# FINAL REPORT

OF CIVIL AVIATION SAFETY INVESTIGATION

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>Serious incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>LLC A Delaware Limited Liability Company</td>
</tr>
<tr>
<td>Operator</td>
<td>Blue Air – Airline Management Solutions S.R.L.</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Boeing Company</td>
</tr>
<tr>
<td>Aircraft</td>
<td>B737-430</td>
</tr>
<tr>
<td>Registration country</td>
<td>Romania</td>
</tr>
<tr>
<td>Registration:</td>
<td>YR-BAS</td>
</tr>
<tr>
<td>Location:</td>
<td>Cluj “Avram Iancu“ International Airport</td>
</tr>
<tr>
<td>Date and time:</td>
<td>07.01.2016 08:00 LT</td>
</tr>
</tbody>
</table>

NO. I 16 - 04  
AKNOWLEDGEMENT

This REPORT presents data, analysis, conclusions and recommendations on civil aviation safety, of the Civil Aviation Safety Investigation Commission appointed by the General Director of CIAS.

The flight safety investigation was conducted in accordance with the provisions of the Government Ordinance No. 51/1999 concerning the technical investigation of civil aviation accidents and incidents, approved with amendments and additions by Law No. 794/2001, of the REGULATION (EU) No. 996/2010 of the European Parliament and of the Council from October 20, 2010 on the investigation and prevention of accidents and incidents occurred in civil aviation and repealing of Directive 94/56/EC and the provisions of Annex 13 to the Convention on International Civil Aviation signed at Chicago on 7 December 1944.

The objective of civil aviation safety investigation is preventing the occurrence of accidents and incidents, by effective determination of causes and circumstances that led to this occurrence and establishing the necessary recommendations for civil aviation safety and it HAS NOT THE PURPOSE of finding guilty, individual or collective responsibilities.

As a consequence, the use of this REPORT for other purposes than preventing the occurrence of accidents and incidents might generate misinterpretations.

In case of any divergence of interpretation of the safety investigation report, the Romanian version shall prevail.
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SYNOPSIS

CLASSIFICATION

Serious incident

Owner
LLC A Delaware Limited Liability Company

Operator
Blue Air – Airline Management Solutions S.R.L.

Manufacturer
Boeing Company

Aircraft
B737-430

Registration country
Romania

Registration
YR-BAS

Location
Cluj “Avram Iancu” International Airport

Date and time
07.01.2016 08:00 LT

On 07.01.2016, the Civil Aviation Safety Investigation and Analysis Center (CIAS) was announced by telephone about this occurrence and subsequently received the „Air Safety Report” (ASR) representing the written reporting of the serious incident in which it was involved the B737-400 aircraft, registered YR-BAS.

CIAS notified about the occurrence of the serious incident the following organizations: the International Civil Aviation Organization (ICAO), the European Commission, the European Aviation Safety Agency (EASA) and the Investigation Body of the United States of America – NTSB which has the quality of design and manufacturing state of the aircraft. NTSB designated an accredited representative for this investigation.

On 07.01.2016 the aircraft Boeing 737-400 type, registered YR-BAS, operated by Blue Air – Airline Management Solutions, was planned to perform a charter flight Bucharest – Barcelona with a stopover on Cluj “Avram Iancu” International Airport (LRCL). The aircraft took-off from Henry Coandă Airport (LROP) at 07:14 LT with the designated callsign BMS 9301. The take-off and en-route flight went normally. In landing phase on LRCL airport, after passing the runway 25 threshold, the aircraft had a prolonged flare flight for almost 10 seconds, touched down the runway and began to reduce its speed but, even though on the last part of the runway the braking system was manually operated, the aircraft speed was not reduced quickly enough to avoid the aircraft stop off the runway. The serious incident occurred at approximately 08:00 LT, at the end of runway 07 of Cluj “Avram Iancu” International Airport.
The landing was on a runway covered with a 3 mm forecasted layer (possibly in reality of maximum one centimeter) of wet snow. There were no victims and the aircraft was not damaged.

The cause of the serious incident is the prolonged flare flight followed by touchdown with runway at a distance of almost 2300 ft (approx. 700 m.) measured from the runway 25 threshold.

The incident was notified in written to CIAS, being registered with no. 0002/2016.

The flight safety investigation was conducted in accordance with the provisions of the Government Ordinance No. 51/1999 concerning the technical investigation of civil aviation accidents and incidents, approved with amendments and additions by Law No. 794/2001, of the REGULATION (EU) No. 996/2010 of the European Parliament and of the Council from 20 October 2010 on the investigation and prevention of accidents and incidents occurred in civil aviation and repealing of Directive 94/56/EC and the provisions of Annex 13 to the Convention on International Civil Aviation signed at Chicago on 7 December 1944.
1 FACTUAL INFORMATION

1.1 History of incident

On 07.01.2016 the aircraft Boeing 737 – 400 type, registered YR-BAS, operated by Blue Air – Airline Management Solutions, was planned to perform a charter flight Bucharest – Barcelona with a stopover on Cluj “Avram Iancu” International Airport (LRCL). According to the flight plan, for Bucharest to Cluj flight the designated alternate airports were Sibiu Airport (LRSB) and Timișoara Airport (LRTR). At 05:45 LT the crew went to the company’s briefing room, within Bucharest "Henry Coandă" International Airport (LROP), where they studied the flight folder prepared by the dispatch department.

According to the file, the meteorological information METAR for Cluj Airport at 05:00 LT was the following: Wind direction and intensity 250° with 3kt (aprox. 1.5 m/s), visibility 3000 m, weather - freezing rain, mist air, coverage of 8/8 and ceiling at 5200 ft. (aprox. 1576 m), temperature -1° C, QNH 995, braking coefficient 95 and the TAF message specifies that temporary between 07:00 LT and 14:00 LT the visibility will be 1500 m, snow fall, the ceiling at 500 ft. (aprox. 151m) with coverage of 5-7/8 and the second ceiling at 3000 ft (aprox. 910 m) with coverage of 8/8.

For Bucharest to Cluj flight the aircraft was fueled with the necessary quantity of fuel, including also the necessary fuel for the alternate airports. The captain decided to add 400 liters more fuel than the calculated necessary, in the end the total amount of fuel was 6330 liters.

The aircraft took-off from Henry Coandă Airport at 07:14 LT, with the designated callsign BMS 9301. The take-off and en-route flight went normally. Before starting the descent flight the crew made the standard check in order to descent, in which they established the approach route for landing, the positioning of "AUTO BRAKE" switch on position 2, flaps 40° and how they should clear the runway after landing and taxiing to the parking platform. After receiving the clearance to start the descent flight from FL 300 (aprox. 9100 m) to FL 120 (aprox. 3637 m), the aircraft started descent. Subsequently, the aircraft received clearance to continue descent at FL 60 (aprox. 1818 m).

With this occasion, on the crew’s request, the air traffic controller communicated them that the route to be followed will be ETORA2T (according to RNAV STAR LRCL map). Before connecting to Cluj Approach (CLJ APP) the air traffic controller from ACC Bucharest communicated to the crew to stop descent at the FL 80 (aprox. 2425 m).
At 07:42:15 LT the crew contacted CLJ APP:

**BMS 9301:** "Cluj Approach, bună dimineața! Blue messenger 9301 we are descending flight level 80 approaching ETORA".

**CLJ APP:** "Buna dimineața, blue messenger 9301! Cluj Approach, radar contact, after ETORA proceed direct to CLJ maintain flight level 80 and expect holding pattern over CLJ about 5 minutes, runway is not ready yet".

At 07:42:44 LT the crew communicated:

**BMS 9301:** "OK, we confirm runway is not ready we are maintaining flight level 80 proceeding to CLJ VOR and expect 5 minutes"

**BMS 9301:** "Please, I advise you we have fuel for maxim 5 minutes for holding"

**CLJ APP:** "5 minutes will be enough"

Considering the evolution of weather conditions at 05.00 LT: freezing rain, temperature -1°C and the fact that starting with 06.00 LT it was about to start the take-offs on LRCL airport, the LRCL Airport Duty Manager decided that it was necessary the preventive intervention on runway with de-icing substances, and before the first take-offs, the airport runway was treated against freezing.

At 05.30 LT, according to METAR, the freezing rain turned into light snow and the runway surface treatment operation also continued on taxiways.

At 07.07 LT, the Operational Service of LRCL received the estimated landing time of BMS 9301 flight for 07.52 LT.

At 07.11 LT the last aircraft took-off from LRCL. The operation conditions on runway, according to METAR at 07.00 LT, were good, braking action 4 (medium to good).

At 07.20 LT, the LRCL on-shift Operations Officer required to Air Traffic Service (CLJ TWR) the entrance on runway of special equipment for snow removing, according to POPR-08 procedure “Snow removing plan for 2015-2016 winter”.

At 07.23 LT, CLJ TWR communicated to on-shift Operations Officer that BMS 9301 will enter in the airport control area at 52nd minute.

At 07.27 LT, CLJ TWR informed the on-shift Operations Officer that BMS 9301 will enter in the airport control area earlier than estimated, namely at 49th minute.

At 07.40 LT, the Airport Duty Manager asked CLJ TWR to inform BMS 9301 to stay for 5 minutes in the holding area in order to appropriately clean the runway and the taxiways.
At 07.43 LT, the CLJ TWR informed the Airport Duty Manager about the aircraft, as follows:

"…entering in holding procedure for almost 2 minutes, this means the 45th minute. They communicated us that they have additional fuel for only 5 minutes of holding, meaning till 50th minute, after which they will start the landing procedure. I ask you to clear the runway at 50th minute”.

At 07.51 LT, the Air Traffic Service communicated to the Airport Duty Manager and to the on-shift Operations Officer the following:

“Blue Air started the approach procedure. Please clear the runway and inform me when it is clear. It will land on runway 25”.

At 07.51 LT, the same minute, the on-shift Operations Officer informs the CLJ TWR that: "All the heavy equipment cleared the runway. The runway is clear."

After cleaning the runway (07:51 LT), the braking action estimated by the on-shift Operations Officer was 4 (medium to good), but due to the moderate snow and the fact that snow was about to lie down until the aircraft landing, the estimated braking action was reduced to 3 (medium) and communicated to CLJ TWR in order to inform the pilot.

At 07:51 LT the crew received clearance for leaving the holding area and to start the descent flight in order to land. At 07:52:08 the CLJ APP air traffic controller also communicated LT the following:

"Blue messenger 9301 at Cluj runway is covered by wet snow between 51 and 100 percent, 3 millimeters and braking action is medium"
The descending flight and alignment on landing direction went normally. At 07:59:10 LT the traffic controller from CLJ TWR to whom the crew was transferred, communicated:

"Blue messenger 9301, buna ziua, Cluj Tower, wind 090 degrees 3 knots, runway 25, cleared to land"

During this radio contact the aircraft was at 4 miles (aprox. 7.2 km) of the runway threshold, on landing direction. At the altitude of almost 800 ft (243.8 m) the crew clearly observed the approach lights and at 300 ft radio altitude (91 m) the crew Captain switched to manual piloting of aircraft (the auto pilot and the autothrottle were disconnected). At the altitude of 50 ft (15.2 m), the crew saw the runway centerline lights and at 45 ft (13.6 m) altitude of the Captain initiated the flare maneuver of the aircraft, by acting the control column backwards at an angle between 5⁰ and 8.5⁰ - 9⁰. The aircraft flared for 10 seconds touching down the runway at a distance of 2300 ft (aprox. 697 m) after the threshold. After touchdown with the runway, the Captain put the engine control levers in "thrust reverse" position and the autobrake system automatically activated. The aircraft started to reduce its speed, in the last part of the runway the Captain operated the brakes with the pedals, and the autobrake system deactivated. Although the braking system was manually operated, the aircraft speed was not reducing fast enough to avoid the aircraft overrun the runway. The trajectory followed by the aircraft from touchdown with runway, was in a slight movement to the right of the centerline, the aircraft exiting the runway at the end of runway 07, with a speed of 10 kt (18.5 km/h). The aircraft stopped in the close proximity of the runway, rotated to the right hand side (according to figures 2 and 3).

![Fig. 2 – Aircraft stopping point](image-url)
After the engine shut down and the situation assessment, the crew decided that the use of emergency evacuation procedure is not required (using slides).

At 08.02.52 LT, the CLJ TWR informed the Airport Duty Manager:

“Blue Air overrun the runway, please go urgently to the end of runway 07”.

At 08.03 LT, the Airport Duty Manager alarmed all airport forces designed to react in emergency situations. They went to the site where is was assessed the aircraft condition which was off the runway.

At 08.08 LT, the Airport Duty Manager requested means of transport for disembarking the passengers.

At 08.09 LT it was communicated to the crew Captain the possibility of disembarking the passengers through the right rear door by using a passenger stairs positioned on the runway.

By using this solution, which was mutually agreed with the crew Captain, they started to disembark the passengers and their luggage at 08.22 LT.

