



Misconfigured MD-82 stalled on takeoff.

Lift Deficit

This aircraft struck terrain while departing with the flaps and slats retracted.

BY MARK LACAGNINA

A series of mistakes and omissions by the flight crew and an inoperative takeoff warning system were among the factors that led to the loss of control of a Spanair McDonnell Douglas MD-82 during departure from Madrid-Barajas Airport the afternoon of Aug. 20, 2008, said the final report by Spain's Civil Aviation Accident and Incident Investigation Commission (CIAIAC).

The crew had rejected a previous takeoff because of an excessively high ram air temperature (RAT) indication and had taxied the aircraft back to the ramp to have the problem fixed. Taxiing out again after an hour's delay, the pilots skipped over critical checklist items and neglected to extend the flaps and slats, an error that was not flagged by the takeoff warning system (TOWS). The crew did not identify — and actually aggravated — the stall

that occurred shortly after the aircraft became airborne. Of the 172 people aboard, 154 were killed and 18 were seriously injured when the MD-82 struck the ground.

Uneventful Arrival

The crew had flown the aircraft to Madrid from Barcelona, arriving shortly after 1000 local time. "The flight was uneventful, and no abnormalities were reported in the aircraft technical logbook," the report said. The second leg, to Gran Canaria in the Canary Islands, was scheduled to depart from Madrid at 1300 as Spanair Flight 5022.

The captain, 39, had 8,476 flight hours, including 5,776 hours in type. He had served as a CASA 212 flight instructor and test captain in the Spanish air force before joining Spanair in 1999. "The reports of his tests, simulator

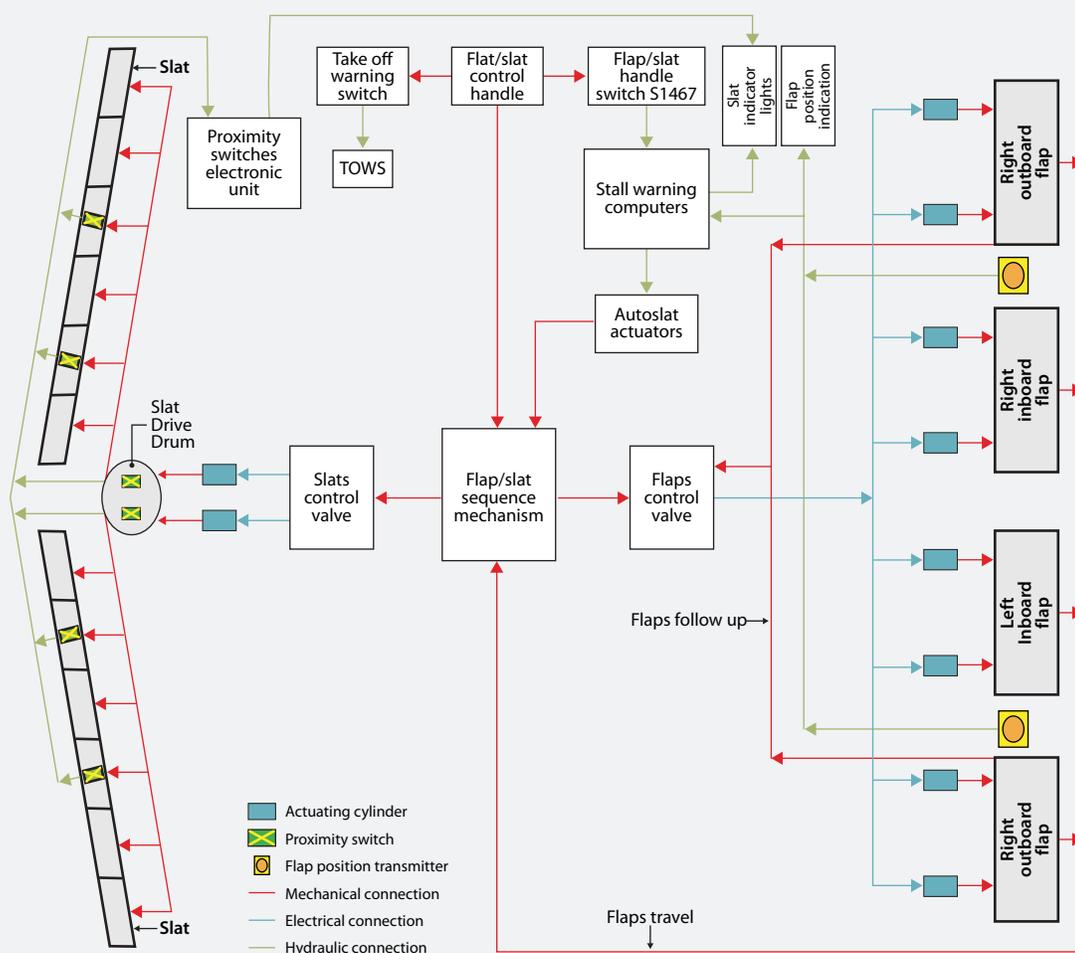
sessions and line training indicate he was an above-average pilot,” the report said. “Crewmembers who knew the captain described him as being disciplined, precise and meticulous in his job, someone who adhered to procedures rigorously.”

