ENGLISH TRANSLATION OF MAIN TEXT OF VENEZUELAN ACCIDENT REPORT JIAAC-9-058-2005

SYNOPSIS

On 16 August 2005, flight WCW 708 took off from Tocumen International Airport (MPTO) in Panama City at 05:59 UTC, bound for Martinique International Airport (TFFF) , flying instrument flight rules (IFR) in instrument meteorological conditions (IMC). In the intermediate section of the route, stratocumulus clouds formed and there was heavy rain. The aircraft was airworthy and did not have any kind of mechanical defects. Once it had reached FL 330, the aircraft started to lose speed continuously until the point at which it reached minimum lift. The aircraft subsequently stalled and there followed a constant descent until it collided with the ground in an area topographically defined as flat, at an elevation of 119 ft above sea level, near the town of Machiques, in Zulia State, Venezuela.

1. INFORMATION REGARDING THE EVENTS

1.1. BACKGROUND TO THE FLIGHT

1.1.1. Operational base

José María Córdoba International Airport, Rionegro, Medellín, Republic of Colombia

1.1.2. Information on the previous flight

The aircraft took off on 15 August 2005, with flight number WCA 701, from Rionegro airport, Medellín, Colombia, with two (2) flight crew, four (4) cabin crew, one (1) dispatcher and one (1) engineer on board. It landed at **05:19 UTC** at Tocumen International Airport in Panama City.

1.1.3. Flight preparation and dispatch

The flight was passenger charter flight No WCW 708, with authorised operating permit No 889 issued by the Colombian Civil Aeronautical Air Transport Authority and its authorised route was from Tocumen International Airport (MPTO) to Martinique International Airport (TFFF).

In Panama, the airline West Caribbean Airways had contracted the services of the company Balboa Logistics & Airport Services Inc., which was entrusted with the embarkation, loading and dispatch processes for the aircraft. Take-off from Panama was scheduled for **03:50 UTC** (22:50 local time). Once the aircraft had been fuelled and loaded, and the one hundred and fifty-two (152) passengers had embarked, it left parking position No 28 at **05:54 UTC**, taking off with a delay of two hours and ten minutes, with a taxi weight of 149,023 lb (according to the load manifest (weight and balance)).

1.1.4. Description of the flight

Taking as a basis the information from the cockpit voice recorder (CVR) and flight data recorder (FDR) transcriptions, and from other documents such as the performance study by the US National Transportation Safety Board (NTSB), the following description has been reconstructed.

On **16 August 2005**, the company West Caribbean Airways operated passenger charter flight No WCW 708, with authorised operating permit No 889 issued by the Colombian Civil Aeronautical Air Transport Authority, its route being from Tocumen International Airport (MPTO) in Panama City to Martinique International Airport in Martinique, at flight level (FL) 350.

The crew added a sufficient quantity of fuel to reach their destination.

The aircraft commenced its take-off run on runway 21L and took off at **05:58:13 UTC**. Once the aircraft was airborne, the landing gear was retracted and the crew commenced the climb to FL 310 (an altitude of 31,000 ft). At **06:04:30 UTC**, the autopilot was engaged, with the aircraft flying direct to position ESEDA, as cleared by Panama Control. About 30 miles before passing over this position, the crew contacted Panama Control and asked to change frequency to Barranquilla Control. Once the frequency change had been cleared and the crew had contacted Barranquilla Control, the aircraft continued its climb to FL 310 (31,000 ft). The crew subsequently requested clearance to a higher flight level in Barranquilla airspace. At **06:17:02 UTC**, the crew contacted Barranquilla Control, receiving instructions to continue their climb to FL 310 (31,000 ft) and to report **at position "SIDOS"**, which they did at **06:25:53 UTC**.

The aircraft reached FL 310 (31,000 ft) at **06:26:00 UTC**. The EPR (engine pressure ratio) values seem to indicate that the airfoil anti-ice system and the engine anti-ice system were probably in operation at this time. According to the recorded flight data, the aircraft was in the cruising phase at this flight level, at a speed of Mach 0.74.

NOTE: Fuel consumption calculations show that for any take-off weight of less than 150,000 lb, the engines can provide sufficient thrust to maintain Mach 0.75 at FL 310 with all the anti-ice systems in operation. Above that weight, this is no longer possible. Consequently, the take-off weight was probably less than or equal to 150,000 lb.

At **06:33:32 UTC** and at **06:34:18 UTC**, the co-pilot asked the air traffic controller for flight path changes in order to avoid storm formations.

At **06:39:13 UTC**, the crew requested clearance to FL 330. Ten seconds later, the aircraft commenced the climb at Mach 0.75. The Mach select mode was activated in autopilot in order to maintain the selected Mach speed (Mach SEL button on the flight guidance control panel – FGCP), and the autothrottle was engaged in the mode to maintain the climb EPR (EPR CL). This involves engaging the autothrottle system in EPR limit (EPR LIM) mode with the climb button (CLB) selected on the performance management system (PMS) panel. As soon as the climb commenced, the Mach speed began to drop.

The climb was twice interrupted, each time for around 20 seconds, at **06:40:43 UTC** at an altitude of 31,450 ft, and again at **06:41:50 UTC** at an altitude of 32,300 ft. In each of these stages of horizontal flight, the Mach speed stabilised, but it dropped again when the aircraft continued its climb. At **06:41:56 UTC**, the recorded autopilot mode changed to "Vertical Speed", a mode which maintains a constant rate of climb. Ten seconds later, the recorded autothrottle mode changed to "Mach EPR limit", in which mode the Mach value is lower than the selected Mach speed, but the aircraft had already reached the maximum permissible thrust above which the protection of the engines could no longer be guaranteed.

At **06:42:30 UTC**, the aircraft captain asked the first officer to disconnect the engine anti-ice systems. At **06:42:40 UTC**, an increase in EPR was recorded, (probably) corresponding to the disconnection of the anti-ice systems. The average EPR value for each of the engines changed to slightly over 2.0.

At **06:43:40 UTC**, the aircraft reached FL 330 and accelerated to long-range cruise speed, reaching a speed of Mach 0.7.

At **6:45:17 UTC**, the captain said "I couldn't get it to accelerate".

At **6:45:30 UTC**, the first officer went to the toilet and the captain remained in control of the aircraft.

At **6:46:02 UTC**, the speed was Mach 0.72, the EPR 2.02 and altitude 33,000 ft.

At **6:46:48 UTC**, the angle of attack decreased to 2.9°, the speed increased to Mach 0.73 and the aircraft remained in level flight.

At **6:47:28 UTC**, the aircraft reached its "target speed" of Mach 0.75 and the angle of attack reached 2.6°.

At **06:47:55 UTC**, the captain again said "I can't accelerate".

At **06:48:02 UTC**, with the speed at Mach 0.75, the autothrottle reduced thrust and changed the mode to maintain Mach speed.