At 08.25.41 the intervention crew communicated to the Airport Duty Manager, the end of passenger disembarking operation.

Further on, the airport contacted a specialized company which provided towing of the aircraft on the runway surface, and thereafter, the aircraft was towed to a parking position with the airport means on Platform 3, where there were proper conditions to perform the technical verification.

At 21.12 LT, the aircraft took-off for positioning flight to international airport Henry Coandă Otopeni.
1.2 Injuries to persons

There were no victims or injuries of passengers and crew.

1.3 Damage to aircraft

N/A.

1.4 Other damage

N/A.

1.5 Personnel information

<table>
<thead>
<tr>
<th>Pilot (Captain)</th>
<th>Male, 32 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>License</td>
<td>RO/FCL/ATPL/…</td>
</tr>
<tr>
<td>Medical certificate</td>
<td>Valid until 09.10.2016</td>
</tr>
<tr>
<td>Flight experience</td>
<td>Total hours 3856 on B737, 289 hours as Captain</td>
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</table>

<table>
<thead>
<tr>
<th>Pilot (copilot)</th>
<th>Male, 49 years old</th>
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</thead>
<tbody>
<tr>
<td>License</td>
<td>RO/FCL/ATPL/…</td>
</tr>
<tr>
<td>Medical certificate</td>
<td>Valid until 10.06.2016</td>
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<tr>
<td>Flight experience</td>
<td>Total hours 2683 , on B737-430  1133 flight hours</td>
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1.6 Aircraft information

<table>
<thead>
<tr>
<th>Manufacturer and aircraft type</th>
<th>The Boeing Company / B737-430</th>
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<tbody>
<tr>
<td>Serial number and manufacturing date</td>
<td>27007 / 01.10.1992</td>
</tr>
<tr>
<td>Nationality and mark</td>
<td>Romania / YR-BAS</td>
</tr>
<tr>
<td>Owner</td>
<td>LLC a Delaware Limited Liability Company</td>
</tr>
<tr>
<td>Operator</td>
<td>Blue Air-Airline Management Solutions S.R.L.</td>
</tr>
<tr>
<td>Engine type and series</td>
<td>CFM 56-3C1 S.N. 720927 / 857977</td>
</tr>
<tr>
<td>Airworthiness certificate</td>
<td>Valid Expiration date: 03.06.2016</td>
</tr>
<tr>
<td>Total number of hours/cycles</td>
<td>56368 / 37972</td>
</tr>
</tbody>
</table>
Fig. 4 - Aircraft Boeing 737-430

It is a "narrowbody" jet airliner, twin-engine, with a maximum capacity of 189 passengers manufactured by Boeing Commercial Airplanes.

<table>
<thead>
<tr>
<th>Crew</th>
<th>2</th>
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<tbody>
<tr>
<td>Passengers</td>
<td>146/159, max.189</td>
</tr>
<tr>
<td>Propulsion</td>
<td>2 motoare turbofan</td>
</tr>
<tr>
<td>Engine model</td>
<td>CFM Intl. CFM56- B2</td>
</tr>
<tr>
<td>Speed</td>
<td>933 km/h 504 kts/ 580 mph</td>
</tr>
<tr>
<td>Mmo (max. Mach)</td>
<td>Mach 0.82</td>
</tr>
<tr>
<td>Service ceiling</td>
<td>11,278 m 37,000 ft</td>
</tr>
<tr>
<td>Flight distance</td>
<td>5,186 km 2,800 NM</td>
</tr>
<tr>
<td>Empty weight</td>
<td>33,650 kg 74,185 lbs</td>
</tr>
<tr>
<td>Max take-off weight</td>
<td>68,039 kg 150,000 lbs</td>
</tr>
<tr>
<td>Max landing weight</td>
<td>56,246 kg 124,000 lbs</td>
</tr>
<tr>
<td>Wing span</td>
<td>28,88 m 94 ft 9 in</td>
</tr>
<tr>
<td>Wing surface</td>
<td>105,4 m² 135 ft²</td>
</tr>
<tr>
<td>Lenght</td>
<td>36,40 m 119 ft 5 in</td>
</tr>
<tr>
<td>Height</td>
<td>11,07 m 36 ft 4 in</td>
</tr>
<tr>
<td>Cod ICAO</td>
<td>B737</td>
</tr>
<tr>
<td>Cod IATA</td>
<td>737</td>
</tr>
</tbody>
</table>

1.7 Meteorological information

At the moment the aircraft took-off, 07.14 LT, the following weather conditions were present:

BUCHAREST-OTOPENI

METAR LROP 070500Z 04005KT 3000 -DZ BR OVC005 02/02 Q0993 R08R/29//95 R08L/29//95 NOSIG=
- Ground wind: 40°/ 5 kts;
- Horizontal visibility: 3 km;
- Weather: light drizzle and mist
- Total coverage: 8/8;
- Cloud ceiling: 150 m;
- Air temperature: 2°C;
- Dew point temperature: 2°C.
- Atmospheric pressure, QNH: 993 hPa.

Runway condition:
- Runway direction: 080;
- Deposit type: 2 – wet and water puddles;
- Deposit expansion: 9 – between 51 and 100%;
- Deposit thickness: – ;
- Braking coefficient (braking action): 95 - good.

CLUJ-NAPOCA

METAR LRCL 070500Z 08004KT 1500 SN BR FEW020 OVC028 M00/M00 Q0994 RMK R07/690294=
- Ground wind: 80°/ 4 kts;
- Horizontal visibility: 1,5 km;
- Weather: moderate snow and mist;
- Total coverage: 8/8; partial coverage: 1-2/8;
- Cloud ceilings: 600 m and 840 m;
- Air temperature: -0°C;
- Dew point temperature: -0°C.
- Atmospheric pressure, QNH: 994 hPa.

Runway condition:
- Runway direction: 070;
- Deposit type: 6 – slush;
- Deposit expansion: 9 – between 51 and 100%;
- Deposit thickness: 02 – 2 mm;
- Braking coefficient (braking action): 94 - medium/good.

SIBIU – Alternate airport

METAR LRSB 070500Z 13002KT 1500V190 2500 -SN BR FEW012 BKN016 OVC020 M00/M01 Q0994 RMK R27/790192=
- Ground wind: 130°/ 2 kts;
- Horizontal visibility: 2,5 km;
- Weather: light snow and mist;
- Total coverage: 8/8; partial coverage first clouds layer: 1-2/8; partial coverage second clouds layer: 5-7/8;
- Cloud ceilings: 360 m, 480 m and 600 m;
- Air temperature: -1°C;
- Dew point temperature: -1°C.
- Atmospheric pressure, QNH: 994 hPa.

Runway condition:
- Runway direction: 270;
- Deposit type: 7 - ice;
- Deposit expansion: 9 – between 51 and 100 /
- Deposit thickness: 01 – 1 mm
- Braking coefficient (braking action): 92 medium/good.

At 07.30 TL, the aerodrome meteorological stations submitted the following weather conditions:

CLUJ-NAPOCA

METAR LRCL 070530Z 10002KT 1200 R25/1400D SN BR SCT013 OVC016 00/M00 Q0995 R07/690294=
- Ground wind: 100°/ 2 kts;
- Horizontal visibility: 1200 m;
- Visibility along runway: 1400m, decreasing in the last 10 minutes of observation;
- Weather: moderate snow and mist - Total coverage: 8/8; partial coverage: 3-4/8;
- Cloud ceilings: 390 m and 480 m;
- Air temperature: 0°C;
- Dew point temperature: -0°C.
- Atmospheric pressure, QNH: 995 hPa.

Runway condition:
- Runway direction: 070;
- Deposit type: 6 – slush;
- Deposit expansion: 9 – between 51 and 100%;
- Deposit thickness: 02 – 2 mm;
- Braking coefficient (braking action): 94 - medium/good.

SIBIU

METAR LRSB 070530Z 28001KT 2500 -SN BR FEW006 SCT009 OVC018 M00/M01 Q0994 R27/790192=
- Ground wind: 280°/ 1 knot;  
- Horizontal visibility: 2500 m;  
- Weather: light snow and misty air;  
- Total coverage: 8/8; partial coverage first clouds layer: 1-2/8; partial coverage second clouds layer: 3-4/8;  
- Cloud ceilings: 180 m, 270 m and 540 m;  
- Air temperature: -0°C;  
- Dew point temperature: -1°C.  
- Atmospheric pressure, QNH: 994 hPa.

Runway condition:  
- Runway direction: 270;  
- Deposit type: 7 - ice;  
- Deposit expansion: 9 – between 51 and 100/%  
- Deposit thickness: 01 – 1 mm  
- Braking coefficient (braking action): 92 - medium/good.

When landing, 08.00 LT, the following weather conditions were present:

CLUJ-NAPOCA

METAR LRCL 070600Z 09003KT 1000 R 25/0900V1400D SN BR SCT009 OVC010 00/00 Q0995 RMK R07/590393=

- Ground wind: 090°/ 3 kts;  
- Horizontal visibility: 1000 m;  
- Visibility along runway 25: variable between 900 and 1400m, decreasing in the last 10 minutes of observation;  
- Weather: moderate snow and mist;  
- Total coverage: 8/8; partial coverage: 3-4/8;  
- Cloud ceilings: 270 m and 300 m;  
- Air temperature: 0°C;  
- Dew point temperature: 0°C.  
- Atmospheric pressure, QNH: 995 hPa.

Runway condition:  
- Runway direction: 070  
- Deposit type: 5 – wet snow  
- Deposit expansion: 9 – between 51 and 100/%  
- Deposit thickness: 03 – 3 mm  
- Braking coefficient (braking action): 93 - medium
SIBIU - Alternate airport:

METAR LRSB 070600Z 24001KT 2000 -SN BR FEW008 SCT009 OVC018 M00/M01 Q0994 RMK R27/590593=

- Ground wind: 240°/ 1 knot;
- Horizontal visibility: 2000 m;
- Weather: light snow and mist;
- Total coverage: 8/8; partial coverage first clouds layer: 1-2/8; partial coverage second clouds layer: 3-4/8;
- Cloud ceilings: 240 m, 270 m and 540 m;
- Air temperature: -0°C;
- Dew point temperature: -1°C.
- Atmospheric pressure, QNH: 994 hPa.

Runway condition:
- Runway direction: 270°;
- Deposit type: 5 – wet snow
- Deposit expansion: 9 – between 51 and 100/%;
- Deposit thickness: 05 – 5 mm
- Braking coefficient (braking action): 93 - medium

During the weather conditions change, on LRCL airport a local SPECI message was issued, at 05.50Z, to update the runway status group, message which indicated the reduction of braking action in case of an aircraft landing:

- Ground wind: 100°/ 3 kts;
- Horizontal visibility: 1000 m;
- Visibility along runway 25: 1200 m, without significant changes in the last 10 minutes of observation;
- Weather: moderate snow and mist;
- Total coverage: 8/8; partial coverage: 3-4/8;
- Cloud ceilings: 180 m and 390 m;
- Air temperature: 0°C;
- Dew point temperature: 0°C.
- Atmospheric pressure, QNH: 995 hPa.

Runway condition:
- Runway direction: 250°;
- Deposit type: 5 – wet snow;
- Deposit expansion: 9 – between 51 and 100/%;
- Deposit thickness: 03 – 3 mm;
- Braking coefficient (braking action): 93 - medium;
AERODROME FORCASTS (TAF)

The aerodrome forecast was amended at 05.00 LT – TAF AMD, available for Cluj-Napoca airport in the period specified for the landing of B-737 aircraft and available to the crew, show the following forecast conditions:

TAF AMD LRCL 070300Z 0703/0712 VRB04KT 3000 -FZRA BR NSC BECMG 0703/0705 3000 RASN BKN015 OVC040 TEMPO 0705/0712 1500 SN BKN005 OVC030=

TAF AMD = amended aerodrome forecast
070300Z = issuance date, 07 and hour, 03.00Z (05.00 LT)
0703/0712 = period of validity: date 07, between 03.00Z and 12.00Z (05.00 LT and 15.00 LT)
VRB04KT = average forecasted wind direction: variable; average forecasted wind speed: 4 kts
3000 = forecasted horizontal visibility: 3000 m
-FZRA BR = significant forecasted weather: light rain with deposit of glaze and mist
NSC = forecasted cloudiness and ceiling: insignificant clouds
BECMG 0703/0705 = gradual change from 03.00Z (05.00TL) to 05.00Z (07.00TL)
3000 = forecasted horizontal visibility: 3000 m
RASN BR = significant forecasted weather: moderate rain and snow (sleet) and mist
BKN015 = forecasted cloudiness and ceiling of the first cloud layer: 5-7/8, 1500 ft (450 m)
OVC040 = forecasted cloudiness and ceiling of the second cloud layer: 8/8, 4000 ft (1200 m)
TEMPO 0705/0712 = temporary, between 05.00Z and 12.00Z (07.00TL and 15.00TL)
1500 = forecasted horizontal visibility: 1500 m
SN = significant forecasted weather phenomenon: moderate snow
BKN005 = forecasted cloudiness and ceiling of the first cloud layer: 5-7/8, 500 ft (150 m)
OVC030 = forecasted cloudiness and ceiling of the second cloud layer: 8/8, 3000 ft (900 m)

Valid/available warnings issued in the reference period
For the period 07.0535Z – 07.0835Z, considering the snow fall intensification, it was issued at 07:00 LT a warning in this respect: the observed moderate snow fall would continue, without changes.

