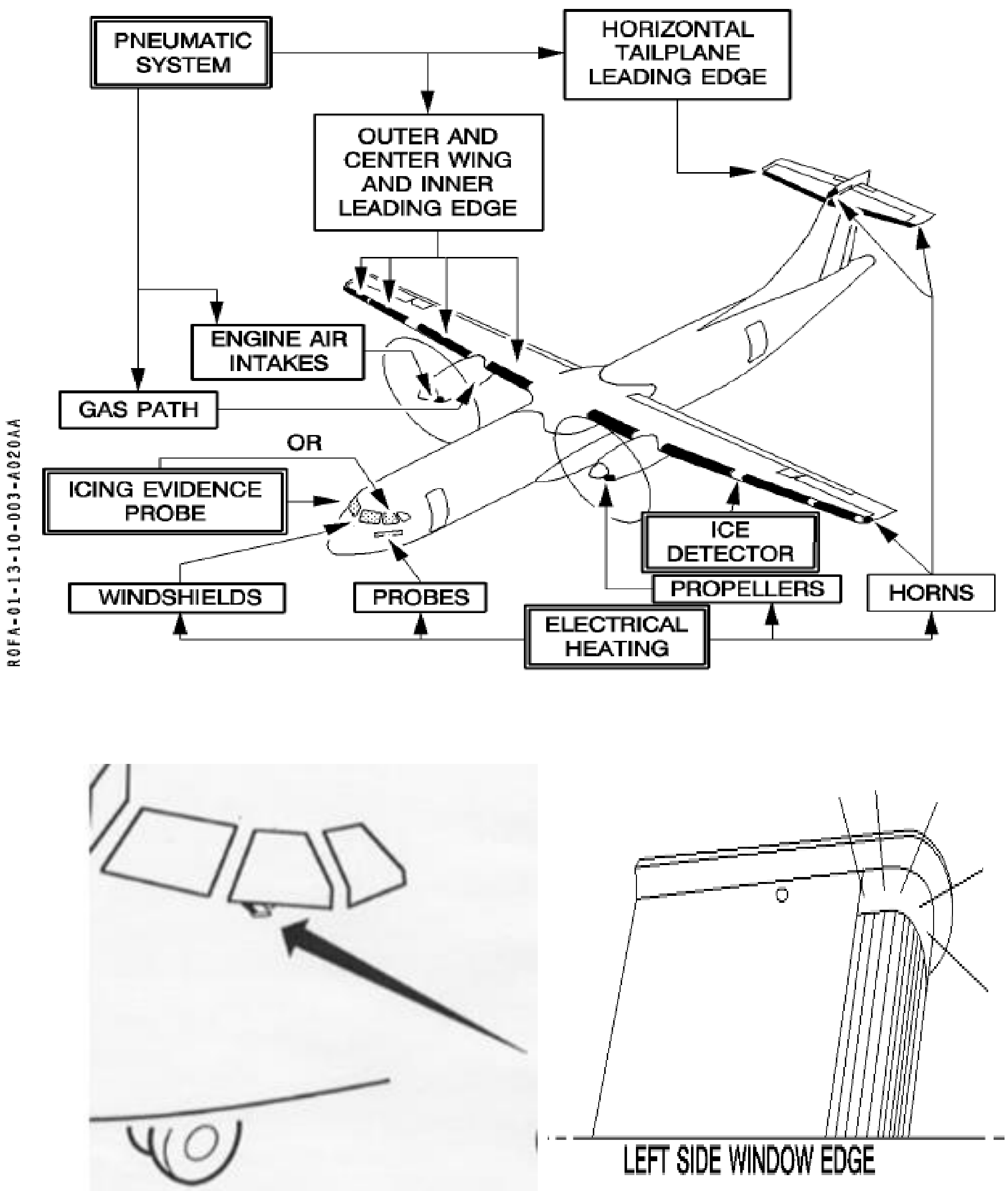


Figure No. 2 Ice Protection Systems and IEP

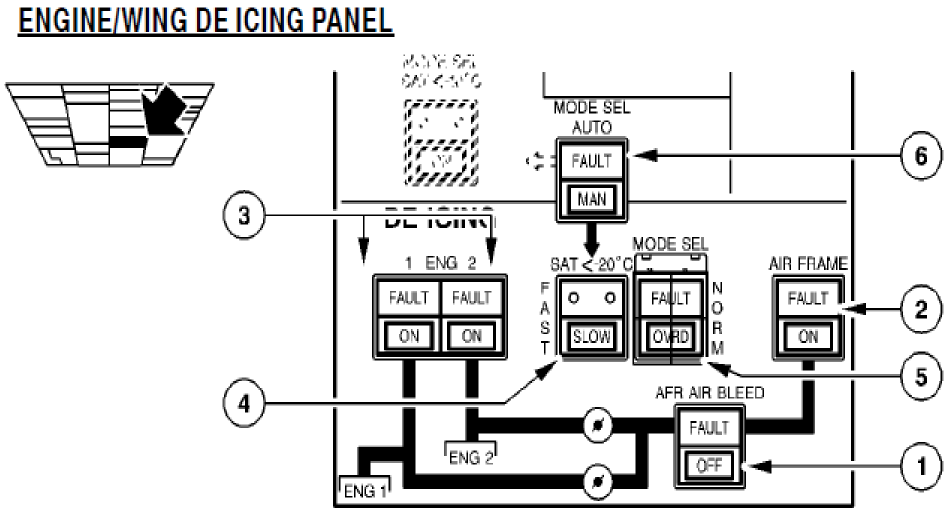


Figure No. 3 De- ice panel

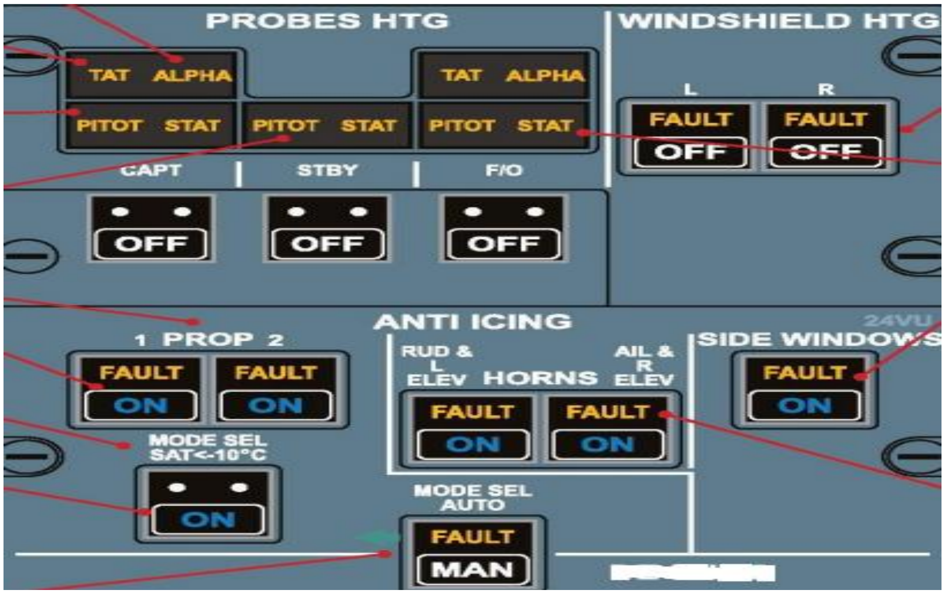


Figure No. 4 Anti- ice panel

1.6.7.2 Ice detection systems:

Additionally, an Anti-icing Advisory System (AAS), which employs a Rosemont ice detector probe, is mounted on the underside of the left wing leading edge between the pneumatic boots. The AAS provides the flight crew with a visual and aural alert when ice is accreting on the detector probe. The aural alert chime is inhibited when the de-ice boots are activated. The visual alert will remain illuminated as long as ice is detected, regardless of whether de-ice boots are activated. (See Figure 1 for diagram of ATR 72 ice protection system)

The AAS was/ is designed to enhance ice detection by using the Rosemont ultrasonic (harmonic/vibrating) ice detector probe which senses ice accretions. The AAS alert signal is generated by the probe on the underside of the left wing.

It is approximately 1/4 inch in diameter and 1 inch long and vibrates along its axis on a 40-kHz [kilohertz] frequency. The system detects changes in vibration frequency resulting from the increased mass of accumulated ice, which, in turn, activates the visual and aural ice accretion alerts in the cockpit (single chime). If ice is detected, the Rosemont probe will initiate a heat cycle to remove the accretion and start the ice detection process again. According to ATR and the manufacturer of the Rosemont probe, the detection system may not reliably detect large super cooled drops that are near freezing (such as freezing drizzle/freezing rain) because there may not be enough heat transfer to freeze the large water drops that contact the probe.

The ATR 72 ice protection system was/is designed with three levels of operation, and provides the flight crew with the ability to choose the level(s) of protection based on environmental conditions.

- ✓ Permanent Anti-ice(Level I) - activates all probe (TAT sensors, AOA sensors, Pitot tubes, static ports) and windshield heating systems permanently, and, according to the ATR 72 Flight Crew Operating Manual (FCOM), must be in operation at all times after engine starts and during flight operations.
- ✓ Anti-ice (Level II) - activates electric propeller heaters, elevator, rudder and aileron horn heat, and electric side window heaters. According to the Airline Standard Operating Procedures (SOP), the Level II protection must be in operation when atmospheric icing conditions exist (visible moisture and the TAT below 7°C).
- ✓ De-ice (Level III) - activates the pneumatic engine intake boots, the wing and horizontal tail plane leading edge boots, and must be used at the first visual identification of ice accretion or when alerted to ice accretion by the AAS. Level III ice protection must remain activated for as long as ice is accreting on the airframe. ATR recommends that flight crews use the IEP as a means of determining when the airframe is free of ice.

- ❖ *Note: It should be noted that the shutdown of Icing Light means the end of the Ice Accretion and does not mean that there is no ice on the aircraft. (Source: FCOM)*
- ❖ *Note: Level I, II, III were in previous aircraft manuals and discontinued in current manuals any more but commonly used by airline personnel*.

Flights in icing condition:

In accordance with the Aircraft Operational Instructions (FCOM), as soon as aircraft is in the icing condition, and as long as it is in these conditions, all anti-icing and speed monitoring procedures must be performed even before the ice is formed.

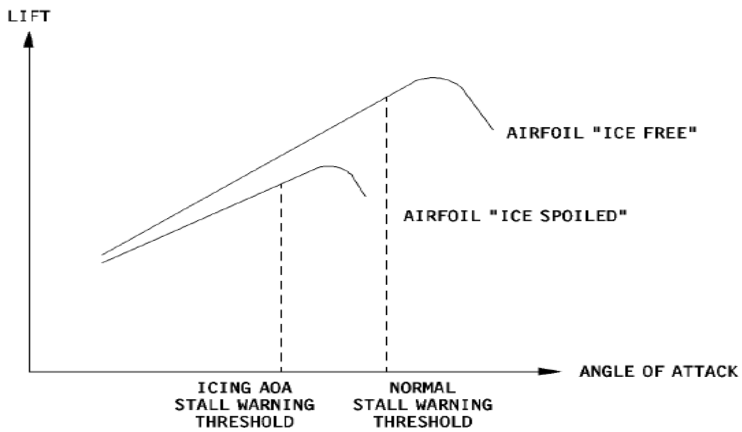
The effects of ice formation on the control surfaces and airfoils are:

1- Decreasing of Lift

2- Drag increase

3- Increasing of Stall Speed

Therefore, in order to create a suitable time frame from the stall, the stall warning threshold must be applied at the lower attack angle, and the stick pusher threshold is also lowered. This is done by pressing any horn anti icing PB in the overhead Anti-Icing panel. Pressing the PB will light up the icing AOA light. So, as long as aircraft is in the Icing condition, the angle-of-attack thresholds of the stall warning and stick pusher are reduced.



The ATR 72 stall protection system Stall Protection System offers the pilot three different devices that provide warnings prior to the aircraft reaching AOA's consistent with "clean" and ice-contaminated flow separation characteristics. These devices are:

An ***aural warning*** and a ***stick shaker***, both of which activate simultaneously when the AOA reaches a predetermined value that affords an adequate margin prior to the onset of adverse aerodynamic characteristic(s); and a ***stick pusher*** that activates when the AOA reaches a subsequently higher value that has been determined to be nearer to the onset of stall. The activation of the stick pusher results in an immediate and strong nose-down movement of the control column.

The stall Protection System on the ATR 72 is controlled by two multi-function computers (MFC), each of which uses information from the following sources for activation:
The AOA probes; the flap position; engine torque; aircraft on-ground/in-flight indication; horns PB anti-ice status; aircraft altitude above or below 500 feet; and the presence or absence of optional De-icers on the inner leading edges.

The stick pusher, which is mechanically linked to the left control column cable, moves the column to the 8-degree nose-down position when the MFC stick pusher activation criteria are met.

The Stall Protection System logic also uses AOA probe information to reduce the triggering threshold when the AOA is rapidly moving toward positive values. According to the aircraft maintenance manual (AMM) for the ATR 72, the phase lead of the triggering threshold has a maximum value of 3 degrees AOA and does not intervene when the anti-icing system is engaged. The Stall Protection System is designed so that a single failure of any component in the system cannot cause the loss of the stick pusher function, improper activation of the stick pusher, the loss of the aural warning alert, or the loss of both stick shakers.

The Stall Protection System on the ATR 72 has icing and non-icing AOA triggering thresholds for each flap configuration. The Stall Protection System activates at lower AOAs when the anti-icing system is activated to account for aerodynamic changes.

Flaps	Normal conditions						Icing conditions					
	Low Power (Torque < 10%)			High Power (Torque > 35%)			Take-off [2]		Cruise		Cruise (int boots) [3]	
	SW		SP	SW		SP						
	CAA conf [1]	EASA conf		CAA conf [1]	EASA conf		SW	SP	SW	SP	SW	SP
0°	16.8°	17.8°	20.9°	16.8°	17.8°	20.9°			11.2°	15.3°	11.2°	15.3°
15°	16.9°		22.1°	16°		21.2°	14.5°	16.4°	10.3°	16.4°	12.5°	16.4°
30°	16.4°		22.5°	15.5°		20.1°			9.1°	12°	12°	17°
Phase lead (ΔαPL)	0°		0°->3°	0°		0°->3°	0°	0°	0°	0°	0°	0°
Hysteresis (ΔαH)	0°		3°	0°		3°	0°	1.5°	0°	1.5°	0°	1.5°

Local AOA Stall warning Threshold

By activating the anti-icing system (former level II), icing AOA light is activated and the pilot will be notified about stall threshold.

ATR 72 F.C.O.M.	CCAS	1.02.10		
		P 9	500	
	GENERAL			APR 08

Whenever ICING AOA is illuminated, the aircraft is protected by an earlier stall threshold as follows :

	AIRCRAFT CRITICAL ANGLE OF ATTACK					
	ALERT and STICK SHAKER ACTIVATION			STICK PUSHER ACTIVATION		
	FLAPS 0°	FLAPS 15°	FLAPS 30°	FLAPS 0°	FLAPS 15°	FLAPS 30°
TAKE OFF	8.0°	8.4°		10.6°	10.9°	
EN ROUTE	8.0°	8.4°	7.7°	10.6°	10.9°	10.8°

Notes
- *EN ROUTEvalues occurs, when 10 mn have elapsed after lift off or when flaps are retracted to 0 whichever occurs first.*
- *Stall alarm alert and shaker are inhibited when aircraft is on the ground*
- *Stick pusher activation is inhibited :*
  - on ground
  - during 10 seconds after lift off
  - in flight, provided radio altimeter is operative, when the aircraft descends below 500 ft.

AOA stall threshold with icing AOA

1.6.7.3Automatic Flight System: (Auto Pilot)

The aircraft is equipped with the Honeywell Digital Automatic Flight Control System (DAFCS). This system is not coupled with an automatic throttle system. The following subsystems are included: the Attitude and Heading Reference System (AHRS), the Air Data System, the Electronic Flight Instrument System (EFIS), the Flight Guidance System (FGS), and the PRIMUS 800 Color Weather Radar System.

The auto flight control system is a standard level of automation on commercial transport aircraft, aiming to decrease the crew workload.

Auto pilot can be disengaged manually by quick action on control columns and with related push button or automatically. The DAFCS is a completely automatic flight control system that provides fail-passive flight director guidance; autopilot, yaw damper and pitch trim functions. The autopilot computers monitor the system continuously and alert the pilots to faults that have been detected in the system.

Autopilot can be disengaged:

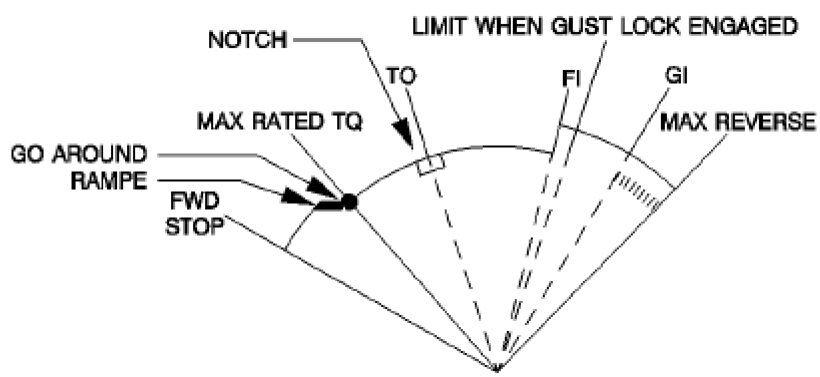
- Manually by action on either one of the following devices
    - Quick disconnect pushbutton on the yoke
    - Action on pitch trim
    - A/P pushbutton on the AFCS
    - YD pushbutton on the AFCS
    - GA pushbutton on the PL
    - Pilot’s force on the pedal over 30 daN
    - Force of pilot on the control column (pitch axis) over 10 daN

- Automatically when The aim of an auto flight control system is to reduce the
    - One of the engagement conditions of the A/P and/or YD is no longer met
    - Stall warning indicator threshold is achieved
    - Disagreement between the two AHRS or between the two ADR.

The aircraft speed should be monitored by the pilots and required throttle be applied by the pilot to reach the desired speed.

1.6.7.4 Power Levers (PL):

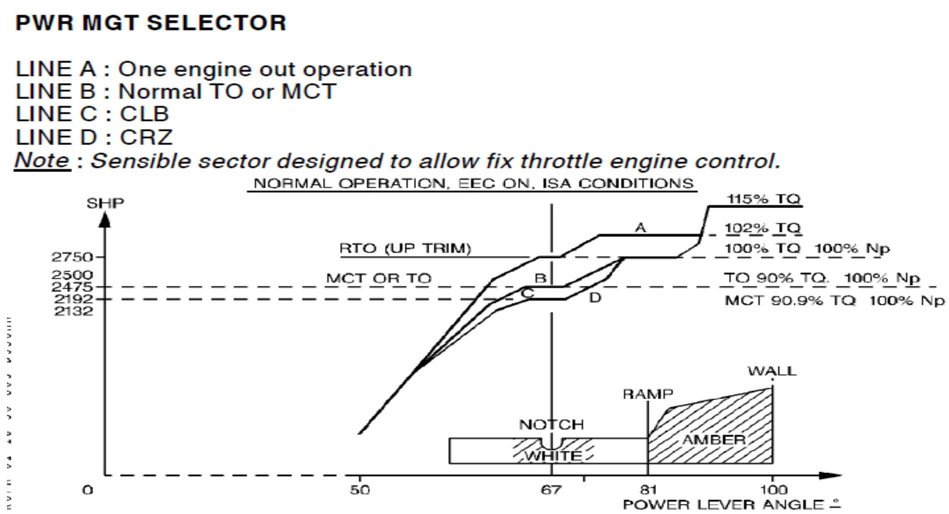
The power levers control the requested engine power. This lever controls the power plant thrust from Max rated TQ to max reverse.



For take-off acceleration, the captain will push PLs from GI to the TO position which is identified by a notch. At landing, the pilot flying will reduce PLs to FI. Then after flight idle gate automatic unlocking, he will act on the triggers to reduce down to GI, and eventually to reverse. Reverse sector is “protected” by a spring rod: a force must be exercised by the pilot to position the PL into reverse sector. Releasing this pull force will bring PL back to around GI.

When the PL is on the MAX rated TQ position, the pilot can increase the power (if necessary) by pushing the PL up the RAMP (after GO AROUND position) to the FWD stop.

When the power levers are close to the notch position, the delivered power depends on the power management setting. When the PL moves forward the notch position, the delivered power becomes independent of the power management setting.



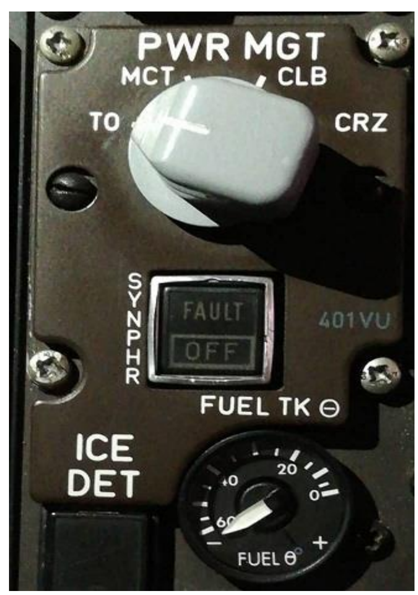
At notch position by the control system delivers max rated power corresponding to the mode selected.

TO : P = 2475 SHP

MCT : P = 2500 SHP

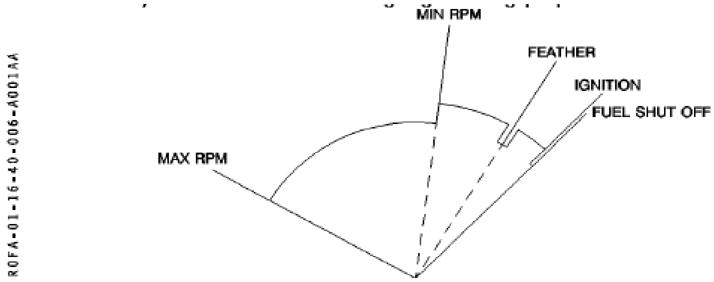
CLB : P = 2192 SHP

CRZ : P = 2132 SHP

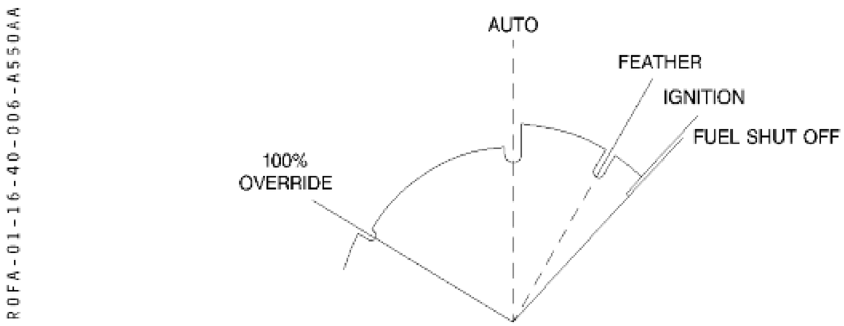


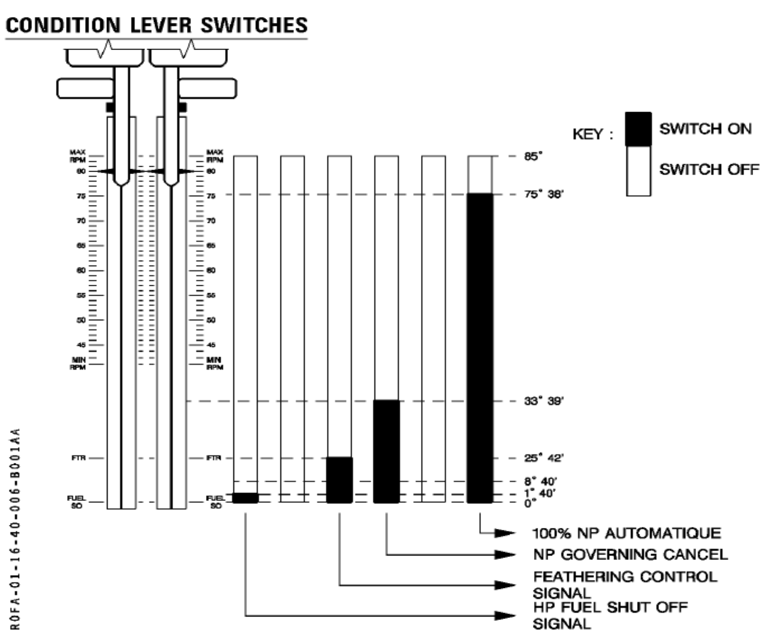
1.6.7.5 Condition Levers (CL):

They operate feathering control, HP fuel shut off valves and propellers speed (NP), controlled by Pitch control unit (PCU) when in blade angle governing propulsion mode.



Maximum propeller speed (NP) will corporate manually on type ATR 72-212 through the condition Level. In other types of ATR 72 Aircraft an auto position is available on condition level. AUTO position controls propeller speed through PWR MGT selector position.

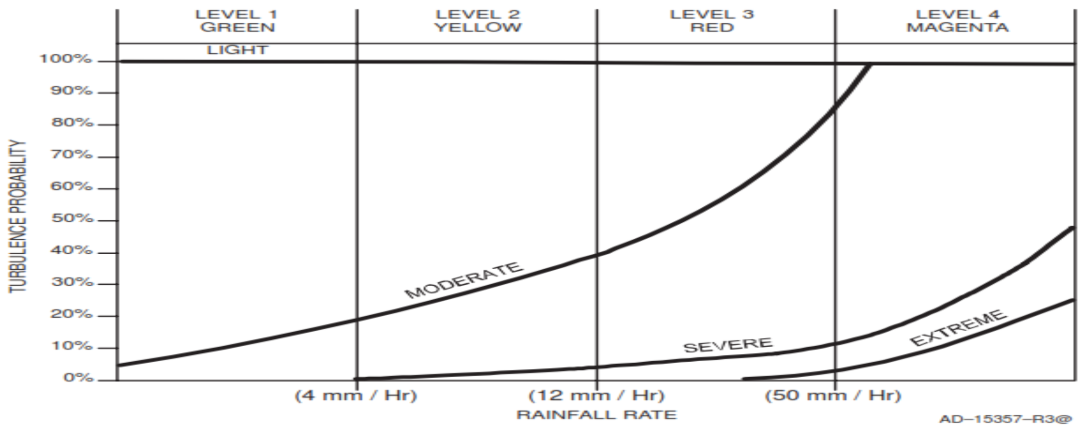




1.6.7.6 Weather Radar:

The aircraft was equipped with the weather radar WR-800 Honeywell that combines several displays on one screen to provide a moving-map depiction of the aircraft position. The weather radar radiates power when operating in any mode other than STBY. The display shows the aircraft's position relative to VOR radials, localizer and glideslope beams, as well as providing real-time information for heading, course selection, distance, groundspeed, desired track, bearings, glideslope or glide path deviations, and other navigational features. The EHSI also incorporates four-color weather radar and displays 3 levels of detectable moisture with four separate colors.

According to the ATR 72 Flight Crew Operating Manual (FCOM), the following colors are used to depict the various cloud densities and percentage of turbulences:



Probability of Turbulence Presence in a Weather Target

Level(storm)	Weather Mode	Map Mode
Level 0	No Detectable Clouds	Black
Level 1	Normal Clouds	Green
Level 2	Dense Clouds	Yellow
Level 3	Severe Turbulence	Red
Level 4	Extreme Turbulence	Magenta

This information is not recorded on the FDR, and the pilots did not make any comments referencing the weather radar; it could not be determined during the investigation if the weather radar was being used during the accident flight. The first officer noted bad weather but it was not cleared to focus on EHSI.

1.6.7.7 Terrain Awareness Alerting System - TAWS:

The aircraft was equipped with EGPWS Mark VIII model Honeywell 965-1206-011 for terrain awareness alerting. It helps to prevent accidents caused by Controlled Flight into Terrain (CFIT). Following an EGPWS warning, the crew must immediately focus their attention on terrain proximity. Positive action to alter the flight path or / and to change the configuration should be initiated immediately.

EGPWS has several inputs and is associated with the following systems:

- ADC 1
- Radio altimeter
- ILS 2
- SGU 1 and 2
- Flaps position
- Landing gear position
- AHRS 1
- Weather radar
- GNSS (if installed) or EGPWS internal GPS card

Installed EGPWS as basic mode configuration has outputs as:

- Visual warning: red ”GPWS” lights illuminate.
- Aural warning:

The EGPWS performs the following alert modes:

- Basic EGPWS modes:

- Mode 1 - excessive descent rate :”SINK RATE” “PULL UP”
- Mode 2 - excessive terrain closure rate :”TERRAIN” PULL UP”
- Mode 3 - altitude loss after takeoff (no relationship with the event) :”DON’T SINK”
- Mode 4 - dangerous terrain clearance. According to speed and / or flaps / gear setting: ”TOO LOW TERRAIN” or “TOO LOW GEAR” or “TOO LOW FLAPS”
- Mode 5 - below glide slope (no relationship with the event)
- Mode 6 - altitude callouts (no relationship with the event).

Enhanced modes:

- Terrain Clearance Floor (TCF), linked with the runway distance
- Terrain Awareness Display (TAD).

A terrain conflict intruding into the caution ribbon activates EGPWS caution lights and the aural message “TERRAIN AHEAD, TERRAIN AHEAD”. The caution alert is given typically 40-60 seconds ahead of the terrain/obstacle conflict and is repeated every seven seconds as long as the conflict remains within the caution area.

When the warning ribbon is intruded (typically 30 seconds prior to the terrain conflict), EGPWS warning lights activate and the aural message “TERRAIN AHEAD, PULL UP” is enunciated, with “PULL UP” repeating continuously while the conflict is within the warning area.