At around **06:49 UTC**, variations in the EPR values probably indicate activations of the anti-ice systems, these values being consistent with "cruise" having been selected with the anti-ice systems turned on. The speed was maintained at Mach 0.75 and began to decrease.

At **06:49:46 UTC**, the autothrottle was again positioned in "Mach EPR limit" mode, which is displayed on the FMA screen as "MACH ALT", and it basically remained in this position until the aircraft entered the stall. However, the Mach speed started to decrease, which indicates that the aircraft was unable to maintain Mach 0.75 at FL 330.

At around **06:50 UTC**, food was served to the flight crew, which is consistent with the comment "Look, a little cake" made by the captain at **6:49:52 UTC**. The co-pilot asked air traffic control for a frequency change in order to contact Maiquetía Control.

At **06:51:09 UTC**, the crew requested and were given clearance to follow a direct route to point ONGAL. The Mach speed continued to decrease and the autopilot compensated with the stabiliser trim in order to maintain altitude.

At **6:51:57 UTC**, the first officer said "Shall I turn it on, captain?" suggesting that the anti-ice systems be turned on. At around **06:52 UTC**, the EPR values coincide with "cruise" having been selected without the anti-ice systems turned on.

At **06:52:43 UTC**, the captain asked whether there was any icing. The first officer replied "no". The speed fell to Mach 0.69.

At around **06:53 UTC**, variations in the EPR values indicate further activations of the anti-ice systems, these values being consistent with "climb" having been selected with the anti-ice systems turned on.

At **06:53:05 UTC**, the co-pilot said "Why, captain? Is there icing on the airfoils?" Two seconds later, indications suggest that the airfoil anti-ice systems were connected. The speed remained at Mach 0.68.

At **06:53:10 UTC**, the captain asked unintelligibly "Is the engine airfoil ... certain?" The co-pilot replied in the affirmative two seconds later.

At **06:55:22 UTC**, the speed continued to fall to Mach 0.65, and the angle of attack reached 5.8°. The captain said "what lousy weather, mate".

At **06:56:05 UTC**, the angle of attack was 6.5° and the speed Mach 0.63.

At **06:56:59 UTC**, at Mach 0.62, the co-pilot asked the air traffic controller for clearance to descend to FL 310. The angle of attack reached 7.2°

At **06:57:10 UTC**, the captain disengaged the autopilot. The speed reached Mach 0.60 and the angle of attack 7.7°. There was no audible alarm.

At **06:57:15 UTC**, the aircraft began to descend. The speed was Mach 0.60 and the position of the horizontal stabiliser was -4.05°.

At **06:57:23 UTC**, the recordings register an altitude alert aural warning, indicating that the selected altitude was not being maintained. Three (3) seconds later, the captain said to the co-pilot "give me three one zero".

At **06:57:44 UTC**, while the aircraft was at 31,700 ft and descending at an approximate rate of descent of 2,500 ft per minute, the EPR value fell sharply to 1.8. At the same time, the recordings show that the stick shaker was activated, and this was followed one second later by the aural warning "STALL" accompanied by the stall warning horn, both of which are part of the stall warning system. These can be heard almost continuously until the end of the recording.

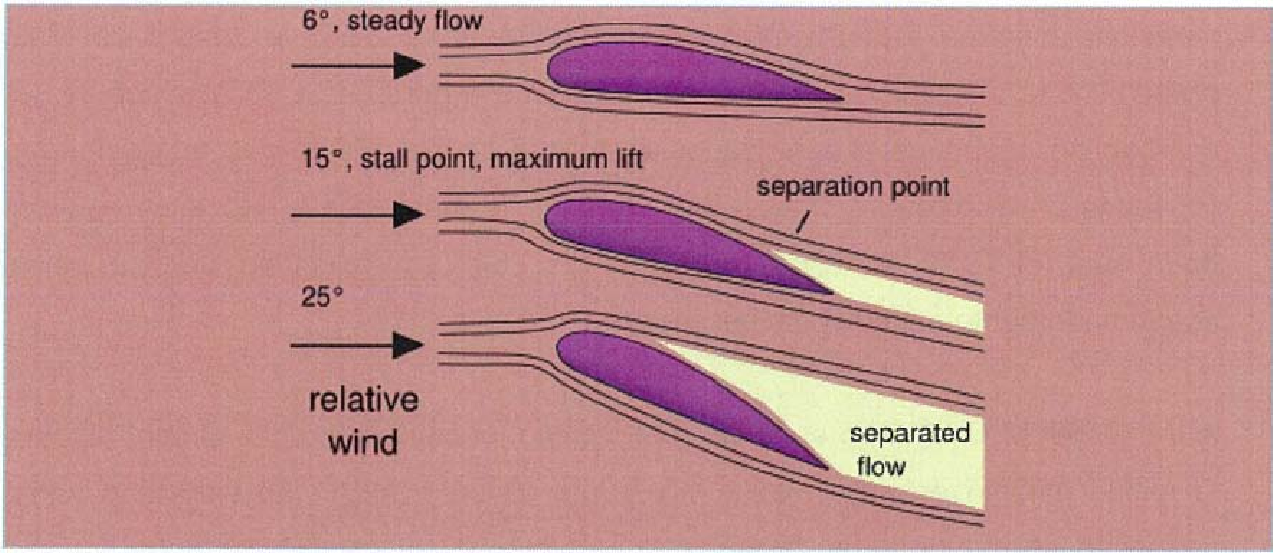
A **stick shaker** is a mechanical device which makes the control column vibrate in order to warn the crew that the aircraft is approaching an excessive angle of attack (AOA) moments before it reaches the stall angle.

Stall is an aerodynamic condition in which the angle of attack increases until it reaches a point at which lift begins to decrease. The angle at which this occurs is called the critical angle of attack. The critical angle of attack is the angle at which the maximum lift coefficient is reached.

Separation of the relative airflow begins to occur at small angles of attack while the attached flow is still dominant. As the angle of attack increases, the separated region on the top of the wing increases in size and reduces the wing's ability to create lift. When the critical angle of attack is reached, the separated area of flow is so great that instead of creating lift it creates a big area of drag.

Fixed-wing aircraft during a stall may experience buffeting, which is turbulence produced by air on an airfoil. Buffeting can cause flight control problems ranging from vibrations to noise, and can also give rise to loss of control. Buffeting is usually a sign that an aircraft is approaching stall speed.

Most aircraft are designed to experience a gradual stall, which will warn the pilots and give them sufficient time to react and take decisions.



Between **06:57:44 UTC** and **06:57:54 UTC**, the EPR fell from 1.89 to 1.16.

At **06:57:46 UTC**, the stabiliser trim started to gradually increase to -5° until the maximum nose up value was reached. The wings of the aircraft, owing to the angle of attack, contributed to producing an effect on the entry of air into the engines, causing the reductions in EPR.