LRCL AD WRNG 04 VALID 070535/070835 MOD SN OBS AT 0500Z NC=

The aerodrome forecast was amended at 05:00 LT – TAF AMD, available for SIBIU airport, backup airport for LROP-LRCL flight of B-737 aircraft and available to the crew, show the following forecast conditions for the reference period:

TAF AMD LRSB 070115Z 0701/0724 24006KT 5000 BR SCT020 BKN030 TEMPO 0701/0703 -FZRA BECMG 0703/0705 3000 SN BKN010 OVC015 TEMPO 0705/0709 1500 SN BKN002 OVC010 BECMG 0709/0711 31012KT BECMG 0718/0720 7000 NSW SCT045=

TAF AMD = amended aerodrome forcast
070115Z = issuance date, 07 and hour, 01.15Z (03.15TL)
0701/0724 = period of validity: date 07, between 01.00Z and 24.00Z (03.00TL and 02.00TL, on 08.01)
24006KT = average forcasted wind direction: 240°; average forcasted wind direction 6 kts
5000 = forcasted horizontal visibiliy: 5000 m
BR = significant forcasted weather: mist
SCT020 = forecasted cloudiness and ceiling of the first cloud layer: 3-4/8, 2000 ft (600 m)
BKN030 = forecasted cloudiness and ceiling of the second cloud layer: 5-7/8, 3000 ft (900 m)
TEMPO 0701/0703= temporary, between 01.00Z and 03.00Z (03.00 LT and 05.00 LT)
-FZRA = significant forcasted weather phenomenon: light rain with deposit of glaze
BECMG 0703/0705 = gradual change from 03.00Z (05.00 LT) to 05.00Z (07.00 LT)
3000 = forcasted horizontal visibiliy: 3000 m
SN = significant forcasted weather: moderate snow
BKN010 = forecasted cloudiness and ceiling of the first cloud layer: 5-7/8, 1000 ft (300 m)
OVC015 = forecasted cloudiness and ceiling of the second cloud layer: 8/8; 1500 ft (450 m)
TEMPO 0705/0709 = temporary, between 05.00Z and 09.00Z (07.00TL and 11.00TL)
1500 = forecasted horizontal visibility: 1500 m
SN = significant forecasted weather phenomenon: moderate snow
BKN002 = forecasted cloudiness and ceiling of the first cloud layer: 5-7/8, 200 ft (60 m)
OVC010 = forecasted cloudiness and ceiling of the second cloud layer: 8/8, 1000 ft (300 m)

1.8 Aids to navigation

LRCL airport is an airport with runway equipped with lighting system and radionavigation for CAT II landings and it has the following radionavigation systems:
- CLJ VOR/DME 111.2 MHz;
  (VHF Omnidirectional Range/Distance Measuring System)
- ICX ILS/LOC 111.9 MHz;
  (Instrument Landing System/Localizer)

Figures 5, 6 and 7 shows the instrumental approach maps published in AIP Romania for LRCL airport.
Fig. 6 Standard RNAV (Area Navigation) instrumental approach map
1.9 Communications

Ground-to-ground conversations

The indicators in the table represent:

1. 229 – CLJ TWR
2. 100 – Airport Duty Manager
3. 110 – On-shift Operation Officer

<table>
<thead>
<tr>
<th>Time</th>
<th>Sender</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>07:20:34 LT</td>
<td>110</td>
<td>229, i'm 110 if we have the clearance for snow removal from the runway and taxiways</td>
</tr>
<tr>
<td></td>
<td>229</td>
<td>110, i'm 229 clear to remove the snow on the runway including taxiways, please announce me when the runway is free</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>Confirm</td>
</tr>
<tr>
<td>07:23:35 LT</td>
<td>229</td>
<td>110, i'm 229 estimated for Blue Air minute 52, landing 25</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>229 confirm minutul 52, la stand 6 cu dirijare</td>
</tr>
<tr>
<td></td>
<td>229</td>
<td>229, i confirm minute 52, at stand 6 with guidance</td>
</tr>
<tr>
<td>07:41:00 LT</td>
<td>100</td>
<td>229 with 100 please if possible hold for more 5 minutes in the area...</td>
</tr>
<tr>
<td></td>
<td>229</td>
<td>Repeat please</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>If possible hold for more 5 minutes in the area in order to appropriately clear the taxiways and runway</td>
</tr>
<tr>
<td>07:43:00 LT</td>
<td>229</td>
<td>100 with 229</td>
</tr>
</tbody>
</table>
100 | I’m listening
229 | 100 with 229 blue messenger enters in holding procedure in almost 2 minutes, minute 45, it communicated that it had additional fuel for only 5 minutes of holding, meaning till minute 50, after which it would start the procedure. I ask you to start clearing at minute 50.

| 07:46:38 LT | 229 | 100, 110, I’m 229 Blue Air entered now in holding procedure till minute 50, at minute 50 we would approve the approach procedure
100 | Confirm 100
110 | Confirm 110

| 07:47:17 LT | 229 | 110, I’m 229 with the request that at minute 50 when you clear the runway to announce me on the runway condition
| 07:47:30 LT | 110 | Confirm 110, the new runway condition would be wet snow, 100% contamination, 3 millimeers thickness, medium braking
| 229 | Wet snow, 3 milimeers thickness, 100%, braking [incomprehensible]
110 | Affirmative

| 07:49:06 LT | 229 | 100 and 110, 229, one minute till minute 50 when you shall free the runway
| 110 | 110 confirms

| 07:51:20 LT | 229 | 100 and 110, 229 Blue Air started the approach procedure, please clear the runway and announce me about clear runway, shall land on runway 25
| 110 | 229, I’m 110 all equipment cleared the runway, free runway
| 229 | I’m 229 thank you

Extracted from radio calls  ATC – YR-BAS aircraft, indicative BMS 9301

| 07:43:47 LT | APP | Blue messenger 9301 last information Kilo
| 07:43:50 LT | BMS9301 | We have Kilo on board
| 07:45:09 LT | APP | 9301 join holding pattern over CLJ, I’ll call back for descent at minute 50, now 45
| 07:45:18 LT | BMS9301 | Copied will join holding over Cluj, now on course 022 and ready for your call, 9301
| 07:49:02 LT | BMS9301 | Blue messenger 9301, can you give us the last met report in Sibiu?
| APP | Standby
| BMS9301 | Thank you
| 07:49:35 LT | APP | Blue messenger 9301, last met report from Sibiu, 0530 Zulu, wind 280 degrees 1 knot, visibility 2 thousand 5 hundred meters with light snow, mist, few at 6 hundred feet, scattered 9 hundred feet, overcast 1 thousand 8 hundred feet, temperature minus 0, dew point minus 1, QNH 0994 and the runway is covered by frozen ruts and ridges 7millimeters
| 07:50:52 LT | BMS9301 | Thank you very much
| APP | And blue messenger 9301 braking action at Sibiu is medium to poor
08:01:46 LT  BMS9301  Tower, 9301, we just overran the runway

08:02:02 LT  BMS9301  You did not understand me PAN PAN PAN we overran the runway

08:02:05 LT  TWR  I’m 229 I confirm ... .i’m the tower I confirm, thank you

08:02:15 LT  BMS9301  So we overran the runway, as we can notice almost nothing happened, we are on ground, the engines still function, we analyze the situation and then we will proceed to evacuation

08:02:25 LT  TWR  I’m the tower, I confirm thank you, we will announce the ground right now and equipment for assistance will come, thank you

08:03:52 LT  TWR  The messenger 9301 all stations on ground have been announced to arrive to you now for assistance. If you can communicate, have you overran the runway, do you have major damage or injuries or it is not applicable?...because I should know what to communicate to the ground

08:04:03 LT  TWR  So we overran the runway exactly to the right, we are in starting procedure ...ah ...stopping procedure of engines and as we can notice it is possible to might have touched the ground with the engine

1.10 Aerodrome information

Airport name: LRCL - Cluj “Avram Iancu” International Airport;

Indicative ICAO: LRCL;

Location: East of Cluj city;

Reference point: Longitude N 46°47'21’’;

        Latitude E023°41'32’’;

Elevation: 1039ft (316m);

Runway direction: 070°/250°

For landing direction 25, LRCL airport is equipped with the following systems:

- PAPI (Precision Approach Path Indicator);

- ALS CAT II(Approach Light System);
The runway marking is presented in figure 8:
Runway 07-25 data:

- Runway length: 2040m (6692.96 ft)
- Runway width: 45m (147.63 ft);
- Runway length for landing: 2040m (6692.96 ft);

LRCL airport obstacle map is presented in figure below:

![Airport obstacle map](image)

**Runway condition:**

- Runway direction: 250°;
- Deposit type: 5 – wet snow;
- Deposit expansion: 9 – between 51 and 100/%;
- Deposit thickness: 03 – 3 mm;
- Estimated friction coefficient: 93 - medium;
Winter runway inspection plan is made according to POPR-08 Snow removing plan for 2015-2016 winter. The purpose of the Plan is to eliminate negative effects caused by meteorologic phenomena specific to winter season aiming to ensure and maintain the airport movement area operational condition. This is made by performing periodic inspection (at least once per hour), of the condition of movement area, in order to have permanent control on the conditions changing (snow, glaze, wind, etc.) and of their effects on the mentioned surface.

1.11 Flight recorders

In order to download and analyze the data recorded by CVR and FDR, both flight recorders installed on aircraft YR-BAS were taken into custody by the investigation commission. Downloading the recording data was made in the laboratory of BEA France. The data downloaded from FDR were validated together with the accredited representative of NTSB and its advisor from Boeing.

After downloading the recorded data, it was found that the audio file corresponding to CAM circuit (Cockpit Area Microphone) presented anomalies, meaning that there were no data recorded. To determine whether this anomaly comes from CVR, there were recorded 25 seconds of audio data on the channel corresponding to CAM. This test led to the conclusion that CVR has no problem in terms of operation.

The absence of audio signal registered on CAM channel might probably be due to an anomaly or defect on signal circuit to recorder (microphone, control unit, connection between the microphone and CAM-CU control unit, connection between the control unit and CVR, the lack of power supply of CAM-CU etc).

The investigation commission recommended to the operator Blue Air - Airline Management Solutions to check and fix the CAM circuit of voice data recording of Boeing 737 aircraft, registered YR-BAS.

The additional tests performed by the operator shows that the control panel of the voice recorder was faulty. The panel was replaced and functional tests were performed; after these tests the recording system of CVR was declared functional.
Fig.11 Cockpit Voice Recorder and Flight Data Recorder

<table>
<thead>
<tr>
<th>Type</th>
<th>Manufacturer</th>
<th>P/N</th>
<th>S/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Data Recorder – FDR</td>
<td>AlliedSignal</td>
<td>980-4700-003</td>
<td>3936</td>
</tr>
<tr>
<td>Cockpit Voice Recorder – CVR</td>
<td>FAIRCHILD</td>
<td>S200-0012-00</td>
<td>00640</td>
</tr>
</tbody>
</table>

1.12 Wreckage and impact information

N/A.

1.13 Medical and pathological information

N/A.

1.14 Fire

N/A.

1.15 Survival aspects

After engine shutdown, the crew and airport operational team evaluated the aircraft condition and reached the conclusion that this had no damage, leaking fuel or other liquids, there are not injured persons onboard and both the passengers and crew members could be disembarked in safety conditions on the emergency right rear door using the passengers embarkation/disembarkation stairs.
After disembarking, the passengers were transported to the arrivals terminal of LRCL, where they received assistance from the air operator and LRCL. After unloading the luggage, the passengers were transported to Sibiu International Airport (LRSB) where they were taken over by another aircraft of Blue Air Company and transported to Barcelona, the final destination.

1.16 Tests and research

N/A.

1.17 Organization and management information

Below there are presented extracts from regulations, procedures, air operator, air traffic service and airport management manuals as follows:

1.17.1 Operator

Operational manual - Part B, edition 03/revision 03/11.03.2015

Extracted from Chapter 2 – Normal Procedures

Normal Checklist -300/-400/-500:

~ Checklist before flight;
~ Checklist before engine start;
~ Checklist before taxiing;
~ Checklist before take-off
~ Checklist after take-off;
~ Descent checklist;
  - Approach and fuel briefing;
  - Approach briefing

Briefing shall be made when the workload and availability allows it. In order to prevent any rush, the preparation for descent and the approach briefing shall be performed before reaching the point of beginning descent. Before starting briefing, the crews are recommended to discuss the specific that are associates with the destination airport. The list below is not complete:
- speed limits;
- weather;
- field;
- TCAS;
- navigation errors;
- traffic;
- Change of runway. The pilot who has control of the aircraft must inform the pilot who monitors the aircraft control, of his intentions on the approach. Both pilots
shall review the approach procedure. Before staring briefing, the pilot who has control of the aircraft shall transfer this control to the monitoring pilot.

