



FATAL V₁ CUT

BY MARK LACAGNINA

Simulated engine failure during a check ride led to a loss of control.

A training and checking captain who was administering an instrument proficiency check to a line captain in an Embraer EMB-120ER Brasilia performed a “V₁ cut” — a simulated engine failure on takeoff — “at a speed that did not allow adequate margin for error,” said the Australian Transport Safety Bureau (ATSB) in its final report on the March 22, 2010, accident at Darwin Airport.

Moreover, the check captain introduced two systems failures — an improper practice during check flights — by moving the left power lever all the way to idle, rather than to a position

corresponding to zero thrust, the recommended procedure. In addition to simulating an engine failure, the check captain’s action disabled the twin-turboprop aircraft’s propeller autofeather system. “This produces much more drag from the ‘windmilling’ propeller than had the propeller automatically feathered,” the report said.

The check captain did not restore power to the left engine when airspeed and heading deviations exceeded tolerances for the exercise, and the line captain exacerbated the situation by increasing power from the right engine and engaging the yaw damper, the report said. The

result was a loss of control, and the Brasilia crashed nearly inverted off the end of the runway, killing both pilots.

The pilots were employed by Airnorth. Based in Darwin, the airline conducted scheduled and charter flights throughout Australia's Northern Territory with a mixed fleet of regional jet and turboprop airplanes. The report said that both pilots were experienced flight instructors and Brasilia captains, and held supervisory positions at Airnorth.

The check captain had 5,664 flight hours, including 3,085 hours in Brasilias. He joined Airnorth in January 2006 and was appointed as a training and checking captain in June 2009. "Pilots that were checked by him reported that he gave thorough preflight briefings before each check flight and that those included the engine failure scenarios that were to be expected," the report said.

The line captain had 8,217 flight hours, including 3,749 hours in type. He was employed by Airnorth as a Brasilia copilot in 2006 and was upgraded to command status a year later.

Both pilots held Grade 1 flight instructor ratings with multiengine airplane training approvals. The line pilot had more than 1,200 hours' experience as a flight instructor and was authorized by the Australian Civil Aviation

Safety Authority (CASA) to conduct command instrument rating renewals.

Less Than a Minute

The check captain was designated as pilot-in-command (PIC) of the instrument proficiency check flight, and the line captain was the pilot flying (PF). "The pilots were reported to have planned and briefed in preparation for the check flight," the report said. "A company pilot later described seeing three columns of briefing information on the whiteboard used by the PIC." Airnorth required that briefings include the maneuvers that were to be flown, including the method the check pilot would use to simulate an engine failure on takeoff.

Before beginning the takeoff at 1009 local time, the PIC advised the airport traffic controller that an engine failure would be simulated on departure. The takeoff was begun from the point where the taxiway leading from the civilian ramp, Taxiway E2, intersects Runway 29 (Figure 1).¹ The aircraft's takeoff weight was about 20 percent below maximum, and the center-of-gravity was near the forward limit. V_1 had been calculated at 100 kt, and V_2 , the takeoff safety speed, was 113 kt.

Although it labeled the exercise as a V_1 cut, the report indicates that the PIC moved the left

power lever to idle immediately after the aircraft lifted off the runway and at an airspeed slightly above V_2 .

"Witnesses reported that the takeoff appeared 'normal' until a few moments after the aircraft became airborne, when it was seen to roll and diverge left from its takeoff path," the report said. "They watched as the aircraft continued rolling left into a

Flight Path



Source: Adapted from Australian Transport Safety Bureau report by Susan Reed.

Figure 1

Embraer EMB-120ER Brasilia



Brazil's Empresa Brasileira de Aeronáutica (Embraer) introduced the twin-turboprop Brasilia in 1985 as a regional airliner and military transport. The EMB-120 replaced the EMB-110 Bandeirante, which originally was designed as a light transport and trainer for the military but was used extensively in commercial aviation. The Bandeirante has Pratt & Whitney Canada PT6A-34 engines rated at 560 kW (750 shp) and carries two pilots and up to 21 passengers. Deliveries to military and civilian operators began in 1972, and more than 500 Bandeirantes were built before production was terminated in 1990.