At **06:58:00 UTC**, the co-pilot twice told the captain that the aircraft was stalling, saying "we're going into a stall, captain".

At **06:58:13 UTC**, at the request of the captain, the co-pilot told the air traffic controller that the crew were continuing the descent to FL 290. The rate of descent was approaching 5,000 ft per minute. The speed was Mach 0.50, whilst the elevator trim was 5 and starting to increase.

At **06:58:15 UTC**, the EPR values dropped sharply. At that point, the values were less than 1.06. The speed was less than Mach 0.50 and the rate of descent was around 5,500 ft per minute.

At **06:58:43 UTC**, the co-pilot, without reporting any emergency, told the air traffic controller that the crew were continuing the descent to FL 240. He did not mention any checklist. At **06:58:50 UTC**, Maiquetía Control asked the crew if there was any problem on board. The co-pilot, at the request of the captain, replied to the air traffic controller that they had suffered a flame-out in both engines. The crew were cleared to descend at their own discretion, given that the EPR was between 1.1 and 1.04. The rate of descent was approaching approximately 7,000 ft per minute.

At **06:59:12 UTC**, at the request of the captain, the co-pilot asked the air traffic controller for the minimum en-route altitude (MEA). The rate of descent was more than 12,000 ft per minute. The controller asked for the aircraft's position or distance from Puerto Cabello (SVPC). The co-pilot replied "negative".

The controller again asked for a position reference, this time in relation to Santa Bárbara del Zulia (SVSZ) or to the Valera (SVVL) radio navigation aid, and the co-pilot again replied "negative".

At **06:59:26**, the autothrottle system (ATS) was disengaged.

At **06:59:47 UTC**, the EPR value rapidly increased, reaching 1.80.

At **06:59:51 UTC**, at the request of the captain, the co-pilot reported to the air traffic controller that the aircraft was out of control. The altitude was approximately 12,400 ft.

At **06:59:56 UTC**, the recorded altitude was 10,950 ft and the position of the elevator trim was 10.8.

At **07:00:01 UTC**, the co-pilot repeated to the air traffic controller that the aircraft was out of control and that there were 152 persons on board. The EPR value was 1.88. The position of the elevator trim was 10.8 nose up. The speed was Mach 0.38, and at that point the following alarms were activated or sounding: **STICK SHAKER, ALTITUDE ALERT, STALL WARNING.**

At **07:00:22 UTC**, the recorders registered the ground proximity warning system (GPWS) warnings **"SINKRATE, WHOOP WHOOP, PULL UP"**. The altitude was 3,105 ft and the position of the elevator trim was 12.5 nose up. The CVR recording stopped at **07:00:31 UTC** and the FDR recording at **07:00:32 UTC**.

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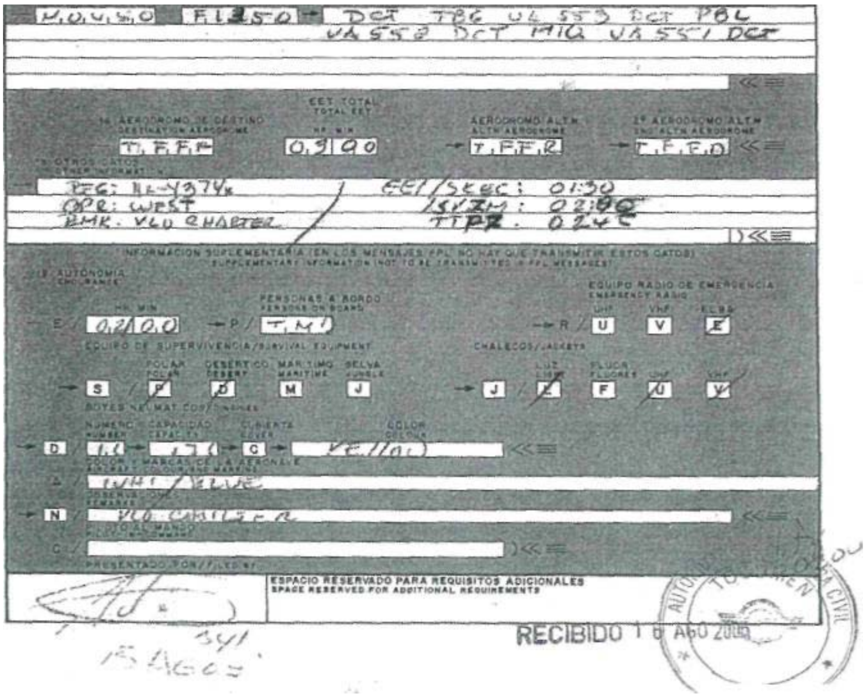
2. ANALYSIS

2.1. PROGRESS OF THE FLIGHT

2.1.1. Preparation of the flight

An analysis of the flight performance of MD-82 aircraft registration HK-4374X belonging to West Caribbean Airways produced the following results:



M0450 F350 DCT TBG UL553 DCT PBL
UA552 DCT MIQ UA551 DCT

EET/SKEC: 01:30
SVZM: 02:00
TTPP: 02:45

ESPACIO RESERVADO PARA REQUISITOS ADICIONALES
SPACE RESERVED FOR ADDITIONAL REQUIREMENTS

RECIBIDO 16 AGO 2005

Fig. 52: Flight plan

2.1.2. Commencement of the flight (Phase I), take-off and climb (Phase II), cruise flight at FL 310

The aircraft lined up for take-off at approximately 06:00:00 UTC, the autopilot was engaged at nine thousand feet (9,000 ft), and the climb profile was executed at high speed and without altitude restrictions (at 300 knots, Mach 0.74). The aircraft took approximately twenty-six (26) minutes to reach FL 310 (at 06:26:00 UTC). According to the performance tables, the normal figure is twenty-one (21) minutes. During the cruise flight at FL 310, various route deviations were requested from ATC in order to avoid bad weather (the information provided by the CVR transcript indicates that at 06:33:32 UTC the first officer asked for clearance for the aircraft to turn left in order to avoid bad weather formations). The aircraft remained at this flight level for about fourteen (14) minutes.

Note: The time the aircraft took to reach FL 310 from take-off was computed from the FDR.

2.1.3. Climb from FL 310 to FL 330 and commencement of the cruise flight (Phase III)

The aircraft then commenced a climb from FL 310 to FL 330 at 06:39:30 UTC with the anti-ice systems turned on. The performance tables, or "two-engine operation cruise altitude capability", do not allow this because of the weight of the aircraft and the use of the ice protection systems, which in this case reduce the aircraft's ceiling by three thousand feet.

This flight level cannot be reached owing to the weight of the aircraft and the use of the ice protection systems, which restrict the power of the engines or what is referred to as the "two-engine operation cruise altitude capability" in the performance tables in the "Airplane Flight

Manual" (AFM).

