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

Contribution to the analysis of the accident to the ATR42-320 registered N902FX operated by Empire Airlines on January 27th 2009, at Lubbock airport (TX)

This paper is intended to contribute to the analysis of the accident that occurred on January 27th 2009, to an ATR42-320 operated by Empire Airline that crashed during an approach near runway 17R threshold at Lubbock airport, Texas. The BEA represented the State of Manufacture for this accident, in accordance with the provisions of ICAO Annex 13. At the end of the Technical Review Meeting in March 2010, the NTSB requested that the parties provide a submission for the analysis of this accident. Although the BEA is not a party to the investigation, it was also invited to make a contribution. The BEA is pleased to provide the following analysis, outside of the provisions of Annex 13 for official comments, which we hope may help the NTSB in its investigation process.

The content of the contribution has been limited to the analysis of the accident, even if at some stages, some factual information has been included for explanatory purposes.

Three main sections have been defined:

- The **sequence of events**, which describes the history of the flight and the sequence of events leading to the accident.
- **Analysis**, which deals in more detail with specific topics related to the accident.
- **Findings** and **probable cause**

The elements of analysis presented hereafter by BEA are in line with the ICAO causal factor approach. They are those that BEA thinks of importance for the understanding of the accident scenario.

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1. Sequence of events

All times in the document are UTC times.

Time altitude	Sequence of event (events, descriptive factors)	Additional information and comments
	Reroute from their initial flight : Flight between El Paso/ Fort Worth Alliance	
09 h 19	Takeoff from Dallas Fort Worth Alliance (AFW) for a cargo flight to Lubbock (LBB), Texas.	
09 h 32 FL163	Icing encounter during end of climb/ cruise	
10 h 02	Due to icing conditions, the crew of CFS8284 asks the controller to descend to FL140. The control authorized the flight level change. Beginning of descent, leaving FL180	Comments from the captain: the icing conditions were "moderate, bordering on severe". According to ATR computations, the icing level corresponds to 80 drag counts.
10 h 03	The crew reports "moderate rime icing at FL180" to the controller	
10 h 19	Descent Checklist	
10 h 21 FL100	level 3 anti ice/deice system is deactivated by the crew	
10 h 22	The approach controller provides the crew with the following information: wind 350° at 10kt, visibility 2 (SM), freezing drizzle, mist, ceiling OVC 500ft, temperature 08°- 09°, braking action advisory are in effect, runway 08/26 closed	
10 h 30 5200ft (1013hPa)	Below 6000ft, the crew encounters again icing conditions (ice detector single chime). level 3 anti ice/deice system is selected by the crew	
10 h 33 m 04	The crew is cleared for the approach ILS RWY 17R.	
10 h 34 m 06	The crew is cleared to land, wind 010°/ 08kt.	This is the last radio communication from the CFS8284.
10 h 34 m 26	Flaps are selected to position 15°. A flap asymmetry is recorded on the FDR.	This indicates a differential position between left and right flaps of about 8 to 10°.
10 h 34 m 51	Interception of the glide slope by the AP in APPR mode	a tailwind component of 15kt is deduced from FDR data.
10 h 34 m 54	Reduction of the engine torque for 10s. As a result, the speed reduces down to 125kt, the AOA increases.	
10h 35 m 04	The captain announces that there is a flap problem	
10 h 35 m 29	The AP disconnected automatically (no action on instinctive disconnect push button) because of stall warning activation (AOA 11°).	Disconnection not detected by the captain The aural stall warning has priority over AP cavalry charge audio warning
10 h 35 m 38	The aircraft starts to deviate to the right of the localizer centreline and above the glide slope.	
10 h 35 m 40 Below 1000 ft	The first officer proposes a go around ("should I go around?") and the captain rejects her proposal	
10 h 35 m 48	The captain takes control of the airplane	
10 h 36 m 00	Stall warning activation and TAWS alarm PULL UP	Aural stall warning as priority on the TAWS PULL UP call out.

Time altitude	Sequence of event (events, descriptive factors)	Additional information and comments
10 h 36 m 19	Several stick shaker activations. The engine power increases	The stall warning can be heard in the CVR. Torque and Np at 100%. The CAS is 125kt.
10 h 36 m 21	The aircraft is out of control in roll (roll right at 34°, left at 50° then at 14° when colliding with the ground.	