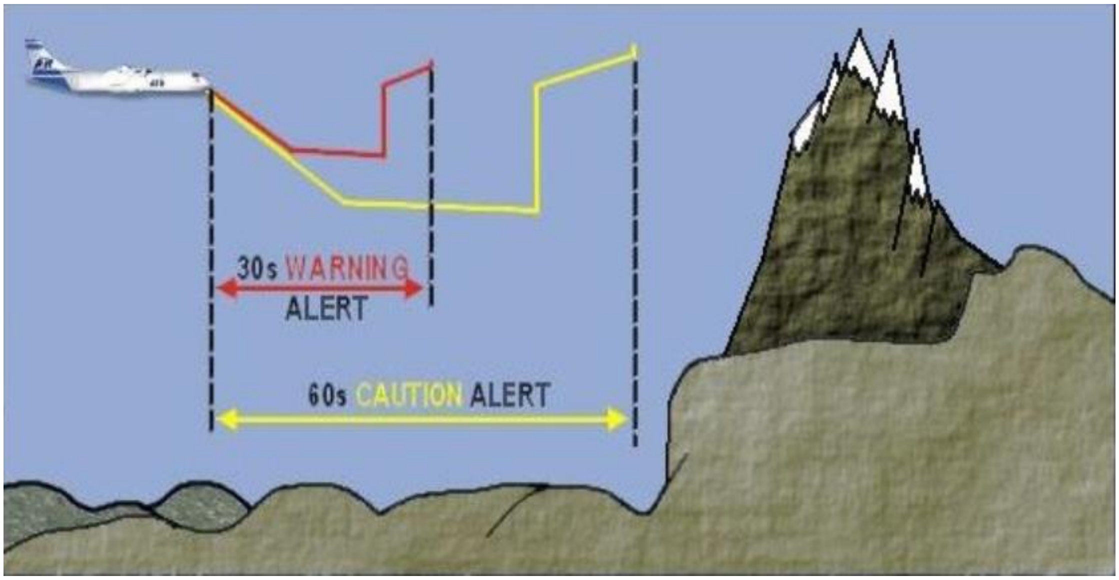


Figure 5, EGPWS – TA principles

The detected evidence on EGPWS behavior showed normal operation of this component.

1.6.7.8 Emergency Locator Transmitters (ELT):

There was one ELT installed on the accident aircraft. The ELT model was ELT96A2560000000 S/N: 3927 made by Air Precision, France. The system is composed of:

- A transmitter - An antenna - A remote control

Once activated, the ELT transmits a 406 Mhz signal via antenna to the SARSAT satellites constellation, allowing quick and precise identification and localization of the distress by the ground based on control centers. The transmitted VHF frequency as 121.5 allows easy tracking of the ELT for the Search and Rescue teams. The ELT will automatically activate itself in case of crash impact as it incorporates an integrated acceleration sensor (g-switch). The ELT also can be manually activated from its front face or a remote control panel or activation system. The hexadecimal identification code downloaded from the ELT was B4C64930B788741. This code corresponds to:

- The country code of Iran (422)
- Aviation type
- An aircraft identification of EPATS

1.7 Meteorological Information:

Weather Information was provided by the dispatch office and was typically presented in the flight release documents. The information was provided for en-route and alternate airports and Yasouj at the time of departure. The dispatch office of Iran Aseman Airlines received information directly from AFTN linked with Iran Meteorological office.

The investigation team performed an in-depth study of the environmental conditions to define the weather phenomenon in which flight 3704 was operating until the time of the accident. Because of the complexity of the environmental conditions, it was necessary to collect and document datas from other sources, and to determine the pertinent weather products, services, and actions of agencies and individuals involved. In addition to information received from the Iran Meteorological Organization, and Dispatch, France Metrological office (METEO France), numerous individuals were interviewed, including pilots having flight experience to Yasouj.

After receiving information about the accident, the general condition of the airspace of the Yasouj airport and neighboring airports from the Meteorological Organization of Iran was the main based information and weather conditions were investigated as the following:

1.7.1 Airport weather (METAR) for Yasouj Airport (OISY):

180300Z 00000KT 9999 FEW040 BKN090 06/ M00 Q1022
180400Z 14006KT 9999 FEW040 BKN090 06/ 00 Q1022
180430Z 08006KT 9999 SCT040 SCT090 10/ M01 Q1021
180500Z 00000KT 9999 SCT040 OVC090 11/M00 Q1021
180530Z 09004KT 9999 FEW035CB SCT040 OVC090 14/M01 Q1022
180600Z 13004KT 9999 FEW035CB SCT040 OVC090 13/M00 Q1021
180630Z 14006KT 9999 FEW035CB SCT040 OVC090 15/M02 Q1021
TAF unavailable

While dispatching the release of the flight, the crew received METAR report at 03:00 UTC for Yasouj airport and the ceiling of the BROKEN clouds was 9,000 ft. from the airfield, so related meteorological information was available in their flight documentations.

Studies showed that the airport traffic forecast (TAFOR) report was not issued for Yasouj airport, so this report had not been made available on the day of the accident. The same proceedings applied to some low-traffic airports in the country, such as Dezful, Lavan, Sanandaj, Yasouj

According to Iran's AIP (Iran Aviation Information Document), the meteorological office of Tehran was responsible for TAF preparation, with a validity period of 30 hrs for the TAF. However, the State Meteorological Organization did not issue the TAF due to the low traffic capacity of the Yasouj airport. The responsible manager in Iran MET office showed that

It was available in Tehran on 30 hours by the request.

At FL210 and before descending, the first officer contacted Yasouj tower and the METAR was delivered by the tower at 05:30 UTC, which included the ceiling of OVERCAST (full coverage of clouds) on 9,000 ft.

The meteorological information of neighborhood regions of destination airport was collected to give more concentration of field condition. The meteorological information of Semirom and Si-Sakht regions were as the following:

1.7.2 METAR for Semirom region:

Semirom METAR report:

180400Z 18018KT 9999 FEW040 BKN190 08/M06 Q1022
180500Z 19008KT 9999 SCT040 BKN180 09/M05 Q1022
180700Z 22035KT 9999 SCT040 OVC100 09/M03 Q1021

1.7.3 METAR for Si-Sakht region:

180400Z 00000KT 9999 SCT040 BKN080 06/M02 Q1027
180500Z 19008KT 9999 SCT040 BKN080 07/M03 Q1028
180700Z 00000KT 9999 SCT040 BKN080 12/M01 Q1027

- METAR for 180600 Z were not available.

1.7.4 Forecasts of Isfahan (OIFM) and Shiraz (OISS) Airports:

According to available flight plan, two alternate airports were assigned to this flight. FORECAST reports of Shiraz and Isfahan airports have been delivered to the pilots.The assessment of the weather for these prioritized airports was:

Shiraz International Airport (OISS)

TAF OISS 1721/1812 28003MPS 7000 NSC
BECMG 1807/1809 24006MPS 7000 FEW030CB SCT035 BKN090
TEMPO 1809/1812 24009MPS 4000 SH RA SCT030CB SCT035 OVC080

Isfahan International Airport (OIFM)

TAF OIFM 1721/1812 02004MPS 7000 FEW035 SCT100
BECMG 1805/18 07 17004MPS 7000 FEW030CB SCT035 BKN090
TEMPO 1809/1812 17009MPS 4000 SHRA SCT030CB SCT035 OVC090

1.7.5 En-Route Prediction:

The available en-route meteorological prediction in flight folder, which was provided by the Meteorological Organization for the Center, West and Southwest of the country, from February 17 to February 18 and in particular February 18 was reviewed. The probability for occurrences of convective instabilities, including in the accident area, was predicted.

The SIGWX map February 18, valid until 12:00 UTC, indicated instability in the region with ISOLATED-EMBEDED-CB, and zero-degree turbulence and moderate icing condition warning from 11000ft.

1.7.6 Regional Forecast:

In the context of the regional forecast of the AREA Forecast (ARFOR), estimated from 00:00 UTC to 12:00UTC on February 18, for the western, southwest, and southern region of the country, unstable conditions with cumulonimbus clouds CBs had been predicted.

W: 6000 SCT 070 BKN120 TEMPO LOC 1500 SHRA / SN / BR SCT 0 65CB BKN070 OVC110

SW: 7000 NSC TEMPO NRTH OF AREA LOC 4000 RA / BR FEW060CB SCT065 BKN120

TEMPO 0612 LOC 1000 DU / SA

405013 27015 410001 26021 420065 21026 430093 21036 440008 23047

Based on ARFOR of southwest Area as reported by Meteorological Office is decoded before:

405013 16005 at ALT5000 ft Tem=13C, wind 270/15 m/s (29 kt)

410001 26021 at ALT 10000 ft TEM=1, Wind 260/21 m/s (40.7kt)

420065 21026 at ALT 20000 ft TEM=-15, wind 210/26 m/s (50.4 kt)

S: 7000 NSC TEMPO LOC OVER SOUTH OF AREA 1500 HZ / BR / DU FEW060CB SCT070 BKN110

C: 7000 NSC TEMPO LOC 3000HZ/BR SCT 065 BKN 120 TEMPO OVER

MNT OF AREA RA/SN FEW 065CB SCT 070 OVC 110

405013 16005 410002 25009 420064 23018 430092 22030 440011 24041

Based on ARFOR of central Area as reported by Meteorological Office is decoded before:

405013 16005 at ALT 5000 ft Tem=13C, wind 160/5 m/s (9.7 kt)

410002 25009 at ALT 10000 ft TEM=2, Wind 250/9 m.s (17.46kt)

420064 23018 at ALT 20000 ft TEM=-14, wind 230/18 m/s (35 kt)

According to the prediction of the area FORECAST and SIGWX, wind speed and temperature in different layers in the WAFS system and wind maps in the middle and upper levels, southwest wind velocity was predicted to be high in the southwest of the country. So, the high headwind for the flight 3704 was predicted.

1.7.7 AIRMET aeronautical alert:

AIRMET aeronautical alert at 02: 28 UTC was issued for the area until 05:30 UTC as:

OIIX AIRMET 01 VALID 180215/180530 OIII OIIX TEHRAN FIR

ISOL CB OBS LOC OVER NW'W'SW'N'AND WEST OF THE CENTERAL AREA TOP ABV FL150 MOV E NC

SFC VIS 5000M TO 1000MDUE TO RA / BR / HZ OBS LOC OVER TEHRAN AND CENTRAL AREA

SFC VIS 4000M TO 2000M DUE TO TS / RA / BR / FCST LOC OVER WEST OF AREA

Isolated CB clouds above FL150 with possibility of rain, thunderstorm in the western region as well as rainy and hazy conditions were predicted.

There was no issued SIGMET including mountain wave phenomenon (MTW) in this area.

1.7.8 Meteorological information by France:

According to SIGWX, the top layer of CB clouds was estimated to FL350.

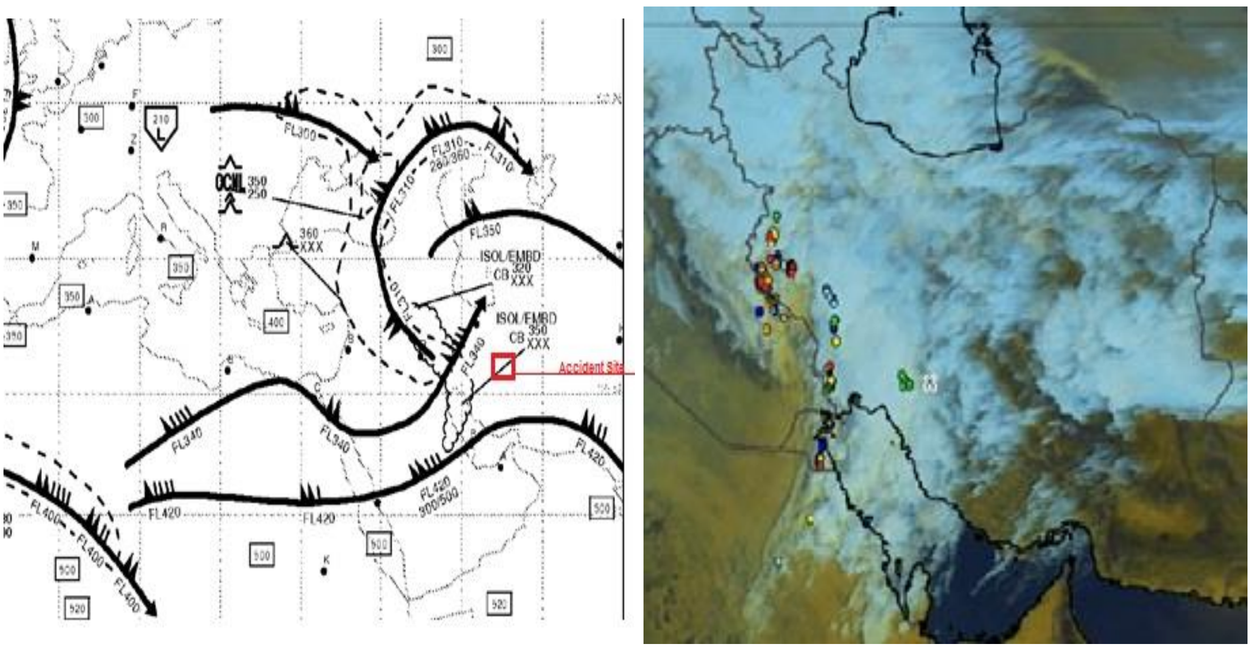
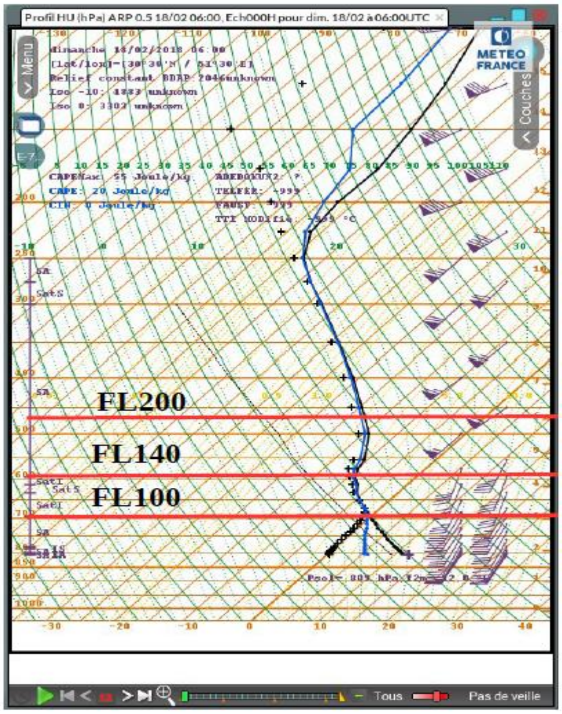


Figure No. 5 Area Forecast up to 06:00 UTC



At 06:00UTC, from FL100: it was planned that vertical movement profile suggested beavailable.

At 06:00 UTC, between FL100 and FL140, the layer presents a slightly unstable and conductive to ascents. These vertical movements are susceptible supply of cloud with humidity favorable to the appearance of icing conditions.

Between FL140 and FL200, the presence of an isothermal layer was noted. In this unstable layer, the droplets of cloudy water brought by the vertical movements (up & down draft) can accumulate while remaining in a state metastable. This layer is conducive to the appearance of severe icing conditions. Water droplets would be super cooled in this layer.

The mountain waves are likely to occur with the following conditions:

- Wind direction within 30 degrees of the perpendicular to the ridge of high ground and no change in direction over a significant height band
- Wind speeds at the crest of the ridge in excess of 15 kt, increasing with height

The above conditions are Likely to have been available for lee waves (mountain waves are the most common form of lee waves). The French meteorological organization had the capability to run its model of wind forecast on the west of the Zagros Mountain, with results being extrapolated to the complete Zagros range. The result of its study underlined a high probability of heavy mountain waves, with wind speed of around 50/60 kt, and vertical wind reaching 10 m/s (around 2,000 ft/min).

Based on FDR Analysis by BEA, drawing the computed vertical wind values versus the range to the DME of Yasouj really shows the oscillations of the vertical wind (Figure 6) with a long range period during the accident flight.

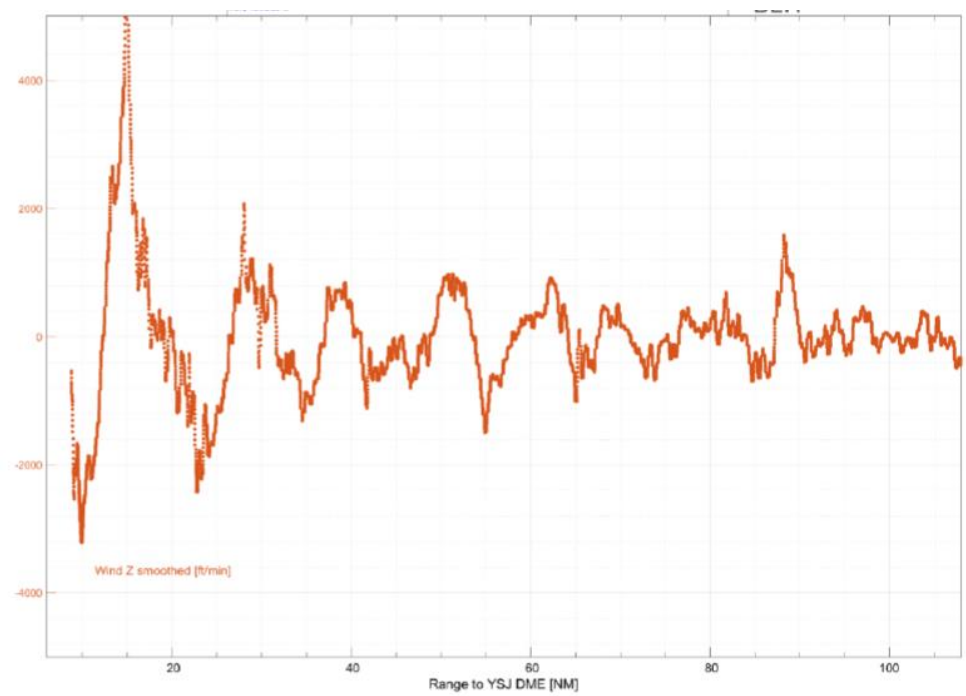


Figure No. 6 calculated Vertical Wind

It was estimated that the accident site had moderate turbulences with conditions moderate up to locally severe icing. There were unstable conditions and stormy in the accident site and it was covered by clouds. The rebuilt SIGWX type chart at the time of accident, computed after the event with global forecast models and available information from daily measurements, was received on 03/03/2018 from METEO France and is provided in Fig.7.

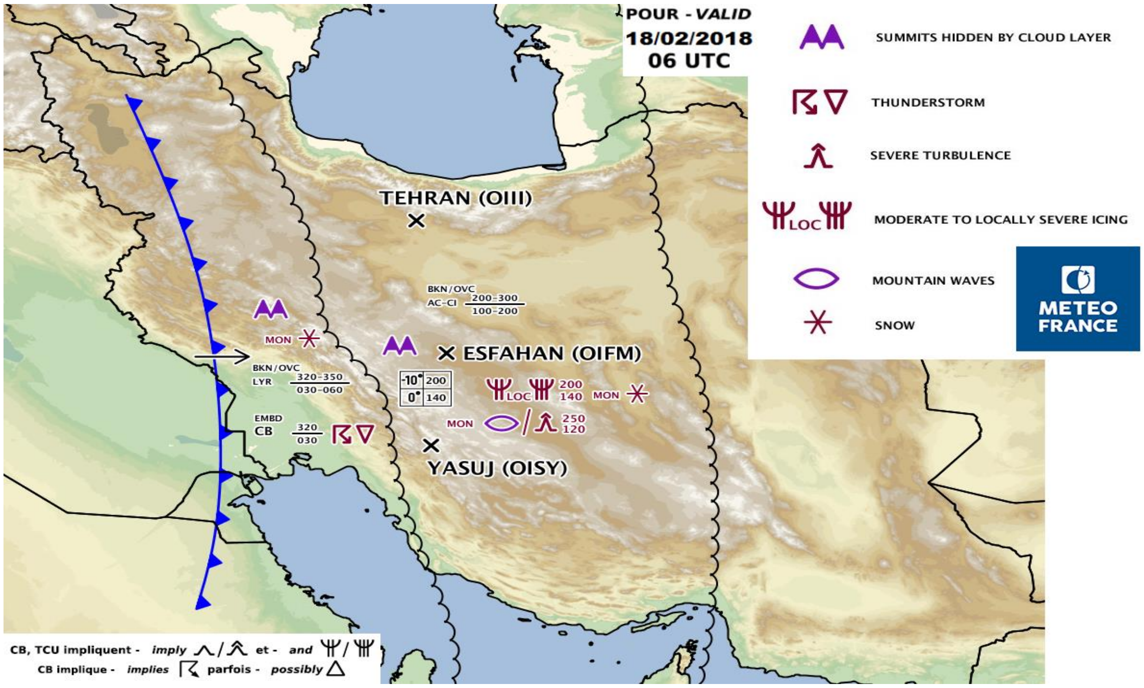


Figure No. 7 SIGWX type chart computed by METEO France by global model

1.8 Aids to Navigation:

Navigation and landing aids were not contributive to the event. Company information and surveys showed that the navigation devices installed on the aircraft before the flight were safe and operational.

Only NDB had been used at the Yasouj airport on the day of the accident. This device was checked after the initial installation according to newly issued national regulations, and the last flight check of the airport was on October 18, 2016 and according to paragraph 6.1 of CAOIRI requirement No. 4410, this type of navigation device did not expire up to new installation or its subsequent review request by the airport operator.

Due to mountain obstacle with elevation up to 13800 ft, at 14 NM of the airport, the flight level should be more than FL160 to receive DME signal from Yasouj airport.

Even though new DVOR facility was installed for the airport but was not approved accordingly and its DME was switched off by the airport authority and related NOTAM had already been issued and the crew was aware of the subject.

1.9 Communications:

During the entire flight time, a stable and normal two-way radio communication between the flight crew and ATC was maintained. The conversations between the crew and different services of ATC as well as the conversations between flight and dispatch were recorded by the corresponding recorders, and used in the course of investigation. The aircraft has two communication devices (VHFs) that were operational at the time of the accident.

1.9.1 Detailed Flight Communications:

A review of the following flight communications is based on information received from the Air Traffic Control Office of Iranian Airports and Navigation Company.

- At 04:02:53 UTC, IRC3704 flight contacted the delivery unit at Mehrabad Airport at the request of FL210 and received the latest Mehrabad meteorological information on ATIS by the name of E and QNH.1014 and asked for engine start up to a maximum of 20 minutes later.
- At 04: 21: 26UTC, the IRC3704 flight, while calling for a refresh call, was approved for engine starting by the controller.
- At 04: 22: 03 UTC, the controller asked the pilot to read the flight take-off permission and assigned the 1543 radar code to the flight. After receiving the permission by the pilot, confirmation was done by the Ground controller on 121.7 frequency.
- At 04: 22: 49UTC, the pilot called the ground unit and requested taxi, so the controller approved aircraft taxi via E8 & E9 & A to hold short RWY 29R.
- At 04:25:48UTC, the Ground Flight Controller delivered flight to Mehrabad airport tower unit.
- At 04:26:00UTC, the pilot contacted the tower and announced his position on his taxi TWYA.
- At 04:32:27UTC, the controller issued clearance for the aircraft to line up RWY 29L and asked the pilot to wait for subsequent command for take-off.
- At 04:33:53UTC, the flight was allowed to take off from the runway, and the wind direction was declared at 060/04Kts, and the pilot was asked to complete Mehrabad 2A SID after take-off and contacted Mehrabad approach radar unit on Call 125.1 Frequency.
- Based on the index of the unit for the flight surveillance tower, the aircraft took off at 4:35 UTC.
- At 04:36:14UTC, the pilot called Mehrabad Airport radar unit and declared his altitude at 5600 feet. At this moment, the IRC3704 flight was detected by the radar and was allowed to climb to FL210. At this moment, the flight was requested to continue along to the ELUSI point.
- At 04:52:56UTC, the pilot called the 2nd sector of Tehran control center (ACC) on Freq.125.7 and reported the FL185 flight altitude and climbing the altitude to FL210 with radar code 1543 by Tehran.
- At 05:14: 44UTC on cruise level FL210, the flight reached the TMA of Isfahan (Isfahan airport controlled area), so was transferred to the Isfahan Airport Flight Approach section on 124.6 frequency.
- At 05:44:45UTC, when the flight was released by Isfahan APP the pilot again established a radio call with the 3rd sector of Tehran ACC and was identified by the radar.
- At 05:47:40 UTC, the IRC3704 flight was delivered to the southern sector of the control center on the frequency of 128.75.
- At 05:49:05UTC, the pilot called the southern sector 3 called the ACC and was identified by the radar.
- Up to this moment, the IRC3704 has maintained FL210 and was controlled by the different control units according to its flight plan and altitude and continued at desired routes.
- At 05:49:27UTC, the first officer called Yasouj airport tower and reported OBTUX position at FL210, requested the latest airport information. The controller also provided requested information including new issued weather on 05:30UTC.

- At 05:52:21UTC, the pilot IRC3704 contacted on the frequency of the Tehran ACC that he was in contact with the Yasouj airport and ready to descend. In response to him, the ACC controller, according to the minimum authorized altitude W144, authorized him to descend to FL170 and continue to the Yasouj airport.
- At 05:52:55 UTC, the pilot contacted the Yasouj airport tower (ASIS officer) and announced his position based on the 35-mile position that the control center in terms of nonexistence other Traffic does not have a limitation to further descend.
- At 05:53:08 UTC, the pilot again contacted the Yasouj airport and announced its position 35NM from the airport and crossing 20,400 feet to 17,000 with No-Objection for further descend by Tehran.
- At 05:53:24UTC, the Yasouj Airport Controller announced the flight for planning Circling NDB approach to land RWY 31 and the wind direction at 090/04Kts, and no traffic has been reported at a lower altitude and report further position.
- At 05:53:40UTC, it was read back by the pilot.

  - *Note: from this time, the operation deputy of the airport came on the frequency and took the roll for continued communications to the flight.*

- At 05:53:53 UTC, the controller told the pilot "captain, final of RWY 31 is almost clear from clouds and you will not have problem for Circling NDB from RWY 31".
- At 05:54:00 UTC, the pilot called the controller:
  "we are going to land and coming to airport overhead on 15,000 feet to and based on our instrument data, we hope to get out from the clouds between 14500 to15000 feet "
- At 05:54:52UTC, communications between the pilot and the controller were exchanged on the weather conditions and performance of the navigation assistance equipment.
- At 05:55:33UTC, the pilot declared his position at 25 miles
- At 05:55:40 UTC, the controller told the pilot:
  "Meanwhile, the left downwind side of the RWY31 seems to be good because, due to the direction of wind speed, clouds are slowly moving to the south of the station"
- At 05:56:00 UTC, the pilot told, "We'll come overhead expect to VMC condition on left downwind to see the Runway"
- At 05:59:06UTC, the controller called the flight, and the pilot declared a14-mile distance and failure to receive a signal of DME from NDB navigation device. The pilot again checked the weather conditions prevailing around the airport.
- The pilot at 05:59:15 UTC informed the tower of his position at 14 NM and the controller notified the pilot: "Know that Left Downwind and Left Base are 31 free from the cloud."
- At 06:00:03UTC, the controller declared the latest airport pressure QNH 1021Hpa.
- At 06:00:10 UTC, the pilot confirmed QNH 1021.
- Subsequently, the controller called the flight from 06:04:04UTC to 06:06:34UTC, and tried to make communication with flight but unfortunately, there was no response.

1.10 Airport Information:

This accident occurred beyond the airport perimeter.

Kohkiluyeh and Boyer- Ahmad province has one airport in the city of Yasouj. The city is surrounded by the Zagros Chain Mountain and the highest peaks of the mountains named DENA are located en-route W144 from Tehran to Yasouj in the north of the airport. The minimum safe en-route altitude (GRID MORA) is 16900 ft. Based on en-route 3.1-71 information of AIP, the related MOCA is 16200 ft, so minimum flight level is FL170 at position of accident site. Due to particular geographical conditions of this airport by the fact, the airlines are not willing to fly there. Most of the airport's flights are operated by Iran Aseman Airlines.

The airport's usable runway is currently 3,500 meters by development of RWY recently but according to Iran's AIP (Iran Aviation Information Publication), it is 2600 meters long because official coordination for approving the real RWY extension was not done accordingly at the time of the accident. Due to the mountainous area, special operating condition was available for the airport. The airport runway lighting system was installed but was not approved on the AIP at the accident time.

Based on Iranian AIP, Yasouj Airport has traffic zone (ATZ) with 7 miles diameter up to altitude 12,500 ft. as class G aerospace with flight information service (AFIS) only. The AFIS unit is not an air traffic control unit, therefore no separation shall be provided by that unit, (so) it is the responsibility of pilots by using the service provided to maintain proper separation in conformity with the rules of the air. There is a local agreement between Tehran ACC and ANS section of Yasouj airport to interchange the flights. Based on the agreement, if there is no traffic in the Yasouj zone, the flight into Yasouj can be delivered from ACC (Class D-controlled aerospace) to Yasouj (Class G). The related responsibilities are not so clearly distributed.

The accident site was located outside of Yasouj ATZ.

According to CAO Directive No. 8010, the National airport operators were required to develop more navigational capabilities with a higher degree of control and it should not be limited to the NDB. In accordance with Para 2.1.2 of these requirement, NDB-based navigation design must be removed by the end of September of 2021. During the development plan of the airport, the new DVOR / DME system has been installed. The related SID/STAR based on DVOR / DME approach had been designed and checked but was not available for this flight and it was planned to be operational from March 29, 2018.

A NOTAM, with validity from the 27th of December 2017 to the 27th of March 2018, indicated that the DME associated to the DVOR was de-activated.

Figure No. 8 View of the Aerodrome

Yasouj airport is in the category of G airports and the provided service was in accordance with the provisions of the Annex 11th to the Chicago Convention as Flight Information Service. The highest statistical Transition Level as FL170 was constantly inserted to related approach chart.

According to Iran's AIP, the airport had only one Circling NDB approach at the time of the accident. The related Circling NDB approach is not dependent on DME. In accordance with published Iran AIP, there was not any Standard Terminal Arrival Route (STAR) to Yasouj Airport, so flights from the source of Tehran en-route W144 should continue & respect MEA with minimum flight level FL170 feet (FL170 is minimum of route) to overhead of the airport then descend to 15,000 feet via holding and making approach to land on RWY 31. The Minimum Obstacle clearance altitude (MOCA) of the route is 16200 ft. However, within 25 miles north of the airport, the minimum safe altitude (MSA) is 15,500 feet. If the flight continue on 15500 ft., it is below route MEA and based on Iranian regulation flight will be in “G” class aerospace and responsibility deliver to the pilot. So, within 25 NM inbound IFR flights can descend to this altitude and should be announced to the ATC.