This briefing shall contain the following information:

- aircraft condition;
- NOTAMs and applicable recommendations of the company;
- procedure in case of failure of communication (if it differs from ICAO);
- METAR / ATIS;
- visibility/RVR- minimum altitude- wind- runway condition- windshear warning – any other factors;
- fuel necessary for moving to alternative airport & and fuel available for holding zone;
- STAR of destination airport:
  o airport name- STAR name;
  o all annotations (if any);
  o MSA (Minimum Safety Altitude);
  o potential procedures P-RNAV;
  o it is reviewed the route from STAR along with all speed and altitude limits;
  o possible errors and risks;
- Take-off height/altitude for autopilot disconnection The company recommends that disconnecting the autopilot to be made at the height of at least 1000 ft (304 m) for accommodating aircraft and flight conditions;

- Instrumental approach map:
  . airport name;
  . runway and expected procedure type;
  . frequencies for aids to navigation and identifications;
  . final approach direction;
  . MSA (Minimum Safety Altitude);
  . transition level;
  . all annotations (if any);
  . highest obstacle on map and localization;
  . necessary visibility/RVR;
  . verification of travel altitudes;
  . locator/radio beacons;
  . angle of landing slope;
  . decision altitude/height; minimum descent altitude/height;
  . visual descent point (if appropriate);
  . missed approach point;
  . missed approach procedure;
- Visual identification means.
- Landing & Stop:
  . available landing distance;
runway condition;
confirmation of landing flaps;
visual slope indicators;
autobraking setting;
reverse thrust;
- Clearing the runway and then the first turn. Taxiing path, parking place and parking means;
- Local or company procedure;

NOTE: Any deviation from standard "CALLOUTS" shall be discussed during Briefing.

- Maneuvers for "Go-around" procedure.

- The "Go-around" procedure may be detailed only for the first flight section of the crew in that day. For the following sections, the person who will pilot the aircraft may shorten the briefing with "Standard maneuvers for Go-around".

~ Approach checklist;
~ Landing checklist;
~ Checklist after landing;
~ Checklist for engine shutdown;
~ Safety checklist;

ILS Approach CAT I

An operation in Category I is a precision instrumental approach and landing using ILS with decision height not lower than 200 ft (61 m) and visibility along runway not less than 550 m.

A pilot cannot continue approach below decision height in Category I without even one of the following visual reference of the destined runway to be distinguished and identified by the pilot:

- elements in approach lighting system;
- runway threshold;
- runway threshold markings;
- runway threshold lights;
- runway threshold identification lights;
- visual landing slope indicator;
- contact area or contact area markings;
- contact area lights;
- runway lateral lights.

Arrival at MAP-Missed Approach Point is determined by DA/H (decision/height altitude) in conjunction with the slope. DA is determined having as reference the barometric altimeter.
Normal landing:

~ Flaps position at landing:

The flaps 15, 30 (for noise reduction) and 40 are in normal landing positions. The runway length and condition should be taken into account when selecting flaps position at landing. The margin of complete maneuver exists for all normal landing positions when the speed is at or above the maneuvering speed for flaps current setting.

~ Precision Approach Path Indicator (PAPI):

PAPI uses lights that normally are on the left or right side of the runway. They are installed in only one horizontal common body.

When the aircraft is in landing slope, the pilot sees two white lights on the left and two red light on the right. PAPI can safely be used by maintaining the height of runway threshold, but it may result in long landing. PAPI is normally calibrated to inspect the runway at 1000 to 1500 ft (304 – 457 m) along the runway.

During visual approaches there are used many methods and techniques so that the landing gear touches down the runway in the desired point. One of the most common used methods is to target the desired touchdown point with runway of the landing gear, then to adjust the descent slope in final approach till the chosen point appears stationary in relation to aircraft (the point doesn’t move up or down in the pilot’s visual field during approach).

~ Disconnecting the autopilot and the engine automatic levers

Before disconnecting the autopilot and/or the engine automatic levers, the person piloting the aircraft shall announce the pilot monitoring flight by using the phraseology: "MANUAL FLIGHT".

~ Flare and landing

When the aircraft “nose” passed the runway threshold, the target point changes toward the far end of the runway. Changing the target point helps at controlling the aircraft recovery during flare. Maintaining a constant speed and rate of descent helps determining the flare point. Flare is initiated when the main landing gear is at almost 20 ft (6 m) above the runway by increasing the recovery position with approximately 2°-3°. This reduces the descent rate.

After the flare was initiated, the engines levers are reduced to idle and small adjustments are made in recovery to maintain the desired descent rate to the runway.
It would be ideal that the main landing gear touches down when the engines levers reached idling speed. Also, a smooth reducing of engines levers to idle helps to a natural descent control of the “nose” associated with reduction of thrust.

**Flare before touchdown with runway should be avoided, because it uses a large part of its available length.**

~ Landing

The aircraft must be maneuvered in such way that landing should be made in the area marked for landing. If markings are not available, the aircraft should land at almost 1000 ft (304 m) beyond the runway threshold. If landing is not made in the desired landing area, it should be normally be initiated the missed approach taking into account the remaining runway length. Intended long landings are strictly prohibited. It is very important to aim that the aircraft shall be oriented on runway direction before landing. Therefore, every effort should be made in order to land on and along the runway centerline. This will provide the best leeway to reduce side control difficulties that appear after landing.

~ Switching to manual braking

When switching from autobrake system to manual braking, the person piloting the aircraft shall announce the pilot monitoring flight by using the phraseology: "MANUAL BRAKING". The disconnecting techniques of automatic braking may affect the passengers’ comfort and the stopping distance. These techniques are:

- it is applied a smooth force on the braking pedal as for a normal stop, until the autobrake system disconnects. As a consequence of automatic braking disconnection, it smoothly releases the pressure from the braking pedal. Disconnecting automatic braking before decoupling the thrust reverser, produces a smooth passing to manual braking.

- automatic braking selector in "OFF" position (it is normally made by the pilot monitoring flight at the request of the piloting person);

1.17.2 Air traffic services

Below there are presented extracts from PIAC-ATS procedure, *Chapter 7 – Procedures for aerodrome control service, subchapter 7.1- Functions of aerodrome control tower.*
The aerodrome control tower (TWR) should issue information and clearance for aircraft under its control so that air traffic on aerodrome and in its vicinity to be performed in safety conditions, orderly and expeditiously, with the purpose of preventing collision(s) between:

- aircraft in flight within the responsibility area assigned to the control tower, including those in taxiing;
- aircraft operating on the maneuvering area;
- aircraft that are about to land or take-off;
- aircraft and vehicles operating on the maneuvering area;
- aircraft on the maneuvering area and existing obstacles in that area.

The functions of aerodrome control tower can be performed by different operational control or work positions, as follows:

- aerodrome air traffic controller, naturally responsible for the operations performed on runway and for aircraft in flight, in the responsibility area of the aerodrome control tower;
- ground air traffic controller, naturally responsible for the traffic controller on maneuvering area, except runways;
- transmission position for on route flight clearance, naturally responsible for the transmission of clearance to start the engines and the on route flight clearance for IFR departing flights.

Extracted from subchapter 7.4 – Information transmitted to aircraft by TWR

Information on aircraft operation

Before the aircraft enters into traffic pattern or begins approach in order to land, TWR should transmit to this one the following information elements, in the required order, except those elements that are known to have been already received by the aircraft:

- the runway about to be used;
- wind direction and speed on surface, as well as their subsequent significant variations;
- QNH altimeter setup and, and if provided in the approved local procedures or at pilot’s request, QFE altimeter setup;

**NOTE:** The meteorological information mentioned above should be in accordance with the criteria that should be applied for normal (routine) and special local meteorological reports.
Extracted from subchapter 7.5 – Essential information on aerodrome conditions

~ Essential information on aerodrome conditions should include significant information referring to:

- construction or maintenance works on the movement area or in its immediate vicinity;
- roughen or damaged parts of runway surface, of taxiways or platforms, no matter if they’re marked or not;
- the presence of snow, of melting snow or ice on the runway, taxiways or platforms;
- the presence of water on the runway, taxiways or platforms;
- the presence of some banks of snow or snow transport in the immediate vicinity of the runway, taxiways or platforms;
- other temporary dangerous elements, including parked aircraft or the presence of birds on ground or in flight;
- failure or irregular operation of the aerodrome lighting system or of any part of it
- any other relevant information

NOTE: There is a possibility that TWR may not always be in possession of the updated information about the conditions on platform. The responsibility of TWR concerning the platform are limited to the transmission, in the attention of aircraft, of the information received from the authority responsible for the platform.

Extracted from subchapter 7.6 – Aerodrome traffic control

~ Traffic on maneuvering area
~ Access on maneuvering area:

The movement of people or vehicles on the maneuvering area of the aerodrome is allowed only with the approval of the aerodrome control tower. The persons including the drivers of all vehicles should obtain the approval of the control tower before entering the maneuvering area. Whether such an approval has been obtained the entry on runway or runway crossing or for any changes in the authorized operations it is necessary a new specific approval from the aerodrome control tower.

1.17.3 Aerodrome administration

Extracted from the Romanian civil aviation regulation RACR-AD-PETA Chapter 10 – Aerodrome maintenance, Subchapter 10.1. General

Para. 10.1.1. In order to maintain the facilities of an aerodrome in a condition which does not negatively affect safety, regularity or efficiency of air navigation, it should be established a maintenance program, including for preventive maintenance, if appropriate.
NOTE 1 – Preventive maintenance is the maintenance work scheduled in order to avoid failure or degradation of the facilities.

NOTE 2 – The term "facilities" includes elements such as runways, taxiways, platforms, paved roads, visual means, enclosures, electrical and sewage systems and buildings.

Para.10.1.2. Maintenance program developing and implementation should meet human factors principles.

Subchapter 10.2. Pavements

Para.10.2.1. All movement areas, including pavements (runways, taxiways, platforms) and adjacent surfaces, should be inspected, and their condition should be regularly monitored as part of the corrective and preventing maintenance of aerodrome, in order to avoid and eliminate any lost objects/rests which might cause damage to the aircraft or might affect the operation of their systems.

Para.10.2.2. The surface of a runway should be maintained in such way to prevent the formation of dangerous irregularities.

Para.10.2.3. A paved runway should be maintained in such way to ensure friction characteristics at or above the minimum specified friction level.

Para.10.2.4. For maintenance purpose, the friction characteristics of runway surface must be periodically measured with a continuous measurement device of friction by using their own watering and documented means. The frequency of these measurements should be sufficient to determine the evolution of friction characteristics.

Para.10.2.4.5. There should be taken measures for corrective maintenance to prevent the passing of friction characteristics, either of the entire runway or of a portion of it, below the minimum specified friction level.

NOTE - A portion of the runway with the length of 100 meters may be considered to be significant for the maintenance action or reporting.

Para.10.2.6. Where there is reason to believe that, because of slopes or uneven areas, the drainage characteristics of a runway or of a portion of it are inadequate, the friction characteristics of the runway in question should be evaluated in natural or simulated conditions representative for local rain, and if necessary, it should be taken the measure of corrective maintenance.

Para.10.2.7. When a taxiway is used by airplanes with turbine power engines, the surface of its shoulders should be maintained so as to be cleared of all stones detached from pavement or other objects that could be absorbed into the airplane engines.
Subchapter 10.3 - Removal of contaminants

Para.10.3.1. Snow, slush, ice, puddles, mud, dust, sand, oil, rubber deposits and other contaminants should be removed from the surface of runways in service as rapidly and as completely as possible to minimize the accumulations.

Para.10.3.2. The taxiways should be maintained cleared from snow, slush, ice, etc. on a surface long enough for the aircraft to run to and from the runway in service.

Para.10.3.3. The platforms should be maintained cleared from snow, slush, ice, etc. on surfaces long enough for the safe maneuvering of aircraft or, where necessary, to tow or pushed the aircraft.

Para.10.3.4. If the removal of snow, slush, ice, etc. from different parts of the movement area can not be done simultaneously, it is recommended that the priority order for runway(s) in service to be determined by consultation with the affected parts, such as rescue and fire fighting service and documented in a snow removal plan.

Para.10.3.5. The chemical substances for removing or preventing the formation of ice and glaze on aerodrome pavements should be used when the condition indicates that their use might have the desired effect. When applying the chemical substances they should act carefully, to not create more slippery conditions.

Para.10.3.6. It should not be used chemical substances that might have dangerous effects for aircraft or pavement or chemical substances that might have toxic effect on the aerodrome environment.