At 06:42:00 UTC, the aircraft climbed and the flight crew changed the autopilot flight mode from "Mach Hold" to "Vertical Speed" without commenting on the matter, presumably manually selecting a climb rate of around five hundred feet (500 ft) per minute, and as they passed FL 320 at 06:42:30 UTC, the captain suggested that they deactivate the anti-ice systems. The co-pilot complied with the instruction and a few seconds later the EPR values indicate that the anti-ice systems were turned off in order to increase the EPR values. However, the autothrottles changed from "EPR limit (Climb)" to "Mach EPR limit", which on the flight mode annunciator is displayed as "MACH ATL", which meant that the current Mach speed, which at that time was 0.72, was less than the selected speed, because the autothrottles were trying to increase the speed to the desired Mach speed, but the selected power was at its limit. The aircraft could not maintain the selected Mach speed in the climb. At that time, the altitude was 32,200 ft.

When the preselected flight level, FL 330, was reached at 06:43:40 UTC, the autothrottle system was left in "Mach ATL" mode during acceleration to Mach 0.76, the speed selected by the crew. The power was maintained at "Max Climb" on the thrust rating indicator (TRI), which resulted in the aircraft accelerating to the desired Mach number, 0.76, and the autothrottle reverted to "Mach hold". The EPR reading was between 2.0 and 2.05. At that time, the flight crew presumably manually selected "Max cruise" on the TRI. The (valid) EPR reading fell to values of between 1.80 and 1.90, with the ice protection systems deactivated.

2.1.4. Phase IV: loss of speed as from FL 330

At 06:48:42, and during the following 30 seconds, the EPR indicator returned to 1.88 and then fell to a level at or below the MCR (Max cruise) limit with the anti-ice systems turned on on both engines and on the wings (EAI and AAI). It is probable that the engine and wing anti-ice systems were turned on at around this time and a major fluctuation in the EPR values commenced.

The aircraft remained in this condition at Mach 0.76 (268 knots IAS) until about 06:49:25 UTC, when the speed began to drop. At 06:49:46 UTC, there was a change in mode to "MACH ATL", which indicates that the ATS was delivering the maximum thrust selected by the crew. This power was less than that required for the flight level, as a result of which the aircraft lost speed. At the same time, the autopilot, which was in "ALT HOLD" mode, maintained the aircraft's altitude by increasing the pitch angle.

At approximately 06:49, as can be seen from Figure 25 on page 54, which shows that the speed was less than Mach 0.73, the aircraft entered a critical zone known as "behind the power curve". The only way to get out of this zone is to descend in order to increase power.

The aircraft's speed continued to drop until around 06:52:00 UTC, when the crew turned on the anti-ice systems. The Mach number fell to 0.71 (250 knots IAS). The slight increase in the EPR values at that time suggests that the crew made a manual throttle change.

At 06:52:40, the crew suggested activating the anti-ice systems. Activation of the anti-ice systems and a change of throttle mode from CRUISE to CLIMB can be seen from the data. This configuration was maintained until the end of the flight.

The horizontal stabiliser trim was moved from 1.1 to 3.8 units nose up between 06:49:00 and 06:57:45. The data show that the angle of attack increased from 2.5° to 7.5° nose up.

This aerodynamic effect of loss of speed is described in Flight Operations Bulletin **MD-80-02-02A** issued by Boeing on 6 August 2002. **No evidence was found that the crew were aware of the content of this Bulletin**.

During this phase, the crew were occupied having their meal delivered to the flight deck and also with communications with MIQ Control Centre. This contributed to the flight crew's not noticing the change of mode and the aircraft's gradual loss of speed, which resulted (for quite some time) in their losing situational awareness or awareness of their surroundings, because they were not taking proper account of the changes which were taking place in the aircraft's attitude and performance at the level at which it was flying (changes in speed, adjustments in power, and changes in flight attitude). The crew continued to keep the aircraft at a flight level at which, according to the performance tables and graphs, and also given the use of the anti-ice systems and their effects on engine performance, it could not be maintained in flight in an appropriate manner.

2.1.5. Phase V: descent from FL 330 until the aircraft entered the stall

At 06:57:10 UTC, the autopilot was disengaged by the captain, who requested clearance to descend to FL 310, and 700 ft before reaching this level the altitude alert warning was heard. It is thought that at that point the captain pulled back the control column with the intention of stabilising the aircraft at the selected level. This change of flight level was perhaps due to buffeting prior to the aircraft's stalling, given its low power level and the upcurrents present. At that time, the aircraft was close to reaching 7.5° nose up.

At 06:57:45 UTC, the sound of vibration from the control column stick shaker can be heard and one second later the stall warning system was activated.

2.1.6. Phase VI: loss of control of the aircraft

Following activation of the stall warning system, the [position of the] stabiliser trim is consistent with the action taken by the flight crew. At the same time, loss of power can be seen in both engines. The EPR values fell to around 1.2. This loss of power can be attributed to the variation in the input airflow (into the engines), which was affected by the wings and by the turbulent air, given the steep angle of attack. This fall in the EPR values was recorded between 06:57:46 and 06:59:54.

It is assumed from the information obtained from the CVR that the captain was focusing on the instrument indications for the engines even when the co-pilot stated that the aircraft was stalling

As the aircraft continued to descend and owing to the inappropriate action taken in increasing the nose-up angle of the stabiliser trim, the aircraft's drag increased, to a point at which recovery was impossible given the remaining altitude.

During the descent, no emergency warning was given to the air traffic controller, nor was any mention made that the flight crew were going through checklists.

At that point, they had still not identified the gravity of the situation and simply made radio contact with MIQ Control to ask for lower flight levels.

Thirty seconds before impact, the EPR values rose to 1.8.

The movement of the horizontal stabiliser during the descent was not continuous, but consisted of intermittent activations of varying duration. In addition, the extent of movement was consistent with the speed of the stabiliser trim primary motor, not that of the secondary or alternate motor. Consequently, the increases in pitch during the descent were due to manual commands. This movement reached twelve (12) units nose up, which is the full extension of the trim.

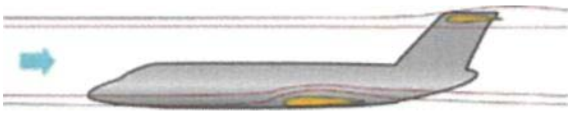
The autopilot was not engaged.

Despite the fact that the elevator and control column parameters extracted from the FDR were not valid, the immediate movement of the stabiliser in a nose-up direction is consistent with inadvertent activation of the trim switches while the control column was being pulled back in order to lift the nose of the aircraft. For the reasons stated above, the initial response was contrary to the procedures for recovering from a stall set out in the aircraft operations manual.