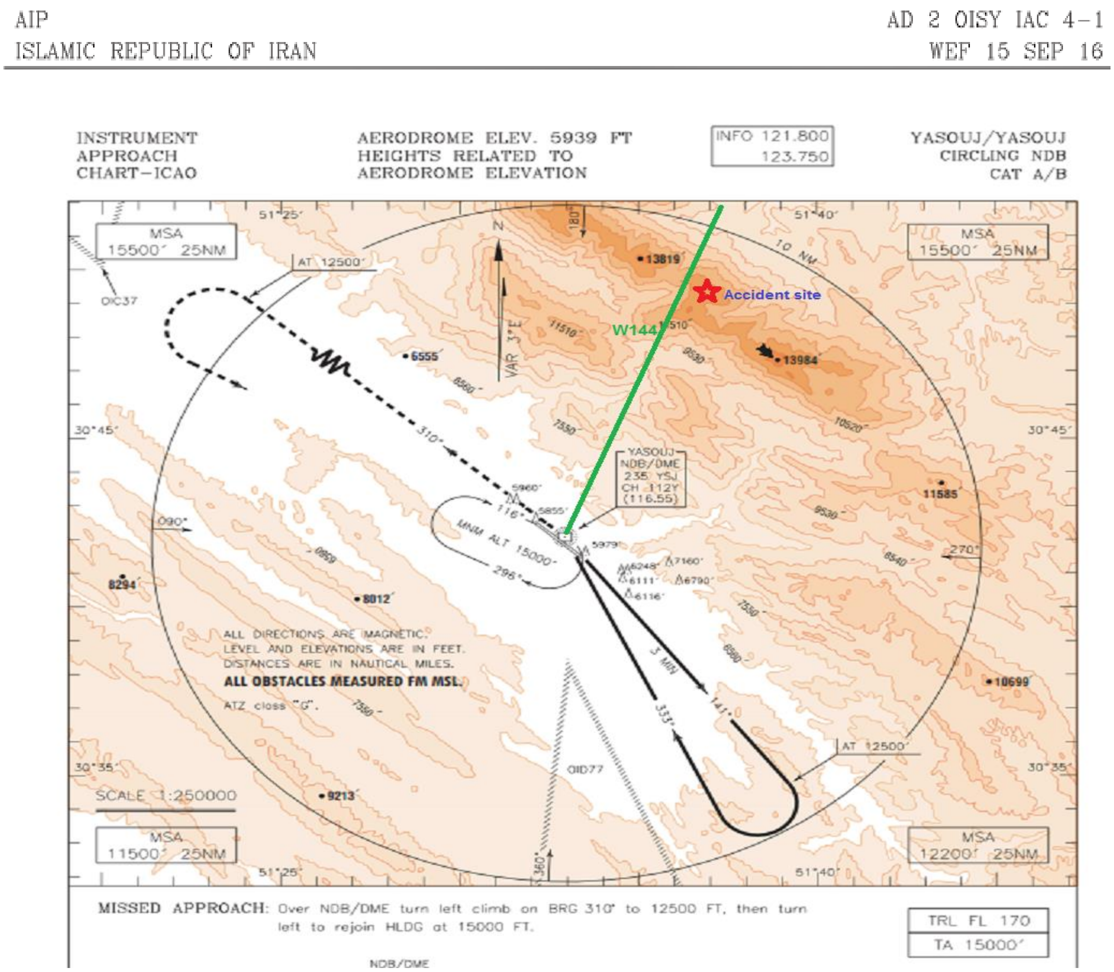


Figure No. 9 Location of accident on Yasouj Approach chart
(The green line & place of accident were added to chart for clarification)

1.10.1 Operation limitation of Airlines for Yasouj Airport:

The history of previous flights of ATR fleet shows that it was common practice to make visual approach to Yasouj airport for landing on RWY 31 or RWY 13 but the airlines recommended circling NDB approach.

Yasouj airport is categorized as category C aerodrome in Aseman Airlines operations manual with obligation on Operating Manual Part C:

5.2 Departure and arrival procedure for Category C aerodromes:

A. in accordance with the weather report (TAF/METAR), the presence of thunderstorm at the actual time of departure / arrival of the intended airports, take off / landing for all airports are not authorized

- **Note 1:** Flights shall be performed in cloud condition of less than SCATTER CB with minimum ceiling of 11000 ft when IAP is based on NDB [due to potential effect of CB on NDB signal]

B. Arrival instructions for the airports which are considered as C category and no STAR has been published :

The approach and landing must be made according to:

1. *Respect the MEA until reaching entry point*

❖ **Note 2:** The entry point of the airports without STAR was not defined.

2. When the aircraft is descending out of ENROUTE in order to make an approach and landing to the designated runway, shall respect to the highest GRID MORA.

3. Then continue to descend if the navigation facility is available and the MSA within 25NM has been published by the state.

4. When the runway is insight, the pilot may request for visual approach according to OM/PART A.8.1.3.2.8.

For flights to Yasouj, the crew has to be qualified for the approach. Both the captain and F/O were internally qualified.

In case of NDB failure, the airlines policy is:

- *Failure known before flight, the flight is performed only if VMC confirmed at arrival*
- *Failure identified during flight, the flight is diverted*

There was no pilot report of NDB failure since the year before during approach to Yasouj airport.

1.11 Flight Recorders:

The characteristics of the flight recorders of aircraft were based on the existing technical records of the airline as follows:

Type Of Memory	Part Number	Manufacturer	Type	Name Of Appliance
Solid State	2100-1020-02	L3-Communications	CVR	Cockpit Voice Recorder
Chip Memory	S800-2000-00	L3-Communications	SSFDR	Digital Flight Data Recorder
CF Memory	Avionica MKII	Avionica	MINI QAR	Quick Access Recorder

Access to crash site was limited and difficult due to snow and deep valley of mountain there, so some introduction trainings were done by Iranian & French investigation team to the search & rescue teams to localize flight recorders.

On the 14th day after the accident, the flight recorders were found and transferred by helicopter to a flat area of Si-sakht and the next day were delivered to the investigator in charge after legal coordination and transferred to Tehran.

Initially, the recorders were transferred to the avionic shop of the Iran Air Company with the cooperation of the experts of the company for downloading.

Based on CAO Directive No;4913, due to the severe impact of the aircraft with the mountain and entered humidity into the components, it was necessary to install the memory of flight recorders on new devices and then try to download the information.

This process was carried out with the available facilities on CVR first, but the received audio file was empty and process was not successful. In accordance with coordination of state of manufacturer, the recorders were sent to the laboratory of the BEA in France.

BEA performed the readout process with the Accident Investigator Kit dedicated to the FA2100 data recovery, following the procedure for data recovery in case of damaged recorder as described by the manufacturer's documentation. The memory of CVR/FDR passed recommended tests successfully and then the memories were installed on new sets and downloading was performed.

1.11.1 Cockpit Voice Recorder:

The Cockpit Voice Recorder was SSCVR type model FA2100-1020-02 with S/N: 293049. Four channels with 30-minute audio channels recording and two 2-hour audio channels can be recorded on this recorder. Channel filtering was performed. The audio files from the engine start in Mehrabad airport were available. The CVR containments transcript is:

Local time	Voices, Sounds, Warnings and Remarks
07h27min56	Beginning of sounds and warnings chronology
07h42min09	Captain: پرواز هم با خودت (You will be Pilot Flying)
08h04min09	Take Off
08h04min49	Gear up
08h08min38	Contact with dispatcher, Off-block 04h25, take off 04h30, ETA 05h40 UTC
08h45min29	Contact with ISN APP
08h52min11	Briefing on NDB App
08h52min40	Discussion about YSJ NDB Approach

Local time	Voices, Sounds, Warnings and Remarks
08h56min33	Discussion about obstacles
09h16min07	كمك خلبان: DME نداريم و نوتامه FO: We do not have DME based on NOTAM
09h16min19	خلبان: يعني DME كار نمي كنه؟ Captain: Does it mean DME is not working?
09h19min12	Delivery to ACC
09h19min28	FO : Good morning flight level 210 position OBTUX request latest field information
09h19min50	TWR: Roger IRC3704 copy latest information at time 05:30 expect NDB circling approach RWY 31 wind 090/04 knots visibility 10 kilometer Few 3500 cumulonimbus scatter 4000 feet overcast 9000 feet Temperature 14 dew point minus 01 and QNH 1022 report when released by Tehran
09h20min30	FO: Correction QNH1022 NDB Circling RWY 31
09h20min37	Captain: ابرها را بخون يكبار request FO to read clouds conditions
09h20min59	Crew expects to get out of clouds at Alt 15000 ft خلبان: برو اورهد ، ۱۵ تا از ابر میایم بیرون
09h21min55	FO : asked about Go-around but the Captain answers to continue on the approach کمک خلبان: Go around شم (آن) , Right Down Wind هست یا Left down wind ؟
09h21min59	FO: Go around كمك خلبان : Go around خلبان: نه ما وارد اپروچ شديم ميريم هرچي اپروچ بگه انجام ميدهيم Captain: No we entered APP; we will do what APP says.
09h21min59	خلبان: وارد اپروچ شدیم دیگه ببین اپروچ چی میگه همونو انجام میدیم
09h22min23	Captain to ATC: Ready for descent
09h22min30	ACC: Descent to FL 170, radar service terminated, continue to destination

Local time	Voices, Sounds, Warnings and Remarks
09h22min45	Horn
09h23min04	خلبان: صبح شما بخير Position 35 mile to Yasouj descending 170
09h23min48	Weather condition request to ATC
09h23min53	خلبان: سلام مجدد ياسوج
09h23min54	TWR: Final for RWY 31 is clear; if you make NDB approach, you can see the RWY خواهش ميكنم كاپيتان تقريباً فاينال ۳۱ مون باز هستش يعني احتمال اينكه NDB circling بزنيد باند رو حتماً مي بينيد.
09h24min07	Captain: We are coming overhead FL 150 and we hope to get out for clouds on FL 145 to 150 خلبان: قربونت برم ما انشالله ميايم ۱۵ تا Overhead انشالله ۱۵ تا ۱۴۵۰۰ از ابر ميايم بيرون
09h24min55	Captain to ATC: Yasouj DME is not working
09h25min06	Captain to ATC: I have the DVOR but I do not have the DME
09h25min19	TWR: Use the DME from the NDB because the DME from the DVOR is not working
09h25min37	Captain to ATC: We are now 25 NM and will report when received
09h25min48	TWR:Left base of the RWY is getting clear by the moving of the clouds
09h26min45	C-Chord (Altitude Alert warning)
09h27min14 09h27min17	Single chime (Master Caution warning) captain: Level 3 on (اخطار يخ زدگى)
09h27min29	Captain: We don't have the Transition Level information
09h27min34	Captain to ATC: Transition level request
09h27min37	First Officer: It should be FL 150
09h27min43	TWR: 170 Captain
09h27min48	Captain to ATC: Yes, thank you
09h27min49	C-Chord (Altitude Alert warning)

Local time	Voices, Sounds, Warnings and Remarks
09h28min08	FO: what bad weather! كمك خلبان : چه هواي خرابي است
09h28min08	C-Chord (Altitude Alert warning)
09h29min03	TWR: IRC3704 your position?
09h29min10	Captain to ATC: Position 14 NM, not received the DME
09h29min15	TWR: Be advised left down wind and left base of the RWY 31 are almost cleared of clouds
09h29min31	First Officer: Left down wind and Left base – We should go overhead لفت دان ويند و لفت بيس – بايد بريم اورهد
09h29min38	Captain: We can't go now – It is behind these clouds آلان كه نميتونيم بريم، پشت اين ابرهاست.
09h30min10	Captain to ATC: Acknowledge QNH 1021
09h30min27	Captain: Why?! (Surprise/Fear) واي؟!
09h30min32	Captain: We ----- cut off this component to be silent. اينا را OFF كنيم و الا دنگ دنگ می کرد
09h30min34	First Officer: Can we get flap? – Could we descend? فلپ بگيريم كاپتان - descend بگيريم؟
09h30min46	Captain: set it on FL140 خلبان : ببندش روي ۱۴ تا
09h30min59	C-Chord (Altitude Alert)
09h31min15	Stall Warning + Stick Shaker
09h31min16	Cavalry Charge (Autopilot disconnection warning)
09h31min16	First Officer: May I set the flaps? کمک: بگيرم فلپ ؟
09h31min20	Cavalry Charge (Autopilot disconnection warning)
09h31min21	Captain: please set Autopilot خلبان: Auto pilot بده.
09h31min25	EGPWS Warning: Terrain ahead
09h31min26	EGPWS Warning: Terrain ahead

Local time	Voices, Sounds, Warnings and Remarks
09h31min28	EGPWS Warning: Terrain ahead
09h31min29	EGPWS Warning: Pull up
09h31min30	EGPWS Warning: Terrain ahead
09h31min31	EGPWS Warning: Pull up
09h31min33	EGPWS Warning: Terrain ahead
09h31min34	EGPWS Warning: Pull up
09h31min34	Cavalry Charge (Autopilot disconnection warning)
09h31min36	EGPWS Warning: Terrain, Terrain
09h31min37	EGPWS Warning: Pull up
09h31min40	EGPWS Warning: Pull up
09h31min41	Continuous Repetitive Chime (CRC, Master Warning)
09h31min42	EGPWS Warning: Pull up
09h31min42	End of the flight
09h31min42	End of recordings

1.11.2 Flight Data Recorder (SSFDR):

The aircraft was equipped with a Fairchild model S800-2000- SSFDR, S/N; 02148 with solid-state memory. 102 flight parameters were recorded on the SSFDR.

The latest evaluation of information and monitoring of flights based on FDA data was performed on the day before the accident. Flight data analysis software of the airline had been used for analysis of FDR information with the following findings:

- ❖ Note: the time setting on aircraft data recording system was not done before flight. The CVR and FDR were synchronized by using the VHF keying of the crew and matched ATC communication in local time format.

Local Time	Recorded data	Remarks
07:47:24	NH2 0→31 M Heading 269^0	The aircraft started ENG #2
07:53:09 07:53:10	Ground speed 0 →1 M Heading 269^0 →262 °	The aircraft taxied with turning
08:03:05 08:03:40	M Heading 195^0 →285 °	Line up on RWY 29L
08:04:04	Ground speed 0 → ↑	Take off run
08:04:41	WOW 1→0 TLP1&2 =73 ^{0}	Landing gears depressed (flight)
08:30:30	Press Alt 20967 →21000 ft TLP1&2 =73 ^{0}	Cruise Level
09:22:38 09:22:41	Press Alt 21000 →20987 ft TLP1&2 =73 ^{0} Pitch v/s engage CAS= 180 kt Selected Vertical speed=-400 ft/min	Beginning of Descend
09:23:06	Select alt 21000→17000 TLP1&2 =73 ^{0} → 63^0	Selection of FL170 on autopilot
09:23:42	Press Alt = 19670 ft Selected Vertical speed-400 →-1000 ft/min	
09:24:07	Press Alt = 19300 ft Select alt 17000→15000	Selection of FL150 on autopilot , CVR: pilot told we are coming OVD on FL150
9:24:46	CAS 200→186 TLP 49→58 Press Alt: 18700 Ft	Decreasing Air speed and advancing power by the pilot
09:24:48	Select v/s -1000→-1500 ft/min Press Alt = 18700 ft CAS =188 knot TLP1&2= 59	The pilot increased rate of descend
09:25:05 09:25:37	TLP1,2=35 TRQ1&2 Less than 4 CAS=187 knots	The throttle decreased to minimum flight idle
09:26:35 09:26:47	CAS 180 → 168 TLP1& 2 49→73 TRQ 1&2 19→64 Pres Alt=16115 Pitch Angle: +4	Downdraft recovery
9:27:14	Single chime (CVR)	Icing detection

09:27:19	DE-ICE switched on Pres Alt =15560 TAT= -6.5	Pilot used De-ice for 2 Min25 sec
09:28:16	Rudder Position Deviate 0 to +2 Vert G +1.22 to 0.75 deviate Press Alt: 14800 Ft	The flight was in turbulence condition
09:28:25	Pitch v/s →Pitch Alt Engage	Auto pilot on ALT mode at FL150
09:28:31	Press. ALT 14777 FT TLP 1&2 =41 TRQ 1&2 =10 Pitch ALT Engage	Minimum flight idle
09:28:40	Barometric setting 1013→1022 mb Press Alt : 14800Ft	Barometric pressure of airport field was set
09:29:16	Pitch : -4 , CAS 203, TQ: 10, Constant Alt	Up Draft recovery by autopilot
09:29:26	CAS 205 knots Press Alt : 14752 TLP: 41 , TQ: 10	Aircraft speed began to decrease with idle power condition
09:29:44	De-ice off Press Alt=14711 , CAS: 186 Pitch Angle: +2 TAT: +8	De-ice was set OFF by pilot
09:29:40 09:29:59	TLP 41 → 59 ° , TQ 8→43 CAS: 186 to 174 Pitch: +7 Press Alt: 14728	Increasing engine power but speed decreased due to downdraft
09:30:00 09:30:43	TAT : 8 to 0 TLP: 59 to 73, TQ: 43 to 66.5 CAS: 173 to 130 Pitch : 6 to 15	Speed reduction and pitch angle increased CVR: On 09:30:26 Pilot Said Why
09:30:43	Pitch Alt → Pitch V/S , Selected V/S: 0 Press. Alt → ↓	FL140 was set on autopilot
09:30:46 09:31:13	Barometric setting 1022→1021 mb Pitch angle 15 → 12 →15 CAS 129 →119 Press. Alt 14750 → 14430 ft	
09:31:13 09:31:20	CAS(min)=117 → 133 knots Press. Alt 14429→14190 ft Trq 1&2 81% → 84%	Stall warning triggered due to AoA increase 09:31:14 and AP disconnected automatically Stall recovery without flap setting

	V/S -1000 → -3000 ft/min AOA +15 → +5 ° Pitch Angle =15 ° → -6 ° Press Alt 14425 TAT: -5 Flap =0 Deg	
09:31:21	CAS=134 knots Trq 1&2 = 84% Vertical Speed = -3200 ft/m AOA = +5 ° Pitch Angle = -7 ° Autopilot Alt mode engage	High Rate of descend
09:31:22	CAS=139 kt Wind Speed =62 kt Roll Angle =-20 AOA=4.9 P-Alt = 14150' Pitch Angle =-8 Selected Alt = FL 150	The pilot engaged autopilot again
09:31:23	EGPWS Warning	
09:31:26	V/S increase to -3900 ft/m Press. Alt = 13869 ft AOA = +6.8 ° Pitch Angle = -6 ° R-Alt = 3643' Wind Speed = 68 kt Roll Angle = -13 °	The Radio Alt was 3643 but aircraft losing more altitude
09:31:32	Auto pilot disengage Press Alt =13471 ft , V/S = -3750 ft/m AOA = +11 ° , Pitch Angle = -5 ° CAS = 167	
09:31:33 09:31:34	EGPWS Warning off EGPWS Warning on AP = Disengaged	
09:31:36	CAS=176 kt AOA= 15.2 Roll Angle = -14	Aircraft reached high AoA near to Stall warning

09:31:38	Roll Angle -5 → -86 ° Left Aileron : 0 → -11 ° R-Alt =576 ft (170 m) P-Alt = 13316 ft Pitch angle -5→ 7.4	Commanded left roll
09:31:41	Pitch Angle = -31° , Roll Angle = -98 ° Press Alt = 13089 ft V/S = -3534 ft/min , CAS = 171kt TLP 1&2 = 73 , Trq 1&2 = 93%	End of Recording

1.11.3 Vertical wind calculation:

1.11.3.1 BEA Computed Wind:

The computed wind was computed from:

- The TAS
- The GPS/GNSS GROUND SPEED parameter
- The true heading
- The GPS/GNSS DRIFT ANGLE provision (GPS) parameter
- The geographic vertical speed
- The LH true angle of attack
- A sideslip value of 0
- The roll attitude (>0= RH wing down) parameter.

The result of the computation was smoothed with a moving average of 11 points.

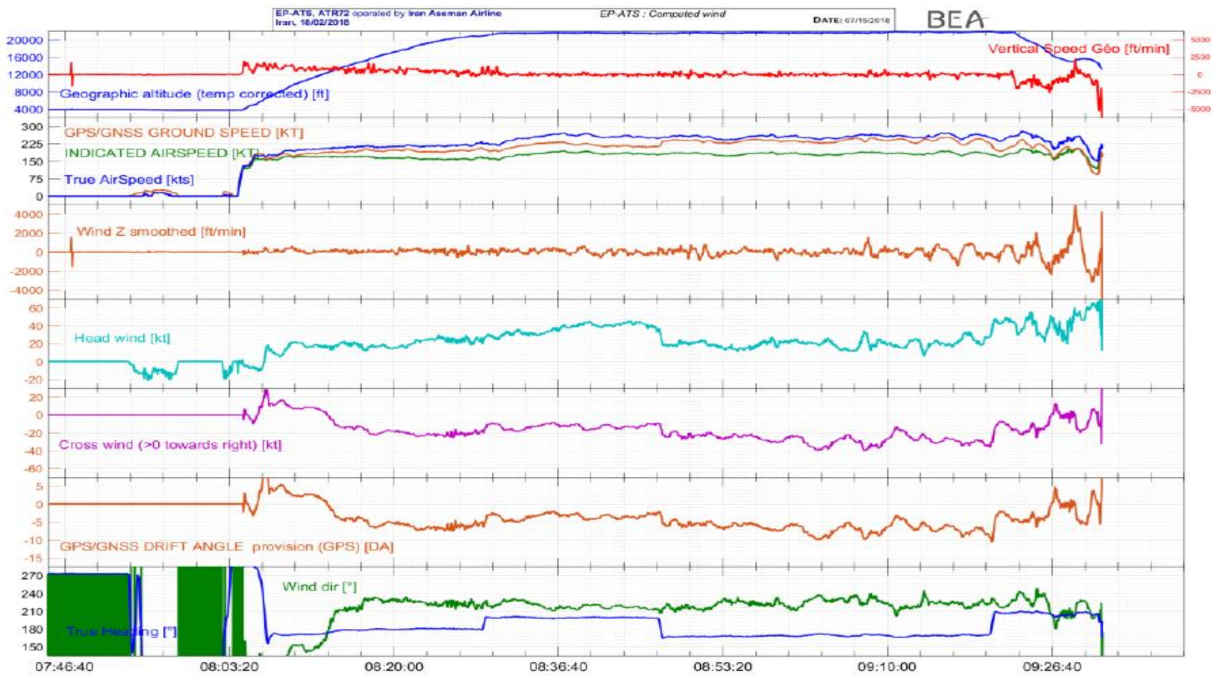


Figure No. 10 Computed wind

The computed wind showed consistencies between the true heading, the true wind direction, the head wind, and the cross wind, the TAS, the GPS/GNSS Ground Speed and the computed drift angle:

- The wind came from an angular sector from 210° to 240 °
- The wind came almost always from the head right of the aircraft (wind direction greater than the true heading with a difference lower than 90°).
- The crosswind and the drift recorded values showed negative values, indicating wind towards left (so coming from the right).

When the difference between the true heading and the wind direction decreased:

- the head wind values had a trend to increase, the difference between the TAS and the GPS/GNSS Ground Speed increased
- The crosswind values had a trend to decrease.

The manufacturer has done wind computation and provided it for the investigation team. The analysis showed:

1. Wind speed was about 50 kt flowing from about 210°.
   Vertical wind varied from -2600 ft/min (upward) to +3000 ft/min (downward):
2. Computed vertical wind varied between -2000 ft/min (upward) and -2600 ft/min (upward). In the meantime, aircraft was leveled off and CAS remained almost constant at 200 kt with low engine torques.

3. Computed vertical wind gradually varied from -2600 ft/min (upward) to +2000 ft/min (downward). In the meantime, the aircraft was leveled off and CAS started to decrease. Engine torques started to increase.
4. Computed vertical wind was about +2000 ft/min (downward) and reached a maximum of about +3000 ft/min. In the meantime, aircraft was leveled off and CAS kept decreasing. Engine torques increased.

From 09:31:00 to 09:31:18 UTC:

- The computed wind speed was around 55 kt coming from about 200°.
- The computed vertical wind was around +2000 ft/min (downward).

From 09:31:18 to 09:31:30 UTC:

- The computed wind speed increased up to around 70 kt and the computed wind direction slightly decreased to about 195°.
- The computed vertical wind decreased.

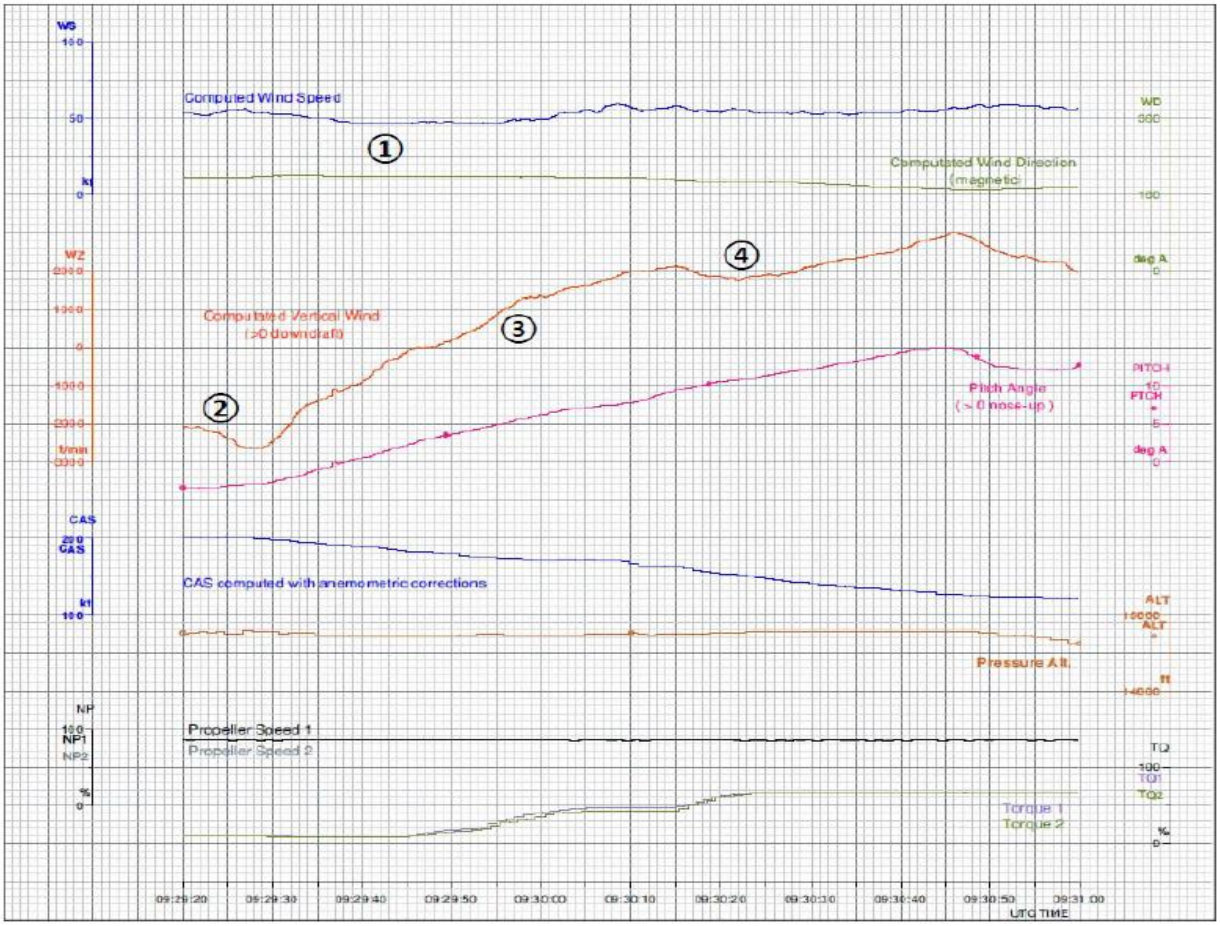


Figure No 11 Wind computation by the manufacturer (9 h 29 min 20 s to 9 h 31 min 00 s)

1.11.3. 2 Computed Vertical Wind by FDR information.