Extracted from the Romanian civil aviation regulation RACR-AD-PETA, Annex 7, Supplement A, Subchapter 6. – Friction characteristics assessment on paved surfaces covered with snow, slush, ice and frost

Para.6.1. If the runway is covered with ice and snow, it is necessary for operation to have reliable and uniform information on the surface conditions of the contaminated runway. For each third of the runway, there are evaluated: contamination type, contaminants distribution and concentration and the depth. An indicator of friction characteristics of the surface is useful to make the evaluation of runway condition. It can be obtained by using a friction measuring equipment; however, there is no international consensus concerning the capability to directly correlate the results obtained with such an equipment with the aircraft performance. However, contaminants such as slush, wet snow and wet ice, resistance at advance caused by the contamination of measuring equipment wheel, among other factors, may cause that the results obtained under these conditions to be irrelevant.
Alin.6.2. Any measuring equipment intended to anticipate the aircraft braking performances in accordance with an approved local or national procedure should be indicated to correlate those performances in an acceptable manner. Information about the ensuring practice of direct correlation with the aircraft braking performance can be found ICAO Circular no.329 – Runaway surface condition assessment, measurement and reporting, Appendix A.

Para.6.3. The runway friction conditions can be assessed in descriptive terms of „estimated friction”. The estimated friction is classified as good, medium to good, medium, medium to poor, and poor, and it is promulgated both in Annex 15 ICAO, Appendix 2 – format SNOWTAM, but also in PANS-ATM, Chapter 12.3 – ATC Phraseology.

Para.6.3. The table below with associated descriptive terms, based on the friction data collected only in cases of compacted snow and ice and therefore, it should not be considered as absolute values applicable in all conditions. If the surface is affected by snow or ice and the estimated friction is reported as "good", the pilots should not expect conditions as good as for a clean and dry runway (where the available friction can be, by case, better than the necessary friction). The indication "good" is relative and it means that difficulties should not be faced in controlling direction or braking, especially at landing. The values in the column „µ measured coefficient” are presented as indication. For each aerodrome it can be developed a specific table in accordance with the measurement equipment used on the aerodrome and in accordance with the criteria and the set of correlation criteria established or agreed at national level. The established µ values will be specific to each friction measuring equipment, tested surface and moving speed.

<table>
<thead>
<tr>
<th>Measured µ friction coefficient</th>
<th>Estimated braking code</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40 and more</td>
<td>Good</td>
<td>5</td>
</tr>
<tr>
<td>between 0.39 and 0.36</td>
<td>Medium to good</td>
<td>4</td>
</tr>
<tr>
<td>between 0.35 and 0.30</td>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td>between 0.29 and 0.26</td>
<td>Medium to poor</td>
<td>2</td>
</tr>
<tr>
<td>0.25 and less</td>
<td>Poor</td>
<td>1</td>
</tr>
<tr>
<td>9 - unsure</td>
<td>Unsure</td>
<td>9</td>
</tr>
</tbody>
</table>

Para.6.5. Over the years there have been attempts to report the braking action to the friction measurements. The industry did not reach the capacity of controlling the entire uncertainty associated with the results provided by the equipment. As a consequence, the values issued by a friction measuring equipment should be used only as part of an overall assessment of runway condition. A major difference between the type of equipment with decelerometer and other types is that when using the type with decelerometer, the operator is an integral part of the measuring process. In addition to the measurements, the operator can feel the attitude of the vehicle in which it is installed the decelerometer and thus can
Para.6.6. It was noticed that it is necessary to provide assessed information on the surface condition, including the estimated friction, for each third of the runway. The thirds are identified by letters A, B and C. In order to report the information to the air service units, section A will always be the section associated to the smaller runway identification number. If the data are transmitted to a pilot in order to land, the runway sections will be nominated as the first, second or third part of the runway. It is understood that the first part is always the first third of the runway for landing purpose. The evaluations are made along the two lines parallel with the runway centerline, situated at almost 3 m on one side and the other of it, or at a distance from the centerline corresponding to the most frequent use. The assessment objective is to determine the type, thickness and coverage degree of contaminants and their effect on the estimated friction given the prevailing weather conditions for sections A, B and C. If it is used a friction continuous measuring equipment, there would be obtained average values starting from the friction values registered for each section. If it is used a friction discrete measuring equipment a as part of the overall assessment of estimated friction there should be performed at least three tests for each third of the runway, where possible. Referring to the condition of the paved surface, the collected and evaluated information, are disseminated using forms established for SNOWTAM and NOTAM (see the Manual for airport services (ICAO Doc 9137), Part 2).

Para.6.7. The Manual for airport services (ICAO Doc 9137), Part 2 offers guiding on testing equipment uniform use and other information on the contaminants removal from the surface and the friction conditions improvement.


Chapter.3 Definitions :

a) DRY SNOW – Snow which can be blown if loose or, if compacted by hand, will fall apart again upon release; specific gravity: up to but not including 0.35.

**OBS.** It is considered dangerous for landing when the thickness of the layer deposited on the runway exceeds 15 cm (over this thickness it is given braking 2);

b) WET SNOW – Snow which, if compacted by hand, will stick together and tend to or form a snowball; specific gravity: 0.35 up to but not including 0.5.

**OBS.** It is considered dangerous when the thickness of the layer deposited on the runway exceeds 8 - 10 cm (over this thickness it is given braking 2);

c) COMPACTED SNOW – Snow which has been compressed into a solid
mass that resists further compression and will hold together or break up into lumps if picked up; specific gravity: 0.5 and over. It is the snow which after snowing is ran over by vehicles and is beaten, which can usually get irregular shapes (with uneven surfaces). The most dangerous form due to the very small braking coefficient and due to uneven surfaces.

**OBS.** It is considered dangerous if it exceeds 1-1,5 cm of thickness, if it is uniform and at any thickness of the layer if it presents uneven surfaces (it would be given braking 1 or 2).

d) **SNOW SATURATED WITH WATER (SLUSH)** - Water-saturated snow which, with a heel-and-toe slap-down motion against the ground, will be displaced with a splatter; specific gravity: 0.5 up to 0.8.

**OBS.** It is considered dangerous when the thickness of the layer deposited on the runway exceeds 5 cm (over this thickness it is given braking 2);

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**Chapter 5 Participant personnel:**

a) On duty Airport Duty Manager;
b) On shift Operations Officer
c) Head of MTA;
d) Airport movement area snow and ice removal equipment drivers

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**Chapter 7 Personnel’s responsibilities**

7.1 The responsibility of initiation and coordination of snow removal falls under the duties of:

a) On duty Airport Duty Manager;
b) On shift Operations Officer

Both during day and also during night the on duty Airport Duty Manager shall carefully monitor the evolution of meteorologic conditions and he shall take the corresponding measures in order to maintain operational the airport movement area.

The on duty Airport Duty Manager shall require to the on shift Operations Officer to make the periodical check (at least once per hour), to the movement area, to have permanent control on the weather conditions change (snow, glaze, wind, etc.) and of their effects on the mentioned area.

If the situation requires it, the on duty Airport Duty Manager, should personally participate in performing the control and should take the corresponding measures depending on weather conditions, on type and quantity of depositions and the contamination degree of the movement area at that moment.
The Airport Duty Manager and the on shift Operations Officer should consider to permanently maintain the airport operation for air traffic and not have delays in launching the snow removal operation that would make ineffective the intervention of equipment at their disposal.

Considering that the airport has an operation program of 24/24 H for air traffic, it is necessary the prompt equipment intervention, in order to be able to face the bad weather with the available equipment.

The responsible persons for launching the snow removal activity shall:

- know the weather forecast for 24 hours and for the following three days;
- launch the snow removal action in case of massive and continuous snowfalls both during day but also during night;
- consider that the snow removal equipment become ineffective and that the snow removal time prolongs a lot if:
  - the snow layer exceeds 10 cm of dry snow;
  - the snow layer exceeds 5 cm of wet snow;

If the snowfall is abundant and continuous, the snow removal action shall be immediately launched.

When taking the decision of starting the snow removal action, the following will be taken into account:

- the activity length in the case of heavy snowfall is about 2-3 hours;
- adding additional forces and preparing the snow removal equipment is of about 1 hour;
- the airport should be permanently operational, which means that the airport movement areas (PDA, taxiways, platforms) to be cleaned whenever necessary;

**NOTE** – The Operations Officer, shall perform a detailed control of the runway, if he was informed that a malfunction occurred to any snow removal equipment, so that it does not remain on the runway, taxiway or platform any part or piece of the damaged piece.

Chapter 9. Equipment activity on the movement area:

a) Cleaning order for the surfaces is: - runway, taxiways, platforms, equipment parking areas and adjacent alleys (see annex 1).

<table>
<thead>
<tr>
<th>Priority</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Runway 07/25</td>
</tr>
<tr>
<td>2</td>
<td>Taxiways - &quot;G&quot;, &quot;F&quot;,&quot;D&quot;,&quot;A&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Platforms - 4, 1 and 3</td>
</tr>
</tbody>
</table>
NOTE: The Airport Duty Manager is the person appointed to maintain the critical areas in optimum operation conditions and he ensure that:

- the ends of runway 07 and 25 are cleared from snow banks, as a priority it is monitored the area of threshold 25;
- the waiting positions for runway 07/25 are cleared from snow banks;
- the embedded lamps are visible and cleaned of ice / snow;

b) the first equipment to enter the runway are: SCHMIDT special truck with snow plough FRESIA brush and blower special trucks with snow plough, brush and blower, that will clean the runway, taxiways and platforms;

c) the next equipment will be the tractor with plough and brush, that will clean the ends of runway 07 and 25, the platforms, the taxiways;

d) URAL snow plow will enter to remove the snow banks during the day, between the aircraft take-off and landing hours;

e) in case of glaze or frost conditions on ground, the Airport Duty Manager, will decide the technical urea spreading, sodium acetate on taxiways D and A and platforms 1 and 3, with the tractor which is provided with a spreader. It will be considered spreading urea before temperatures drop below -5, -6 °C so that not to cause freezing of the mentioned areas for the treatment to be effective. At temperatures below - 5°C, - 6°C it would be considered sodium acetate spreading or liquid deicing;

f) technical urea spreading, sodium acetate or liquid deicing will be made according to the following method:

- it would be started with applying material on the surface in the immediate vicinity of taxiways D, A, then following platforms 1 and 3;
- in case of glaze on platforms 1 and 3 it will intervene with technical urea, sodium acetate or liquid deicing material depending on situation

REMEMBER - for runway 07-25, taxiways F, G and platform 4, it shall be used only Clearway solid deicing substance or Aviform liquid deicing substance. To spread Aviform liquid substance, for this purpose it will be used the MAN truck provided with substance spreading nozzle ramps;

g) liquid deicing spreading will be made according to the following method:

- it would be started with applying material on the surface in the immediate vicinity of of runway centerline, namely of the taxiways F, G, then following platform 4; then it continues with applying liquid on the surfaces that are more distant from the runway centerline till covering the entire surface of the runway and taxiways F and G.
h) during snow removal, when the equipment will clear the runway, it will be parked on the platform from the technological road which connects between the taxiway D and runway 07-25 (road parallel with taxiway G), or in another designated area, to be able to intervene again in the shortest time in case of necessity (see annex 1).
2 ANALYSIS

2.1 GENERAL

During the analysis of this serious incident the investigation Commission has mainly focused on the last part of the flight, especially the on the briefing before descending. Attention was granted also to the mission briefing, available meteorological information, and how the analysis of these data has influenced the fuel reserve that was determined.

The investigation Commission determined that during the mission preparation there were not discussed or studied the particularities of the runway in Cluj, even if none of the pilots has landed in winter time on that runway. (The Captain landed once in summer time, while the first officer never landed there). In the commission’s opinion, studying the map of the new runway would have enabled identification of references to clearly identify the “Touchdown Zone”, the beginning of it being the recommended contact area with the runway, even when the markings were missing being covered by snow.

The mission file contained all necessary meteorological information available at that hour and, under such conditions the crew should have taken into account the frizzing rain forecasted for Cluj and also the following snow falls. The investigation Commission has issued the opinion, that these conditions would have provided justification enabling the Captain to decide additionally 400 liters of fuel to the mission’s necessary fuel (that includes also the flight toward one of the alternate aerodromes), a fuel quantity enabling an aerodrome area holding time higher than the 5 minutes which were established as a limit. To start descending for landing the crew prepared the cockpit and listened on ATIS the most recent weather report for Cluj and based upon determined the approach flight route to be followed, the speeds, the flaps extension to be applied and the value 2 for the automatic braking system (according to the CVR). The Standard Arrival (STAR) Procedure, initially selected on the Flight Management System (FMS), was a classic procedure not using the RNAV points and so the entered into radio contact with ACC Cluj. The commission’s position is that the crew lost time to reset the procedure and to initiate RNAV STAR, a time which would have been available to discuss the runway condition.