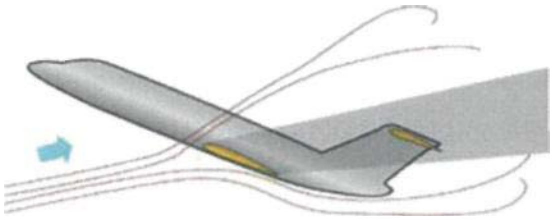
In the descent phase, as the aircraft went through FL 250, the speed increased to one hundred and fifty (150) knots. During this phase, the movement of the horizontal stabiliser was in steps, commensurate with the recorded manual movements. At 06:59:50 UTC, the flight crew reported that they were going through fourteen thousand feet (14,000 ft) and that the aircraft was out of control.

As the descent continued and the horizontal stabiliser continued to move to its maximum position nose up, the drag created by the aircraft continued to increase, which in turn resulted in an increased rate of descent (similar to what is referred to as a deep stall). After this, as the aircraft continued to descend, it reached a point at which recovery was impossible given the remaining altitude and the inappropriate selection of the pitch attitude.

The tape stopped at 07:00:31 UTC. The site of the accident confirmed that the aircraft crashed in a nose-up attitude. This coincides with the data extracted from the FDR, and with the evidence obtained from the analysis carried out on the bulbs in the central warning panel, which indicates that the aircraft's anti-ice system was being used.



Normal flight



Deep stall condition - T-tail in shadow of wing

Fig. 53: Illustration of a deep stall

A deep stall is a very dangerous type of stall which affects certain aircraft designs, notably those with a T-tail configuration, like the MD-82. In these designs, the turbulent wake of the wing, which has stalled owing to the angle of attack, "blankets" the horizontal stabilizer, rendering it completely ineffective, with the result that the aerodynamic effects which allow control of and changes in pitch attitude (nose up and nose down) are lost, making it impossible for the aircraft to recover from the stall.

The analysis of the accident site confirmed that the aircraft crashed in a nose-up attitude, i.e. with the trim stabiliser in the maximum nose-up position. The data obtained from the FDR confirm this attitude.

Background to be taken into account in this investigation

An accident suffered by a DC-8 aircraft belonging to the airline **Airborne Express** can be taken as an example, because it is particularly relevant to this case. In this accident, a stall was deliberately induced at medium altitude (approximately FL 140 or 14,000 ft) during a post-maintenance night test flight. The stick shaker, however, failed to activate. Once the crew noticed the stall, they tried to recover the aircraft using engine power only. It descended in a stall for at least seventy (70) seconds until it collided with the ground. An interesting aspect of this accident is that the manoeuvre was carried out at night, and the process of recovering from a stall in these conditions (IMC) is very difficult. In the case of this accident, the NTSB concluded that the carrying-out of such manoeuvres at night without a visible natural horizon deprived the crew of an important visual attitude reference which could have helped them significantly during the process of recovering from the stall.

In another case in 1997, an **American Airlines** aircraft, during a climb beyond its capability, started to lose power and subsequently went into a stall, albeit managing to maintain intermediate altitude, when the crew inadvertently disconnected the autothrottle system and failed to notice the loss of speed. This incident occurred over the space of approximately one (1) minute, and if the crew had been monitoring the speed, the loss of power would have been easily detectable. In another similar incident, a **Pinnacle Airlines** aircraft at FL410 during a climb exceeded its capability, arriving at this flight level using the wrong configuration and the autopilot vertical speed mode. The aircraft reached the desired altitude without sufficient reserve power to accelerate. In this case, the crew noticed the aircraft's loss of performance but reacted too slowly to prevent the stall, which was accompanied by loss of control of the aircraft.

Two very important cases are worth mentioning. One involved **Scandinavian Airlines System (SAS)** in 1998, the incident affecting a **MD-81** aircraft at FL 330, in which the crew noticed the loss of power followed by buffeting and subsequent activation of the stick shaker, identified an engine flame-out problem and initiated an immediate descent. During recovery, the engine EPR values returned to normal and the crew were able to control the situation and land at the airport of origin. The second involved **Spirit Airlines** in 2002, in an incident in which an MD-82 aircraft experienced a loss of thrust in its engines while climbing to FL 330, with a drop in the EPR, N1 and speed indications. The stick shaker was subsequently activated and the crew decided, at the appropriate moment, to descend in order to recover the aircraft, managing to land without major complications.

It is important to note that the above incidents, in addition to stall certification tests and wind tunnel tests, demonstrate that all series of the MD-80 aircraft can be recovered from a stall in normal flying conditions if the appropriate recovery procedures (as described in the manufacturer's manuals) are used.

2.2. HUMAN FACTORS

The "human factors" area of aviation accident and incident investigation emphasises the importance of the performance of human beings in conditions which involve exposure to elements which they encounter outside their natural environment, and makes reference to their adaptation to a series of learning processes in order to be able to successfully carry out their role.

To this end, analysis of "human behaviour" is used in order to investigate factors which cause or contribute to accidents and incidents, considering the probability that within its limitations is the risk of inappropriate operation of one of the functions which guarantee flight safety.

In the case under investigation, we have focused on the actions of the flight crew and present them in two (2) flight phases, taking into account the importance of the execution of incorrect procedures, which in each phase of the operation contributed to the accident. The first phase involved the actions taken prior to, and the second phase those taken after, the loss of lift.

ACTIONS PRIOR TO THE LOSS OF LIFT OR STALL

Use of the anti-ice system in the established performance conditions

On the MD-80, the anti-ice system is operated by a switch on the overhead panel. There is one system for each engine. When the switch is in the up position, the system is turned off, and when the switch is in the down position, the system is turned on. There is a similar two-switch system for the "airfoil" system. As regards this system, we conclude that it is probable that the EPR variations recorded by the FDR, with at least eight (8) different configurations owing to changes in the anti-ice system over a period of nine (9) minutes, were the result of use of the switch, specifically manipulation of the anti-ice system switches, giving rise to variations in engine power when the airfoil anti-ice system was activated, including activation on a single engine.

The above conclusion is confirmed by the CVR transcript, in which reference is made to the anti-ice system, with comments made about the status of the anti-ice system on two occasions, whereas it should be pointed out that neither of the pilots made reference to any thrust configuration or EPR during the flight.

In this accident, it is important to highlight the absence of any timely interpretation of the aircraft's drop in power (the speed fell from Mach 0.76 to Mach 0.60 over a period of 10 minutes), of the changes in the pitch attitude over the transverse axis of the aircraft, and lastly of the warnings associated with multiple trim adjustments when the aircraft was trying to maintain the selected altitude. It can be inferred from this that an appropriate flight level was not maintained [because] an appropriate level of situational awareness or awareness of surroundings was not being maintained. Situational awareness is the ability to perceive, know or be aware at any time of what is happening around us, and in this accident there are various elements which suggest an absence of such awareness, which we will detail below:

a) non-perception of the time at which each of the events relating to the aircraft's performance occurred: attainment and maintenance of the desired altitude, maintenance of speed, response of the aircraft to various changes of adjustment or selection of options in the autopilot and autothrottle systems, and attainment of the engine pressure ratios (EPRs);

b) non-perception of changes in the aircraft's attitude;

c) non-perception of and inappropriate reaction to the warnings given by the alarm/alert mechanisms/systems that the aircraft was stalling;

d) failure to correlate the aircraft's weight and balance with the performance it could provide at the selected or planned altitudes, both in the planning (before take-off) and execution of the flight.