The French Accident Investigation Authority (BEA) made vertical wind calculation by request of investigation team. The history of the flight was compiled using validated flight data parameters and CVR information. Time is given in local time:

Note:

- « = » indicates a constant trend
- « ↑ » indicates an increasing trend
- « ↓ » indicates a decreasing trend
- « ~ » indicates a copy of previous values
- « - » indicates a lack of value
- Green background indicates positive vertical wind (Updraft)
- Yellow background indicates negative vertical wind (Downdraft)

Local time	Altitude IAS/TAS GS	Comment
7:42:08	3847	HSIS selected to the right-hand side. (First officer will be pilot flying)
8:04:38	3753 108 ↑/ 115 ↑ 115 ↑	VR reached
8:04:41	3775 117 ↑/ 124 ↑ 125 ↑	Nose wheel no more compressed (take off)
From 8:30:36 To 9:22:37		Cruise phase
9:22:45	20,961 ↓ 185 =/259 = 215 ↑	CVR: "Horn" The autopilot altitude changed
9:23:04	20,647 ↓ 188 ↓/262 ↓ 225 ↑	Local computed vertical wind: -1,068 ft/min
9:24:04	19,352 ↓ 202 =/274 = 227 ↓	Computed vertical wind became positive (170 ft/min)
9:24:15	19,200 ↓ 197 =/267 = 221 ↓	Local computed vertical wind: +1,121 ft/min
9:24:36	18,918 ↓ 194 ↑↓/261 ↑↓ 210 ↓	Local computed vertical wind: - 587 ft/min
9:24:51	18,741 ↓ 189 ↑/254 ↑	Local computed vertical wind: +1,311 ft/min

	209 ↑	
9:25:00	18,582 ↓ 194 ↑↓/260 ↑↓ 217 ↑	Power Lever(PL) moved aft : in 8 s, reached Flight Idle(FI) Local computed vertical wind: -+617 ft/min
9:25:04	18,490 ↓ 196 ↓/262 ↓ 220 ↑	Local computed vertical wind: -+2,116 ft/min
9:26:10	16,722 ↓ 179 ↑↓/235 ↑↓ 235 ↑↓	Local computed vertical wind: -1,947 ft/min
9:26:16	16,585 ↓ 180 ↓↑/235 ↓↑ 197 ↓	Local computed vertical wind: - 961 ft/min
9:26:34	16,159 ↓ 175 ↓/226 ↓ 177 ↓	Local computed vertical wind: - 2,455 ft/min 1 s later, pitch values reached a local maximum of + 4.3°
9:26:52	15,947 ↓ 157 ↓↑/202 ↓↑ 163 ↓↑	Local computed vertical wind: +77 ft/min
9:26:55	15,878 ↓ 160 =/205 = 165 =	Local computed vertical wind: -1,609 ft/min pitch values reached a local maximum of + 4.5°
9:26:59	15,847 ↓ 163 =/208 = 167 ↑	Local computed vertical wind: - 695 ft/min
9:27:30	15,482 ↓ 180 =/228= 190 ↑	Local computed vertical wind: + 501 ft/min
9:27:44	15,290 ↓ 176 ↑/223 ↑ 190 ↑	Local computed vertical wind: - 696 ft/min
9:28:21	15,132 ↓ 203 ↓/255 ↓ 210 ↓	Local computed vertical wind: + 2,008 ft/min ,1 s later, pitch values reached a local minimum of – 2.8°
9:28:29	15,062 ↓ 198 ↑↓/249 ↑↓ 205 ↓	PL at FI position. Slight forward move to 40° pedestal in 4 s Local computed vertical wind: + 1,885 ft/min Pitch values – 2.8°
9:28:52	15,043 = 199↑↓/250↑↓ 197 ↑	Geographic altitude: 15,001 ft increasing Computed vertical wind value: +3,137 ft/min increasing
9:29:01	15,011 = 198 ↑ /250 ↑ 201 ↑	Local Minimum for the pitch: -6.2° nose down PL quite at FI (39°) TQ values ~10% Local computed vertical wind:+ 5,583 ft/min
9:29:46	14,951 = 184 ↓ / 236 ↓	Downward vertical speed value: -16 ft/min. Pitch value 2.6° increasing

	190 ↓	
9:30:18	14,981 ↑ 158 ↓ / 202 ↓ 144 ↓	PL in the notch. They stayed inside the notch till the end of the flight The vertical wind value: -1,987 ft/min
9:30:27	15,001 = 146 ↓ / 187 ↓ 130 ↓	CVR: pilot said "Why" Computed vertical wind: - 2,025 ft/min Pitch value: 11.7° increasing
9:30:45 1	15,001 ↓ 129 ↓ / 164 ↓ 104 ↓	Pitch reached a local maximum 14.9° 1 s later: local computed vertical wind: - 3,245 ft/min
9:30:50	14,977 ↓ 125 =/159 = 98 =	Pitch value: 12.7° Computed vertical wind: - 2,870 ft/min
9:31:12	14,681 ↓ 122 ↓/ 154 ↓ 93 =	local computed vertical wind: - 2,196 ft/min Pitch value: 14.7° Roll 0° Left Aileron: 3.0°
9:31:18	14,595 ↓ 119 ↑/ 150 ↑ 93 ↑	local computed vertical wind: - 2,941 ft/min Pitch value: 6.0° Roll -5° left wing down
9:31:23	14,383 ↓ 137 ↑/ 171 ↑ 105 ↑	A/P engaged roll -20° left wing down
9:31:34	13,635 ↓ 171 / 210 164 ↑	A/P disconnection
9:31:38	13,487 ↓ 175 / 214 181	Stall warning Roll engaged to the left: -20° in 1 s Left aileron position: -9.9°
9:31:39	13,463 ↓ 185 / 227 193	Roll: -88° left wing down Left aileron position: 12.6° Rudder: 5.3°
9:31:42	13,239 170 / 208 184	Last valid altitude No vertical mode recorded Computed geographic altitude: 13,214 ft

Drawing the computed vertical wind values versus the range to the DME of Yasouj really shows the oscillations of the vertical wind with a long-range change during the accident flight.

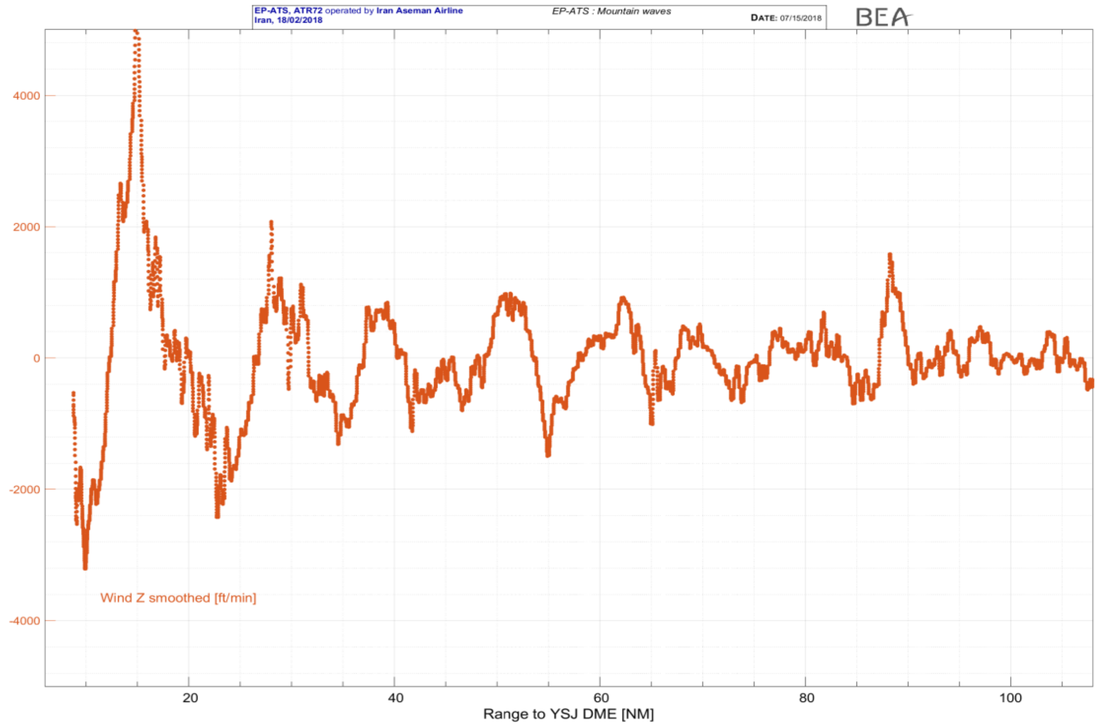


Figure 12: Computed vertical wind during the accident flight.

1.12 Wreckage and Impact Information:

The aircraft wreckage was identified at 10:30 on January 20, 2018. The accident site was located at a distance of 8.5 nautical miles from the Yasouj airport near a village and the mountain range "NOQOUL" in the area of "PADENA" (4000 meters height).

The accident site was found by localizing tail section of aircraft with Aseman Airlines logo on vertical stabilizer.

Figure No. 13 Accident Site:

Figure No. 14 Accident Site:

Figure No. 15 Recovery of Victims on Accident Site:

Figure No. 16 Accident Site on June 2018

The wreckage was fragmented with a large amount of debris spread over an area in a sloping rocky ravine which was covered by snow. Due to snowfall during the night the after accident time, the wreckage was covered with snow completely and it was not possible to find parts of the aircraft and transfer the pieces easily. The technical investigation on wreckage parts was not possible. At the scene of the accident, the Mountain ravine and local winds had been felt to endanger any flight to the accident site to access the site.

Victims and Wreckage site analysis identified that the impact occurred on the left-hand side of the aircraft first.

Findings of the accident site and the wreckage could be very helpful to the accident analysis, but in this regard, there were two major problems for the accident investigation team:

A. It was not possible to dispatch a specialized team to the altitude of the accident.
B. All places are sometimes covered in 4-meter-deep snow, which made it impossible to remove the victims completely and needed parts.

After the accident, a Fokker 100 on a route near KAVOT (S-E of Yasouj) received an ELT signal on 121.5 MHz's. Neither a signal nor satellite was received by Area Control Center.

A SAR Helicopter dedicated weak signal on two days after the accident (on 121.5 MHz, no signal on 406MHz)

The wreckage was found on the 20th of February, close to the top of the highest mountain on W144 track (approx. 350 ft below the top), on the north face of the chain mountain, at an altitude of between 13185 ,13054 ft (top of the mountain:13,412 ft). The point of impact is 8.5 NM north of the airport.

Wreckage site is located at the following GPS location: **30° 49' 25.51 N 51° 36'56, 76 E** The site is characterized by a slope of about 30° and is covered by snow.

1.13 Medical and Pathological Information:

When the aircraft crashed into the mountains, all the occupants died, and all their corpses were fragged in small pieces. A large number of collected bodies by the search team were transferred to the Yasouj Forensic Medicine Facility and transferred to the Shiraz hospital following legal procedures for DNA sampling and compliance with the tests carried out by the families. Detection and delivery of corpses were made by the decision of judicial authorities. DNA test was required to identify the remains of the victims. Therefore, sampling blood from the families of victims of traumatic diseases began in different cities and samples of similar DNA were determined and collected in an information system and sent to the Shiraz University of Medical Sciences.

Toxicological examinations of pilots could not be conducted by the Iranian forensic authorities

Medical history of the pilots:

The medical history of the pilot showed that he had heart Coronary Artery Bypass Grafting in 2010; then he was subjected to OML. Also, he had glass limitation. Due to long time period for finding corpse of pilot, it was not possible to do post-mortem toxicological examinations.

The first officer had only glasses limitation which was endorsed on his medical license.

1.14 Fire:

There was no evidence of fire in flight. Also, there were no signs of post impact fire.

1.15 Survival Aspects:

The aircraft ATR-72 was in operation in economy seat layout and the aircraft was equipped with all necessary safety equipment tools in the cabin.

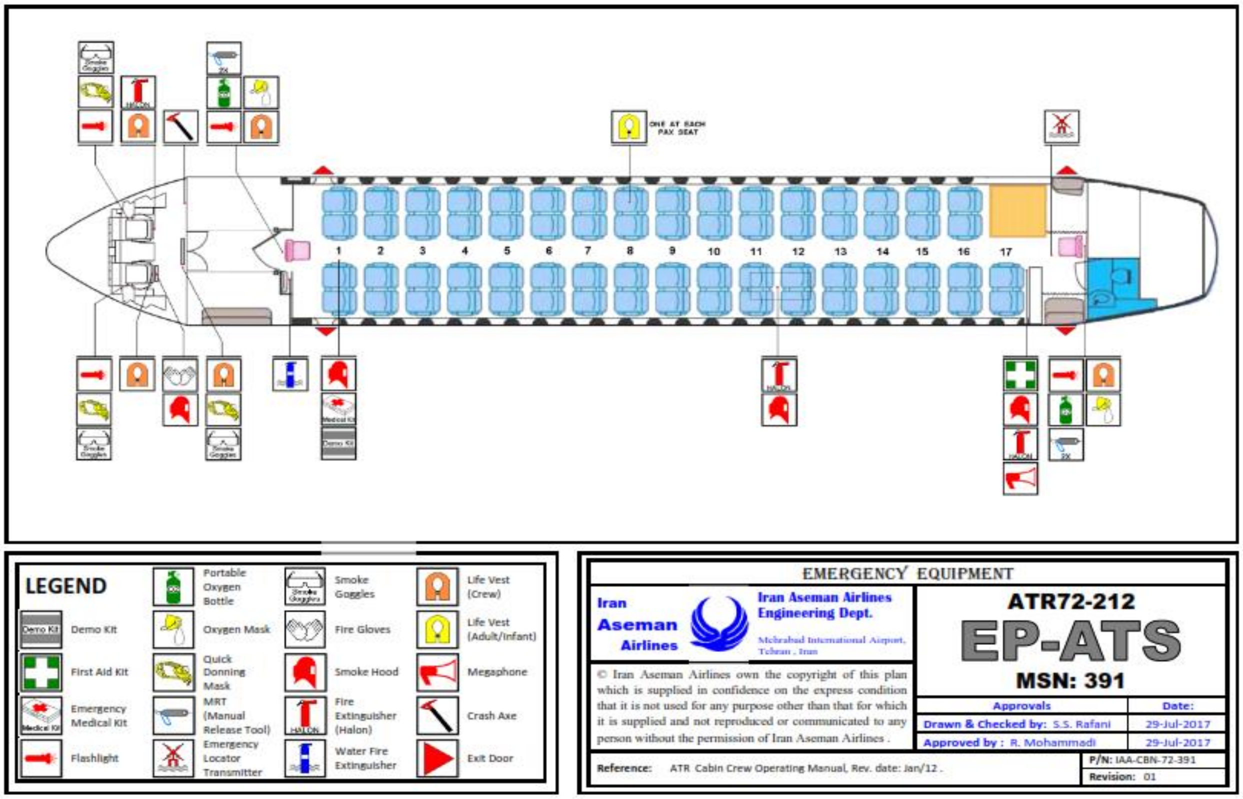


Figure No. 17 ATR72, EP-ATS cabin configuration

Aircraft collision with the terrain caused the immediate death of all the aircraft's occupants.Due to the severity of the aircraft collision with the mountain, the bodies of the occupants are completely destroyed, and according to geographical conditions (Mountains) and severe weather phenomenon, including heavy snow, collecting of victims was so hard.

The investigative report issued by judicial office stated that the occupants sustained fatal injuries due to multiple anatomical separations secondary to high-speed impact of aircraft accident.

1.15.1 Search and Rescue Operations:

The initial search and rescue operations at the accident site were managed by the CAOIRI. Total Search and Rescue Service was managed by Crisis management of Infrastructure ministry with coordination of local authorities. All related organizations in the region were informed and the search and rescue teams were dispatched to the area in the vicinity of the crash point. The aircraft location was too far from the city and the mountain area was not easily accessible. The helicopter services followed the rescue team instruction for locating the exact point of crash.

All efforts were accomplished by flying helicopters and other air carriers and remotely piloted aircraft system (RPAS) as well as following satellite information from related international sources to allocate the point of impact. One en-route flying F100 aircraft received (Emergency Locator Transmitter) ELT signal on 121.5 FRQ while flying at a position in the south east of Yasouj and several other flights in the region were called by Tehran Control center for any sign of ELT transmission but no positive result was found.

1.15.2 Surveillance and rescue measures:

- When the flight number 3704 was missed, the search and rescue committee was immediately established at the Tehran control center of the country (ACC) and the necessary information was provided to the relevant authorities.
- The Aircraft Accident Investigation Board of the Civil Aviation Organization of Iran provided the necessary information to the Crisis Committee of the Ministry of Roads and Urban Development, the vital organizations and the crisis management of the country.
- At the same time, crisis managements were established in the provinces of Tehran, Fars, Isfahan and Kohkiluyeh and Boyer-Ahmad.
- The Civil Aviation Organization of Iran, in accordance with the subject of Appendix 12 of the Chicago Convention, took the necessary steps to establish the "Search and Rescue Committee", and operation of the "Crisis Management Center" was initiated at the Civil Aviation Organization.
- Initially, search operations began with two helicopters from the provinces of Shiraz and Isfahan; however, due to low ceiling of the cloud and the atmospheric phenomena of the region, it was not possible to identify aircraft accident site and expediting helicopters returned to Yasouj Airport.
- At the same time, coordination with national and military organizations was done to dispatch the necessary facilities to the region and use all of the country's capabilities to find the crash point.
- A core team consisting of a pilot, air traffic controller, a meteorological expert and an expert of geographic used radar scope images of the area and flight paths, then identified the probable position of the impact point accordingly.
- Setting of go team such as helicopters and RPAS was carried out, but due to the low altitude cloud coverage and poor weather condition on 19 Feb 2018, the investigation was unsuccessful.
- On Tuesday 20/02/2018, in coordination with the Air Force of the Islamic Republic of Iran, two fighter aircraft flew over the area and took air images from the site with detection cameras, which accurately traced the wreckage of the aircraft and the point of the collision. Subsequently, at about 10:00 AM, the wreckage was detected visually by a MIL171 helicopter and the crash site location was approved. Large portions of the tail cone and the vertical stabilizer, with the rudder attached, were found connected to empennage.

1.16 Tests and Research:

1.16.1 Research about ATR history:

The ATR 72 is a twin-engine turboprop, short-haul regional aircraft developed and produced in France and Italy by aircraft manufacturer (ATR Company), a joint venture formed by French Aérospatiale aerospace company(now Airbus)and Italian aviation conglomerate Aeritalia (now Leonardo S.p.A.). The number "72" in its name is derived from the aircraft's standard seating configuration in a passenger-carrying configuration, which can expand to 78 passengers in a single-class arrangement with maximum 22000 kg MTOW. The aircraft ATR72, EP-ATS had 74 passenger seats classification with 20963 kg take-off weight.

There are some reported accidents of this type of aircraft which are related to icing condition of the flights and some modifications on aircraft anti-ice system were applied. We can refer to samples such as accident in 1994 in the U.S.A., 2002 in Taiwan, 2010 in Cuba in which control of the aircrafts were lost . A probable cause of lost control might be icing condition as a hazard for the aircraft and related risk should be managed by the crew and airlines.

The ATR has passed design certification requirements of EASA for receiving approval to product the aircraft but some modifications and airworthiness directives were applied on this aircraft type to improve its flight safety. The AD 1996-207-031R1, AD 1999-015-040, AD 2009-0170 are samples which were mandated on this type of aircraft.

A deep review of ATR past events has been performed, particularly on loss of control occurrences, in order to identify possible common signs. This study concluded that there was no similarity between those occurrences and this accident and special geographical condition of accident site and mountain wave was focused. Finally, a performance simulation was requested by the Iranian Investigation team to the Manufacturer.

1.16.2 Performance Simulation:

The engineering performance simulation investigation was performed by ATR and validated by BEA at the request of the Investigation team based on DFDR data. During the simulation, DFDR data were matched and taking into account the actual flight control inputs and Kinetic energy of the aircraft was calculated based on engine thrust and flight condition. The purpose of this simulation was to estimate the actual aircraft aerodynamics performance (drag and lift) based on the DFDR parameters of the accident flight and to compare them to the design information of type aircraft parameters. The results would determine possibility of the performance degradation on aircraft.

In the first BEA report it was indicated that aircraft did not show any performance degradation and no specific drag was highlighted throughout all the simulations and computations but in detail analysis of the data based on APM manufacturer some degradation points were found near accident time. The degradation points of aircraft performance were due to aerodynamics effects of mountain wave at local area. Although during the descent, the anti-icing and de-icing system were used, no handling quality and performance degradation were noticed.

The behavior of the aircraft was due to adverse weather conditions, with mountains waves leading to strong vertical wind speeds. The simulation was based on the takeoff weight and CG data from the load and trim sheet. The SAT at the time of aircraft descending from FL170 to FL150, the simulation revealed a good consistency of aircraft performance motion during the decent for approaching Yasouj aerodrome. So, the aircraft behavior was due to aerodynamic effect (down draft) of mountain wave.

1.16.3 Flight Simulation:

The airline uses a simulator in Malaysia for periodic proficiency check of the pilots. The cockpit of simulator is modified with APM based on AD 2009-0170. The related system was put off by training pilots to simulate real condition to airline fleets. The accident flight was reconstructed by an investigator on an ATR simulator based on the evidence of this flight. Not all flight conditions can be physically re-created on commercial simulators. Hence mountain waves cannot be physically re-created accordingly.

Additionally, the accident scenario was reconstructed on the simulator based on the evidence of this flight with engaging APM system. At some times of the flight simulation, APM warning lights appeared.

On Stall recovery without ice Accretion, a gentle push down together increasing power as needed are required. Several attempts were made in stall condition and it was understood that stall recovery procedures can recover aircraft from stall condition according to FCOM in normal condition without affected vertical wind.

The airline used aircraft FCOM version 2013 at the time of the accident which noted that:
Recovery of stall approaches should normally be started as soon as stall alert is perceived:
A gentle pilot push (together with power increase if applicable) will then allow instant recovery as mentioned in FCOM. Then on effective FCOM and QRH, stall recovery described as:

ATR 72	EMERGENCY	1.10	
		SEP 13	100

RECOVERY AFTER STALL
or ABNORMAL ROLL CONTROL

CONTROL WHEEL .... PUSH FIRMLY
- **If flaps 0° configuration**
  - FLAPS .... 15°
  - PWR MGT .... MCT
  - R CL 1 + 2 .... MAX RPM
  - R PL 1 + 2 .... NOTCH
  - ATC .... NOTIFY
- **If flaps are extended**
  - PWR MGT .... MCT
  - R CL 1 + 2 .... MAX RPM
  - R PL 1 + 2 .... NOTCH
  - ATC .... NOTIFY

R <u>Note</u>: this procedure is applicable regardless the LDG GEAR position is (DOWN or UP)

There was not enough support by the manufacturer for the airlines due to embodied sanctions , so some specialists and training pilots were updated SOP with available received manuals accordingly .The airlines published a standard operating procedures (SOP) for all ATR fleets and determined a procedure for stall indication as abnormal situation as below which had differences from FCOM:

IRAN ASEMAN AIRLINES	ABNORMAL & EMERGENCY PROCEDURES ABNORMAL SITUATIONS	03.01.03 Page 2 JAN 17

72-500

Flight events	PM	PF
AT 1ST STALL INDICATION OR IN CASE OF EFFECTIVE STALL	X DO FLAPS .... 15°	X DO CONTROL COLUMN .... NOSE DOWN UNTIL OUT OF STALL [1] X COMMAND "FLAPS 15" [2] X DO CONTROL WHEEL............ ROLL TO WINGS LEVEL [3] PL .... INCREASE AS NEEDED
OUT OF STALL		X DO APPLY GENTLE ACTION FOR RECOVERY [4]
RECOVERY COMPLETE		X DO RETURN TO THE DESIRED FLIGHT PROFILE [5]

[1] The priority is to reduce the angle of attack.
Crew members must accept to lose altitude. To recover from a stall or approach to stall and maintaining the altitude at the same time is not possible.

[2] If the aircraft is in flaps 0° configuration, extend flaps to 15° during the recovery.
In all other configuration and for any flight phase maintain the current configuration for the recovery.

[3] To correctly orientate the lift vector for recovery.

The stall recovery procedure in Airline SOP and aircraft FCOM has differences on setting engine power and condition level of propeller. The FCOM recommended MAX RPM and MCT in notch position but SOP requires the pilot to increase power as needed. Increase of power is not clear for the crew.

The research showed that new version FCOM of ATR published on January 2018, introduced a new procedure for stall recovery. The crew is required to increase power but the amount of power is not defined clearly and if CL is not forwarded to MAX, the engine will not reach MAX RPM in emergency condition. Also, this procedure for increasing power is the same as SOP procedure.

ATR EP / 72 FCOM	PROCEDURES NON NORMAL OPERATIONS EMERGENCY PROCEDURES	PRO.NNO Page n°32

STALL

58995803-e615-41b3-8bb9-b0f2175ed226 — 2.1 — ALL

STALL

- ► CONTROL COLUMN.. PUSH
  Reduce the Angle Of Attack.
- ► ENG PWR ....INCREASE
- ■ **If FLAPS 0**
  - ► FLAPS... EXTEND TO 15
    Increase margin above stall and lift coefficient – Reduce the Angle Of Attack
- ► BANK...WINGS LEVEL

WARNING
- ► STICK PUSHER ACTIVATION : NO OPPOSITE ACTION
- ► FLAPS : DO NOT RETRACT
- ► RUDDER : USE WITH CARE

- ► ATC ....NOTIFY
- **When out of stall**
  - ► FLIGHT PATH.. RECOVER SMOOTHLY

1.16.4 Flight Data Monitoring of the Airline:

The flight data Analysis for this type of aircraft (MTOW below 27 tones) is not mandatory based on AIR-OPS requirement of CAOIRI but Iran Aseman has a department in charge of analyzing flight data within quality & safety division. The flight data are downloaded from aircraft QAR every week.

A monthly committee is organized to review the trends and registered top events.

Several Visual approaches were detected frequently to Yasouj airport. A high rate of descent was observed as a trend. High rate of descent is one of the top 3 events for the approaches in Yasouj.

Reviewing of flight history of accident pilot showed that he made several approaches to Yasouj airport with different altitudes below FL170.

The Airlines provided 6 months of raw data files of the ATR fleet to the investigation team for analysis by the manufacturer. The results of the analysis show that during this period there were:

- 114 flights from Teheran to Yasouj
- 5 "types" of approach paths identified
- 26 flights on W 144 (N°5 in green)
- The Flights on trajectories 1,2,3 and 4 were not on the published IFR procedure and made as Visual approaches

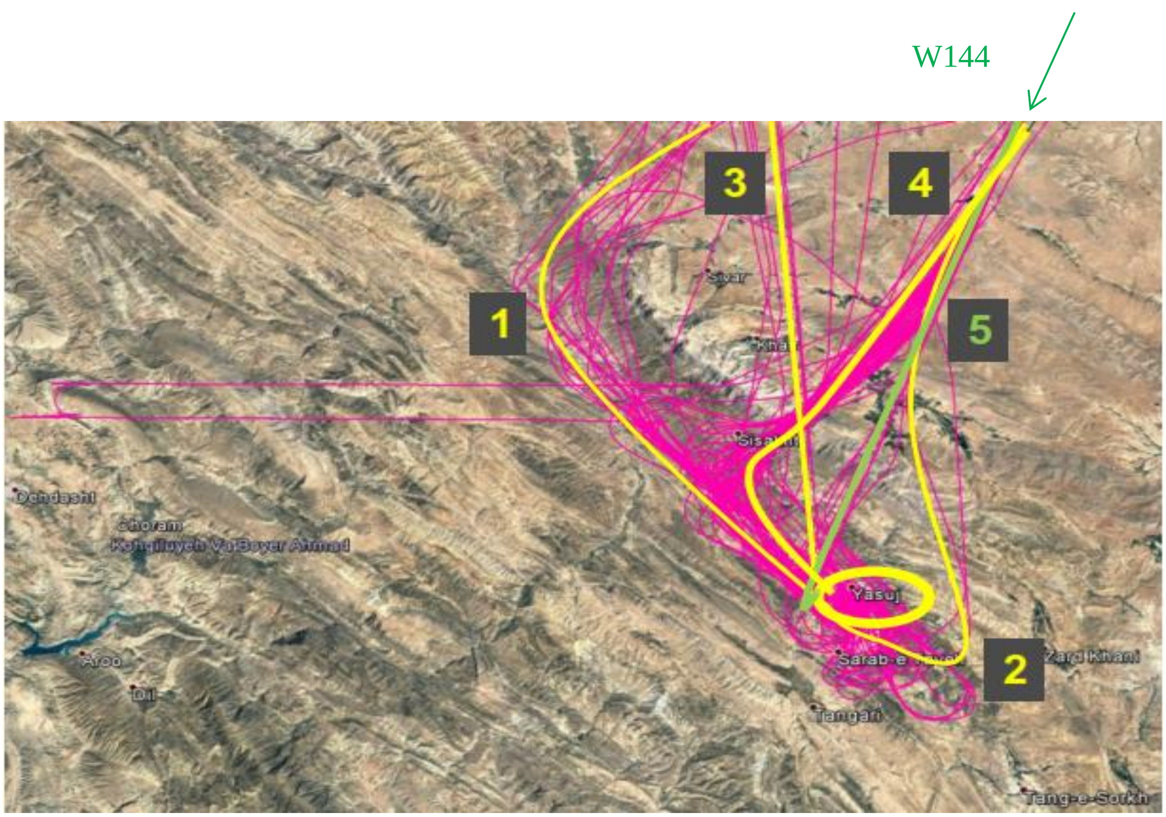


Figure No. 18 Flight Paths of ATR Fleet previous flights

1.17 Organizational and Management Information:

The aircraft belonged to the Iran Aseman Airlines. Brief information about organization of the company described as:

a) The Aseman Airlines is affiliated with the National Pension Fund in the Ministry of Cooperatives, Labor and Social Welfare. The airlines had well-known experience in training personnel but economic/organizational factors over the past ten years have led to the transfer of specialist personnel, such as aircraft pilots and engineers, which have occasionally separated from airline and joined other airlines. This subject is also seen in the ATR fleet of the Company, and the previous flying history of the pilot in India is the same example.
b) The Aseman Company had a valid Air Operator Certificate (AOC) from CAOIRI.
c) The company had valid certificate for continuous airworthiness management for the organization (CAMO) for all types of her fleets.
d) The Aseman Airlines had fleet types of Boeing B727, B737, Airbus A320, A340, Fokker F100 and ATR72 aircraft.
e) Heavy maintenance centers of this company's fleet are located At Tehran, Mashhad and Shiraz airports. For maintenance and repair of the ATR aircraft, a hanger was used at Shiraz Airport.

1-18 Additional Information:

The Annex 6 of ICAO recommended FDA for aircraft over 20 tones. The airline has done the recommendation; however, the Civil Aviation authority of country did not make any objection to the subject.

Aseman Airlines established FDA under the supervision of the safety and quality assurance management. The findings and risks identified by FDA are transferred to Safety Review Committee of the airlines by responsibility of company's CEO and required risk assessments are taken into account and control of known risks.

There was not any sign of unlawful activity on the flight, so security investigation was not done during the accident investigation.

1.19 Useful or Effective Investigation Techniques:

The standard and normal techniques based on ICAO Accident Investigation Manual (DOC.9756) were applied.

2. ANALYSIS:

It is necessary to analyze factual information of the accident to find out the accurate scenario of accident. The analyses of the events are described in the following different manners to conclude the accident:

2.1 Basic Scenario of Accident:

On 18/02/2018, the aircraft took off from Tehran Mehrabad at 04:35UTC, carrying 59 adults and one child as passengers and 6 crew members. The aircraft flew along the airway W144, on cruising level of FL210. The minimum en-route altitude for W144 is FL170.