The first officer, 31, had 1,276 flight hours, including 1,054 hours in type, and was hired by Spanair in 2007. “Pilots who had flown with him described him as a serious and disciplined pilot who was polite and made an effort to collaborate,” the report said. “They specifically noted how much he loved to fly and how happy he was to have the chance to do so.”

The MD-82 was manufactured in 1993 and had accumulated 31,963 flight hours and 28,133 cycles. The aircraft has two trailing-edge flaps and six leading-edge slats on each wing (Figure 1). “All the sections are mechanically linked so that the extension and retraction movements are synchronized,” the report said. “The flaps and slats are operated jointly on the flight deck with a single flap/slat control lever, situated on the front right of the cockpit’s central pedestal.”

Markings on each side of the control lever slot show various flap positions from 0 degrees, or fully retracted, to 40 degrees, or fully extended. Flap positions from 0 to 24 degrees

MD-82 Flap/Slat System



TOWS = takeoff warning system

Source: Spanish Civil Aviation Accident and Incident Investigation Commission

Figure 1



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captain established contact via cell phone with the operator's maintenance control center (MCC), located at its headquarters in Palma de Mallorca, to request guidance and information regarding the problem," the report said.

MCC personnel told investigators that they instructed the captain to reset the "Z-29" circuit breaker, which guards the electrical circuit that heats the RAT probe. When the captain replied that he already

The control lever on the right side of the center pedestal is in the position at which the flaps and slats are fully retracted.

are marked for takeoff; positions from 24 to 40 degrees are marked for landing.

'Slight Problem'

The crew began taxiing from the stand at 1310. The aircraft was lined up on Runway 36L and had just received clearance for takeoff when the crew told the airport traffic controller, "Look, we have a slight problem. We have to exit the runway again." The controller asked if they wanted to return to the ramp, and the crew replied that they were communicating with company technical specialists and would advise of their intentions as soon as possible.

The "slight problem" was the high RAT indication. The external probe for the RAT system is not supposed to be heated, for anti-icing, while the aircraft is on the ground. However, the crew observed the indication increase precipitously, due to the lack of sufficient cooling airflow, as they taxied the aircraft to the runway. Recorded flight data showed that the RAT indication was 104 degrees C (219 degrees F) when the aircraft was lined up on the runway.

The crew received authorization to park on a taxiway while they studied the problem. "The

had reset that circuit breaker, the MCC referred him to the company's on-site maintenance facility for further assistance.

The crew then radioed the airport traffic controller and Spanair's maintenance shift supervisor and ground assistance agent that they were returning to the ramp because of "an overheating RAT probe." The controller cleared the crew to park at a remote stand.

The ground assistance agent advised that a replacement aircraft was available at the airport, "but the crew decided to wait until maintenance reported on the scope of the malfunction," the report said.