When the Blue Air aircraft was entering the area, CLJ APP required the crew additional 5 minutes holding, because “the runway is not ready”. The crew communicated:

“I advise you we have fuel for maxim 5 minutes for holding”.

The crew was aware about the meteorological conditions at the airport since they listened the ATIS (Automatic Terminal Information Service) messages and didn’t
required details when the ATCO broadcasted that “the runway is not yet ready”, but, in the commission’s opinion, taking into account that the meteorological situation in Sibiu indicated a runway condition worse than the one in Cluj, it would have been perhaps better to allocated more than 5 minutes for the holding area, to be assured that the runway could best cleaned from snow contamination. The crew never analyzed that the runway condition information indicated the friction coefficient decrease, which would have enabled additional measures such as putting the Auto Brake Switch on maximum. As well, in the commission’s opinion, by establishing this 5 minutes limit, the captain was looking forward that the holding time should not affect the fuel reserve to reach one of the alternate airports. The crew never thought that the broadcasted message could be understood as a fuel limit message and, independent on how well the runway was cleaned, the machinery would clear the runway at the established minute, so that CLJ TWR transmitted to the Airport Duty Manager that the Blue Air aircraft:

“is entering the holding procedure in approximately 2 minutes, at minute 45, it broadcasted that it has additional fuel for just 5 minutes holding” and asked that the runway clearing should be started at minute 50”.

Analyzing the airport administration according to POPR-08 “Planul de deszăpezire pentru iarna 2015-2016 (Snow removal plan for the winter 2015-2016)”, the Airport Duty Manager has undertaken measures to maintain the airport movement surface condition by preventive action with deicing materials to ensure the safe take-off of the aircraft, parked during the night at Cluj airport.

Before the Blue Air aircraft arrival in the area, CLJ TWR approved the request of the Airport Duty Manager, that the snow removal equipment shall enter the runway. Entering the runway, while analyzing the meteorological conditions and the runway surface condition, he requested CLJ TWR that the aircraft shall fly in holding area further 5 minutes, so that the runway could be properly cleared.

The investigation commission, taking into account POPR-08 sect. 7.3, position 9 “Driver of airport movement surfaces snow removal and deicing equipment are fully responsible to perform snow removal in good conditions so that after clearing the runway this shall be properly available for operational use”, determined that this operation could be performed, considering the meteorological condition, closer to the landing moment.

It shall be mentioned that, runway braking coefficient was estimated. Due to lack of time, the skidometer "ASFT T 10-VW SHARAN", owned by the airport was not employed. When concluding duty the Airport Duty Manager, taking into account the snow fall and the time when the equipment left the runway related to the aircraft position has communicated a medium braking action. According to MOTNE-“93” encoding, the last change was broadcasted to the crew by the TWR Cluj ATCO.

The investigation Commission didn’t identify any discussion between the pilots regarding this information and possible changes that would be required. The
commission’s opinion is that it was neglected the fact that between the moment of estimating the braking action and the landing time will be some 10 minutes, during which the fallen snow would change the braking coefficient estimation towards 92 (medium to poor braking). The investigation Commission estimates that at the moment of changing the evaluation from 94 to 93, the crew should have repeated the necessary landing distance calculation, observing the values in the table from the "Quick Reference Handbook/ Performance Inflight" for the flaps extension 40 and, as a safety measure, braking coefficient 92 (medium to poor braking). In the pilots’ instruction manual in the chapter entitled "Advisory Information", in the sub-chapter "Normal Configuration Landing Distance" is stated the table, also included in QRH, provides information supporting the crew to determine the aircraft performance regarding the effective landing distance according to different runway conditions and different braking system configurations.

There also stated the influences that might affect the actual aircraft landing distance such as height and speed over the runway threshold, the landing slope and the final flight segment before touch-down, employment of jet reverse, use of aerodynamic brakes, use of the wheels braking system and the runway surface condition. These information are relying on the assumption that the runway condition assessment as wet/contaminate is constant along the whole runway length. This means a uniform assessment of the whole wet snow/standing water layer thickness over the entire runway thickness. This information can't cover all possible contamination combinations and do not take into account different factors, such as runway residual rubber contamination or the paint for markings covering large surfaces at the runway thresholds. Taking into account such statements it’s the operator’s decision to establish the operation politics based on the training and experience of their crews.

As a consequence, according to the instruction manual, it is a usual crew practice, that, when under meteorological conditions influences and, only when the runway condition is different from normal (clean and dry runway), to calculate the necessary landing distance, further comparing with the stated runway length. For this serious incident the crew showed the Commission the calculation performed in-flight to determine if the declared runway length for good to medium braking distance could enable the safe stopping of the aircraft. The crew’s conclusion was that they could land safely. The investigation Commission repeated the calculation, but considered a medium to poor braking.

From our calculation, shown below, it’s resulting that the landing distance was included in the declared runway length, independently if the automatic braking system switch would be positioned on 2, 3, "MAX AUTO" or if it was used the "MAX MANUAL" braking procedure. But for medium to poor braking, in this situation, independent from the settings, the declared runway length was insufficient to enable the safe stopping of the aircraft. Further there are shown the calculations for following common landing conditions:
- Declared runway length—6693 ft. (2040 m)
- Runway length measured from the "touchdown zone"—5709 ft. (1740 m)
- Landing weight—48t;
- Flaps—40˚;
- Temperature—0˚C;
- Wind speed—3 kt.;
- Wind direction—100˚;
- Landing direction—247˚;
- Runway altitude—1039 ft. (approximately 317 m.);

### CASE 1: Braking action—medium; pilot braking "MAX MANUAL":

<table>
<thead>
<tr>
<th></th>
<th>Adjustment landing weight</th>
<th>Adjustment RWY altitude</th>
<th>Adjustment wind speed</th>
<th>Adjustment temperature</th>
<th>Adjustment RWY slope</th>
<th>Necessary RWY length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing weight 52 t</td>
<td>-352</td>
<td>+150</td>
<td>+321</td>
<td>-210</td>
<td>-36</td>
<td>=5413 ft. (1650 m)</td>
</tr>
</tbody>
</table>

### CASE 2: Braking action—medium; automatic braking system switch position on "MAX AUTO":

<table>
<thead>
<tr>
<th></th>
<th>Adjustment landing weight</th>
<th>Adjustment RWY altitude</th>
<th>Adjustment wind speed</th>
<th>Adjustment temperature</th>
<th>Adjustment RWY slope</th>
<th>Necessary RWY length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing weight 52 t</td>
<td>-360</td>
<td>+160</td>
<td>+324</td>
<td>-210</td>
<td>-32</td>
<td>=5472 ft. (1668 m)</td>
</tr>
</tbody>
</table>

### CASE 3: Braking action—medium; automatic braking system switch position on 3:

<table>
<thead>
<tr>
<th></th>
<th>Adjustment landing weight</th>
<th>Adjustment RWY altitude</th>
<th>Adjustment wind speed</th>
<th>Adjustment temperature</th>
<th>Adjustment RWY slope</th>
<th>Necessary RWY length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing weight 52 t</td>
<td>-368</td>
<td>+160</td>
<td>+336</td>
<td>-225</td>
<td>-28</td>
<td>=5805 ft. (1769 m)</td>
</tr>
</tbody>
</table>

### CASE 4: Braking action—medium; automatic braking system switch position on 2:
If the crew would have calculated also the length for medium to poor braking action, they would have found out that the declared runway length was insufficient.

**CASE 5: Braking action medium to poor; pilot braking "MAX MANUAL":**

<table>
<thead>
<tr>
<th>Landing weight 52 t</th>
<th>Adjustment landing weight</th>
<th>Adjustment RWY altitude</th>
<th>Adjustment wind speed</th>
<th>Adjustment temperature</th>
<th>Adjustment RWY slope</th>
<th>Necessary RWY length</th>
</tr>
</thead>
<tbody>
<tr>
<td>6960</td>
<td>-472</td>
<td>+210</td>
<td>+492</td>
<td>-270</td>
<td>-72</td>
<td>= 6848 ft. (2087 m)</td>
</tr>
</tbody>
</table>

In this situation the captain would have had, in the commission’s opinion, two options:

1. To require renewed snow removal so that braking action should be returned to at least medium, involving a holding area flight extended over the 5 minutes initial foreseen;

2. To cancel landing in Cluj and choose one of the alternate airports.

The results of these calculations are compared with the declared/published runway length, the calculation taking into account the 1000 ft. (approximatively 300 m) measured from the runway threshold, which have to be deducted from the total runway length, representing the recommended place for the aircraft runway contact. This place is marked on the runway by markings representing the beginning of the "touchdown zone".

The values in the table also include the 15% increase as a safety measure. From the manufacturer’s report, following the FDR data analysis, it’s resulting that the landing flare was initially at 45 ft. (14 m) with more than 25 ft. (8 m) higher than the recommended height. This greater height determined an extended landing flare, delaying the runway contact. FDR data show that the aircraft followed the regular landing slope with a tailwind of 5 - 10 kt. (9 - 18 km/h), determining an increased ground speed, another factor influencing the extended landing flare and, after
touchdown required an increased braking force. The aircraft had contact to the runway on a distance of 2300 ft (697 m) beyond the runway's threshold, leaving 4393 ft. (1339 m) of remaining runway, a distance that, according to the previously shown calculation is leading to the conclusion that safe stopping on the runway surface was impossible. The report including detailed analysis of the FDR downloaded data is shown in section 2.3.1.

The Commission is considering that it would have been possible to safely stop the aircraft on the runway surface if the 1316 ft. (401 m) lost from the "touchdown zone" would have been used. In the training manual there is stated that extended landing flare should be avoided before runway touchdown, otherwise a significant an important available runway length will be lost. The aircraft shall land closest possible to the beginning of "touchdown zone". Thus, for the effective situation in our case, in the opinion of the investigation commission, the crew, finding out that they do not recognize the "touchdown zone", should have continued by initiating the landing interruption (Missed Approach). In this way the crew would have created itself several options to remain in the holding area and to require a new intervention to clean the runway contamination, to abort the landing in Cluj and choose one of the two alternate airports, or to repeat the landing procedure, considering the first attempt a runway recognition maneuver.

Additionally to the clear explained consideration in the FDR report, the Commission appreciates that other factors influencing this extended landing flare could be taken into account, such as no recognition of the "touchdown zone" by the pilots because the markings were covered by snow and the unfamiliarity with the runway in winter conditions.

2.2 FLIGHT OPERATIONS

2.2.1 CREW CALIFICATION

Operational the crew was qualified to operationally conduct the flight, but none of the pilots landed during the winter on that runway, to be familiar with the particularities of this runway under winter coverage. For example the G taxiway, on the left side of the runway is a visible reference indicating the beginning of the "Touchdown Zone". If the runway contact would have taken place at the beginning of this zone, the aircraft would have had enough available braking space and, it's possible that this serious incident out be avoided.

The Commission analyzed as well the way the two pilots communicated between themselves, concluding that the crew fulfilled the standard conditions, but there were also some dysfunctions such the missing of any discussion regarding the evolution of the runway condition, the evolution of the meteorological conditions and additional measures required. There is a moment during the approach flight
when the First-officer communicated to the Captain the message "SPEED", the aircraft flying at that moment at about 50 ft. (15m), and captain should have replied "CORRECTING", while immediately acting to reduce excess speed.

Analyzing the CVR and FDR downloaded data the Commission didn't identify such answer of the Captain, the speed was not adjusted so that during overflying of the runway threshold the aircraft had towards the established $V_{Ref}$ of 129 kts(239 km/h), an excess of 11 kts (20 km/h), meaning 140 kts (259 km/h). It’s possible that the First-officer’s message was not heard by the Captain, since it was immediately followed by automatic announcements generated by the aircraft’ GPWS.

### 2.2.2 METEOROLOGY

On 07.01.2016 Romania was influenced by a Mediterranean cyclone with a trans-Balcanic trajectory, evolving from the Adriatic Sea to the north-western Black Sea basin (Fig. 12). During the mentioned time frame the Mediterranean depression determined at 08.00, atmospheric pressure values (QFF) according to the map of Romanian with effective observation data at ground level, generally between 990.1 hPa in extreme south-east of the country and 1001.6 hPa in northern Moldavia.