The Minimum Safe Altitude north of Yasouj Airport, within 25NM, is 15,500 ft above mean sea level.

Yasouj airport was equipped with an NDB, DME and runway lighting. The published/approved instrument approach for Yasouj was only a circling NDB approach for RWY 31.

According to ATC recordings, the aircraft reported overhead OBTUX waypoint on the airway W144 at 05:52 UTC and was cleared to descend to FL170.

At 05:53 UTC, it was transferred to Yasouj Tower (AFIS) and instructed to descend as approved profile to overhead Yasouj.

At 05:55UTC on FL186, the aircraft exited from control radar coverage due to mountainous area. The crew reported 25NM from Yasouj at 05:55UTC and reported 14NM from Yasouj at 05:59UTC.

At 06:00UTC the crew acknowledged the QNH reported by Yasouj tower. This was the last communication of the flight and at 06:04UTC when Yasouj tower called flight, she did not reply anymore. The crew did not indicate any emergency nor abnormal situation for flight. The aircraft was cleared for circling NDB approach for RWY 31 and descend as profile, report approaching overhead.

There was no evidence of pre-existing technical malfunctions or other failures of the aircraft structure, flight control systems, power plants or propellers that would have contributed to the accident.

Based on factual information, the aircraft was flying in the clouds in icing condition and the pilot tried to fly in unauthorized altitude and decided to descend to 15 000 ft to get out of the clouds/icing conditions. It then reached an unsafe altitude and margin from the mountains. The flight was continued by cutting off the anti-ice/de-ice systems. During the level off at 15000ft the aircraft encountered mountain wave phenomenon caused by strong wind vectors (updrafts and downdrafts). The mountain waves' downdraft led to an aircraft airspeed decrease that the flight crew did not counteract. This led to an undesired aircraft state, low energy, and consequently a stall condition.

The pilots could not be well aware of the existing vertical wind as effect of mountain wave which might cause loss of aircraft performance to overview the situation (indicated speed, pitch, power) and take appropriate recovery actions. At the end of flight, pilots tried to recover kinetic energy of the aircraft in order to control the flight but the aircraft low energy could not compensate high rate descend of flight and the altitude clearance from the mountains was not sufficient to prevent the accident.

The research for accident site took two days. A search and rescue team consisting of CAOIRI, Iranian Airport &ANS Company, Military organizations helped local authorities to find the accident site. On time technical crash site investigation was not possible. It was the first experience of extensive aircraft accident in the region, so search and rescue was prolonged due to the limitation of related organizations.

2.2 Analysis on pilot Certification:

The flight crew passed the required approved training and was certificated by the CAOIRI. There was no evidence of any pre-existing medical condition that might have affected the flight crew's performance.

Setting of the crew for this flight, especially the two pilots, was focused based on the limitation of the pilot in command (OML) which belonged to his responsibility and also the airlines.

The pilot certification was issued by the CAOIRI on the basis of Annex 1 and the relevant internal regulations of the Civil Aviation Organization. This procedure has been changed since 2017, which approved similar regulations of the European Union (EASA) for the competence of aviation personnel. Air Crew regulations are currently being followed for pilot certification. The limitation of the pilot in command was reviewed to concentrate about crew setting of the flight.

Current regulations of Air Crew ***(effective from Apr 21, 2017):***

(d) Operational limitation codes

(1) Operational multi-pilot limitation (OML - Class 1 only)

(i) When the holder of a CPL, ATPL or MPL does not fully comply with the requirements for a Class 1 medical certificate, it shall be assessed whether the medical certificate may be issued with an OML valid only as or with qualified co-pilot ". This assessment shall be carried out by the licensing authority.

(ii) The multi-pilot operations when the other pilot is fully qualified in the appropriate type of aircraft, is not subject to an OML and has not reached the age of 60years.

(iii) The OML for Class 1 medical certificates may only be imposed and removed by the licensing authority.

- *Note: CAO.IRI issued current medical certificate of the pilot based on the above regulations and added medical limitation in addition to item (ii) to other flying pilot for him on Sep 25, 2017due to common rules of previous PEL regulation.*

Previous CAOIRI regulation:

PEL-MED privileges of license holders aged 60 years or more:

(a) Age 60-64. The holder of a pilot license who has attained the age of 60 years shall not act as a pilot of an aircraft engaged in commercial air transport operations, except:

1-As a member of a multi-pilot crew and provided that such a holder is the only pilot in the flight crew who is younger than 60 years of age and who has no medical and operational limitations.

2. The medical examination shall be based on the following requirements:

(b) Age 65. The holder of a pilot license who has attained the age of 65 years shall not act as a pilot of an aircraft engaged in a commercial pilot license or an aircraft transport pilot license operation.

Also, the operation manuals of airline included:

5.1.1.2 Crew medical fitness:

5) The captains who have attained 60 years of age shall require flying with pilots that are younger than 60 years of age without any medical restriction and are not permitted to act as PIC or FO after the age 65.

As was mentioned in the factual information, the pilot had CABG before the age of 60, so he could fly as "a pilot or a qualified co-pilot". Due to this medical restriction (OML), after 60 years of age, he should only fly with a fully qualified "***Pilot"***.

According to ICAO annex 1, the concept of a ***"Pilot"*** is deemed to be a licensed person to fly with a type of aircraft as a pilot or co-pilot. CAOIRI authorized the pilot in command (P_1) to fly another fully qualified pilot without any medical and operational limitation and younger than60 years old. The "***fully qualified pilot***" definition was not determined in the regulation which may consist of different published certifications in terms of P_1 / P_2 that showed in both pilot certificates. The definition of "***Qualified Copilot***" has not been determined in the Civil Aviation Regulations either.

The meaning of "***Fully Qualified Pilot***" was asked from EASA and it was found that fully qualified pilot does not include the pilot or copilot under training or supervision or in the process of certification. Therefore, the first officer of this flight was in accordance with the terms set out for a fully qualified pilot.

The first officer had medical limitation and had to wear corrective eyeglasses during the flight. The eyeglasses limitation was observed a medical limitation based on CAOIRI regulation (Aircrew AMC1 MED.B.001), so the crew setting was not correct due to endorsed limitation (OML) of pilot in command certificate and should have been prevented at their briefing time before departure. However, this non-compliance of the crew with the CAOIRI regulation did not have any impact on the event. Furthermore, the issuance of a Pilot Training Certificate (TRE, TRI) for the pilot in command might have led to some limitation for his training activities as an on ground trainer.

2-3 Analysis of Flight Preparation:

According to the company procedure, the pilots refer to the Dispatch unit and receive the flight file to prepare for flight. If there is a discrepancy between the pilots, the dispatcher, the technician and ..., the decision making will be transferred to the Operation Control Center of airlines (OCC) which includes technical, operational, and commercial and security directors.

On this flight, the pilot received the flight documents and signed them with no objection about weather conditions to refer the flight decision to the OCC. The crew was briefed about weather conditions by dispatcher. However, the ceiling of the cloud was less than operational minima for Yasouj airport but due to acceptable conditions at two alternate airports based on airline operations manual, flight documents were also accepted by the pilot in command and he commenced the flight.

2.4 Analyses of Meteorological Requirements before Flight:

At the time of releasing flight from dispatch (03:00 UTC), the conditions of the Yasouj airport did not meet the flight aerodrome operating minima of the airline due to the ceiling of broken (BKN) cloud on 9000 Ft from the airfield. According to the Airlines Operations Manual part C the minimum ceiling should be 11,000 feet above ground for approach and landing in Yasouj airport.

The weather chart shows a degraded situation with the possibility of the presence of isolated CB embedded, thunderstorm, rain and hail. Associated with these phenomena, the crew was able to encounter the presence of some turbulence.

Also, the company operations Manual (OM-A) allows the pilot to perform flight if the weather is acceptable for two alternate airports. According to the acceptable meteorological reports of the Alternate airports (Shiraz and Isfahan), the pilot accepted to perform the flight.

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a second destination alternate airport shall be specified on the OFP and the ATS flight plan under one or more of the following conditions:

1. When, for the destination airport, meteorological conditions at estimated time of use will be below the IAA,s established airport operating minima.
2. When, for the destination airport, meteorological information is not available (unless the authority will not permit the initiation of flight in the absence of such information)

8.1.2.5 En-route emergency airports

Since all routes that IAA is flying is not over remote or sparsely populated areas there is no need for en-route emergency airports.

According to the Meteorological Organization report, the TAF report for Yasouj airport had not been published in general and it should have been considered before flight accordingly. The Iranian AIP shows that TAF can be issued in Tehran and valid for 30 hours and it was not available at the time of accident. The issue had been considered neither by the airlines, nor by related authorities including Meteorological organization. Although in AIP information was issued by Iranian Airport & air navigation Service Company, there no effective community with Iranian metrological organization to correlate published data in AIP.

The surveillance about implementation of annex 3 in CAOIRI was justified by a committee lead by Ministry of road and urban development but clearly the committee was not accomplished and also there was no standard agreement by concerned meteorological authority and aviation service providers.

2.5 Analysis of Meteorological Requirements in flight:

Assessment of METAR showed that at 03:00 UTC, despite the fact that the weather conditions of destination airport were below the operational Minima, the pilot accepted flight based on OM with two alternate airports. The condition of clouds in the airport became better before departure at 04:30 UTC, which could not prohibit the flight. During the flight, the weather conditions of Yasouj airport became worse, which caused the first officer to contact the tower and got it before descend.

The latest weather information provided to pilots at 09:19:30 from Yasouj Airport was:

"Visibility more than 10 kilometers; the clouds are sprawling between 3500 and 4000 feet of the CB type and in 9000 feet (15,000 feet above sea level) Overcasting clouds and gradually

increased to the cloud cover, and the ambient temperature was between zero and 2 degrees at the time and the station pressure was reported to be 1021 HectoPascal.''

The telephone conversations between the tower of Yasouj airport and the meteorological expert of the airport confirmed the above situation.

''Wind 130/ 4 kt the height of the CB 3500 feet above the ground. Spreading clouds of 4,000 feet of ground level and 9,000 feet sky covered by overcast clouds, temperatures of 13 degrees, DEW point = 0, and QNH = 1021 Moisture 39%''

The analysis of the conversations related to the current weather situation in Yasouj and the conversations between the Yasouj tower and the meteorological office of the airport indicated that:

The cloud ceiling was about 9,000 feet above the airfield (15000 ft MSL) and was below operation minima of the airline. In accordance with the Operations Manual, the cockpit crew should assess the weather conditions of the destination airport. In the present case, they were not allowed to continue for landing at Yasouj Airport. As per the OM, they should have diverted to one of the two alternates aerodromes, Esfahan or Shiraz. Also, this subject was mandated according to the operating instructions and internal circulars of the airlines for type "C" airport (including this airport) with safety flight barriers that the flight should not be landed in celling condition below 11,000 feet or more than scattered cloudy condition. The real condition was overcast with ceiling of 9000 ft.

Mountain wave phenomena:

The satellite forecasting provided by the Iran Meteorological Organization for western and southwestern regions of the country on February 18, 2018 (day of the accident) identified the probability of a convective instability event in Yasouj area, which is characterized by instability in the Isolated- Embedded CB) and a moderate icing condition warning at zero altitudes of 11,000 feet. Based on the satellite data, METEO France had confirmed up to severe icing conditions, as experienced during the flight. So the flight was continued in icing condition and the pilots used de-icing system consistent with the weather forecasts.

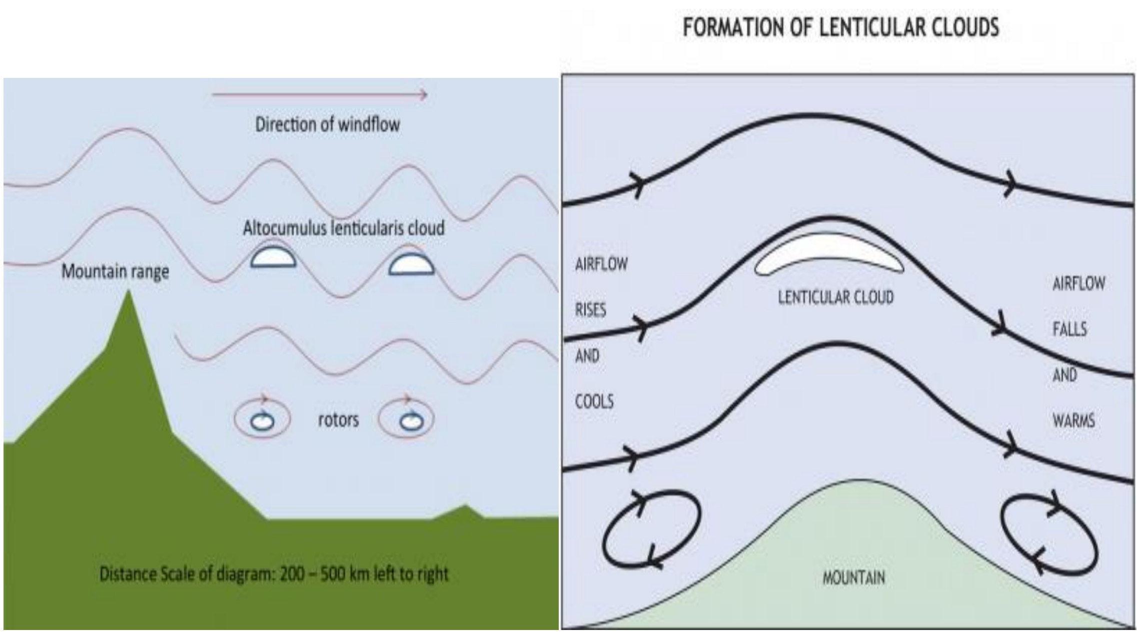
The wind calculation by FDR data showed that there was 60kt headwind for the aircraft while flying at 15000 ft to the airport. Mountain wave is a hazard for the aircraft. Normally, the mountain wave can lead to icing, temperature difference, wind shear and up & down draft which can affect flight adversely. Also, the shape of the recorded vertical acceleration was consistent with an aircraft flying inside turbulences.

Mountain Waves are defined as oscillations to the lee side (downwind) of high ground resulting from the disturbance in the horizontal airflow caused by the high mountains. The wavelength and amplitude of the oscillations depend on many factors, including the height of the mountain relative to surrounding terrain, the wind speed and direction and the instability of the atmosphere.

Formation of mountain waves can occur in the following conditions:

- Wind direction within 30 degrees of the perpendicular to the ridge of mountain and no change in direction over a significant height band
- Wind speeds at the crest of the ridge in excess of 15 kt, increasing with height
- Stable air above the crest of the ridge with less stable air above and a stable layer below the ridge

Vertical air stream (up & down drafts) with turbulences can reach more than 3,000 ft/min. Mountain Waves are associated with severe turbulence, strong vertical currents, and icing. The combination of these strong vertical winds and surface friction may cause rotors to form beneath the mountain waves, causing severe turbulences with high load and acceleration on the aircraft. Usually, the pilots should be careful for speed monitoring and stall prevention.



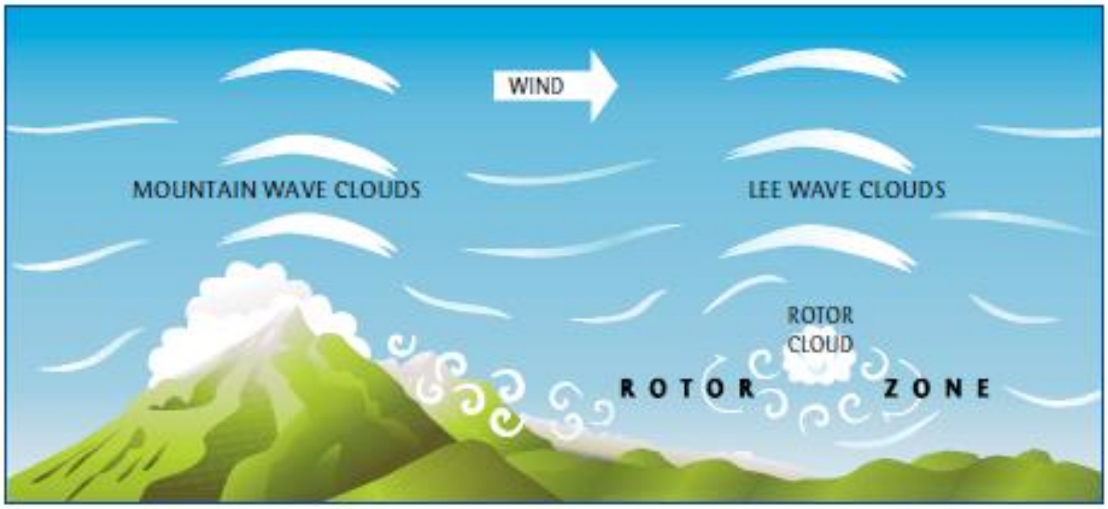


Figure No. 18 Effect of Mountain Wave

The aircraft tracking and FDR analysis showed the flight crossed the Up & down draft. The updraft and downdraft computed wind values were confirmed by the aircraft attitude. Following the engagement of the altitude hold mode, an updraft wind made the autopilot request a pitch down attitude, while a downdraft wind made the autopilot request a pitch up attitude. The reactions of the autopilot were consistent with maintaining the aircraft at the target altitude. The crew increased the engine power from 47% to 73% TQ by moving the PL up to the notch. However, despite the continuous decrease of the indicated airspeed, the crew did not increase the engine power until its full capacity (no change of the power management, no selection of a propeller speed of 100 %, no move of the PL beyond the notch position). The selected power (max power with the engine settings at that time: 2132 SHP) is more than 22 % below the maximum power of the engine (max power with PL at the ramp and propeller speed at 100%: 2750 SHP). This selected engine power was not sufficient to stop the decrease of the airspeed. The aircraft performance was not enough against high rate of down draft (about 3200 ft. /min). So, near the mountain the aircraft experienced significant reduction in airspeed and wing lift factor as effect of down draft.

Normally, the best practice for mountain wave relies on keeping vertical separation flight path from the mountains as Minimum Obstacle Clearance (MOC). The subject of mountain wave is included in ICAO document No. 8168 (Procedures for Air Navigation Services Vol .II) as increased altitudes/heights for mountainous areas:

1.7.1 When procedures are designed for use in mountainous areas, consideration must be given to induced altimeter error and pilot control problems which result when winds of 37 km/h (20 kt) or more move over such areas. Where these conditions are known to exist, MOC should be increased by as much as 100 per cent.

1.7.2 Procedures specialists and approving authorities should be aware of the hazards involved and make proper addition, based on their experience and judgment, to limit *the time in which an aircraft is exposed to lee-side turbulence and other weather phenomena associated with mountainous areas. This may be done by increasing the minimum altitude/height over the intermediate and final approach fixes so as to preclude prolonged flight at a low height above the ground. The operator's comments should also be solicited to obtain the best local information. Such increases should be included in the State's Aeronautical Information Publication (AIP), Section GEN 3.3.5, "Minimum flight altitude"*

However, there are some responsibilities for approving authorities about the hazard of mountain wave, but the context of ICAO document may include ANS and AIROPS authorities but does not note the responsibility of aircraft design authorities.

The ATR 72-200 aircraft was certified under JAR (Joint Airworthiness Requirements) 25 by the France DGAC on October 25, 1985 which was converted to EASA CS.25 accordingly. Based on CS 25.1581 the flight manual should contain the information necessary for safe operation of the aircraft. The adverse weather chapter of aircraft FCOM includes procedures to encounter icing condition, cold weather operation ,wind hazards, volcanic ash but does not describe mountain wave effects and limitation of aircraft performance to encounter it.

The airline was approved based on CAOIRI AIROPS regulation. The regulation required the airline to set Operation manual as:

AMC3 ORO.MLR.100 Operations manual — general

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(a) The OM should contain at least the following information, where applicable, as relevant for the area and type of operation:

...... 8.3 Flight Procedures:

8.3.8 Adverse and potentially hazardous atmospheric conditions. Procedures for operating in, and/or avoiding, adverse and potentially hazardous atmospheric conditions, including the following:

(a) Thunderstorms, (b) Icing conditions… (i) Mountain wave

Chapter 8.3.9.10 of airlines operations manual Part-A has briefing of mountain wave and warning for crew as below and the crew should be aware of the subject if the crew has been trained about OM effectively:

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8.3.9.10 Mountain waves

These form in the lee of a range of mountains when a strong wind is blowing broadside on (within about 30 degrees) to the range. They are usually in the form of standing waves, with several miles between peaks and troughs; they can extend to 10000 or 20000 feet above the range and for up to 200 or 300 miles downwind.

Encounter with mountain waves can be recognized by long-term variations in airplane speed and pitch attitude in level cruise. Variations may be large. Altitude can usually be maintained by the autopilot height-lock but in severe cases, it may be necessary to change power if speed alters dangerously. Bear in mind that at cruise height the margin between low and high speed limits can be relatively small. The effect of mountain waves reduces with increased height. At normal cruise altitudes, mountain waves are usually free from clear-air turbulence, unless associated with jet streams or thunderstorms.

The accident site was located in the mountain named Dena with elevation of about 13860 ft. The minimum flight path FL170 was determined by the ANS authority for the region and related last ATC clearance was for FL170. At 09:26 aircraft left FL170 for 15000 ft on track 200 degrees towards Yasouj YSJ NDB. Based on instrument approach chart (Circling NDB), minimum sector Altitude (MSA) is 15500 ft. According to CVR conversation, pilot decided further descend because he expected to get out of the clouds around 15,000 ft. with flight idle.

The crew was monitoring and maintaining a speed between 180 and 200 kt the speed accordingly. Then flight encountered mountain wave and the effect of the mountain waves increased while the aircraft was getting closer to the mountain. The crew tried to increase speed by advancing power lever up to notch position and managing at that time between 180 and 200 kt. They reacted with delay to the speed decay due to mountain wave and did not request the full power capacity of the power plant in due time. After that, the crew set 14000 ft. on autopilot and set power management to MCT but aircraft speed was continuously decreasing while the selected engine power was not sufficient to stop the decrease of the airspeed. Finally, the aircraft stall warning was activated. In reaction to stall warning, the flight crew applied pitch down which caused reducing aircraft distance to the mountain and leading to EGPWS activation.

The aircraft experienced high rate vertical wind due to the down draft of mountain wave. During the last portion of the flight, the pilot used MCT power with PL in notch position (TQ=92%). But the down draft exceeded the performance of the aircraft with these settings and the aircraft continued to uncommand descend. However changing flap setting could help them based on first officer recommendation.

The flight was still in IFR condition, so selection of altitude below airport MSA (15500 ft) on the north part of aerodrome was not appropriate. Based on Airlines OM, the crew was authorized to perform a visual approach when the runway is insight and the pilot shall request for Visual Approach according to OM, and then he could descend below airport MSA.

Also, the pilot did not request visual approach, so selecting the altitude below airport MSA (15500 ft.) on the north part of aerodrome was a human error; however, the crew could not proceed visual approach for landing based on available ceiling and coverage of the clouds. The ATC communication showed that AFIS officer informed improvement of cloud condition of the airport and based on the CVR file, the crew spoke about the decision to fly to airport overhead the left downwind to see the runway.

According to airlines OM for arrival at airport, the crew briefing shall cover at least the following items:

- *Any deviation from standard procedures.*
- *Applicable minimum altitudes during descend, arrival and initial approach.*
- *Type of approach/landing, applicable crew co-ordination procedure, flap setting to be used.*
- *Approach profile, descend limit and, for non-precision approaches, point D, rate of descend, hard altitude constraints and MAPt.*
- *Missed Approach Procedure.*
- *Runway condition and landing distance (if marginal) and required ignition setting.*
- *Initial taxi-in route.*
- *Set-up of NAV-equipment, QNH.*
- *Operational impact of local situation, weather and aircraft deficiencies if not yet covered.*

Based on CVR findings related briefing subjected to Minimum Altitude, weather and adequate action based on OM was not done accordingly and first officer reviewed go around procedure only.

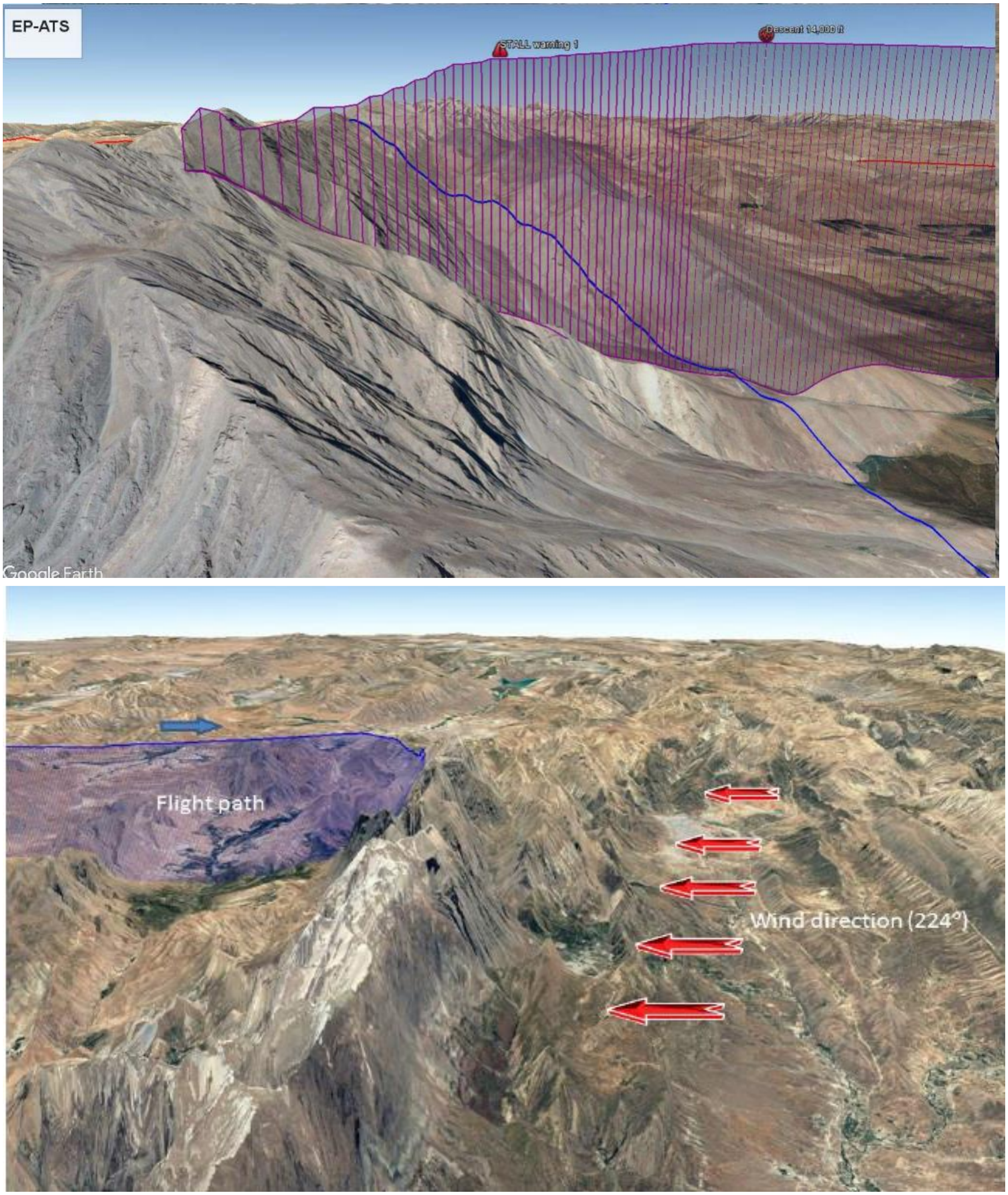


Figure No. 19 the Flight Path for Yasouj provided by BEA

Figure No. 20 Speed Variation for Flight

2.6 Analysis of Flight Recorders:

The aircraft took off from Tehran Merhabad International Airport at 08:05 LMT

At 09:19:30, when the flight was controlled by Tehran ACC, the crew contacted Yasouj information for weather conditions. Yasouj information answered FEW CB 3300, scattered 4000, overcast 9000. So overcast 9 000 ft corresponds to 15 000 ft QNH because Yasouj is located at 6000 ft altitude from sea level.

While passing OBTUX, the aircraft was cruising at FL210 on W144 airway, with autopilot engaged. The aircraft was cleared to descend to FL170 and handed over to Yasouj tower. As soon as reporting 15000 ft (MSL) ceiling of the clouds to the crew, they initiated descend by selecting FL150 while passing FL193. The CVR confirmed neither reading descent checklist nor call out of flight level by the cockpit crew and No information about the transfer of aircraft control was found in CVR communications. The principle of CRM was ignored at this time. During the descent, passing FL156 the airframe de-icing system was selected for 2 minutes and 26s and then turned off at altitude15, 000 ft. The recorded vertical acceleration in FDR shape was consistent with turbulent conditions before 15,000 ft.

Before reaching altitude 15000ft, the altimeter setting was changed to QNH 1021. The aircraft leveled at 15,000 ft. During one minute, the IAS was around 200 kt with engine power levers retarded to minimum flight idle (engine torque around 10%) and aircraft pitch down attitude, mainly around -5°. Such an aircraft behavior during an altitude hold (pitch down, no power requested and stable speed) was consistent with an aircraft flying in updraft wind.

From 09:29:28 to 09:30:45, due to the vertical wind change, the autopilot adapted the pitch angle of the aircraft to maintain the target altitude (altitude hold mode engaged) and the pitch values increased gradually so the IAS decreased, drag increased accordingly. As the engine requested power was progressively pushed but not set enough to the pitch change relatively, the

IAS values decreased. Based on CVR, the pilot told "why" which might be due to understanding low speed and focused on putting off a system which led to warning prevention. They might have referred to AoA after disconnecting LEV II anti-ice system. The pilot did not see relative information based on his assumption.