ACTIONS FOLLOWING THE LOSS OF LIFT OR STALL

This phase is marked by the inability to recover aircraft engine power following the loss of lift. The CVR transcript indicates that the stall protection system was activated and gave the crew a clear indication to carry out recovery action. The transcript in fact indicates that the first officer correctly identified the situation as a stall and told the captain so at least twice. The problems were observed only from the engine indications, and once the crew noticed the loss of altitude, they took action to use pitch control to keep the nose up. Moreover, no comment was made about checklists.

It should be pointed out that the crew training on simulators provided by the airline West Caribbean did not cover recognition of buffeting (vibration or shaking in connection with loss of wing lift) or procedures for recovering from a stall in MD-80 aircraft at high altitude. NASA's Aviation Safety and Reporting System issued Search Request No. 6712, dated 6 December 2005 (see Annex 6), which summarises a large number of MD-80 series aircraft stall incidents, and reflects the importance of including detection of and recovery from high-altitude stalls in simulator training .

Set out below are three tables describing the various characteristics to be assessed in the analysis of the findings, in the light of a series of skills which are considered relevant for optimal crew performance, namely person, procedures and general situational context or environment. The first column describes the general characteristics to be assessed in order to carry out a "psychological post-mortem" of the captain at the time of the accident. It should be pointed out that most of these characteristics were obtained from interviews with direct family members, friends and work colleagues, and from a detailed study of the captain's training background and flying experience.

Table No 6 "Human factors associated with the captain"

Handling of resources appropriate for the activity of pilot-in-command	Skills assessed	Findings	Associated psycho-emotional factors
Himself	• Leadership • Management • Self-perception: self-esteem and self-image • Self-criticism • Responsibility • Assertive communication • Teamwork • Decision-making • Working under pressure • Positive organisational environment • CRM (cockpit resource management) philosophy	Six months **without pay** Loss of role as provider Unstable working relationship Family rejection of work situation Frustration in the working environment Neglect of flight planning **Delay in flight owing to payment for fuel** **Absence of CRM (cockpit resource management)** Lack of communication with co-pilot Inappropriate handling of leadership **Personality features** Inflexible/strict Self-demanding Extreme self-control Overprotective/dependent Low insight **Background** Failure to grieve (loss of father) - Failure to prioritise in highly demanding situation	Depression Stress Frustration Psycho-physical fatigue Anxiety Low self-esteem

Table No 6 describes the factors which significantly affected the behaviour of the pilot at the time of the accident. It can be seen from these that he was subject to high amounts of stress and anxiety as a result of the financial status of the airline, which gave rise to work instability, all of which was reflected in a highly insecure organisational environment. In this connection, it is important to point out that as a result of the unstable pay situation, the pilot had been obliged to set up a family bar/restaurant business in order to obtain some income, thereby not only cutting down his number of rest hours but also reducing his development expectations as a professional pilot.

The psycho-emotional factors described in this table show that the captain's performance of his duties was negatively affected.

Table No 7 "Human factors associated with the captain"

Handling of resources appropriate for the activity of pilot-in-	Skills assessed	Findings	Associated psycho-emotional factors

command			
Handling of cockpit and procedures	• Knowledge of the system • Handling of automatic systems • Monitoring of the instrument panel • Monitoring of the environment • Handling of abnormal and emergency procedures • CRM (cockpit resource management) philosophy • Handling of checklists • Adequate experience on the MD-82 in the role of captain	**Late start as a professional pilot** Belated professional expertise Less anticipation and planning of actions, which is associated with taking greater risks **Low level of technical expertise** - As regards simulator checking, no training on high-altitude stalls Occasional rehearsal of item approaching a stall in simulator sessions **422.19 total flying hours as an MD-82 captain** - Insufficient for expertise as an MD-82 captain - Negative transference **Operation of the aircraft outside the limits and parameters laid down in the manufacturer's performance manual** **- Absence of CRM (cockpit resource management)** - No mention of any going-through of memory items or checklists, or application of emergency procedures **- Absence of psycho-emotional follow-up on renewal of periodic medical certificate** - Absence of information on cognitive deterioration	Inadequate cockpit performance - Limited integrated thinking with capacity for analysis and synthesis - Low level of attention to multiple secondary stimuli - Absence of feedback with co-pilot - Insufficient flying experience on MD-82s

Analysis of Table No 7 reveals that the captain did not have sufficient experience to operate the aircraft's automatic flight system modes. According to the CVR recordings, no mention was made of having identified the loss of speed or the buffeting (moments before the actual stall). There is also no evidence of any recognition of the emergency, given that the performance table was not checked, nor were the memory items gone through on the checklist in order to recover from the stall.

Table No 8 "Human factors associated with the captain"

Handling of resources appropriate for the activity of pilot-in-command	Skills assessed	Findings	Associated psycho-emotional factors

Environment	• Positional awareness • Situational awareness • Analysis of information • Anticipation and planning	**Understanding of the alarms** **- Inappropriate flight planning** - Considering a flight level outside the limits laid down in the tables - Absence of updated meteorological information given the adverse atmospheric conditions **- Absence of CRM (cockpit resource management)** - Disassociation from reality - Ignorance of the warnings present	Reduced state of alertness (low level of attention and concentration during the flight) Inadequate planning capacity Failure to take appropriate decisions in the emergency situation

What emerges from Table No 8 are inadequate anticipation and flight planning, as evidenced by the failure to update the flight plan meteorological information, and despite the presence of adverse atmospheric conditions before and during the occurrence of the accident, no decision was taken to change the route in order to prevent ice formation, resulting in continuous use of the anti-ice systems, plus the fact that the altitude selected in the flight plan, given the take-off weight, was outside the limits indicated in the performance tables for the aircraft.