As well, the cyclone clouds’ system was formed by clouds layers determining high nebulosity, 8/8 all over the country. In the extra-Carpathian regions the partial (low level) nebulosity was represented by Stratus type clouds with a general nebulosity 6/8 and the cloud base at 300 m in Moldavia, Dobrogea and Muntenia and 300-600 m in Oltenia. A second clouds layer, Nimbostratus-Altostratus, determined a general 8/8 nebulosity and precipitations, moderate snow fall in northern and center Moldavia, rain and sleet, locally with glaze deposits in southern Moldavia and rain in Dobrogea and Muntenia, as well as locally in Oltenia. In the intra-Carpathian regions, especially in Transylvania, but also in mountain areas overflown by the aircraft YR-BAS, the lower cloud layer was consisting of Stratocumulus clouds, with the base of about 600 m and 100-200 m in the southern Carpathian region, while in north-west Transylvania also Status clouds with the base at 600 m. A second clouds layer was formed by Nimbostratus-Altostratus or Altocumulus-Altostratus clouds, generating precipitations as snow, sleet and even rain with glaze deposits (Figures 13 and 14).
Figure 12 Synoptic map of Europe 07.01.2016, 06.00 LT

Figure 13 Map of Romania – Effective observation data 07.01.2016 at 07.00 LT.
Analyzing images transmitted by the meteorological geostationary satellite for Europe METEOSAT-10, it is revealed also the presence and evolution of the cloud system covering the whole geographical area of Romania, showing the cloud system layers and its consistency, by white color nuances (Figure 15).

Fig. 14 Map of Romania – Effective observation data 07.01.2016 at 08.00 LT.

Fig. 15 Imagine from METEOSAT – 10, RGB, 07.01.2016, 08.00 LT

Radar images provided by the S band radar located at Bobohalma show, as well, that the cloud system, mainly the Nimbostratus-Altostratus cloud complex, which
determines significant precipitations, had the upper limit on the route section between Sebes-Medias and Cluj-Napoca, approximatively at 5000 m (Figures 16 and 17), an element showing the potential of this cloud system to generate moderate precipitation in the mentioned area, during the time frame preceding the initialization of the landing procedure.

Fig.16 Radar image with the upper cloud limits – ECHOTOP 07.01.2016, at 07.49 LT

Fig.17 Radar image with the upper cloud limits – ECHOTOP 07.01.2016, at 08.02 LT
Although, quantitative moderate precipitation, as sleet and snow, can be identified with radar images that are revealing the precipitation intensity (Figures 18 and 19), during the time frame of about 10 minutes preceding the aircraft landing.

Following of the analysis of the meteorological maps issued by ROMATSA, valid for 06.00UTC (08.00TL), it is revealed that these show accurately, by the prognosis of significant meteorological phenomena, as well for SFC- 15000FT AML (figure.20 ) as for FL10-450 (fig.21), the meteorological conditions of the flight. So regarding the map valid for SFC- 15000 ft. AML, for the section between the
Southern Carpathians and the area of Cluj Napoca airport, were valid following prognosis data:

- Full nebulosity: 8/8;
- Partial nebulosity: 5-7/8;
- Prognosis clouds: Stratus, with the base at 150 m and upper limit at 600 m; Stratocumulus, Altocumulus and Altostratus from the base at 600 m.
- Horizontal visibility: 1-3 km in the mountain area, and occasionally 3-5 km in Transylvania;
- Significant meteorological phenomena: moderate snow fall in the mountain area, rain, sleet, snow and, isolated, rain and drizzle with glaze deposit in Transylvania;
- Level of the isotherm of 0°C: ground and FL 020;
- Dangerous meteorological phenomena: moderate turbulence over FL 020, moderate icing and, occasionally, severe icing until FL 025.

Regarding the map valid between FL 100 and FL 450, for the route Bucharest-Otopeni – Cluj Napoca, the significant meteorological phenomena were moderate turbulence and icing until FL 170.

Figure 20  Significant phenomena prognosis map SFC – 15000 FT

Valid for 07.01.2016, at 08.00 LT
Taking into account the moment when the crew received clearance to leave the holding area by initiating the landing procedure and the moment they landed there were at least 10 minutes, it might be appreciated that as the moderate snow fall continued and while the snow removal equipment left the runway at least 10 – 12 minutes before the landing, the snow layer on deposit in this maximum 12 minutes timeframe was about 10 mm. The assessment of the new deposed snow layer takes into account the mean moderate snowfall layer deposit, which according METOFFICE, 2009, is about 40 mm/h. As a consequence the snow deposit within approximatively 12 minutes, under the condition of humid (wet) runway after previous deicing material treatment, was maximum 10 mm, determining a reduced tire adhesion and a less efficient braking action, affecting the braking distance. Thus, it may be appreciated that compared to the ATIS broadcasted information - medium friction coefficient, in reality, at the landing the friction coefficient was on the limit of 93 or even a little less.
2.2.3 AIR TRAFFIC CONTROL

Analyzing the ATC activity and observing applicable regulations, the commission has not identified any error. This analysis observed as well the way the aircraft was guided and the cooperation with the airport staff.

Obviously, and confirmed by ATC Cluj TWR, due to meteorological conditions the ATCO had no visual contact with the aircraft. This explains why, at the first broadcast of the crew after the runway excursion, the ATC provided clearance to leave the runway and to enter the taxiway, the situation being cleared only when a second broadcast was issued beginning with "PAN, PAN, PAN". It has to be taken into account that currently the distance between the control tower and the new runway is higher than the one measured between the tower and the old runway.

From the point of view of operating the ground to air navigation aids, the Investigation Commission has not identified any dysfunction, while concerning the ground to ground communication, after declaring the emergency, there were several occasions when the Cluj TWR ATCO asked priority to communicate with the airport staff. It should be stated that at that moment the ATCO was the single communication between the crew and the staff, and, therefore, the Investigation Commission considers very important that this one shall be able to provide priority to messages transmission.

From the point of view of the cooperation between ATC Cluj TWR cooperated with ATC Cluj Approach and with the airport staff, in the opinion of the Investigation Commission, there are possible several adjustments. Between the moment when the snow removal equipment left the runway until the moment the aircraft landed there was a 8 – 12 minutes break, when it the snow continued to fall, and the runway contamination changed. The Commission considers that a better cooperation between the two ATCO and the Airport Duty Manager would have enabled a longer operation time for the snow removal equipment. ATC Cluj Approach has permanently the radar position of the aircraft, and, by coordinating with the crew, they may estimate the landing. This information, provided in due time to ATC Cluj TWR, enable the ATCO to decide the moment when the runway shall be cleared without affecting flight safety. Taking into account the meteorological conditions and the fact that he could not see the aircraft, the Investigation Commission appreciates that the ATCO established a safety margin ignoring the effect of the extended time interval between the clearing the runway by the snow removal equipment and landing of the aircraft.
2.2.4 AERODROME

The Investigation Commission analyzed the runway snow removal activity, mainly according to the procedure of the International Airport “Avram Iancu” Cluj - POPR-08, PLANUL DE DESZĂPEZIRE PENTRU IARNA 2015 – 2016 (SNOW REMOVAL PLAN FOR THE WINTER 2015-2016). This procedure is issued according to the regulation RACR-AD-PETA and was approved by airport director general. Extracts of the two documents are presented within this report at section 1.17.3.

The Investigation Commission hasn’t identified any error in the runway snow removal activity, but it should be taken into account that the skidometer "ASFT T10 – VW SHARAN" for the determination of the runway braking coefficient was not used. The regulation RACR-AD-PETA shows that, especially for wet snow, the result provided by such equipment is irrelevant. When communicating the runway condition the Airport Duty Manager, estimated the braking as medium, friction coefficient μ 0,35 -0,30 (encoding MOTNE 93), but he stated that making this assessment he took into account the braking downgrading during the time between the equipment clearing the runway and the moment when the aircraft will land. The runway was cleaned focusing on its central area, along the center line, so that the Commission appreciates that the snow layer on the runway sides could have been higher than one centimeter (Please refer to Figure 22).

Figure 22   Image of the runway shortly after the serious incident

The crew statement shows that they saw clearly the center line lighting, supporting the conclusion that on this center are the snow layer was less than 1 cm thick, but possible higher than 3 mm related to the moment of the
assessment. The Investigation Commission considers that it is possible that the way the information circulated between the crew, ATC TWR Cluj and the airport staff could have enable a wrong conclusion of last ones, that the aircraft would have reached the available fuel limit, and compulsory minute 50 means the moment when snow removal equipment should be out of the runway. The runway clearing activity started with aircraft wheels contact area and the last cleaned zone was the one where the aircraft should have entered the taxiway.

As a consequence, the period when the beginning of touchdown area was exposed to a new layer of snow is higher than the one between the leaving of the vehicles and the aircraft landing. The discussions of the Commission members with the staff involved in coordination of the snow cleaning activities revealed that the staff perceived the message sent by the crew through ATC TWR Cluj as an emergency message and then, they didn’t think if, according to the meteorological conditions, would require asking for a new extension of the runway intervention time. The Investigation Commission is supporting the previously expressed point of view that better coordination and information between those involved in this serious incident would have prevented the occurrence.

2.3 AIRCRAFT

2.3.1 FLIGHT RECORDERS

The data downloaded from FDR and CVR were analyzed along with representative of NTSB and the specialists from Boeing and it was generated a report as follows:

FDR Data Analysis

Time history plots of the pertinent longitudinal and lateral-directional parameters are attached as Figures 1 through 4. The FDR data show the airplane configured for a flaps 40 instrument landing system approach (Figures 23 and 24). Based on the recorded heading and navigation radio frequency data, the approach was conducted to Runway 25 (Figure 24). This is not consistent with the report which states the approach and landing were performed on Runway 07. The data show the airplane at 800 feet radio altitude with the autopilot and autothrottle engaged (Figure 23). The airplane was established on glideslope and localizer. Airspeed was maintained at 135 knots throughout the approach. Based on the recorded gross weight and flap detent, the landing reference speed (VREF) should have been 130 knots. The airspeed maintained during the approach was consistent with VREF+5, which is the
Flight Crew Training Manual (FCTM) recommended approach speed for the event conditions. A sink rate (negative vertical speed) of 700 feet per minute (fpm) was required to maintain the glideslope at the recorded ground speed. The autopilot and autothrottle were disengaged simultaneously at 300 feet radio altitude. At about 200 feet radio altitude, a slight increase in thrust, combined with a decrease in the tailwind component, resulted in the airspeed increasing to 140 knots (Figure 24). Just after the thrust increase, the airplane began to deviate above the glideslope. The landing flare was initiated around time 13,690 seconds (45 feet radio altitude) with a column pull to 5 degrees with momentary increases to 8.5 and 9 degrees. Sink rate was arrested to less than 100 fpm. Thrust was reduced to idle at time 13,695 seconds. Touchdown occurred approximately 10 seconds after flare was initiated at time 13,699.6 seconds, as evidenced by a spike in Nz, a slight drop in longitudinal acceleration, and movement of the speedbrake handle. During the flare, airspeed bled off to VREF.

The auto-speedbrakes deployed at touchdown per design (Figure 23), and at touchdown, the crew commanded reverse thrust. Initially after touchdown, brake pressure of approximately 400 pounds per square inch (psi) was applied. It is presumed that the initial brake application came from the autobrake system; however, this cannot be verified as the autobrake discrete was not recorded on the FDR. The crew reported autobrake 3 was selected. The deceleration initially exceeded the autobrake 3 deceleration level and reached 0.3 g’s. As the airplane decelerated to 80 knots ground speed, deceleration approached the autobrake 3 level (Figure 25). Slightly before time 13,714 seconds, the crew temporarily commanded maximum brake pressure on the left brake, which would have disengaged the autobrake system (assuming it was activated). The brake pressure on the left brake was temporarily relaxed as the crew commanded nearly 8 degrees of left rudder pedal (Figure 26). The relaxation in brake pressure caused a reduction in the deceleration to 0.16 g’s (Figure 25). As the crew began releasing the left rudder pedal, increasing left brake pressure was commanded which caused an increase in the deceleration to 0.2 g’s. The brake pressure was relaxed again and a reduction in the deceleration to 0.16 g’s occurred. Maximum brake pressure on both brakes was commanded beginning at time 13,724 seconds which resulted in deceleration increasing to 0.2 g’s. While decelerating through 32 knots, deceleration began decreasing in the presence of maximum brake application. The most likely cause of this decrease is increasing runway contamination. As the crew held maximum braking, nearly 5 degrees of right rudder pedal was applied which caused the airplane to turn right (Figure 26). The heading change also resulted in the airplane deviating to the right of runway centerline, as evidenced by the localizer deviation. As the airplane deviated from the centerline, the crew applied left rudder and differential braking to the left to arrest the heading change and deviation from runway centerline. The airplane departed the right side of the runway at time 13,742 seconds. The spike in normal load factor is indicative of departure from the paved surface onto an unimproved surface.
**Ground Track Analysis**

A ground track was generated to show the airplane’s path during the approach and landing rollout (Figures 27 and 28, respectively). Runway 25 at Cluj-Napoca has a width of 148 feet and a length of 6693 feet, which includes the displaced threshold for Runway 07. Longitudinal and lateral distances were calculated using a combination of inertial data (ground speed, drift angle, heading), glideslope/localizer deviation, and airport information (runway dimensions, taxiway dimensions, etc.). The distances were then referenced to the runway. The known final resting spot of the airplane was used as an anchor for the ground track.