2. Analysis

Decision to initiate the flight, from the dispatch and from the captain

The meteorological conditions at the destination airport were freezing precipitation (-FZDZ, -FZRA, -PL, -FZPL, -FZRAPL) for several hours (since 05 UTC) without any significant change. Empire airline dispatch stated that due to meteorological conditions they decided to replace the Cessna Caravan by an ATR 42, which is de-iced, to carry out the flight to Lubbock.

This decision to dispatch the flight was mainly based on information included in Empire GOM (General Operations Manual, approved by the FAA) regarding the flight in freezing rain/freezing drizzle. The GOM clearly states that when light freezing rain, light or moderate freezing drizzle or light, moderate or heavy snow is falling aircraft may land". The investigation highlighted that this policy was widely shared by the dispatch employees. The captain followed the decision of the dispatch and decided to initiate the flight to Lubbock airport. According to Empire Airline, this policy was written by the airline by using the titles from the holdover tables from the airline's ground de-icing program. ATR specifies that the information coming from the holdover tables are applicable for ground operation and that it is difficult to assess their validity after takeoff in freezing drizzle and freezing rain conditions

The AFM (Aircraft Flight Manual) states that flight in freezing rain and freezing drizzle or mixed icing conditions (supercooled liquid water and ice crystals) may result in severe icing conditions. ATR defines severe icing by visible cues on the aircraft and mentions that pilots must exit these conditions when encountered.

In conclusion, based on this guidance, nothing prevented the aircraft being dispatched. However, the information is unclear and makes the decision to initiate the flight when freezing drizzle is forecast at destination airport very difficult. Indeed, icing severity can only be assessed in flight.

Crew encounter with icing conditions in flight

Reaching the top of climb, the aircraft entered an icing area. The icing amber light illuminated accompanied by a single chime. Between the beginning and the end of the cruising phase at FL 180, the airspeed dropped by about 9 knots and the AOA increased by about 1°. This corresponds to a drag coefficient increase of about 80 counts. The icing seemed to be lighter at the beginning of the cruise, increasing from about 9 h 56 on.

The anti-ice / de-ice system level 3 was selected at about 9 h 33. The captain recalls the icing conditions to have been « moderate, bordering on severe ».

The crew then requested to descend to FL 140, which the ATC allowed him to do. The anti-ice / de-ice system level 3 was deactivated just before 10 h 22 while descending through FL 100 and the controller provided the crew with the information about light freezing drizzle. The performance analysis showed that at the end of the descent the aircraft was mostly or completely clear of ice.

Note: according to SOP, anti-ice / de-ice system level 3 may be deactivated as soon as the aircraft exits icing conditions.

The recordings show there was a sharp temperature drop at about 6000 ft. Between about 10 h 29 min 50 and 10 h 30 min 50, the aircraft descended from 6000 ft to 5000 ft and the temperature decreased from 0°C to -14°C. The crew then encountered icing precipitation. The level 3 was selected at about 10 h 30, in the middle of that descent (probably as a consequence of the icing warning light and single chime). ATR performance analysis showed that the additional drag generated by these icing conditions reached about 120 counts on the drag coefficient.

Icing detection by the crew

The accident airplane was not equipped with an ice evidence probe (IEP). According to ATR, the IEP had been installed on all ATR42-500 and ATR72 airplanes and ATR had provided all operators with the service bulletin and kit necessary for installation of the IEP on ATR42 airplanes already delivered. This retrofit was not carried out by the previous owner of the aircraft at the time of supply of the service bulletin and kit (Continental Express), nor was it performed subsequently to its sale to the owner at the time of the accident (Federal Express).

The primary mode of ice detection by the crew is the visual detection of ice formation on the aircraft. The benefit of the IEP is to improve the monitoring of ice accretion by the crew when encountering or leaving icing conditions. If the IEP is missing, the propeller spinner visual check is necessary. During the interview the first officer stated that she saw icing on the spinner during the descent into LBB. Although the IEP was

missing, the crew detected that the ice was accreting on some parts of the aircraft.

Decision to initiate the approach, choice of the approach 17R

To land in LBB that night, the crew elected to perform an ILS RWY 17R for the following reasons:

- runway 08/26 was closed
- the back course ILS was not available

Additionally, the ceiling and visibility were close to the minimums required to perform a circle to land for RWY35L. The ILS RWY17R approach followed by a landing on runway 17R was the option best guaranteeing the safety of the flight that night in LBB.