Table No 9 "Human factors associated with the co-pilot"

Handling of resources appropriate for the activity of pilot-in-command	Skills assessed	Findings	Associated psycho-emotional factors
Himself	• Self-perception: self-esteem and self-image • Responsibility • Assertive communication • Teamwork • Decision-making • Working under pressure • CRM (cockpit resource management) philosophy	**Six months without pay** Unstable working relationship Frustration in the working environment Diminished ego **Delay in flight owing to payment for fuel** **Absence of CRM (cockpit resource management)** Lack of communication with captain Personality features Submissive and obedient Cooperative Respectful of authority Repressed Dependent Methodical Altruistic	Depression Stress Frustration Low self-esteem

Table No 10 "Human factors associated with the co-pilot"

Handling of resources appropriate for the activity of pilot-in-command	Skills assessed	Findings	Associated psycho-emotional factors
Handling of cockpit and procedures	• Knowledge of the system • Handling of automatic systems • Monitoring of the instrument panel • Checking of the environment • Handling of abnormal and emergency procedures • CRM (cockpit resource management) philosophy • Handling of checklists • Adequate experience on the MD-82 in the role of co-pilot	**Had held an MD-82 co-pilot licence rating for about one (1) year** - The anticipation and planning of the consequences of actions were limited by his experience **862.10 total flying hours as an MD-82/Let 410 co-pilot** - Sufficient to operate as a co-pilot on the MD-82, but not sufficient to have acquired the expertise needed in order to take control of the situation **Operation of the aircraft outside the limits and parameters laid down in the manufacturer's performance manual** **- Absence of CRM (cockpit resource management)** - No mention of any going-through of "memory items" or checklists, or application of emergency procedures	- Inadequate cockpit performance - Absence of feedback with captain - Insufficient flying experience on MD-82s
Environment	• Positional awareness • Situational awareness • Analysis of information • Anticipation and planning	**Inappropriate flight planning** - Absence of updated meteorological information given the adverse atmospheric conditions **- Absence of CRM (cockpit resource management)** - Disassociation from reality	Reduced state of alertness (low level of attention and concentration during the flight) Reduced planning capacity Failure to take appropriate decisions in the emergency situation

Given the importance of training in CRM (cockpit resource management) as a philosophy designed to ensure adequate handling of cockpit resources, the objective of which is to create an organisational safety culture, taking as guidelines the development of attitudes focused on effective leadership, assertive communication and teamwork, we have described the human factors associated with the co-pilot in Table No 9, which enable us to correlate the aspects which had a significant bearing on the actions which culminated in the accident in question.

From this information we can draw the following conclusions:

1) The existence of a positive correlation (strictness/submissiveness and self-control/obedience) between the profiles or features which characterised the two flight crew members explains the absence of appropriate communication and hence the lack of interchange of information in connection with memory items and checklists, and the taking of actions without verbalisation or manifestation of any kind of emotion in a very tense (stressful) situation.

2) The generation gap (given that the captain was 40 years old and the co-pilot 21) in conjunction with the behaviour profile described in the point above substantiate the inadequate handling of hierarchies and the consequent lack of teamwork.

3) The insufficient experience of the two pilots, resulting from their [lack] of flying hours on MD-82s and the absence of training on this specific emergency, explain the failure to notice the drop in engine power and suggest the use of defence mechanisms related to dissociation from reality, thereby generating a negative effect on decision-making.

4) The diminished state of alertness resulting from the fatigue caused by the delay in the flight, the state of professional instability and uncertainty of the crew, and certain factors which distracted their attention during the flight, explain the moment of conflict and loss of situational awareness or awareness of surroundings which occurred, as a result of which the flight crew failed to recognise in a timely and appropriate manner the abnormal situation which was developing and deteriorating as time went by and a series of events which could have been identified and properly dealt with before they turned into an extremely critical and irreversible negative situation which culminated in a fatal accident.

5) This human factors analysis also allows us to draw the following conclusions:

   a) The flight planning was inadequate and incomplete, because the effects of the weight and balance of the aircraft on the "expected" performance at the selected or planned altitude were not appropriately checked.

   b) The analysis of the meteorological conditions along the selected flight route was incomplete or inappropriate.

   c) The level of situational awareness of the two crew members was insufficient, owing to their inability and delay in recognising in a timely and correct manner what was happening in terms of the expected performance of the aircraft in order to take appropriate corrective action.

   d) There was an absence of effective communication between the captain and first officer during the flight, together with which the following was evident:

- inadequate feedback;
- insufficient effective interchange of ideas;
- lack of assertiveness;
- absence of timely and appropriate responses;
- possible channelling of attention on the part of the captain;
- absence of any "challenge" to obtain appropriate responses and eliminate the channelled-attention situation;
- inadequate process of recognition of abnormal situations, problems or emergencies;
- inadequate decision-making process.

2.3. ORGANISATIONAL FACTORS

At the time of the accident, the airline was having financial problems which were affecting its operations. Of the airline's three MD 80 series aircraft, only the one involved in the accident remained. In 2005, the airline was sanctioned twice by the Colombian Civil Aeronautical Authority, once for an excess weight of 1,652 kg on a flight in 2004, and once when an annual inspection revealed infringements in crew rest hours, flying time and leave periods, a failure to provide crew with regulation training, and inconsistencies in aircraft records and flight documents.

3. CONCLUSIONS

3.1. GENERAL

3.1.1. The aircraft was airworthy.

3.1.2. The crew were duly trained and fit to perform flight WCW 708.

3.1.3. There was sufficient fuel and it was of the appropriate type for the flight.

3.1.4. The aircraft followed the route laid down in the flight plan, with a few minor deviations owing to the bad weather in upper airway UA 553.

3.1.5. Use of the anti-ice system resulted in a reduction in the engine pressure ratio (EPR), which in the given performance conditions owing to the inappropriate configuration of the ATS in EPR Limit Cruise mode, affected the aircraft's power status, causing a gradual decrease in flying speed. This caused the aircraft to fly behind the power curve, in which situation the thrust required by the aircraft to maintain its speed was greater than that which it was producing.

3.1.6. The evidence shows that there was inadequate monitoring of the speed indications, as a result of which the continuous loss of speed was not identified, whereupon there was a drop in power resulting in the aircraft's ending up behind the power curve with a steep angle of attack (AOA).

3.1.7. The crew recognised a degree of deterioration in the performance of the aircraft, and asked to descend to FL 310. As the aircraft reached approximately FL 317, there was a fall in engine thrust, at which point the stall warning system (stick shaker) was activated together with the stall warning horn.

3.1.8. At the point when the stall warning system was activated, the angle of the horizontal stabiliser trim started to gradually increase until it reached the full nose-up position.

3.1.9. The engines were operating at high revs, producing power seconds before the aircraft collided with the ground.

3.1.10 On 6 August 2002, the manufacturer of the aircraft issued a flight operations bulletin, warning operators of MD-80s that the aircraft could decelerate to the point of stalling before the autopilot disengaged, if the thrust required to maintain flight level was greater than that available. We were unable to obtain clear evidence of dissemination or instruction within West Caribbean in connection with procedures in abnormal or emergency situations in cases of loss of lift at high altitudes.

3.1.11 In December 2005, NASA issued a report analysing various cases of situations similar to this accident affecting MD-80 series aircraft, and recommending improvements in crew training on flight simulators to deal with situations of loss of lift at high altitudes.

3.2. CHAIN OF EVENTS

3.2.1 The financial crisis affecting West Caribbean generated an unfavourable climate for air operations by creating an environment characterised by uncertainty and stress.