The ground track analysis results indicate the airplane was established on glideslope and localizer nearly 2 nautical miles (~12,000 feet) prior to crossing the threshold. Approximately 1500 feet prior to crossing the threshold, the airplane began deviating right of centerline and eventually deviated 20 feet to the right by threshold crossing; however, the airplane began moving back towards centerline after threshold crossing. The airplane crossed the threshold at 45 feet. Nearly 200 feet after crossing the threshold, the crew initiated landing flare with a 5-degree column pull. At 1400 feet beyond the threshold, the sink rate reached 0 fpm and remained at 0-100 fpm until touchdown at approximately 2300 feet beyond the threshold. Prior to touchdown, the crew started moving the throttle levers to the reverse thrust position.

At touchdown, the auto-speedbrakes deployed and approximately 400 psi of brake pressure was presumably commanded by the autobrakes. As the airplane decelerated, the autobrakes commanded an increasing amount of brake pressure. With approximately 1900 feet of runway remaining (4800 feet beyond the threshold), the crew began commanding left rudder in conjunction with maximum manual brake pressure on the left brake. The pressure applied to the right brake was nearly half of the pressure applied to the left. At 70 knots ground speed, with 1600 feet of runway remaining (5100 feet beyond the threshold), brake pressure was released before being commanded to near maximum levels on the left brake nearly 300 feet further down the runway. The brake pressure was released again with approximately 1000 feet of runway remaining. As the Runway 07 displaced threshold was crossed at 48 knots ground speed, maximum brake pressure was commanded to both brakes while right rudder was commanded. The right rudder resulted in the airplane deviating to the right of centerline. With 200 feet of runway remaining, differential braking to the left and left rudder was applied; however, the airplane continued deviating to the right of centerline. As the crew applied differential braking, the thrust reversers were stowed. The airplane departed the end of the runway approximately 75 feet to the right of centerline and came to rest approximately 10 feet beyond the runway and 80 feet right of centerline.
Calculated Airplane Braking Coefficient

The airplane braking coefficient ($\mu_{\text{Airplane}}$) was calculated for the landing and is shown in Figures 25, 28, and 29.

Background

Airplane braking coefficient ($\mu_{\text{Airplane}}$) is a calculated term defined as the ratio of the deceleration force from the wheel brakes relative to the normal force acting on the wheels. The deceleration force from the wheel brakes is calculated from the total airplane deceleration minus aerodynamic drag and thrust components, and the normal force acting on the wheels is essentially weight minus lift. The airplane braking coefficient is an all-inclusive term that incorporates effects due to the runway surface, contaminants, and airplane braking system (e.g., antiskid efficiency, brake wear, tire condition, etc.). Therefore, airplane braking coefficient ($\mu_{\text{Airplane}}$) is not equivalent to the tire-to-ground friction coefficient ($\mu_{\text{Runway}}$) that would be measured by an airport ground vehicle.

In simple terms, the airplane braking coefficient represents the braking capability of the airplane and only represents the runway characteristics when the brake/antiskid system is friction-limited. The brake/antiskid system is friction-limited when the commanded brake pressure is greater than or equal to the brake pressure governed by the antiskid valve. The antiskid system adapts to the runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking. When not friction-limited, the airplane braking coefficient represents the level of braking applied.

An airplane braking coefficient was calculated using the basic physics relationship that the sum of the longitudinal forces ($F_x$) equals the product of the mass and the acceleration to derive Equation 3 below, as follows:

$$F_x = \text{max (1) where}$$

$$F_x = F_x, \text{gear} + F_x, \text{thrust} + F_x, \text{aerodynamic}, \ (1.1)$$

$$F_x, \text{gear} = \mu_{\text{airplane braking}}^* F_z, \ (1.2)$$

$$F_z = W + F_z, \text{aerodynamic}, \ (1.3)$$

and

\[ m \text{ is the airplane mass}=\text{weight/gravity (weight is from the FDR weight information),} \]

\[ ax \text{ is the kinematically corrected FDR acceleration data, } W \text{ is the airplane weight.} \]
The thrust and aerodynamic forces ($F$, thrust and $F$, aerodynamic) were estimated using mathematical models extracted out of the engineering simulation. The unknown gear force ($F_x$, gear) is defined as the unknown airplane braking coefficient ($\mu_{\text{Airplane}}$) times the summation of the normal forces ($F_z$). The normal forces acting on the airplane are weight and the normal components of the aerodynamic forces.

Substitution of Equations 1.1-1.3 into Equation 1:

$$\mu_{\text{Airplane}} \times (W + F_{z, \text{aerodynamic}}) + F_{x, \text{thrust}} + F_{x, \text{aerodynamic}} = \max$$  (2)

Solving for the airplane braking coefficient:

$$\mu_{\text{Airplane}} = \frac{(\max - F_{x, \text{thrust}} - F_{x, \text{aerodynamic}})}{(W + F_{z, \text{aerodynamic}})}$$  (3)

The following is provided for reference. Boeing has associated Pilot Reported Braking Action to $\mu_{\text{Airplane}}$ levels as described in the table below. The $\mu_{\text{Airplane}}$ to braking action has been chosen to be conservative. The airplane braking coefficients in the table below are used in the generation of the advisory landing distance information for reported braking actions in the Reference (c) 737 Quick Reference Handbook (QRH).

**Table 1: Airplane Braking Coefficient**

<table>
<thead>
<tr>
<th>Pilot Reported Braking Action</th>
<th>Airplane Braking Coefficient ($\mu_{\text{Airplane}}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>~0.40</td>
</tr>
<tr>
<td>Good</td>
<td>0.20</td>
</tr>
<tr>
<td>Medium</td>
<td>0.10</td>
</tr>
<tr>
<td>Poor</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Assumptions**

Airplane braking coefficient extraction method assumes that

1) the FDR airplane acceleration data are valid
2) any aerodynamic, propulsion, flight controls, or gear modeling errors are small
3) other external forces, including runway slope and drag produced by the contaminants are negligible
4) There were no braking system anomalies that would have affected the braking action. It is estimated that the calculated airplane braking coefficient has an uncertainty of +/- 0.02.

**Analysis**

During the initial part of the rollout, the majority of the deceleration was due to the aerodynamic (speedbrakes) contribution (Figure 29). At 3000 feet beyond the threshold, brake pressure reached 400 psi and contributed 0.1 g’s to the deceleration. The gear contribution remained at 0.1 g’s for the next 2000 feet of runway despite a steady increase in brake pressure most likely commanded by the autobrake system. The steady gear contribution in the presence of increasing brake pressure is the first indication of a lack in braking effectiveness and a degraded runway surface. Deceleration reached a maximum at 3700 feet beyond the threshold and decreased beyond that point due to the decreasing contribution of the aerodynamic and thrust components. The crew started to apply maximum brake pressure on the left brake slightly after 4850 feet beyond the threshold, without an increase in the deceleration. The brakes briefly became friction limited at 5100 feet. As the crew reduced brake pressure, deceleration was reduced by one-half. The brakes became friction limited again at 5500 feet beyond the threshold as brake pressure was commanded slightly below the maximum level. Brake pressure was relaxed then increased to the maximum level for both brakes as the airplane crossed the Runway 07 displaced threshold. As maximum brake pressure was achieved, the brakes became friction limited. In the initial portion of the friction-limited braking, the $\mu_{\text{Airplane}}$ was approximately 0.08. Since braking was friction limited, it can be assumed $\mu_{\text{Airplane}}$ represents the runway surface. A level of 0.08 represents braking action between Medium and Poor. As the airplane approached the end of the runway, $\mu_{\text{Airplane}}$ decreased below 0.05 representing Poor braking action.

**Flight Operations Guidance**

The 737CL FCTM contains guidance pertaining to landings including the landing flare and deceleration section. The Flare and Touchdown section contains the following guidance regarding flare:

“Special attention must be given to establishing a final approach that assures safe threshold clearance and gear touchdown at least 1,000 feet down the runway…."

The FCTM also mentions:

“Initiate the flare when the main gear is approximately 20 feet above the runway by increasing pitch attitude approximately 2°-3°….‘’
The FCTM goes on to say:

"Do not allow the airplane to float or attempt to hold it off. Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed... Do not prolong the flare in an attempt to achieve a perfectly smooth touchdown. A smooth touchdown is not the criteria for a safe landing."

Analysis of the landing indicates the flare was initiated at 45 feet radio altitude, approximately 25 feet above the recommended height. This had the effect of prolonging the flare and delaying touchdown. The airplane initially touched down 2300 feet beyond the threshold which was beyond the touchdown zone. The delayed touchdown resulted in less runway available to stop. Since degraded braking action was present, additional runway would have been beneficial in this event.

Conclusion

The FDR data show a stable approach to Cluj-Napoca Runway 25 with the glideslope and localizer centered. Low visibility with snow was reported at the time of landing. A calculated tailwind of 5 to 10 knots was present during the approach. This resulted in an elevated ground speed at touchdown, which resulted in more energy that had to be dissipated during rollout. A prolonged landing flare resulted in a touchdown point beyond the touchdown zone approximately 2300 feet beyond the threshold that left 4400 feet of runway to stop the airplane. Later in the rollout, friction-limited braking was encountered, which limited the ability to stop the airplane on the remaining runway. Touching down sooner would have made additional runway available for stopping, a significant factor in this event given the degraded braking action. The airplane departed the paved surface at approximately 10 knots and came to rest 10 feet beyond the runway and 80 feet to the right of runway centerline. An analysis of the FDR data showed all deceleration devices functioned per design.
Fig. 23 FDR Data
Fig.24 FDR Data
Fig.26 FDR Data
Fig. 29 FDR Data
3 CONCLUSIONS

3.1 FINDINGS

- This crew landed the first time during wintertime at this airport;
- During the briefing, the crew did not discussed the particularities to land on this runway while covered by snow;
- Additional fuel to the necessary mission fuel (that includes also the flight to one of the alternate airports) enabled only five minutes holding area flight;
- The briefing for the descent was incomplete and no additional measures according to the runway condition were established; the STAR procedure was improperly set in FMS;
- During the landing the crew saw only the PAPI system lights and the runway central line lighting;
- During tail wind landing, the airspeed (140 kt./259 km/h) was 11 kt higher than the VREF recommended by QRH;
- The aircraft recovery was performed at 45 ft., 25 ft. more than the height recommended by 737 Flight Crew Training Manual;
- The aircraft was conducting approximatively 10 seconds flare flight;
- The aircraft touched down on the runway at a distance of about 2300 ft. (approximatively 700 m) measured from the threshold of runway 25;
- When operating the rudder pedals to correct the direction deviation there was not a maintained a constant pressure on the brakes;
- The snow removal equipment cleared the runway about 10 minutes before the aircraft landing;
- The runway was cleared in the area along the runway center line;
- At the moment of the landing it was possible that the wet snow layer should have about 1 centimeter;
- The "ASFT T10 – VW SHARAN" skidometer was not used to determine the friction coefficient;
- It is possible that the ATC CLJ TWR message concerning the holding area flight time of the aircraft was understood by the airport Operational Team as an emergency call;
Due to the meteorological conditions when this incident occurred, the ATCO CLJ TWR wasn’t seeing the runway ends;

During ground to ground communication with airport staff, ATCO CLJ TWR, repeatedly required priority;

After issuing the alarm message the intervention at the aircraft was performed in due time according to the applicable airport procedures;

Passenger disembarking was conducted on the runway using airport disembarking stairs;

The aircraft was returned to the runway without incidents and then towed on airport apron.

3.2 Causes of the serious incident

The serious incident occurrence cause was the performance of an extended flare flight, followed by the runway touchdown at a distance of about 2300 ft. (approx. 700 m) measured from runway threshold 25.

Favorable causes:

- Wind direction 100° ("tail wind"), intensity 5 -10 kts (9 - 18 km/h);
- During landing, VREF was higher with 11 kts (140 kt/259 km/h) than VREF (129 kt/239 km/h) at runway threshold, recommended by QRH;
- Aircraft recovery at the height of 45 ft. (approximatively 13,7 m), with 25 ft. (approximatively 7,5 m) more than the Boeing recommended height;
- Runway covered 51-100%, with wet snow, possible about 1 cm thick;
- Insufficient visual reference;
- Inconstant braking system pedals pressure.
4 RECOMMENDATIONS

The Investigation Commission makes following recommendations:

1. It is recommended that the air operator Blue Air shall review the criteria to determine the componence of the flight crew when they have to perform a charter flight towards a new destination or a rarely used airport.

2. It is recommended that the International Airport "Avram Iancu" Cluj (LRCL) shall check again the mode of usage and functionality of the ground-to-ground communication system, so that communication priority for ATCO Cluj TWR shall be provided.

3. It is recommended that ROMATSA and the International Airport "Avram Iancu" Cluj (LRCL) shall establish a common procedure to optimize the time interval between the moment of clearing the runway by the snow removal equipment and the moment of an aircraft landing, without affecting flight safety.

Note: The documents and analysis objects used for the elaboration of the flight safety Investigation Report are confidential and they are stored at the Civil Aviation Safety Investigation and Analysis Center, according to legal provisions.