However, the tailwind, within aircraft limitation, made the approach and the landing more difficult for the crew (increase in vertical speed on the final approach glide patch, increase in landing distances)

Speed bug setting

The examination of both airspeed indicators (captain and first officer sides) revealed that the internal bug related to the minimum approach speed and target touchdown speed at landing and the yellow bug related to the approach speed not considering wind effect plus 5 knots were not correctly set as required for a normal flaps 30 landing in icing conditions at 33 000 pounds. The internal bug was set to 106 Kt instead of 116 kt. The yellow bug was set to 112 kt instead of 121 kt. The white and red bugs are the minimum airspeed to operate the airplane with flaps 0 respectively in non-icing conditions or in icing conditions and were correctly set to 123 kt and 143 kt.

The CVR revealed that the first officer announced the speed setting during the briefing “one oh six is the icing speed…one oh six one twelve…uh three and forty three…”. The captain answered that it was good for him.

As the flap asymmetry occurred and prevented the flaps from reaching the 30 degrees position, it appears that the anomalies in settings the internal and yellow bugs had no influence on the accident.

At the time of the accident, Empire Airlines had no policy for setting internal bug in cruise for a visual indication of degraded performance (speed loss) and no crosscheck confirmation policy for setting the airspeed bugs.

Flap asymmetry, detection and handling of the procedure by the crew

Flap asymmetry
The FDR recorded a flap asymmetry. It was countered by the autopilot that applied a 6° left wing down aileron (e.g. about 20° control wheel to the left or counter clockwise), indicating that the left flap was more extended than the right flap.

In case of flap asymmetry, the hydraulic power needed for the extension is cancelled as soon as the differential positions of the left and right flaps reaches 9°, from which can be deduced that the left flap extended to about 9° while the right one did not extend at all.

Due to damage sustained during the accident and post-impact fire, the examination of the flap system made it impossible to understand the reason for the flap asymmetry.

Detection
The problem of flap extension was not immediately detected by the crew despite the flap indicator information: it took about 40s for the captain to verbally comment the flap problem ("we have no flaps"). The crew became aware of a flap issue, which was not further identified as a flap asymmetry.

- The flap problem was not detected during the landing checklist. The adaptation of the procedure by the airline: flaps condition levers to go, that delays the checking of the 30° flap position didn't help the crew in detecting the flap problem.
- The cues available for the crew to detect the flap asymmetry were:
    - Outside markings on the flap fairings
    - The control wheel position at about 20° to the left
    - A message RETRIM ROLL L WING DWN probably illuminated on the ADU panel with possibly an AILERON MISTRIM warning light

  On the other hand, the fact that the autopilot was engaged when they selected the flaps to 15° didn't help the crew in detecting the asymmetry.

Note: No specific flap asymmetry warning was installed on this aircraft when the ATR 42 was certified, it was determined that a cockpit indication of a flap asymmetry was not required. Later models were designed with the cockpit indication. Although it was demonstrated that a flap asymmetry did not result in an unsafe flight condition, later models used the multi-function computer to display the indication, first on ATR 72 airplanes, and then on ATR 42-400/-500 airplanes but on those later models, the flap indicator provides the position of the left hand flap and not an average position between left and right flaps.

Handling of the FLAPS JAM / UNCOUPLED / ASYM procedure
The procedure is the same in case of a flap jam, uncoupled or asymmetry. The handling of the FLAPS JAM / UNCOUPLED / ASYM procedure requires setting the flaps control lever near flaps present position and then applying REDUCED FLAP LANDING procedure. According to the captain, he said that he tried to move the flap handle

several times, then took a flash light to see if the breakers were OK. This was improvisation by the captain and a waste of time in trying to identify the reason of the flap failure at this phase of the flight. The captain said that he had no time to rebug the speed and wanted to land as soon as possible. The REDUCED FLAP LANDING procedure requires recalculating VmHB, VmLB and LDG DIST, which takes too much time at this phase of the flight. The situation would have required from the crew a decision that would have placed them in a situation where they would have had more time to fully apply the procedure.

Decision to continue the approach when not stabilized

Shortly after the autopilot had initiated the final descent, the airspeed increased by about 10 kt and the PIC reduced the torque of both engines to nearly flight idle. The airspeed consequently decreased down to about 125 kt while the angle of attack increased. This ultimately triggered the activation of the stall warning (cricket aural warning and stick shaker) at 10 h 35 m 29, the AOA reaching the threshold value for icing conditions (11°). The autopilot hence disconn ected. This autopilot disconnection was rapidly followed by a right rolling movement, showing that the aircraft was not trimmed on roll axis.