Brasílias initially were powered by 1,119 or 1,194 kW (1,500 or 1,600 shp) PW115 engines driving Hamilton Standard four-blade composite propellers. The aircraft can accommodate 30 passengers, a flight attendant and two pilots. The extended-range EMB-120ER was introduced in 1993 and became the standard version the next year. The major change was an increase in maximum takeoff weight to boost usable fuel capacity to 3,308 L (874 gal).

The EMB-120ER has 1,343-kW (1,800-shp) PW118A engines. Maximum weights are 11,990 kg (26,433 lb) for takeoff and 11,700 kg (25,794 lb) for landing. Maximum climb rates at sea level are 2,500 fpm with both engines operating and 550 fpm with one engine inoperative. Cruise speeds at 25,000 ft are 313 kt, maximum, and 270 kt, long-range. Maximum range with reserves is 800 nm (1,482 km). Stall speed in landing configuration is 89 kt.

More than 350 Brasílias were built before production was terminated in 2001.

Sources: Embraer, *Jane's All the World's Aircraft*

steep nose-down attitude. The witnesses lost sight of the aircraft behind trees to the south of the upwind end of the runway, from where a column of black smoke was seen shortly afterwards. ... The aircraft had descended

through the surrounding trees and impacted terrain in a steep 65-degree nose-down, partly inverted, right-wing-low attitude.”

The accident had occurred 51 seconds after the takeoff was initiated. The Brasilia struck terrain about 500 m (1,641 ft) south of the departure threshold of Runway 29.

“The investigation found no evidence of mechanical failure, nor had local conditions contributed to the development of the accident,” the report said. “Analysis of the flight data and cockpit voice recordings found that a flight condition was allowed to develop that rapidly became uncontrollable.

“Significantly, there was only a very short period of time — possibly between four and five seconds — from when the PIC first recognized that the maneuver was not being flown within prescribed tolerances to when the loss of control occurred. This was such a brief period of time that it did not allow the PIC to analyze and ‘troubleshoot’ the problem. The only course of action that would have avoided a loss of control would have been to immediately restore power to the left engine and to stop the exercise.”

The report added, “A prompt remark from the pilot under check that he was unable to control the aircraft might have triggered such a response from the PIC.”

‘Exacting Maneuver’

During training and subsequent proficiency checks, pilots are required to demonstrate competency in handling a failure of the critical engine at V_1 , the report said, defining V_1 as “the critical engine failure speed or decision speed.”²

“The V_1 cut is an exacting maneuver because accurate control of the aircraft is required to accelerate to a safe flying speed, become airborne and obtain a predicted climb performance with the critical engine powered back to simulate an inoperative engine with its propeller feathered,” the report said.³ “The sequence requires an aircraft to be flown at low airspeed and with reduced performance, while controlling asymmetric thrust, at low altitude.”

Pilots experienced in conducting training and check flights in the aircraft told investigators that handling a V_1 cut requires careful attention to the pitch attitude and the application of substantial aileron and rudder control force to maintain lateral and directional control. Tests conducted in a Brasilia flight simulator showed that maintaining control after the left power lever was moved to idle was difficult because of the control inputs required. “The pilot flying ... demonstrated that the only way to maintain sufficient aileron control was to place his left hand under the end of the left control yoke ‘ram’s horn’ to provide the additional leverage necessary for lateral control,” the report said. When aileron control force was relaxed, a rapid right roll occurred, and the roll continued despite application of full right rudder and reapplication of full right aileron, as occurred in the accident sequence.

“The sequence was repeated with the pilot not flying restoring power on the left engine just after the simulator commenced the uncontrollable left roll,” the report said. “The reintroduction of power at that point demonstrated that recovery to normal flight was possible in the simulator.”

Airnorth’s training and checking manual included the following statement regarding simulated engine failures: “Check pilots must continuously monitor the reaction of the trainee to the loss of power by keeping one hand guarding the control column, feet resting on the rudder pedals and thrust levers guarded throughout the exercise, and must be ready to oppose incorrect control inputs or to discontinue the exercise by restoring power.”