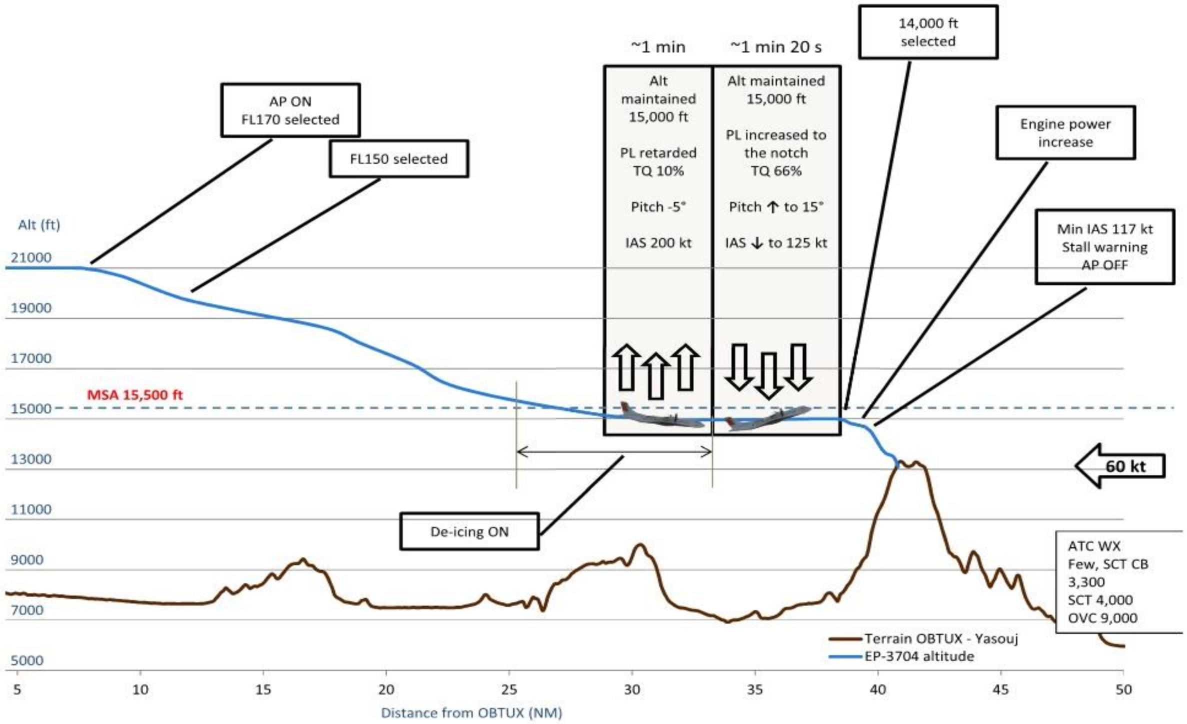


Figure No. 21 Up & Down draft for flight prepared by ATR

At 09:30:44, 25s after the power levers were set to the notch, the IAS reached 129 kt (the minimum low bank manoeuver speed in normal conditions for the given aircraft weight (VmLBO) was 132 kt), the pitch attitude was around +15°, both engine torques were at 67%. The aircraft then started to descend towards the new selected altitude of 14,000 ft.

At 09:31:14, the IAS reached a minimum of 117 kt. The angle of attack of the aircraft increased and the stall warning threshold was reached caused triggering the stick shaker followed by the stick pusher activation. By the stick pusher activation, the pitch attitude decreased to 2°. Due to the stall warning, the AP disengaged. A limited roll rate ($5°.s^{-1}$) to the left was induced but not counteracted by the flight crew. The aircraft rolled left and reached 20° left wing down. A pitch down input of the captain was recorded at 09:31:20 and the pitch attitude decreased down to -9°. The crew did not stall recovery procedure completely.

- *Based on SOP, the crew should push down the nose until out of stall, and get 15 degree flaps, roll to wings level and increase power as needed. The crew did not set flap although the first officer asked the pilot about flap setting. MCT power was previously set on the PWR MGT selector.*

- *Based to on date QRH, at this situation crew should push control wheel firmly, get 15 degree flap, set MCT power, CL to max RPM, PL to notch and then notify the ATC. This procedure is different from SOP.*
- *There is a reference in new QRH of FCOM with version 2018 or SOP that the crew should increase power as required for stall recovery which does not limit pilot for advancing Power lever. But if crew does not set CL to MAX, propeller will not reach MAX RPM on the type of ATR72-212.*

At 09:31:23, at 14,200 ft and IAS 137 kt, the autopilot was re-engaged again and took the control of the pitch and roll attitude. Pitch increased up to -5° and aircraft rolled right to 12°. The pitch increased and reached -4°, while the aircraft rolled to the right, banking 12° right wing down.

During the last A/P engagement, the A/P did not have the authority to capture the requested altitude without first overshooting it due to the initial conditions: engagement at less than 500 ft from the target altitude, at a vertical speed of more than 4,000 ft/min. The BEA analysis of the recorded parameters validated the autopilot behavior. The non- capture of the selected altitude of 14,000 ft was only due to the initial condition of the A/P engagement: close to the selected altitude with a high initial vertical speed to allow the capture of the selected altitude without first overshooting it.

From 09:31:24, EGPWS alerts triggered (Terrain ahead caution, then terrain ahead Pull Up warning).

At 09:31:32, pilot tried to pull up the aircraft then 2s later the autopilot disengaged while the EGPWS alerts continued until the end of the recording.

2.7 Technical Analysis on the Aircraft:

The control of the aircraft was available for pilots and its various aircraft mechanisms were in accordance with the demand of the cockpit crew. The aircraft indication systems provided correct information to the pilots at least until 3 seconds before the end of the recording. It should be noted that the aircraft engines also operated in accordance with the pilot's demand. Based on available information, the aircraft systems were working normally during the accident flight, also the FDR data showed the de-ice system was turned on for 2 minutes and 25 seconds.

Regarding the implementation of the Airworthiness Directive No. 2009-0170 and Alternative method of Compliance (AMOC), this AMOC was sent neither to CAO IRI nor to the EASA; however, the context of AD determines that AMOC should be issued by EASA for European countries (EU). The manufacturer issued AMOC for airlines to get approval from CAOIRI.

Some notes about AD implementation are stated as:

1- CAOIRI received an application and declaration form (Form 126) and its data sheet for applying for airworthiness certificates, completed by that company, performing all the technical arrangements approved by the CAMO of the company. The condition of mentioned AD was not declared in form 126, to the CAOIRI.

2- In accordance with the provisions of CAOIRI Part-M, M.A.303, any applicable airworthiness directive must be carried out within the requirements of that airworthiness directive unless otherwise specified by CAOIRI.

Applicable airworthiness directive means:

(i) Those airworthiness directives that are issued by first state of design of the aircraft, its engines or components.

(ii) By derogation of point (i), when the CAOIRI issues an airworthiness directive, this airworthiness directive is applicable.

3- The AD context includes the performance degradation only due to Sever Icing condition as reason for applicability of AD and did not mention to other causes of aircraft performance degradation.

The ATR 72-212 has Type certificate from EASA and FAA at the same date, but the CAOIRI was not defined related "first state of design of the aircraft" in this condition.

As the ATR-72 had TC (Type Certificate) from FAA too, this AD had not been issued by Federal Aviation Administration (FAA) yet. The operators and related authorities which follow FAA aviation policy are not required to implement the AD as mandatory improvement for safety of the aircraft.

Even though Aseman airlines had selected EASA AD's for ATR-72 as reference, it did not declare lack of this AD implementation to CAOIRI.

2.8 Analysis on icing condition:

Icing conditions are defined as follows:

- Ground icing conditions
- Atmospheric icing conditions:

Atmospheric icing conditions exist when OAT on ground and for take-off is at or below 5°C or when TAT in flight is at or below 7°C and visible moisture in the air in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow sleet and ice crystals).

In such a situation, the pilots must (in accordance with the anti-icing instruction) keep the anti-ice system ON and operative (former called Level II). Also the pilot should use the de-ice system (former called Level III) by observing the ice formation on IEP or ice detection warning.

The pilot used the de-ice system (former called Level III) for 2 minutes and 24 seconds at 09:27:21 LMT (4 minutes and 15 seconds) before the accident. When the TAT increased above 7° C, it was switched off. After 10 seconds, TAT decreased to 7 C and below, but de-icing remained in OFF position.

Aircraft FCOM noted that:

R *Note : Experience has shown that the last part to clear is the ice evidence probe. As*
R *long as this condition is not reached, the icing speeds must be observed and the*
R *ICING AOA caption must not be cancelled.*

Based on FDR & CVR, the crew canceled Icing AOA caption and never spoke about any observation on Ice Evidence Probe (IEP).

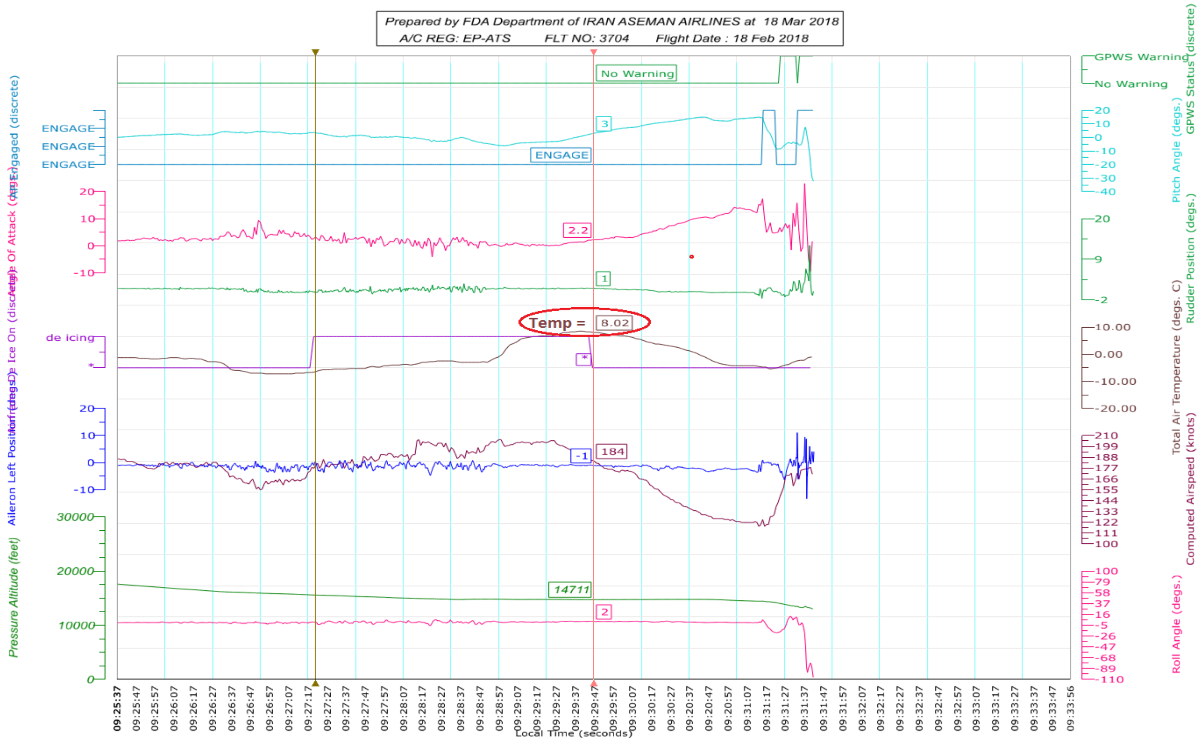


Figure No. 22 Temperature Graph of FDR

The aircraft encountered icing en-route and this was part of the flight crew workload. Both CVR and DFDR evidence indicate the flight crew responded appropriately to this condition, in accordance with FCOM and training. This is substantiated by the fact that aircraft stall occurred at 117kts, which corresponds to the stall speed for a clean aircraft (non- ice contaminated).

Assessment on severe icing conditions:

Severe icing conditions are conditions beyond Design and Certification Envelope conditions and the Ice Protection System cannot guarantee safe operation of the aircraft under these conditions. The pilot should change the route or change flight altitude to escape from the situation, timely, in coordination with the ATC.

Visual cue identifying severe icing is characterized by:

- *ice covering all or a substantial part of the unheated portion of either side window(and/or)*

- *Unexpected decrease in speed or rate of climb (and/or). The following secondary indications:*

  - ✓ *Water splashing and streaming on the windshield.*
  - ✓ *Unusually extensive ice accreted on the airframe in areas not normally observed to collect ice. Accumulation of ice on the lower surface of the wing aft of the protected areas.*
  - ✓ *Accumulation of ice on propeller spinner farther aft than normally observed.*

The following weather conditions may be conducive to severe in-flight icing:

- *Visible rain at temperatures close to 0c ambient air temperature (SAT).*
- *Droplets that splash or splatter on impact at temperatures close to 0c ambient air temperature (SAT).*

Severe condition can cause droplets of water at an ambient temperature of about zero degrees Celsius, which is referred to as the Thermal phenomenon in the FCOM book (FCOM adverse weather). In this phenomenon, the TAT is above zero degrees Celsius and the SAT is close to zero degrees Celsius. In such a situation, water droplets are not frozen due to the positive temperature of the leading edge and freeze with delay behind protected parts. This ice formation site is outside the area protected by the de-ice system, so activating the de-ice system cannot eliminate formed ice in such places. As a result, the performance of the aircraft will be degraded.

According to the Iran Meteorological Report, at the time of the accident, an unstable layer, turbulence and freezing level at altitude of 11000ft. were predicted. The flight was in higher level with possibility of icing from moderate to severe condition. Two opinions can be raised that are focusing on as:

a) Ice Contamination on the wing:

Icing condition usually is a hazard toward the flights for ice contamination on aerodynamics surfaces**.** An ice-contaminated wing will stall at a lower angle of attack or higher airspeed than a clean wing. Minute amounts of ice (equivalent to medium grit sandpaper) covering the leading edges or upper surfaces of wings can increase the stall speed up to 15 knots. The aircraft manufacturer accompanied stall warning with angle of attack (AoA), and normally stall warning will appear before real stall condition. The crew should have energy management and set icing bug on indicated airspeed indicator and monitored aircraft speed to be more than VmLBO for safe flight.

At the time of the accident, the aircraft weight was about 20t. At this weight, the related speeds were defined by the manufacturer. The speed limitation of the accident aircraft was as:

Speed in 0 Flap	Normal (White BUG)	Icing Condition(Red BUG)
Min Maneuvering speed in Low Bank (VmLBO)	132 kt	157kt
Min Maneuvering speed in High Bank (VmHBO)	137 kt	162 kt
Stall Speed flap 0 or 15	112 or 96	

If crew understands severe icing condition, special consideration should be observed as:

Procedure for operation in atmospheric icing conditions:

As soon as and as long as atmospheric icing conditions exist, the following procedures must be applied:

ANTI–ICING (propellers, horns, side–windows) . . . . ON
PROP MODE SEL . . . . According to SAT
NP . . . . set _ 86 %
Minimum maneuver/operating
Icing speed . . . . BUGGED AND OBSERVED
ICE ACCRETION . . . . MONITOR

NOTE : horns anti icing selection triggers the illumination of the "ICING AOA" green light, and lowers the AOA stall warning threshold.

At first visual indication of ice accretion and as long as atmospheric icing conditions exist, the following procedure must be applied:

– ENG START rotary selector . . . . CONT RELIGHT
– ANTI ICING (propellers, horns, side windows) . . . . CONFIRM ON
– DE ICING ENG 1 + 2 . . . . ON
– AIRFRAME DE ICING . . . . ON
– Eng and airframe MODE SEL . . . . ACCORDING TO SAT
– Minimum maneuver/operating
Icing speed . . . . CONFIRM BUGGED AND OBSERVED

If flight entered to the severe icing condition, the following procedure should be adopted:

SEVERE ICING

R MINIMUM ICING SPEED .... INCREASE by 10 kt
PWR MGT .... MCT
R CL 1 + 2 .... 100% OVRD
R PL 1 + 2 .... NOTCH
AP (if engaged) .... FIRMLY HOLD CONTROL WHEEL and DISENGAGE
SEVERE ICING CONDITIONS .... ESCAPE
ATC .... NOTIFY

- **If an unusual roll response or uncommanded roll control movement is observed :**
  Push firmly on the control wheel
R FLAPS .... EXTEND 15
- **If the flaps are extended, do not retract them until the airframe is clear of ice.**
- **If the aircraft is not clear of ice :**
  GPWS .... FLAP OVRD
  STEEP SLOPE APPROACH (≥4.5°) .... PROHIBITED
R APP/LDG CONF .... MAINTAIN FLAPS 15
  APP SPEED .... "REDUCED FLAPS 15 LDG icing speeds" + 5 kt
  Multiply landing distance FLAPS 30 by 2.12

The aircraft kinetic energy management normally is kept by setting suitable speed bug and monitoring speed. The aircraft speed reached lower than minimum maneuvering speed (VMLBO) in icing condition even VMLBO in normal condition at last portion of the flight.

The stall warning was triggered based on increased AoA (17.2 Deg) and speed of 117 kt. The hypothesis of ice contamination was not more probable because the aircraft's stall warning speed did not increase so more based on flight recorder information and below minimum safe speed of aircraft ws132 Kt.

At 09:29:38 LMT, in the CVR, the pilot said "we can't go now- it is behind these clouds" which needed to cross the forward clouds to reach overhead and based on FDR, after 15 seconds, the total air temperature (TAT) decreased from 7 C at about the last two minutes of the flights with de-ice systems in OFF position from 09:29:47 LMT and setting off anti-ice system including icing AOA before 09:30:53 LMT. If the aircraft had been in visible moisture, the situation might have caused hazard of icing condition for the aircraft which could have adverse effect on lift factor of the wings for the end of the flight.

b) Ice formation on the propeller and spinner:

The consequence of ice formation on the propeller and spinner is thrust reduction and increasing drag. This phenomenon has other consequences such as: significant vibrations due to propeller residual icing (unbalanced) and throwing ice plate to the fuselage with high sound. The evidence of accident did not show these consequences.

Ice formation on the propellers can be prevented by using the Lev II anti-ice system. During accident flight, the crew used related system without any abnormality and switched off later. The engines did not fail during flight and performance analysis on the aircraft and engine power showed that the speed decreasing was not related to ice formation on spinner or propeller. There was no sign of vibration accordingly.

The aircraft anti-ice system incorporates anti-icing prop fault with amber fault light and aural warning. If pilot encounters the fault, he should follow the procedure below. The evidence of flight recorders did not show any abnormality of related system.

ANTI-ICING PROP FAULT

ALERT

CONDITION	VISUAL	AURAL
One or more blade heating units inoperative	- MC light flashing amber - ANTI ICING amber light on CAP - Associated FAULT amber light on overhead panel	SC

PROCEDURE

ANTI-ICING PROP FAULT
LEAVE AND AVOID ICING CONDITIONS ANTI-ICING PROP affected side .... OFF ■ **If propeller unbalance due to ice becomes excessive** CL 1 + 2 .... MOVE TO MAX RPM FOR 5 MINUTES

COMMENTS

- If propeller unbalance due to ice becomes significant periodically moving both CL to MAX RPM will modify centrifugal forces allowing ice elimination.

2.9 Aircraft Performances Analysis:

The accident aircraft was not equipped with APM. In each of the following condition presented, the aircraft performance monitoring system (APM system) activates and the pilot will be alarmed for performance degradation of the aircraft:

- *Icing AoA light is on*
- *Airframe De-Ice ON*
- *ice accretion detected at least once during flight*

The investigation team requested BEA with cooperation of manufacturer to perform simulation of APM warning for the crew performance evaluation; therefore, a simulation was conducted to check if it would have provided alerts to the flight crew during the accident flight if it had been fitted.

The simulation is based on parameters recorded in the DFDR and is therefore not an exact representation of what could have occurred in reality, even though experience has shown that the simulation was generally very close to the actual behavior with the following alerts:

Time	Alert	Comment	
9h 22 min 45 s	N/A	Crew engaged anti–icing system	Icing conditions detected by the flight crew
9h 26 min 40 s	Simulated DEGRADED PERF	Aircraft drag and drag gradient reach the triggering threshold	
9h 26 min 40 s	Simulated INCREASE SPEED	IAS decreases below the minimum severe icing speed	
9h 27 min 14 s	Master Caution (not recorded)	Ice detector triggering	
9h 27 min 21 s	N/A	Crew engaged airframe de icing system	
9 h 27 min 26 s	Simulated ~~INCREASE SPEED~~	IAS increases above minimum icing severe icingspeed	
9 h 28 min 16 s	~~DEGRADED PERF~~	Aircraft drag decreases below trigering thresholds	
9 h 32 min 13 s		Crew disengaged airframe de icing system	
9 h 30 min 34 s	Simulated CRUISE SPEED LOW DEGRADED PERF	Aircraft is considered in cruise by APM (due to level off). Speed and drag meet the triggering conditions	No icing conditions detected by flight crew
9 h 30 min 36 sec	simulated INCREASE SPEED	Fast drag increase associated with fast IAS decrease(46 Kt/s)	
9 h 30 min 56 sec	Simulated ~~CRUISE SPEED LOW~~	Aircraft is not considered in cruise any more by APM	
9 h 31 min 44 sec	Simulated ~~INCREASE SPEED~~	Speed increases above minimum severe icing speed	

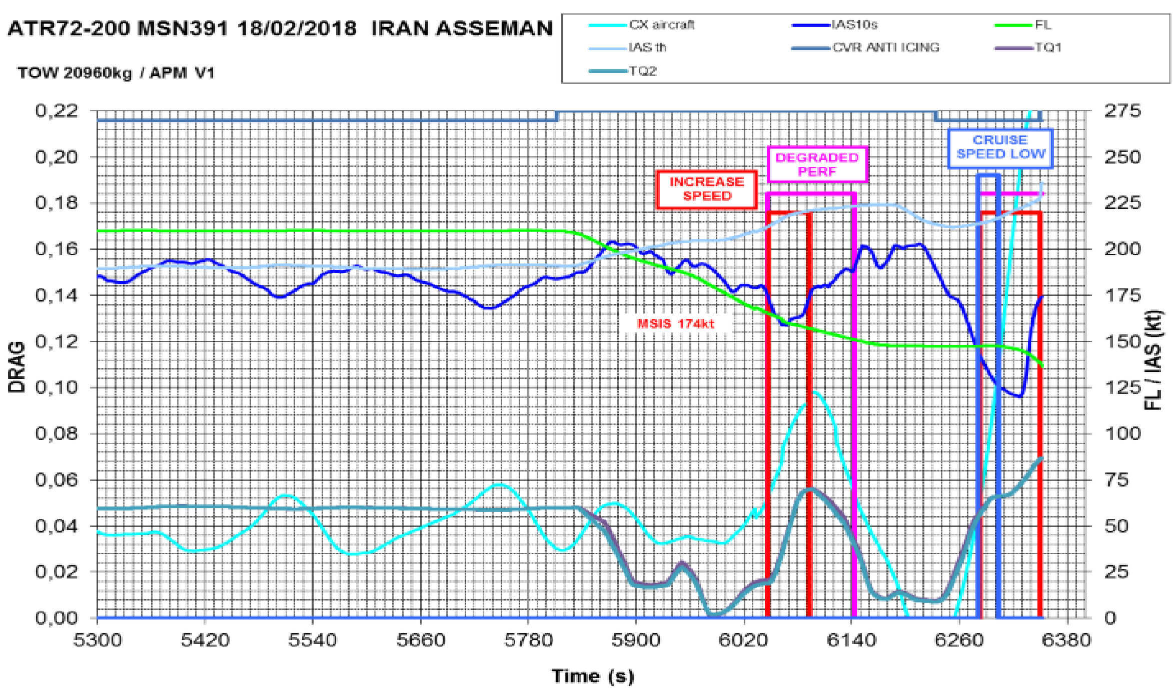


Figure No. 23 APM Simulation Analysis

The APM system was designed to monitor the energy state of the aircraft and alert the flight crew when some conditions are met, any external phenomenon having an influence on the aircraft TAS will have an influence on the total mechanical energy, and will be detected by the aircraft performance monitoring as a low aircraft energy state. The system alerts are based on calculation of Drag coefficient (Cx).

As a conclusion, the APM simulation tends to show that the alerts that would have triggered are linked to a decrease in performance due to external conditions (wind gradient) rather than icing, as illustrated in the following Figure:

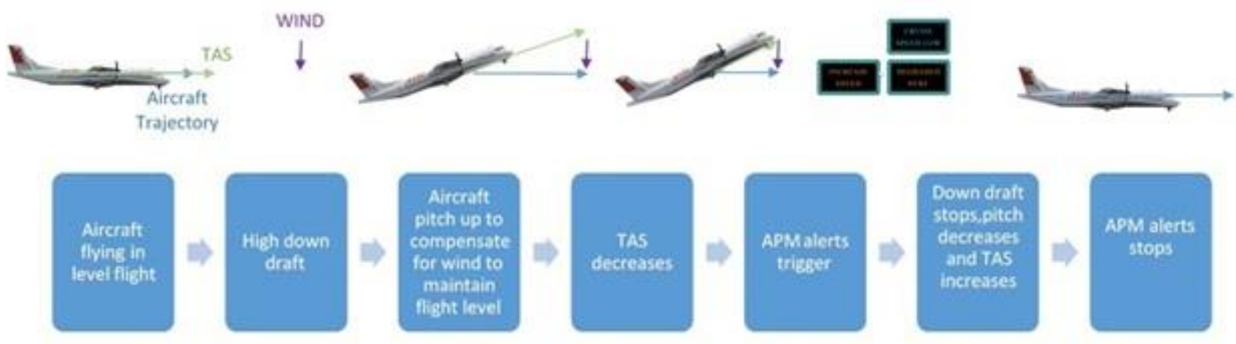


Figure 24. Illustration of wind effect on APM calculation

The average value of the computed Cx was 0.043 during the level off at FL 210 which is a consistent value for this aircraft. Specific periods of interest that are highlighted in the figure:

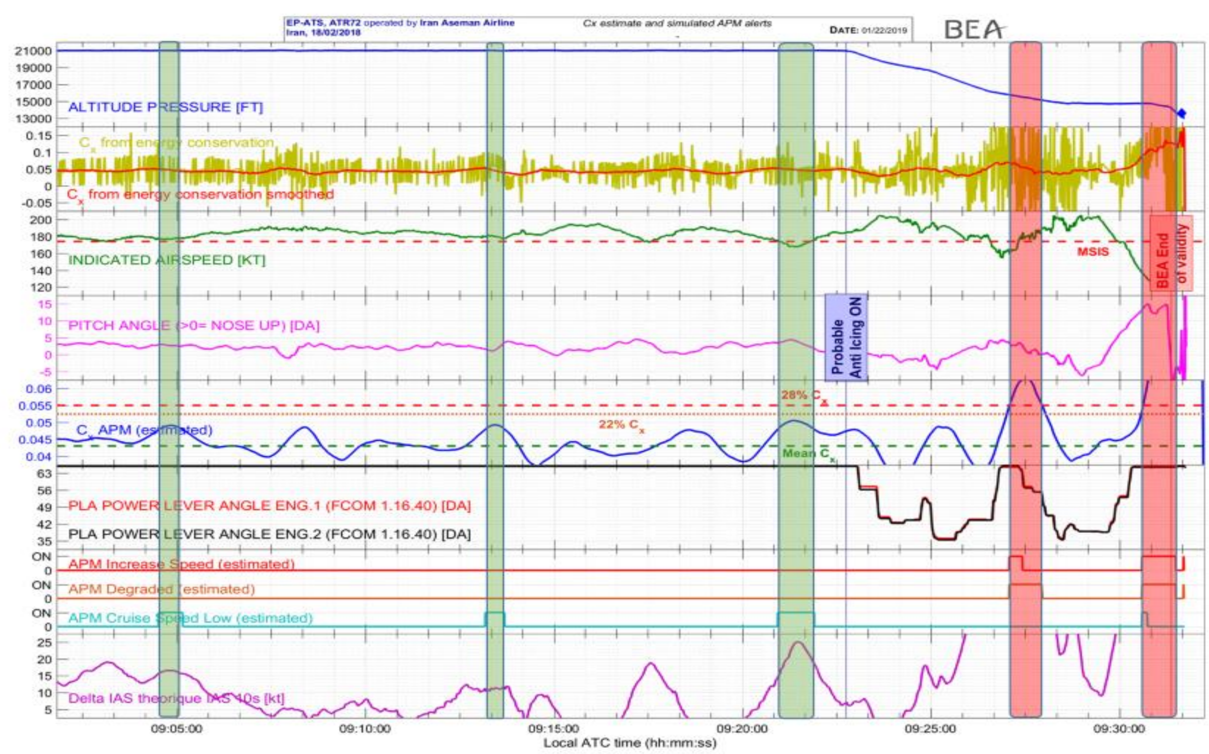


Figure 25. Estimate of Cx and potential APM alerts

Periods highlighted in green:

All those periods occurred during the cruise at FL 210. The aircraft was flying outside of any icing conditions. However, the estimated drag coefficient reached values higher than the APM threshold triggering. The performance of the aircraft during the cruise was analyzed as:

- The aircraft performance was consistent with the expected values
- The aircraft encountered adverse weather conditions, especially strong wind vectors. The autopilot adapted the pitch value to stay at the selected altitude leading to an oscillation of the IAS.

The impact of the mountain waves encountered by the aircraft would have led to the triggering of the APM alerts (provided Anti Icing protection had already been engaged before during the flight) with at least several Cruise Speed Low alerts.

Periods highlighted in red:

At that time, the anti-icing level had been previously engaged. APM alert would have then been triggered. APM calculation uses smoothed values over a rolling average of 60 s. The true increase of the Cx occurs before any APM alert triggering. During the flight of the event, the Cx increase leading to the first simulated APM alerts started at 9 h 26 min 00 s, the Cx increase leading to the second simulated APM alert occurred at 9 h 30 min 00 s.