Two maintenance technicians met the aircraft at the stand and confirmed that the RAT probe heating circuit was energized. The technicians and the pilots discussed the use of dry ice to cool the probe, a remedy that eventually was rejected.

One of the technicians then consulted the minimum equipment list (MEL) and found that the aircraft could be dispatched with the RAT probe heating system inoperative if icing conditions were not forecast for the flight. After receiving confirmation from the maintenance shift supervisor, "the maintenance technician finally

proposed to the captain that the aircraft be dispatched with breaker Z-29 pulled so as to disconnect the electrical supply to the RAT probe heater,” the report said. “The captain agreed.”

According to provisions of the MEL, the circuit breaker was pulled, the RAT display was labeled “INOPERATIVE,” the RAT probe heating circuit was checked to verify that it was de-energized, and the proper entries were made in the technical logbook and on a release-for-service document.

Interrupted Checklist

The temperature in the passenger cabin increased while the aircraft was parked with the engines shut down. There was no external electrical power available at the stand, and, with an ambient temperature of 30 degrees C (86 degrees F), the aircraft’s auxiliary power unit apparently provided insufficient power for the air conditioning system. The purser advised the captain several times that the cabin was hot.

Passenger discomfort and the schedule disruption likely caused the captain to feel frustrated and rushed, the report said, noting that these factors, plus the first officer’s distraction about whether the autothrottle could be used for takeoff with the RAT probe heat inoperative, contributed to a breakdown in crew coordination.

After restarting the engines at 1407, the pilots began the “After Start” checklist. However, upon reaching the final item, a check of the flap and slat settings, the captain interrupted the checklist by asking the first officer to request clearance to begin taxiing.

The crew apparently did not return to the checklist and “thus missed its first opportunity to discover that the aircraft’s configuration was not correct for takeoff,” the report said. While

waiting for taxi clearance, the pilots attended to other tasks, such as calculating an engine pressure ratio (EPR) setting of 1.95 for takeoff and discussing whether to use the autothrottle or set thrust manually.

At 1414, the captain asked the ground traffic controller for an estimate of the expected delay in receiving taxi clearance. “They were told there was no delay and [were] given instructions to taxi to the Runway 36L holding point,” the report said.

Cockpit voice recorder (CVR) data showed that the pilots and a Spanair flight attendant occupying the cockpit jump seat engaged in nonpertinent conversations while the aircraft was being taxied to the runway. This constituted another distraction for the flight crew, the report said.

The crew missed several more opportunities to find that the aircraft was not configured properly for takeoff, the report said. The “Taxi” checklist, for example, requires a check that the automatic reserve thrust system is armed, an action that is inhibited if the slats are not extended. “The CVR revealed that while doing this item, the captain told the first officer that they would attempt a takeoff with autothrottle and that if it did not work, they would do it in manual,” the report said, noting that the crew did not observe, or did not recognize the significance of, the absence of the indication that the reserve thrust system was not armed.

Moreover, *expectation bias* likely played a role when the first officer called out a flap setting of 11 degrees while conducting both the takeoff briefing and the final check before takeoff. “There is a natural tendency for the brain to ‘see’ what it is used to seeing (look without seeing),” the report said. “In this case, the first officer, accustomed to doing the

final checks almost automatically, was highly vulnerable to this type of error, which was possibly exacerbated by the restlessness he displayed throughout the flight preparations involving the availability of autothrottle during takeoff. ... The captain, for his part, should have been monitoring to ensure that the answers being read aloud by the first officer corresponded to the actual state of the controls.”

‘Engine Failure?’

The crew began the takeoff from Runway 36L at 1423, with the first officer apparently the pilot flying. The CVR recorded callouts of “sixty,” “one hundred,” “V one” (at 154 kt), “power check” and “rotate” (at 157 kt). The MD-82 lifted off after using 1,950 m (6,398 ft) of the 4,349-m (14,269-ft) runway. Four seconds later, the stick shaker activated, the stall-warning horn sounded and a synthetic-voice “stall” warning was generated.