3.2.2. No account was taken either in the flight planning or in the flight dispatching of the limits laid down in the performance tables with regard to take-off weight, planned flight level, aircraft weight throughout the flight, or propulsion ceiling.

3.2.3. There is also no evidence that the flight crew were aware of the aircraft's performance limits in the given conditions. They were probably [also] unaware of previous accidents affecting MD-80s and of the flight operations bulletin (FOB)

3.3. CAUSAL FACTOR

Given the aerodynamic and performance conditions, the aircraft was flown into a critical situation, which resulted in its losing lift. Subsequently, the cockpit resource management (CRM) and decision-making as the emergency progressed were misguided. The reasons for this were as follows:

a) Insufficient or inappropriate awareness of surroundings (or situational awareness), which meant that the flight crew were not fully aware or aware in time of what was happening in terms of the performance and behaviour of the aircraft.

b) Lack of effective communication between the flight crew, which limited, within the decision-making process, the possibility of choosing appropriate and timely alternatives and of establishing the relevant priorities in the action which was taken while a critical or emergency situation (a condition of loss of lift at high altitude) was developing.

The cause of the accident has been found to have been determined by the failure to take pertinent action to correct the aircraft's entry into a stall, and from the start of the emergency until the collision of the aircraft with the ground, the prioritisation and execution of procedures were misguided. In sequential terms, an operation was initiated outside the limits and parameters laid down in the manufacturer's performance manual, in conjunction with inappropriate flight planning which failed to take into account the climate aspects, in addition to erroneous and belated interpretation of the loss of power by the aircraft on the part of the flight crew. Consequently, the evidence indicates that **human factors** should be classified as the cause of this accident.

4. RECOMMENDATIONS

Pursuant to Chapter 3 and section 5.4.1. of Chapter 5 of ICAO Annex 13, which specifies the strictly administrative nature and purpose of the recommendations of any accident investigation, and without these conclusions indicating any presumption of blame or liability, we wish to consider means of preventing recurrence of the causes which gave rise to this accident.

In the same vein, in accordance with Article 97 of the Civil Aeronautical Act in force, which stipulates as follows: "The purpose of the investigation of aviation accidents and incidents shall be to determine the causes and factors which contributed to the occurrence, with a view to implementing corrective action which will prevent recurrence thereof, without prejudice to any civil, criminal or administrative liability generated, as established in accordance with the law", the present Civil Aviation Accident Investigation Board submits the following recommendations:

To the aeronautical authorities

- 058/2005-AA1: Require **effective** training of flight crew in the use of the performance tables, focusing on a knowledge of the limits applicable when operating an aircraft in flight, in order to ensure that the altitude margins laid down in the operations manuals are not exceeded, thereby averting high-altitude stalls. We also recommend that dispatchers and all staff involved in the preparation of flight plans be instructed in the aspects associated with their specific working roles and the implications or effects on the performance of aircraft in the various flight phases.

- 058/2005-AA2: Require the inclusion in flight crew training of recovery from high-altitude stalls. This is justified on the grounds that in simulator training, low-altitude stalls are induced, from which the aircraft can recover more quickly, because it can increase power in order to maintain altitude in a more accelerated manner, whereas at high altitudes, the behaviour of aircraft is different, calling for more precise manoeuvres in terms of time of execution.

- 58/2005-AA3: We recommend the updating and assessment of the financial statements of the airlines operating the public air transport service, not only during the certification process but also as a process of permanent oversight or continuous monitoring, with a view to verifying that airlines' finances are sufficient to cover the operations for which they are authorised, and with a view to taking appropriate action in the event of deterioration in those finances, in order to guarantee safe provision of services and maintenance of airworthiness.

- 58/2005-AA4: In those countries in which there are air operators certified to operate MD-80 series aircraft, require the inclusion in the flight crew training programme of a review of the accident and incident statistics in relation to the operation of this aircraft type, especially those linked to the configuration of the autopilot and autothrottle modes. We also recommend that it be ensured that the content referring to the description of MD-80 series aircraft autopilot modes in the flight operations bulletin (FBO) issued by Boeing be included in the corresponding training manuals and programmes .

- 58/2005-AA5: In those countries in which there are air operators certified to operate MD-80 series aircraft, increase and optimise the requirements in the flight crew training programmes in the presence of buffeting at high altitudes, and also those with regard to the various configuration modes for the autothrottle system (ATS), the anti-ice system, and the monitoring of altitude and speed and their relation to aircraft power status.

- 58/2005-AA6: Consider the implementation of a cockpit resource management (CRM) programme as part of the procedures to be assessed in simulator and flight training, via its inclusion in the memory items required in any emergency. For that purpose, controlled training situations similar to this case could be generated, in which appropriate reactions are considered or required in order to maintain or recover an appropriate state of alertness or situational awareness in order to verify what is happening and subsequently carry out the desired decision-making process in an appropriate manner.

- 58/2005-AA7: Require aircraft operators and aeronautical training centres to step up training in relation to situational awareness, assertiveness and effective communication within the topics scheduled for cockpit resource management (CRM) in order to bring about a definitive change in operational culture in flight crew, in the course of which open consideration should be given, with the professional maturity this aspect requires, to the establishment of specific measures or procedures to improve the interchange of ideas (communication) between flight crew, so that the decision-making processes can be carried out in a timely and appropriate manner without producing obstacles or conflicts of competence during flights, and so that agreements and clear, precise and positive rules can be established before take-off for the purpose of ensuring appropriate planning and execution of those flights.

To the aircraft manufacturer (Boeing)

- 58/2005-ODF1: Study the possibility of designing a new algorithm or of reviewing (with a view to improving) the existing algorithms in these aircraft or systems to provide alarms or warnings in sufficient time for flight crew, firstly to recognise in good time aural and/or visual indications of any abnormal or hazardous situation, and secondly also to react in time to such alarms or warnings and then carry out a rapid and appropriate analysis and decision-making process. In this particular case, the present Civil Aviation Accident Investigation Board suggests that an additional alarm, both aural and visual (e.g. lights and a voice saying "Warning: Performance", "Warning: Performance Conflict", etc.), in what is determined to be sufficient time, could alert the crew and put it in a state of situational awareness in a more appropriate manner, and initiate more timely corrective action in order to avert this type of accident. We therefore recommend analysis of the inclusion of an additional audiovisual warning appropriate to the situation detailed here and to the causal factors of this accident.

To the manufacturers of flight data recorders (FDRs)

- 58/2005-OTR1: Include or add the parameter relating to changes of angle of attack (AOA) during a flight, which was not recorded on the FDR equipment of the aircraft involved in this accident.

- 58/2005-OTR2: Verify that the current FDR equipment already includes this angle of attack (AOA) parameter, which, when a flight simulation was carried out, proved to be very useful in attempting to determine with greater precision the events which actually took place in the sequence which culminated in the accident being investigated here.

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