After this point the approach was clearly not stabilized:

- In speed
- Glide and localizer deviations appeared
- TAWS alarm PULL UP was triggered
- Stick shaker activated several times.

The fact that the approach was not stabilized and the procedure consecutive to a PULL UP TAWS call out should have triggered a decision from the captain to go around. Despite the questioning of the first officer whether she should perform a go around, the captain decided to continue the landing because, due to the environmental conditions (icing), he wanted to land as soon as possible.

Poor CRM did not allow him to change his action plan:

- After the flap event, communication between the crew was poor
- Due to the change in pilot flying during the approach, the role of each pilot was probably unclear at this time; the fact that the captain briefed the approach and the first officer flew the beginning of the approach increased this confusion,
- There was no call out from the pilot monitoring (sink rate, speed, localiser and glide slope deviations, etc.).

Aircraft Handling by the captain below 800ft

The airspeed had increased to about 140 kt when the Captain took control of the aircraft, at the F/O's request. He slightly reduced the

power of the engines but, being about 2 dots above the glide path, increased the vertical speed. The airspeed kept increasing.

At about 10 h 35 m 57, he reduced engine power down to almost flight idle and two seconds later he applied a strong input by pulling the control column then turning the control wheel to the left. The action was most probably caused by the aircraft going below the clouds and the Captain seeing the runway on the left while the aircraft was just back on the glide path.

It resulted in a sharp increase of the AOA that activated the stick shaker at an airspeed of about 155 kt. The aircraft rolled 20° left.

Note: following this strong input, the recorded average flaps position increased to about 4.5°. (e.g this could show that the right flap wasn't completely jammed).

The Captain reduced the vertical speed, the airspeed decreased and the aircraft deviated from the glide path. At 10 h 36 m 13, the aircraft was 3 dots above the glide path with an airspeed of about 130 kt. The Captain slightly decreased the right roll angle.

Loss of control

At 10 h 36 m 19, the AOA had increased up to the stick shaker activation. The airspeed was then about 125 kt. The stick shaker activated very briefly. As a result the Captain pushed on the control column and quite rapidly stopped. The AOA kept increasing and the Captain increased the power of the engines. The stick shaker activated again and lasted about 6 seconds. As a result the captain pushed stronger on the column, applied 14° of LWD aileron and full left rudder deflection to counter the right roll of the aircraft that reached 34°.

The aircraft then rolled rapidly to the left, which the Captain countered by using 14° of RWD aileron and full right rudder. He also pulled on the control column and the aircraft started to bank to the right. The airplane finally hit the ground with a roll angle of 16° right and an airspeed of about 130 kt.

3. Findings and probable cause

The investigation showed that:

- The flight crew was properly certificated and qualified in accordance with applicable regulations
- The airplane was properly certified, equipped, and maintained in accordance with applicable regulations

- For this flight, the Captain was the pilot monitoring and the First Officer was pilot flying
- The meteorological conditions in Lubbock, Texas consisted of light freezing drizzle
- The aircraft was dispatched in accordance with applicable guidance and regulations
- The crew elected to land on runway 17R
- The PF called out inappropriate speed bug settings that were approved by the PM
- During cruise at FL180 and below 5000 ft, the aircraft entered icing conditions to which the crew reacted by selecting level 3 on the anti-ice / de-ice system
- A flap asymmetry occurred that was countered by the autopilot
- The crew identified a flap issue tardily and did not apply the FLAPS JAM / UNCOUPLED / ASYM procedure
- Inadequate power setting during the final descent led to an airspeed reduction and the activation of the stick shaker
- The First Officer suggested to go around ; the Captain decided to continue the landing and took over the controls
- The approach was not stabilized
- At a height of about 200 ft, the crew lost control of the airplane which collided the ground short of the runway
- The degraded aircraft performance resulting from ice accumulation and the flap asymmetry did not affect the flight crew's ability to fly and control the airplane
- The lack of CRM prevented the crew from taking appropriate decisions and actions in an abnormal situation

The probable cause of this accident was the Captain's inappropriate decision to continue the approach despite:

- the flap problem that required time to apply the appropriate procedure,
- the First Officer's suggestion to go around,
- the unstabilized approach, notably shown by the lack of airspeed monitoring and multiple stall and TAWS warnings.

Contributing to the accident was the flight crewmembers' poor performance after the flap event, including both pilots deviations from standard operating procedures.