“The first officer said ‘engine failure’ in a questioning voice,” the report said. “A second later, at 1424:15, the captain asked in a very loud voice how to turn off the warning voice.” Digital flight data recorder (DFDR) data showed that airspeed was 168 kt and that the aircraft was 25 ft above the runway with a nose-up pitch attitude of 15.5 degrees and a right bank angle of 4.4 degrees.

The bank angle increased to 20 degrees as the first officer retarded the throttles, resulting in a momentary decrease in EPR from 1.95 to 1.65 in both engines. “The throttles were immediately moved to their maximum thrust positions, resulting in EPR values of around 2.20 [the maximum for takeoff],” the report said. “These values remained constant until the end of the [DFDR] recording.”

'The aircraft could potentially have flown if the pitch angle had not been so high and the bank angle had been controlled.'

The stick-shaker and aural stall warnings continued, and "bank angle" warnings were generated by the enhanced ground-proximity warning system as the right bank reached 32 degrees. Pitch attitude was 18.3 degrees when the aircraft reached its highest height above the ground, 40 ft, at 1424:19. The MD-82 descended, slowly at first, and drifted right until striking the ground between Runway 36L and Runway 36R.

"The first part of the aircraft to impact the ground was the tail section, followed almost immediately by the right wing tip and the right engine fairings," the report said. The aircraft then traveled down a slope and over a road, and struck an embankment, where a fuel-fed fire erupted.

Post-accident performance calculations and simulations revealed that, even with the flaps and slats retracted and the power reduced to 1.65 EPR, "the aircraft could potentially have flown if the pitch angle had not been so high and the bank angle had been controlled," the report said.

Defective Relay?

No TOWS warnings had been generated during the takeoff roll. The system is designed to generate warnings, when the throttles are advanced for takeoff, if the parking brake is not released or if the flaps, slats, spoilers or horizontal stabilizer are not configured properly. For example, if the TOWS detects that the slats are retracted, it sounds a warning horn and generates a verbal warning, "Slats."

Although TOWS is a go/no-go item for flight, and McDonnell Douglas recommended that it be checked before each flight, Spanair required an operational check of the system only before the first flight of the day. Thus, the pilots likely checked the system before taking off from Barcelona but not before the takeoff attempt at Madrid, the report said.

Investigators were unable to determine conclusively why the TOWS did not sound an alarm. De-energizing the RAT probe heat circuit would not have affected the system. However, the report discussed the possibility that faulty contacts in the "R2-5" relay, an

electromechanical component of the aircraft's ground-sensing system, might have affected both the TOWS and the RAT. Among the relay's functions are to disable the RAT probe heating system and enable the operation of the TOWS when the aircraft is on the ground.

Boeing, which merged with McDonnell Douglas in 1997, told the CIAIAC that it was aware of 13 cases from 2000 to 2008 in which TOWS failures discovered during preflight checks were solved by replacement of the R2-5 relay. During the same period, 71 RAT probe overheats and four combined TOWS failures and RAT probe overheats were solved by replacing the relay. "In some of these cases, the relay was found 'stuck' in the 'air' position," the report said.

DFDR data showed that the RAT probe on the accident aircraft had overheated on the ground five times in the two days preceding the accident. "These events involved three different crews," the report said. Three events were not noticed, and two were not reported until after the flights were completed. "Different maintenance practices were used to deal with the two reported cases," the report said. "The maintenance tasks did not succeed in solving the problem."

Furthermore, the maintenance performed just before the accident flight focused on complying with MEL provisions enabling the aircraft to depart rather than fixing the RAT problem, the report said.

Among the many recommendations made by the CIAIAC during the accident investigation were requirements that the source of a malfunction be identified before using an MEL and that specific instructions be provided for troubleshooting malfunctions of the RAT probe heating system.

The commission also recommended that flight crews of MD-82s and similar aircraft be required to conduct an operational check of the TOWS before every flight. ➤

This article is based on the English translation of CIAIAC report A-032/2008, "Accident Involving a McDonnell Douglas DC-9-82 (MD-82) Aircraft, Registration EC-HFP, Operated by Spanair, at Madrid-Barajas Airport on 20 August 2008," July 26, 2011.