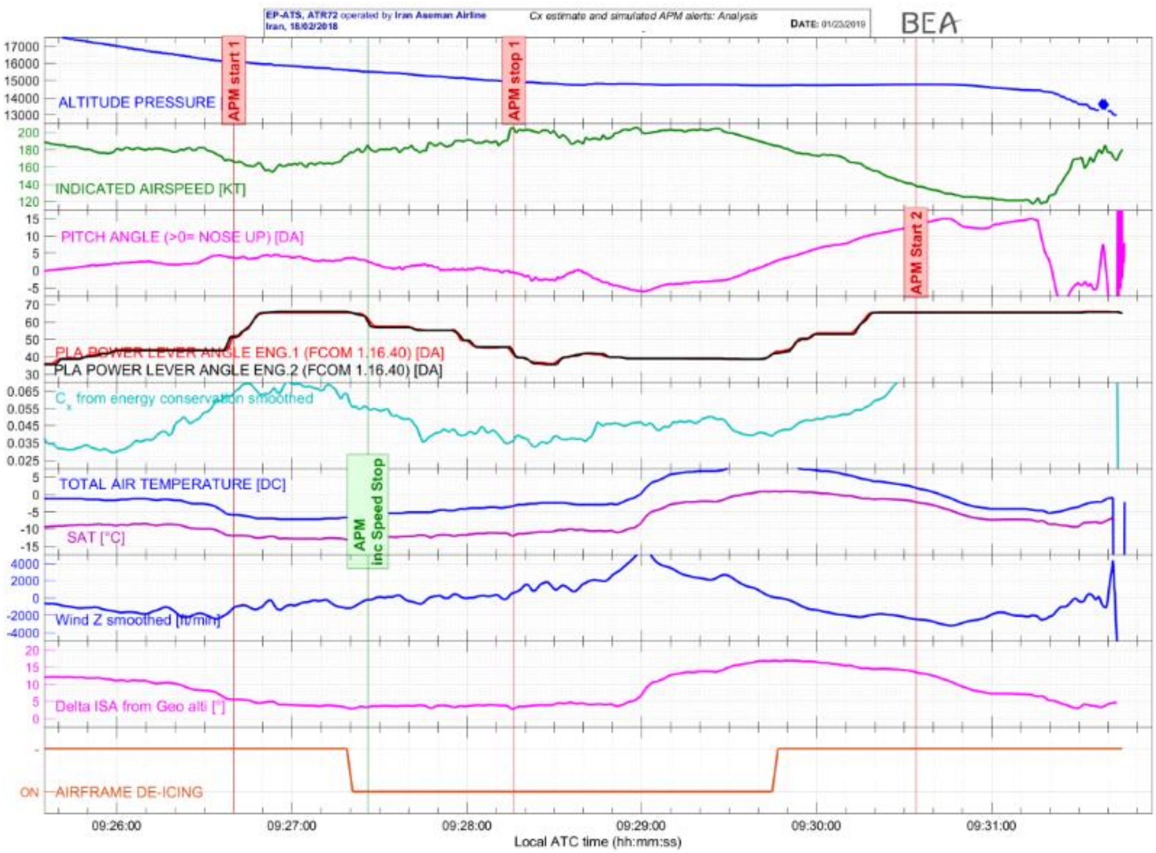


Figure 26. Simulated APM alerts - Analysis

The first simulated APM alerts (both Degraded Performance and Increase Speed) would have been triggered at 9 h 26 min 40 s. however the pilot used more power accordingly and degraded situation was finished on 09:27:26 s. The first simulated APM alerts:

- They were triggered more than 30 s before the ice detector caution and the true Cx increasing occurred 70 s before the ice detector caution.
- The degraded performance alert stopped while the SAT was still lower than -10°C.

❖ *Note: when SAT is below* -10°C *and De-ice system ON, the condition of ice contamination exists, so stopping APM alerts means aircraft performance is normal with no ice contamination.*

At the time of the true Cx increase, the aircraft was descending with limited thrust, a pitch angle increasing above 3° nose up and downdraft wind values reaching -2,000 ft/min. The IAS decreased. As soon as thrust increased, IAS values stopped decreasing and increased again.

- The second simulated APM alerts would have been triggered at 9 h 30 min 34 s. The second time the true Cx increase, the aircraft leveled off, facing a downdraft wind of -1,400 ft./min, whose strength went on increasing and reached more than -3,200 ft/min. The pitch angle values were greater than 6° increasing and the IAS was at 173 kt decreasing. The increase of the thrust did not allow stopping the decrease of the energy. Compared with the first simulated APM triggering, the aircraft was facing a more difficult situation in terms of energy management:

  - The aircraft leveled off. During the first simulated APM alerts, the aircraft was descending, allowing then a gain of energy.
  - The strength of the downward wind went on increasing, reaching more than -3,000 ft/min and stayed rather strong (more than -2,000 ft/min during more than 1 minute). During the first simulated APM alerts, the strength of the downward stopped at -2,000 ft/min and decreased quite immediately.
  - The delta ISA was greater than 15° at the time of the true C_x increase (second simulated APM alert). It gradually decreased to 7.5° in 1 minute. During the first simulated APM alerts, the delta ISA was around 5°. The engine power was then greater during the first simulated APM alerts.

The second simulated APM alerts (9 h 30 min 35 s to at least 9 h 31 min 22 s) were due to the downdraft wind encountered by the aircraft. The aircraft was facing worse conditions than during the first simulated APM alerts. However, in this period of time De-ice and maybe Anti-ice systems were OFF.

The crew reaction to APM alerts will be as following procedures, if the APM was installed on the aircraft. Although the APM was not available on the aircraft accident, the subject is assessed to evaluate recovery actions of the crew for preventing future accident.

"CRUISE SPEED LOW" light illuminated

Appears in cruise only, to inform the crew that an abnormal drag increase induces a speed decrease of more than 10 kt compared with the expected speed.

Crew action: ICING CONDITIONS and SPEED . . . . MONITOR

"DEGRADED PERF" light illuminated with CAUTION and SINGLE CHIME

Mainly appears in level flight after CRUISE SPEED LOW or in climb to inform the crew that an abnormal drag increase induces a speed decrease or a loss of rate of climb. The most probable cause is an abnormal ice accretion:

Crew action: AIRFRAME DE-ICING ON . . . . CHECK
IAS > RED BUG + 10 KT . . . . MONITOR
AP (if engaged) . . . FIRMLY HOLD CONTROL WHEEL and DISENGAGE

If SEVERE ICING conditions are confirmed (unexpected decrease in speed or rate of climb, visual cues)
or
If impossibility to maintain IAS > RED BUG + 10 kt in level flight
or
If abnormal aircraft handling feeling

Crew action: SEVERE ICING procedure (4-05) . . . . APPLY

If not

Crew action: SCHEDULED FLIGHT . . . . CONTINUE
ICING CONDITIONS and SPEED . . . . MONITOR

"INCREASE SPEED "light illuminated flashing with CAUTION and SINGLE CHIME

Appears after DEGRADED PERF to inform the crew that the drag is abnormally high and IAS is lower than RED BUG + 10 KT.

If abnormal conditions are confirmed:
Immediately push the stick to increase speed to recover minimum IAS = red bug + 10 kt

Crew action: SEVERE ICING procedure (4-05) . . . . APPLY

The APM logic focuses on drag primarily as a consequence of ice contamination of the airfoils only. However, as a consequence of the logic, the alerts can also be triggered by other factors including strong wind vectors. In this scenario, the undesired aircraft state occurred during very strong wind vectors (mountain waves). The primary indication of such condition remains the aircraft total energy. The three kinds of APM alerts will help the crew to alert degradation of aircraft performance only. The subject may be assessed in two ways:

1- The APM alerts will be helpful for crew situational awareness about aircraft performance.
2- The crew will rely on APM alerts only and his situational awareness will depend on it and other unsafe conditions caused by adverse weather effects (icing, wind shear, mountain wave etc.) will not be focused any more.
3- As such, any APM alert would have only reconfirmed the aircraft low energy state with an associated time lapse.

All required action tasks by the crew for APM alerts will be recovered if the crew has situational awareness of other aircraft unsafe conditions as a result of adverse weather conditions. Also, APM alerts may have an effect on crew awareness of recovering severe conditions too.

The Performance analysis of the aircraft showed that if APM had been installed on the aircraft, APM would have alerted the crew at time 09:30:34 LMT about performance degradation to increase the crew awareness but CVR voice showed that pilot said "why" at time 09:30:26 LMT (7 seconds before the alert) . So the crew was awarded of aircraft condition (performance degradation) before APM alert probably by focusing on IAS indicator and the copilot recommended flap setting. The total crew reaction to all APM alerts could not be estimated but the APM warning might lead the pilot to perform Severe icing procedure and did not activate autopilot again.

2.10Analysis on Human Factor:

A review of "human factors" describes the performance of pilots in the accident flight:

Pilot Incapacitation:

The pilot communication recorded in the CVR and crew actions based on FDR data were reviewed & evaluated. There was no emergency medical situation between the two pilots that could affect control of the flight. Up to the time of aircraft impact on the mountain, the pilot and first officer did not announce abnormal physical conditions, so there was no evidence for pilot incapacitation.

Pilot Situational Awareness:

The CVR records led the investigator to the subject of pilot awareness .The investigation team focused on the behavior of the pilot as a commander of the flight. Research continued on the findings from flight data recorders and the Operation analysis which may conclude that the pilot made continuous errors. Based on research, the pilot's behavior from 24 to 72 hours before the accident was normal. He had normal habitual and natural events in his life and enough rest before the flight. He had normal living with his family without any psychological and social problems.

The six components and parameters are considered in the accident as:

1. ***Aircraft warning systems and lack of pilot's situational awareness:***

The factual information showed that the aircraft warning systems had normal operation and based on the pilot request and aircraft situation, the related indications and alarms were triggered normally. Action of the pilots was relative to their situational awareness. The crew was not fully aware of the situation of mountain wave, which finally led to stall warning activation with no recovery procedure applied. The flight crew did not expect to encounter abnormal severe situations, including vertical wind, stall warning, so due to lack of adequate situational awareness, the flight crew did not put full engine power and flap to solve low energy situation of the aircraft. The crew reactions were not effective enough to compensate for abnormal conditions which ended in the accident, so the pilot did not have enough situational awareness about the severity of flight conditions and the environment, including mountain waves and icing condition. However, some guidance of the copilot based on his finding was not adopted by the pilot.

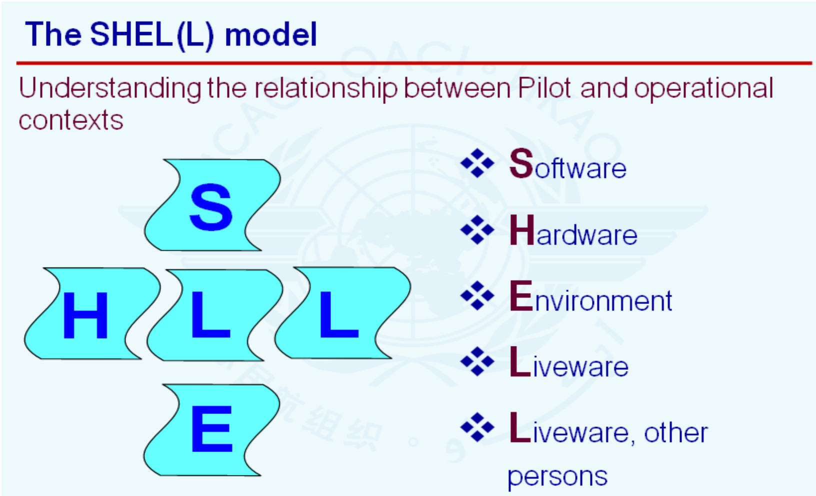
The crew reactions did not compensate for the abnormal conditions which ended in the accident, so the pilot did not have situational awareness about the severity of flight conditions and environment, including mountain wave and icing conditions.

2. ***Pilot's behaviors (pilot's lack of knowledge of the situation - incorrect decision making and related effective factors – pilot's errors and his risk assessment , Cockpit management and , Training Process and upgrading to instructor pilot)***

Based on the results of medical evaluations, medical records; the pilot was 62 years old having a history of CABG. His license included operational Multi-pilot limitation (OML) with authorization to fly with another pilot (fully qualified pilot) under 60 years of age and without medical limitation. The first officer had glasses limitation and based on CAOIRI regulation "glasses limitation" was included in medical limitations so the pilot was not authorized to fly with first officer. Of course, the medical limitation of the pilot was not a contributive factor in this accident.

The CVR audio files showed that some recommendations of the first officer were not accepted /adapted by the pilot, which denied the role of the first officer on the flight. In some portions of the flight, the first officer reviewed go-around procedures – bad weather conditions- flap setting for stall recovery which never got any response by the pilot. Such evidence shows lack of effective communication between the two pilots and the first officer as pilot flying did not order his request to the senior pilot as chief pilot of the ATR fleet in the airlines as authority gradient phenomena. This subject was against CRM principles.

• ***Pilot Awareness*** depends on his imagination of what is happening around him and understanding the environmental elements in a time-location, conditions of the aircraft and inside and outside environment. The SHELL model describes the factors that affect the pilot's behavior and his role as a central key point of Liveware in this model: The following items which led to lack of pilot's awareness as described in the model:



Based on global model of safety called SHELL model, the pilot was assumed as a decision-making axis, the following factors have contributed to the accident according to the factual information:

Software and Programs:

- Not following operation manuals – not using checklist – lack of concentration on meteorological forecast – incomplete hazard identification from FDA system- unavailable SIGMET- ineffective training about OM and weather phenomenon

Hardware:

- Putting off the AoA - unable radar surveillance for flight- lack of APM warning system

Environmental factors:

- Turbulence and mountain waves - mountainous region - cloud and icing condition

Relationship with other people:

- Incomplete briefing with dispatcher - non effective supervision by pilot to first officer as pilot flying -not pay attention to first officer recommendations and warnings - Failure to approve actions- Unnecessary communication between pilot and Yasouj Tower - not following check lists.

3. Airport:

The accident did not happen on the airport field and the factors of airport had minimum effect on the flight but the lack of TAF report was a point which could help the pilot to make the decision to cancel the flight. The TAF could be available for 30 hours before flight according to published Iranian AIP, but he subject was not followed and was mentioned in AIP. The information showed that TAF had not been published for the airport before and never has been made available for any of previous Aseman Airlines flights. The responsibility of checking status of AIP information was delegated to the operation section of the airports, which was mentioned in the AIP accordingly.

4. Procedure and Operational Process:

The procedures of the AIP charts and minimum altitude of en-route and also airport landing charts were not followed by cockpit crew. Also, the operation process of operation manual (OM) and aircraft manuals had not been done accordingly and abnormal procedures related to stall recovery based on simulator training were not either achieved accordingly.

5. Organizational factors of the company:

Human errors are a known factor in most aircraft accidents. These errors are often experienced by competent and experienced humans while using modern equipment. Unfortunately, errors may have occurred during the previous flights and these errors could have been hidden (Hidden Failures). The updated safety management system in the airlines can be used to discover latent conditions or practical drifts by checking flight information (FDA) or receiving voluntary reports or sufficient monitoring of the operation process.

The airlines FDA was done and some significant practical drifts of the flights were reported to the managers concerned.

6. Environmental and weather conditions:

The aircraft was flown on the mountainous area. The crests of the waves may be identified by the formation of lenticular clouds (lens-shaped), if the air includes sufficient moisture. Mountain waves may extend into the stratosphere and become more pronounced as height increases. Mountain waves can occur up to high level of flights. The vertical airflow component of a standing wave may exceed 8,000 ft/min. The crew should be aware of mountain wave effects on the flight. Few accidents in the world have been recorded by mountain waves. There was not enough guidance to mountain wave in the aircraft manuals. Also, the crew had not been familiarized with this subject previously. The lack of capacity of the Iranian meteorological center to issue SIGMET about Mountain Wave or Severe Mountain wave (MTW or SEV MTW) was an important contributive factor.

At the date of the accident, a flight of RJ100 belonging to Qeshm Air reported turbulence when crossing the accident site on FL270.

3. CONCLUSIONS:

3.1 Findings:

1. The scheduling of cockpit crew (pilot and first officer) for this flight was not correct based on the medical limitation specified in the pilot license issued by CAOIRI regulations. Two pilots were certified for the aircraft type based on AIRCREW regulation but due to extra medical limitations issued for the pilot, they were not allowed to fly at the same time together and the subject was not carefully monitored by the pilot, nor was it applied by the operation planning section of the company.

2. The aircraft was certified, equipped, and maintained in accordance with CAOIRI regulations and approved procedures, except implementation of an airworthiness directive which was not followed.

3. There was no evidence of an aircraft structural or system failure that would have either played a role or contributed to the accident cause.

4. The forecasts produced by the Iranian Meteorological office clearly showed worse weather conditions (Strong wind vectors, isolated CBs and moderate icing). METEO France conducted a post-event study and also reported near to severe weather conditions.

5. The flight crew contacted Yasouj tower and received latest weather information that was below applicable Minima with meteorological information based on airline Operations Manual.

6. The pilots had sufficient training, including meteorology and procedure of operations manual but the reaction was against their training.

7. The crew reached altitude of 15000 ft at 19 NM that was below MSA (15,500 ft) and MOCA(16200 ft) which was not allowable.

8. The flight crew’s actions for stall recovery were not performed according to abnormal procedures of the aircraft in FCOM& SOP. The pilot did not use flap 15 and maximum engine power with MAX RPM to recover stall condition.

9. The FCOM procedure for stall recovery and procedure in QRH was different and neither of the documents failed to guide the crew to use MAX RPM by advancing condition lever for type ATR 72-212.

10. Based on the analysis of all available data, and investigation analyses, the flight had encountered icing conditions and the de-ice system was used for 02:26 minutes. After that, both de-ice & anti-ice systems were switched off.

11. The aircraft handling performance was degraded during the accident flight. The aircraft faced mountain wave phenomenon with vertical wind reaching 3000 ft/min and probably residual on the last minute of the flight. The effects of mountain wave had the main role in degradation of aircraft performance.

12. The manufacturer did not provide documentation to address hazard of mountain wave behavior in FCOM. However, this hazard is described inside the operator SOPs.

13. The AD 2009-0170 mentioned only icing as a reason for its applicability and does not include other factors leading to aircraft performance degradation.

14. All aircraft systems, including ice detection/protection system were installed in accordance with European design standards JAR Part 25.

15. The topographic properties of the destination area (mountainous area) might have been subjected to a specific weather phenomenon. This phenomenon was not taken into consideration by the national meteorological authority, nor by the operator. The weather office of IRI did not issue any SIGMET on this kind of threat to the flights. Consequently, the crew did not anticipate the mountain wave phenomenon.

16. The simulation packages developed by the aircraft manufacturers for the training does not typically provide any possibility to simulate mountain wave real conditions. The simulation provides the crew with training on low-energy identification and management.

17. There was a lack of effective communication between the two pilots against principles of the cockpit resource management (CRM). Also, standard call out and concentration on indicators and related warnings were major factors which unfortunately were missed in the cockpit and could reduce the pilots' awareness.

18. The Iranian Meteorological Organization did not issue weather forecast (TAF) for the Yasouj Airport due to low traffic capacity of the airport. The Meteorological procedures were not in line with the AIP content related to the provision of a TAF with a validity of 30 hours; however, the Yasouj airport administration added a difference note to related AIP page.

19. Iranian meteorological center had not issued SIGMET about Mountain Wave.

20. There was no standard level agreement between meteorological authority and concerned ANS/Airport operator about the type of serviced aviation meteorological reports.

21. The coordination between CAOIRI and meteorological organization as Mereology authority was not enough to implement standards of annex 3(6.2.1), (9.1.3). However, based on national Civil Aviation Law, the supervisory committee should be established by Ministry of Road and Urban development to manage issued technical meteorology information for aviation industries.

22. The responsibilities of the organizations for Search and Rescue of aircraft accident in the region of airport outside were not coordinated enough.

3.2 Probable causes:

The main cause of the accident:

The accident happened due to many chains of considered causes but the **"Human Factor"** had the main role in the conclusion of the scenario. The Cockpit Crew's action which caused dangerous conditions for the flight is considered as the main cause. Based on the provided evidence as follows:

- Continuing to Yasouj airport for landing against Operation Manual of the Company, due to low altitude ceiling of the cloud and related cloud mass. They should have diverted to an alternate airport.
- Descending to unauthorized altitude below minimum of the route and MSA
- Lack of enough CRM during flight
- Failure to complete the stall recovery (flap setting, max RPM)
- Inappropriate use of Autopilot after Stall condition
- Inadequate anticipation for bad weather based on OM (Clouds, Turbulence, and Icing)
- Quick action to switch off anti-ice system and AOA on the last minute of the flight
- Failure to follow the checklists and standard call out by both pilots

Contributing Factors:

The contributive factors in this accident include but are not limited to the following:

- ➢ The airlines was not capable of detecting systematic defectives about:
  - Effectiveness of crew training about Meteorology, OM, SOP etc.
  - enough operational supervision on pilots' behaviors
- ➢ The non-provision of SIGMET including Mountain Wave or Severe Mountain wave
- ➢ Unclear procedure for stall recovery in FCOM & QRH for type ATR72-212 fleet.
- ➢ Lack of warning in aircraft manuals by manufacturer for flight crew's awareness about mountain wave.
- ➢ Lack of APM System to alert the crew about performance degradation

3.3 Other Deficiencies and Shortcomings:

In the process of the accident investigation, some detailed deficiencies and shortcomings were found and should be considered as latent conditions by related authorities:

- o AD accomplishment and related monitoring
- o Sanctions imposed on aviation industry and the direct effect on Flight safety
- o Unnecessary/nonstandard communication between ATC and the crew
- o Unclear definition of the Fully Qualified Pilot and Qualified Copilot in Aircrew regulations
- o Weather forecast (TAF) in the airports based on annex 3
- o Procedure in the Civil Aviation Organization for approving alternative method of compliance regarding aircraft AD's
- o Poor coordination between local Crisis management with authorities for aviation accidents
- o Time setting of aircraft flight data recording (FDR) either by technicians or pilots

4. SAFETY RECOMMENDATIONS:

4.1 Simultaneous safety recommendations with accident investigation:

As the initial findings of this accident and taking action to prevent similar accidents in the country, the following safety recommendations were issued in the preliminary report of the accident:

I. *CAOIRI to take decision about operation of ATR72 fleet of the Aseman Airlines based on noncompliance with AD 2009-0170, and to ensure compliance of introduced alternative method of compliance (AMOC) for safe flight and related training and operational procedures are complied.*

II. *CAOIRI to review and make the necessary action to review operation manuals of airlines for changing flight mode from the IFR to the Visual Mode (V App) with required risk assessment to enhance the safety of the flights.*

III. *CAOIRI to improve procedures for verifying implementation of the technical requirements on the aircraft airworthiness and take necessary enforcement for enhancing safety requirements in the airlines.*

IV. *All crew and airlines are requested to research/monitor about the limitations of the crew certificates before planning of crew for the flight.*

V. *All airlines should review required process of briefing between dispatcher and pilots on weather information before dispatch release of the flights to ensure safe operation of flights with consideration of available weather conditions.*

4.2 New Safety Recommendations:

Considering the final results of the investigation to prevent similar accidents and incidents, and to improve the safety of the flights, the Aircraft Accident Investigation Board (AAIB) issues the following safety recommendations:

To ICAO:

1. To consider implementation of annex 8 of Chicago convention standards to ensure state of design and manufacturer to support other contracting states for necessary information and effective components required for the safety of the aircrafts and remove civil aircraft from related embargoes.

2. To define responsibility of aircraft designers and manufacturers to address hazard of mountain wave in aircraft documents for the crew.

To European Union Aviation Safety Agency (EASA):

3. To make related communication with European Commission to ensure aviation authorities of EU countries as state of design and manufacture to support operating airlines for flight safety requirements and separate the civil aviation activities from embodied sanctions.

4. To clear definition of qualified copilot and fully qualified pilot in subject of OML in the Aircrew Regulation as the*" safety study*".

5. To ensure all aircraft manuals have full description of mountain wave hazards and preventative requirements and guidance.

6. To revise stall recovery procedure in ATR72-212 FCOM based on findings of this report and provide it to the aircraft operators.

7. To revise AD 2009-0170 to include whole probable factors leading to the aircraft performance degradation.

To Ministry of Road and Urban development in IR Iran:

8. To stablish aviation meteorology supervisory committee to define oversight over annex 3 to ICAO convention and issuance of technical meteorological information.

To Interior Ministry of IR Iran:

9. To define responsibilities of the involved organizations in crisis management for participation in Search and Rescue Program of aircraft accident, and to observe related training and exercise.

To I.R of Iran Civil Aviation Organization:

10. To review aviation personnel certification regulations in accordance with the findings of the report and clear the definition of qualified copilot and fully qualified pilot and the necessary instructions to be issued to airlines.

11. To improve procedures about the lack of compliance of airlines with the requirements and mandatory technical publications contributing to ensure safety of the aircraft operation.

12. To define source of technical publications (First state of design) for each type of aircraft that needs to be followed by the airlines.

13. To set required plans for auditing the airports that do not include the Aerodrome Certification requirement again annex 14.

14. To develop the Aviation Search and Rescue Program in the country, especially outside of the airport with related coordination with governmental organizations.

15. To empower regulatory supervision in Annex 3 requirements.

16. To make suitable oversight to Iranian Aeronautical Information publication (AIP)

To IR of Iran Meteorological Organization:

17. To research about requirement for issuing weather forecast (TAF) for the airports, based on annex 3 of ICAO convention.

18. To research about the possibility of issuing mountain wave hazard warning in SIGMET for the flights.

19. To coordinate with CAOIRI about implementation of Annex 3 Standards.

To Iranian Airports and Air Navigation Company:

20. To facilitate weather forecast of the airports with the provisions of the Organization and the Annex 3 with coordination of meteorological organization and update the information in the AIP.

21. To advice Air Traffic Controllers to be subject to using standard phraseology.

22. To proceed delivery of pilot reports (PIREP) about adverse weather phenomenon for other flights.

23. To revise responsibility of controlling of the flight between ACC delivery time and ATZ of class G aerospace.

To Aseman Airlines:

24. To revise/update operational manual about the conditions of all airports for their intended flights

25. To plan timely additional training courses for all operational personnel on the subject of the operations manual.

26. To plan advanced meteorological training courses for pilots and dispatchers.

27. To revise operation manual about responsibility of the dispatch unit to review the file of all flight information after briefing by the pilots, if one of the requirements contained in the OM is not available, the decision about flight should be referred to the operation control center (OCC) of the airline.

To All Airlines:

28. To include the meteorological training program, including mountain wave subject for operational personnel and correspondence of its condition on operation manuals.

29. To receive an updated country's aeronautical information publication (AIP) in the airline and set related necessary training for operational employees.

30. To review their flight routes in accordance with aircraft performance focusing on Mountain wave characteristics with the principles of the safety management system and related risk assessment.

5- APPENDICES:

- BEA Comments to The Final Report
- Yasouj Information in AIP
- EASA AD No.2009-0170

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du Développement durable
et de l'Energie

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

BEA COMMENTS

The BEA has been consulted for the draft final report on the accident that occurred on 18th February 2018 to the ATR 72 -212 registered EP-ATS.
In accordance with paragraph 6.3 of ICAO Annex 13, the BEA requests that the following comments be appended to the Final Report.

FCOM

The report mentions that there is no any reference in QRH of FCOM with version 2018 or SOP that the crew is authorized to push power lever up to RAMP or Wall for stall recovery to increase power.
The FCOM states that the first action for stall recovery must be to reduce AoA. It must then be followed by an increase of power. The amount of power is not specified. This is in accordance with the Upset Prevention and Recovery Training Aid AUPRTA Revision 3 and international best practices for stall recovery. ATR FCOMs related to the stall recovery procedure are harmonized amongst all ATR models and are in line with the best practices as per the latest work carried out at the ICAO level. Indeed, a common procedure has been established as a result of a close cooperation between ICAO and Airbus, ATR, Boeing, Bombardier, and Embraer. The Upset Prevention and Recovery Training Aid (AUPRTA) highlights that best practice is to first reduce Angle of Attack when recovering from stall. The ICAO AUPRTA Rev.3 Section 7.3 is available to the public on the ICAO website. A change of this procedure might have adverse effects in terms of practices and trainings.

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Zone Sud – Bâtiment 153
200 rue de Paris
93352 Le Bourget Cedex
France
Tél. : +33 1 49 92 72 00
Fax : +33 1 49 92 72 03
www.bea.aero

Mountain waves

The awareness of meteorological phenomena, such as the mountain waves, and the associated risks to operations is covered in both the Aircrew Regulation and the Air OPS Regulation at the respective levels[1]. This awareness and any training related to it are part of the general knowledge of a pilot and applicable regardless of the specific aircraft: different meteorological conditions are part of the theoretical training programme for the licence issue (LAPL, PPL, CPL and ATPL).

Icing

The report focuses a lot on icing conditions and ice protection devices although the performance calculations made by both BEA and ATR, confirm there was no significant performance degradation associated with icing. The predominant environmental condition affecting this flight was the wind strength and direction (mountain waves).

Loss of energy

During the flight, the indicated speed, pitch and power were indicative of the loss of energy and there was a possibility to take appropriate recovery actions. At the end of flight, pilots tried to recover kinetic energy of the aircraft in order to control the flight but the altitude clearance from the mountains was not sufficient.

Engine power selection

More details could be provided in the report on the engines selected power to allow better understanding of the situation. During the event, the selected power (max power with the engine settings 2132 SHP) is approximately 22 % below the maximum power of the engine (max power with PL at the ramp and propeller speed at 100%: 2750 SHP). The selected engine power was not sufficient to stop the decrease of the airspeed.

[1] These regulations are applicable in Iran by decision of the Iranian Civil Aviation Organization.

trtAD 2. AERODROMES

OISY AD 2.1 AERODROME LOCATION INDICATOR AND NAME

OISY - YASOUJ / National

OISY AD 2.2 AERODROME GEOGRAPHICAL AND ADMINISTRATIVE DATA

1	*ARP coordinates and site at AD*	304149N 0513300E
2	*Direction and distance from (city)*	NW, 3.2 NM from Yasouj
3	*Elevation / Reference temperature*	5939 FT / 29.4° C
4	*MAG VAR / Annual change*	3° E (2012)
5	*AD Administration, address, telephone, telefax, telex, AFS*	Iranian Airports & Air Navigation Company (IAC) Yasouj Airport P.O.BOX: 75914-96131 Yasouj - Islamic Republic of Iran Tel : +9874 – 33333552, 33310200-1 Telefax: +9874 – 33333651 Telex: NIL AFS: OISYYDYX http://yasouj.airport.ir
6	*Types of traffic permitted (IFR/VFR)*	IFR/VFR
7	*Remarks*	NIL

OISY AD 2.3 OPERATIONAL HOURS

1	*AD Administration*	0330 - 1130 (0230 - 1030), other times O/R
2	*Customs and immigration*	NIL
3	*Health and sanitation*	NIL
4	*AIS Briefing Office*	NIL
5	*ATS Reporting Office (ARO)*	Service available by ATS
6	*MET Briefing Office*	NIL
7	*ATS*	0215 - 1330 (0115 - 1230), other times: O/R
8	*Fuelling*	O/R
9	*Handling*	O/R
10	*Security*	H24
11	*De-icing*	NIL
12	*Remarks*	PPR for non-scheduled flights at least 48 hours before EOBT from Yasouj aerodrome.

OISY AD 2.4 HANDLING SERVICES AND FACILITIES

1	*Cargo - handling facilities*	NIL
2	*Fuel / oil types*	Jet A1
3	*Fuelling facilities/capacity*	2 trucks, 4000 liters & 8000 liters
4	*De - icing facilities*	NIL
5	*Hanger space for visiting aircraft*	NIL
6	*Repair facilities for visiting aircraft*	NIL
7	*Remarks*	Defueling is available. One truck with ability 7000 liters.

OISY AD 2.5 PASSENGER FACILITIES

1	*Hotels*	Available in the city
2	*Restaurants*	Available in the city
3	*Transportation*	Taxis
4	*Medical facilities*	Hospital in the city
5	*Bank and Post Office*	Available in the city
6	*Tourist Office*	Available in the city
7	*Remarks*	NIL

OISY AD 2.6 RESCUE AND FIRE FIGHTING SERVICES

1	*AD category for fire fighting*	CAT 5
2	*Rescue equipment*	Available in accordance with AD category for fire fighting
3	*Capability for removal of disabled aircraft*	NIL
4	*Remarks*	NIL

OISY AD 2.7 SEASONAL AVAILABILITY - CLEARING

1	*Types of clearing equipment*	2 blades fitted into trucks
2	*Clearance priorities*	1- RWY 2- TWY 3- Apron
3	*Remarks*	NIL

OISY AD 2.8 APRONS, TAXIWAYS

1	*Apron surface and strength*	Surface: Asphalt Strength: NIL
2	*Taxiway width, surface and strength*	Width: 23M Surface: Asphalt Strength: NIL
3	*Remarks*	Apron dimensions: 75 X 150 meters.

OISY AD 2.9 SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEM AND MARKINGS

1	*Use of aircraft stand ID signs, TWY guide lines and parking guidance system of aircraft stands*	Taxing guidance signs at intersection with TWY and RWY and at holding positions Guide lines at apron Nose-in guidance at aircraft stand
2	*RWY and TWY markings and LGT*	RWY marking: Designation, THR, TDZ, centre line, edge & end RWY lighting: See OISY AD 2.14 below. TWY marking: Centre line, edge TWY lighting: See OISY AD 2.15 below.
3	*Stop bars*	NIL
4	*Remarks*	NIL

OISY AD 2.10 AERODROME OBSTACLES

In approach / TKOF areas			*In circling area and at AD*		*Remarks*
1			2		3
RWY/Area affected	*Obstacle type Elevation/ HGT Markings/LGT*	*Coordinates*	*Obstacle type Elevation / HGT Markings/LGT*	*Coordinates*	
a	b	c	a	b	
			Building 6016 FT AMSL NIL	304306N 0513220E	
			Water tank 6099 FT AMSL NIL	304303N 0513239E	
13 / APCH 31 / TKOF	Building 5919 FT AMSL NIL	304257N 0513131E	Com mast 6231 FT AMSL NIL	304254N 0513307E	
			Hill 5855 FT AMSL NIL	304232N 0513208E	
13 / APCH 31 / TKOF	Building 5922 FT AMSL NIL	304303N 0513135E	BTS antenna 6060 FT AMSL NIL	304245N 0513244E	
			Power line 6206 FT AMSL NIL	304412N 0513036E	
			Power line 6215 FT AMSL NIL	304418N 0513043E	
			BTS antenna 6111 FT AMSL	304201N 0513335E	

In approach / TKOF areas			*In circling area and at AD*		*Remarks*
1			2		3
RWY/Area affected	*Obstacle type Elevation/ HGT Markings/LGT*	*Coordinates*	*Obstacle type Elevation / HGT Markings/LGT*	*Coordinates*	
a	b	c	a	b	
			BTS antenna 6112 FT AMSL NIL	304158N 0513338E	
			Wind sock 5968 FT AMSL NIL	304146N 0513312E	
			Power line 5979 FT AMSL NIL	304132N 0513331E	
			Com mast 7131 FT AMSL NIL	304113N 0513550E	
			Flood light 6248 FT AMSL NIL	304104N 0513453E	
			Flag 6790 FT AMSL NIL	304041N 0513608E	
			Building 6117 FT AMSL NIL	304108N 0513428E	
			Building 6127 FT AMSL NIL	304104N 0513433E	
			Com mast 6211 FT AMSL NIL	304058N 0513440E	
			Com mast 6191 FT AMSL NIL	304059N 0513431E	
			DVOR 5979 FT AMSL NIL	304136N 0513324E	
			Com mast(Red, White) 7160 FT AMSL NIL	304113N 0513551E	
		→	Mast 6172 FT AMSL (89 FT AGL) NIL	304058N 0513442E	
		→	Mast 6175 FT AMSL (105 FT AGL) NIL	304058N 0513440E	
		→	Mast 6237 FT AMSL (125 FT AGL) NIL	304103N 0513446E	
		→	Mast 6224 FT AMSL (164 FT AGL) NIL	304248N 0513306E	

OISY AD 2.11 METEOROLOGICAL INFORMATION PROVIDED

1	*Associated MET Office*	Yasouj
2	*Hours of service* *MET Office outside hours*	H24 --
3	*Office responsible for TAF preparation Periods of validity*	Tehran 30 hours
5	*Briefing/consultation provided*	In person and by telephone: +9874-33335001-3
6	*Flight documentation* *Language(s) used*	abbreviated plain language text English/Persian
9	*ATS units provided with information*	Yasouj AFIS
10	*Additional information (limitation of service, etc.)*	METAR issuance intervals : 30 minute during 1 hour before and after schedule flights and other time every 1 hour

Note: Subject concerning items 3 to 8 and 10 not available.

OISY AD 2.12 RUNWAY PHYSICAL CHARACTERISTICS

Designations RWY NR	*TRUE BRG*	*Dimensions of RWY (M)*	*Strength(PCN and surface of RWY and SWY*	*THR coordinates THR geoid undulation*	*THR elevation and highest elevation of TDZ of precision APP RWY*
1	2	3	4	5	6
13	132.60°GEO	2599 X 45	26/F/C/Y/T Asphalt	304230.17N 0513206.28E GUND –13 FT	THR 5842 FT
31	312.61°GEO	2599 X 45	26/F/C/Y/T Asphalt	304133.19N 0513318.34E GUND –13 FT	THR 5939 FT

Slope of RWY - SWY	*SWY dimensions (M)*	*CWY dimensions (M)*	*Strip dimensions (M)*	*OFZ*	*Remarks*
7	8	9	10	11	12
1.1 %	200 X 45	200 X 150	NIL	NIL	THR RWY 13 displaced 290M.
1.1 %	140 X 45	140 X 150	NIL	NIL	

OISY AD 2.13 DECLARED DISTANCES

RWY Designator	*TORA (M)*	*TODA (M)*	*ASDA (M)*	*LDA (M)*	*Remarks*
1	2	3	4	5	6
13	2599	2799	2799	2309	NIL
31	2309	2739	2739	2599	NIL

OISY AD 2.14 APPROACH AND RUNWAY LIGHTING

RWY Designator	*APCH LGT type LEN INTST*	*THR LGT colour WBAR*	*VASIS (MEHT) PAPI*	*TDZ LGT LEN*	*RWY Centre Line LGT LEN, spacing, colour INTST*	*RWY edge LGT LEN, spacing colour, INTST*	*RWY End LGT colour WBAR*	*SWY LGT LEN colour*	*Remarks*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
13	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*
31	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*	*NIL*

OISY AD 2.15 OTHER LIGHTING, SECONDARY POWER SUPPLY

1	*ABN location, characteristics and hours of operation*	On top of the control tower building, FLG G and W, 26 flashes per minute HN and during IMC
2	*LDI location and LGT* *Anemometer location and LGT*	NIL
3	*TWY edge and centre line lighting*	NIL
4	*Secondary power supply/switch-over time*	Available Switch-over time: 08 - 15 sec
5	*Remarks*	NIL

OISY AD 2.16 HELICOPTER LANDING AREA

NIL

OISY AD 2.17 ATS AIRSPACE

1	*Designation and lateral limits*	Yasouj ATZ: A circle, radius 7 NM centred at 304149N 0513300E (ARP)
2	*Vertical limits*	12500 FT AMSL
3	*Airspace classification*	G
4	*ATS unit call sign* *Language(s)*	Yasouj Information English / Persian
5	*Transition altitude*	15000 FT AMSL
6	*Remarks*	Transition level : FL170

OISY AD 2.18 ATS COMMUNICATION FACILITIES

Service designation	*Call sign*	*Frequency*	*Hours of operation*	*Remarks*
1	2	3	4	5
AFIS	Yasouj Information	123.750 MHZ 121.800 MHZ	0215-1330 (0115-1230), other times O/R	For Ground movement

OISY AD 2.19 RADIO NAVIGATION AND LANDING AIDS

Type of aid, CAT of ILS (For VOR/ILS, give VAR)	*ID*	*Frequency*	*Hours of operation*	*Site of transmitting antenna coordinates*	*Elevation of DME transmitting antenna*	*Remarks*
1	2	3	4	5	6	7
NDB	YSJ	235 KHZ	H24	304204.5N 0513255.8E		
DME	YSJ	CH 112Y (116.550 MHZ)	H24	304204.5N 0513255.8E		
DVOR/DME	YSJ	116.550 MHZ CH 112Y	H24	304136.0N 0513324.1E		
DME unusable within 2NM around station DVOR unusable in the FLW area counter clockwise direction: 1 - 100° - 090° beyond 25 NM, BLW 22000 FT AMSL. 2 - 055° - 020° beyond 25 NM, BLW 26000 FT AMSL 3 - 330° - 055° beyond 40 NM, BLW 32000 FT AMSL						

OISY AD 2.20 LOCAL TRAFFIC REGULATIONS

NIL

OISY AD 2.21 NOISE ABATEMENT PROCEDURES

NIL

OISY AD 2.22 FLIGHT PROCEDURES

Traffic pattern is defined as below:

a. For fighter and heavy fixed-wings ACFT 7500 feet,
b. For other fixed-wing ACFT 7000 feet and
c. For helicopter 6500 feet.

Note: see AD 1.1 item 7 for criteria.

OISY AD 2.23 ADDITIONAL INFORMATION

1- Strolling dogs exist on the movement area.

2- Isolated aircraft parking position located at turn pad runway 13.

OISY AD 2.24 CHARTS RELATED TO AN AERODROME

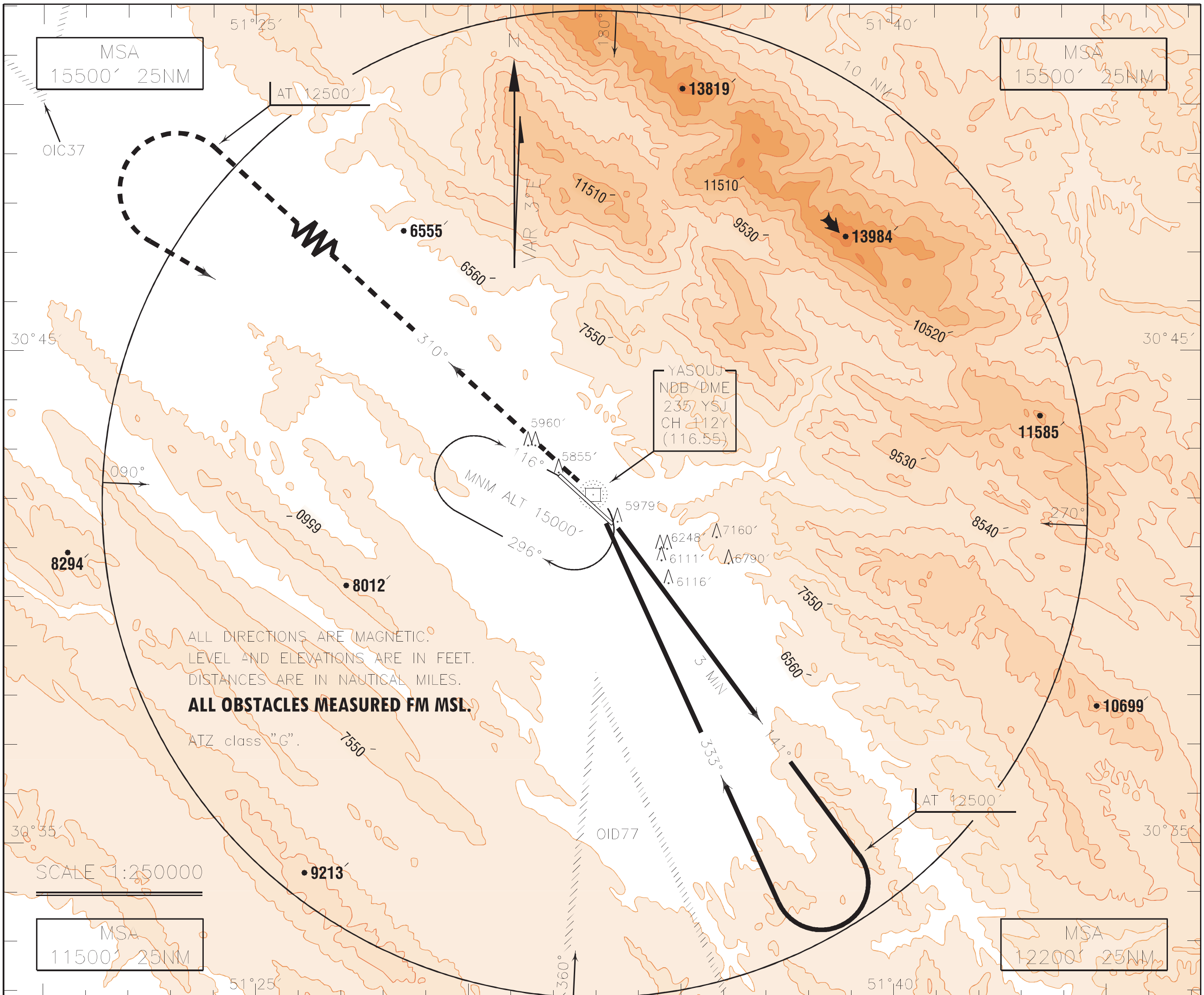
Aerodrome Chart - ICAO .... AD 2 OISY ADC
Instrument Approach Chart – ICAO ....AD 2 OISY IAC 4-1
AD 2 OISY IAC 4-2

INSTRUMENT
APPROACH
CHART-ICAO

AERODROME ELEV. 5939 FT
HEIGHTS RELATED TO
AERODROME ELEVATION

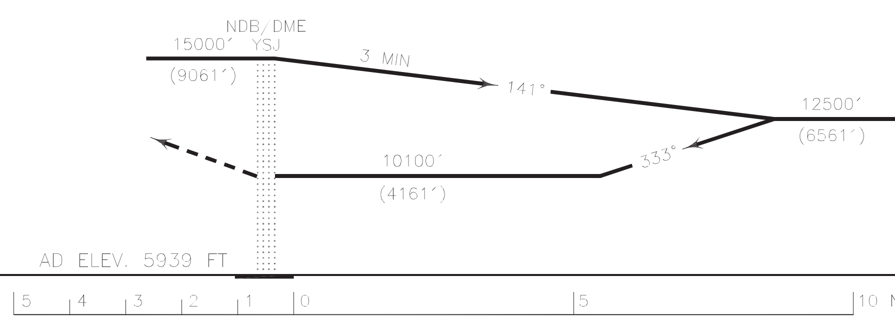
INFO 121.800
123.750

YASOUJ/YASOUJ
CIRCLING NDB
CAT A/B



MISSED APPROACH: Over NDB/DME turn left climb on BRG 310° to 12500 FT, then turn left to rejoin HLDG at 15000 FT.

TRL FL 170
TA 15000´



NOTE:

1-Circling not outhorized to the north of AD.

2-Contour intervals are to be selected at 990 FT (300 M).

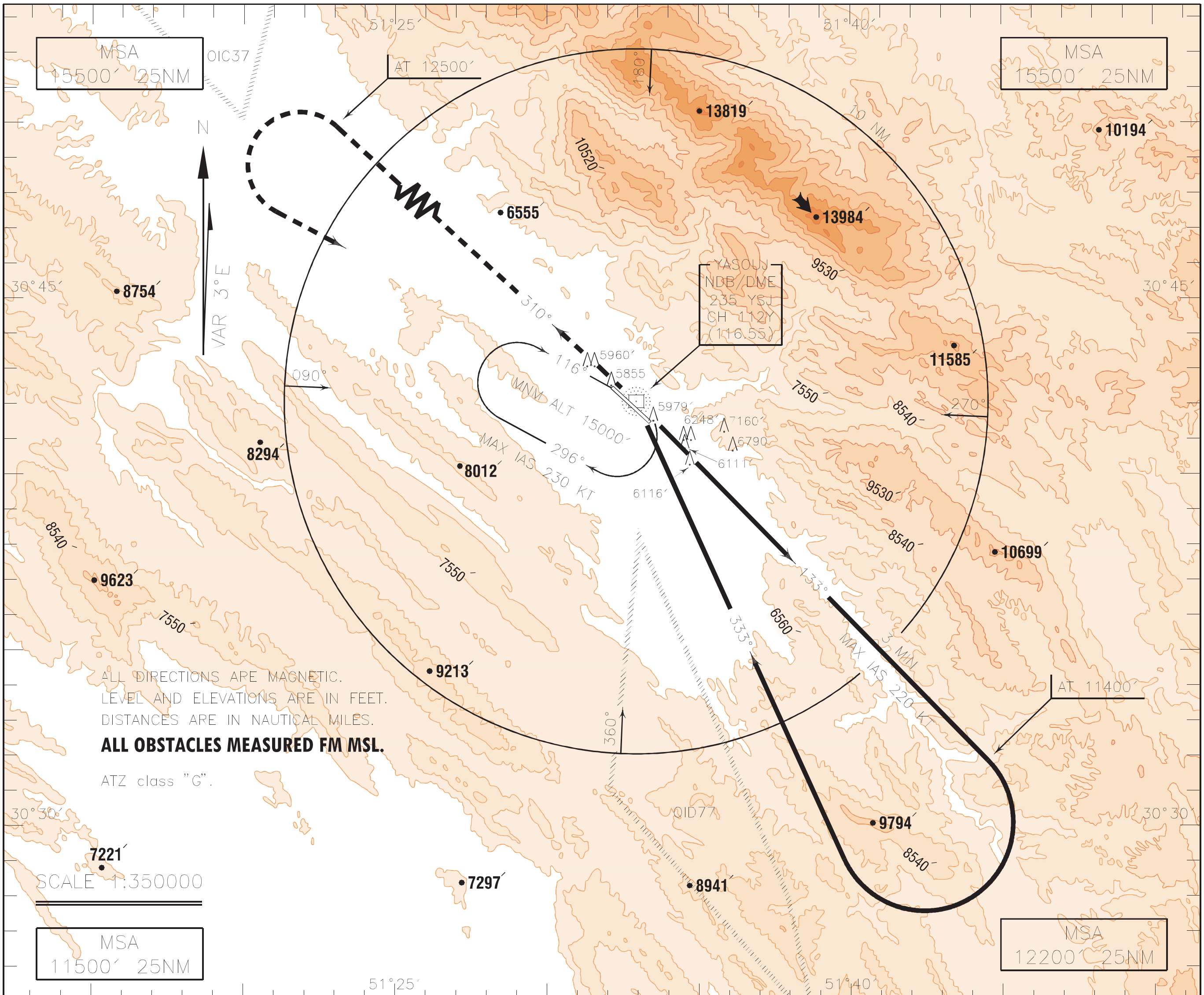
OCA(H)	A	B	C	D
Straight				
Circling	10100´(4161´)			

INSTRUMENT APPROACH CHART-ICAO

AERODROME ELEV. 5939FT
HEIGHTS RELATED TO AERODROME ELEVATION

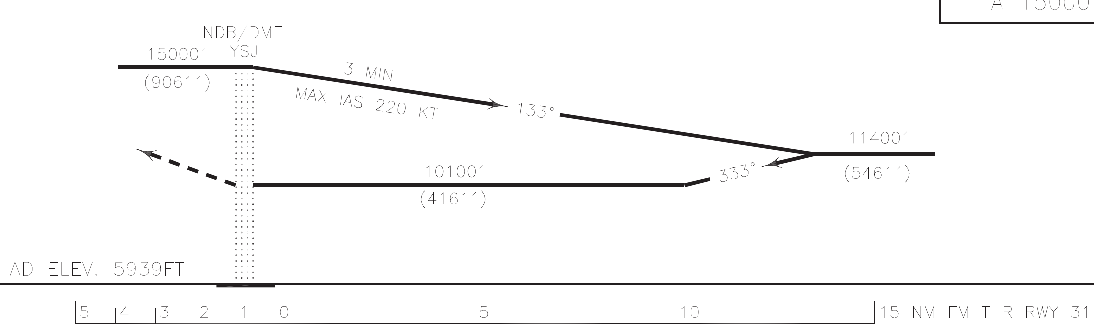
INFO 121.800
123.750

YASOUJ/YASOUJ
CIRCLING NDB
CAT C/D



MISSED APPROACH: Over NDB/DME turn left climb on BRG 310° to 12500 FT, then turn left to rejoin HLDG at 15000 FT.

TRL FL 170
TA 15000´



NOTE:

1-Circling not outhorized to the north of AD.

2-Contour intervals are to be selected at 990 FT (300 M).

OCA(H)	A	B	C	D
Straight				
Circling			10100´(4161´)	

EASA	AIRWORTHINESS DIRECTIVE
	AD No.: 2009-0170 **Date: 10 August 2009** Note: This Airworthiness Directive (AD) is issued by EASA, acting in accordance with Regulation (EC) No 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation.

This AD is issued in accordance with EC 1702/2003, Part 21A.3B. In accordance with EC 2042/2003 Annex I, Part M.A.301, the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs. Consequently, no person may operate an aircraft to which an Airworthiness Directive applies, except in accordance with the requirements of that Airworthiness Directive unless otherwise specified by the Agency [EC 2042/2003 Annex I, Part M.A.303] or agreed with the Authority of the State of Registry [EC 216/2008, Article 14(4) exemption].

Type Approval Holder's Name :	**Type/Model designation(s) :**
ATR - GIE Avions de Transport Régional	ATR 42 series and ATR 72 series aeroplanes

TCDS Number :	EASA A.084
Foreign AD :	Not applicable
Supersedure :	None

ATA 31	**Indicating / Recording Systems - Multi Purpose Computer (MPC) with Aircraft Performance Monitoring (APM) Function - Installation**

Manufacturer(s):	ATR - GIE Avions de Transport Régional (formerly AEROSPATIALE – AERITALIA, AEROSPATIALE – ALENIA, AEROSPATIALE ATR– ALENIA, EADS ATR – ALENIA).
Applicability:	Model ATR 42-200, 42-300, 42-320 aeroplanes that are not already equipped with Multi Purpose Computer / Aircraft performance Monitoring (MPC/APM) per ATR Mod. 08420 (SB ATR42-31-0071), and Model ATR42-400 and 42-500 aeroplanes that are not already equipped with MPC/APM per ATR Mod. 05567 or by retrofit through SB ATR42-31-0068, and Model ATR 72-101, 72-102, 72-201, 72-202, 72-211, 72-212 and 72-212A aeroplanes that are not already equipped with MPC/APM per ATR Mods 05567 or 08392 or 08442 or by retrofit through SB ATR72-31-1051 or SB ATR72-31-1050 or SB ATR31-1054 respectively.
Reason:	This Airworthiness Directive (AD) is intended to minimize hazards on ATR42/72s aeroplanes associated with the inadvertent encounter of severe icing conditions (which are beyond current certification envelope requisites for Part 25 aeroplanes) by providing the flight crew with measurable and objective evidence and timely alert when such severe ice conditions are encountered.

The accumulated experience on the worldwide fleet of commuter aeroplanes, and recently reported ATR42/72 in-flight incidents, show that a long exposure to severe icing conditions, outside the certification envelope, can result in “unsafe conditions” leading to rapid performance degradation leading to sudden stall of the lifting/controlling aerodynamic surfaces and subsequent loss of control of the aeroplane.

Prolonged exposures to these severe icing conditions are due to the lack of crew awareness of these extreme environmental conditions leading to their late detection and/or untimely or incorrect application of the existing AFM procedures, which require the flight crew to actively monitor the encountered icing conditions and to leave them as soon as they are recognised as severe.

Current ATR42/72 AFM emergency procedures for the encounter of severe icing conditions - as mandated by AD F-1999-015-040 R2 - remain valid and must be applied by the flight crew. However, their application is based on the detection of such severe icing conditions by means of flight crew subjective interpretation of:

- an unexpected decrease of the aeroplane speed and/or rate of climb and/or;
- a set of very different visual cues like ice covering unheated portion of either forward side windows, possibly associated with water splashing and streaming on the windshield and/or;
- several secondary indications based on visual observation of ice accretion on different parts of the airframe.

All these together require the flight crew to perform a final qualitative judgement based upon its experience to fly icing conditions, and which could be different depending on the specific circumstances of each case where other concurrent environmental factors like poor light conditions, night operations, etc.., can impair the decision-making process.

In addition, even if the severe icing conditions are quickly identified by the crew and the escape manoeuvre promptly initiated, it may still take a few minutes for the aircraft to exit these conditions.

In order to improve flight crew situation awareness in icing conditions, ATR developed a new function called Aircraft Performance Monitoring (APM) that is available on ATR aeroplanes with Multi Purpose Computer (MPC) installed.

The APM processes a collection of different parameters (among them the aeroplane take-off weight as selected by the crew on a specific rotary selector), and in particular computes and compares the actual drag on the current flying path with the theoretical/expected value. From the comparison, a measurable and objective determination of the performance degradation possibly due to abnormal ice accretion can be calculated. When the performance degradation passes given thresholds, the APM annunciates warning signals by triggering up to two different levels of alerts while on climb/descent and three levels of alerts on cruise to the flight crew to make them aware of potential severe icing conditions degrading the aircraft performance.

It is recognised that, although the ice protection system of the aeroplane is compliant with the current certification envelope for flight into known-icing-conditions, the possible unsafe condition originating from a prolonged exposure to severe icing environment will be annunciated by the alert(s) provided by the APM, which has proved to be reliable during its in-service

	experience. Because the APM warning will only indicate the significant aerodynamic penalties, the current AFM Emergency Procedures for severe icing remain totally valid and applicable. No relief to the pilot procedures concerning the current visual cues to detect severe icing conditions can result from this AD because APM function provides flight crews with objective indications which complement and enhance the situation awareness. EASA has therefore decided to make mandatory the APM system for ATR 42 and 72 series aeroplanes.
Effective Date:	24 August 2009
Required action(s) and Compliance Time(s):	Required as indicated, unless accomplished previously: Not later than the second "C" check or within 72 months, whichever occurs first after the effective date of this AD, install a Multi Purpose Computer (MPC) with Aircraft Performance Monitoring (APM) in accordance with the accomplishment instructions of: • Service Bulletin (SB) ATR42-31-0071 revision 07 (Mod 008420) for ATR42-200/300/320 aeroplanes. • SB ATR42-31-0068 revision 07 (Mod. 05567) ATR42-400/500 aeroplanes. • SB ATR72-31-1051 revision 09 (Mod 05567) for ATR72-101/102/201/202/211/212/212A aeroplanes. Installation of a MPC/APM done before the effective date of this AD in accordance with earlier revisions of the aforementioned SBs, satisfy the requirements of this AD. **NOTE 1**: Mod.05567 was factory-incorporated onto ATR 42-500 aeroplanes from Manufacturer Serial Number (MSN) 641 onwards and on ATR 72-212A aeroplanes on MSN 699, 722 and 724, and from MSN 726 onwards. **NOTE 2**: At the effective date of this AD, an appendix 15 describing the specific aeroplane procedures associated to the APM is included in the following Normal Revisions of the AFM: - AFM 42-200/300/320 Normal Revision 27 dated April 2008. - AFM 42-400/500 Normal Revision 13 dated October 2008. - AFM 72-101/102/201/202/211/212 Normal Revision 22 dated July 2008. - AFM 72-212A Normal Revision 11 dated July 2008.
Ref. Publications:	**ATR Service Bulletins**: ATR42-31-0068 original issue up to revision 07; ATR42-31-0071 original issue up to revision 07; ATR72-31-1051 original issue up to revision 09; ATR72-31-1054 original issue up to revision 04; ATR72-31-1050 original issue up to revision 01; **Aeroplane Flight Manuals**: AFM 42-200/300/320 Normal Revision 27 dated April 2008; AFM 42-400/500 Normal Revision 13 dated October 2008; AFM 72-101/102/201/202/211/212 Normal Revision 22 dated July 2008;

	AFM 72-212A Normal Revision 11 dated July 2008. The use of later approved revisions of these documents is acceptable for compliance with requirements of this AD.
Remarks :	1. If requested and appropriately substantiated, EASA can approve Alternative Methods of Compliance for this AD. 2. This AD was posted on 24 April 2009 as PAD 09-059 for consultation initially until 29 May 2009 and later extended to 30 June 2009. The Comment Response Document can be found at http://ad.easa.europa.eu. 3. Enquiries regarding this AD should be referred to the Airworthiness Directives, Safety Management & Research Section, Certification Directorate, EASA. E-mail ADs@easa.europa.eu. 4. For any questions concerning the technical content of the requirements in this AD, please contact: ATR - GIE Avions de Transport Régional Continued Airworthiness Service Tel.: +33 (0)5 62 21 62 21 - Fax: +33 (0) 5 62 21 67 18 E-mail: continued.airworthiness@atr.fr