Dual Failures

Airnorth procedures complied with CASA guidelines for simulating engine failures in flight with the use of zero thrust. “The PIC had correctly demonstrated the simulation of engine failures during his training for check pilot approval,” the report said. “However, on the accident flight, he selected flight idle. This meant that, instead of a simulated engine

failure, the PIC had in fact simulated the failure of both the left engine and its propeller autofeather system.”

Simulating more than one system failure during a check flight is prohibited by CASA and Airnorth. Investigators were unable to determine whether the PIC’s selection of flight idle was deliberate or inadvertent. “It was possible that the PIC had decided to deviate from the operator’s approved procedure in order to test the recognition by the candidate of the additional failure of the autofeather system, before setting zero thrust — a technique that was reported to have been used by other training and checking pilots in the industry,” the report said.

When armed properly, the autofeather system automatically feathers the propeller — that is, positions the propeller blades to an angle producing minimum drag — when it senses that engine torque has dropped below about 24 percent in a Brasilia. With the system disengaged, the drag produced by the windmilling propeller decreased the aircraft’s performance and controllability. “The simultaneous failure of an engine and its propeller autofeather system has much greater consequences for aircraft handling than the failure of the engine alone,” the report said.

The situation worsened when the PF increased power from the right engine and engaged the yaw damper. A component of the aircraft’s automatic flight system, a yaw damper commands movements of the rudder to counteract excessive yawing caused by turbulence and to dampen lateral “Dutch roll” oscillations. “The operator’s flight operations manual for the EMB-120 stated that the yaw damper was not to be used for takeoff or landing, and that the minimum speed for its use during one-engine-inoperative flight was 120 kt,” the report said.

The cockpit voice recording indicated that the Brasilia’s heading was 20 degrees left of the runway centerline when the PIC said, “Heading, mate, disengage.” Shortly thereafter, the PF said, “Yeah, disengaging.” Investigators determined that the

The situation worsened when the PF increased power from the right engine and engaged the yaw damper.

CAUSALFACTORS

statements likely referred to an agreement between the pilots to disengage the yaw damper. However, this “would have required the pilot under check to take one hand off the flight controls at a time when both hands were needed to fly the aircraft,” the report said.

Strong Recommendation

In a September 2009 letter to Brasilia operators, Embraer had advised that single-engine training procedures should be initiated by moving a power lever to achieve 20 percent torque, the zero-thrust setting, and that the associated condition lever be left at maximum rpm. A note at the end of the letter said, “Nevertheless, Embraer strongly recommends that all EMB-120 training be performed in an EMB-120 simulator.”

The accident aircraft, VH-ANB, was one of 21 Brasilias registered in Australia. Although an EMB-120 simulator had been installed at a Melbourne-based

training facility more than a year before the accident, the instructor assigned to Airlorth had not completed requirements to conduct simulator training and check flights in the simulator. “At the time of the accident, the operator was about to transition all of its EMB-120 asymmetric training and checking to the simulator,” the report said. “The accident flight was to have been one of the last training and checking flights to have involved asymmetric flight in the actual aircraft.”

This article is based on ATSB Transport Safety Report AO-2010-019, “Loss of Control — Embraer S.A. EMB-120ER Brasilia, VH-ANB; Darwin Airport, Northern Territory; 22 March 2010.” The report and a computer animation based on the recorded flight data are available at <atsb.gov.au>.

Notes

1. The report did not specify the takeoff distance available from the intersection or the likely reasons the pilots did not back-taxi to the approach end of Runway 29.

A diagram in the *Darwin Airport Master Plan 2010* indicates that about half of the 3,354-m (11,004-ft) runway was available at the intersection.

2. The European Aviation Safety Agency and the U.S. Federal Aviation Administration define V_1 as “the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the maximum speed in the takeoff, following a failure of the critical engine at V_{EF} at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.” V_{EF} is the speed defined during performance certification at which the critical engine is assumed to fail during takeoff.
3. The *critical engine* is defined as “the engine whose failure would most adversely affect the performance or handling qualities of an aircraft.” The left engine on the Brasilia is the critical engine because its propeller produces less asymmetric thrust than the right-engine propeller in an engine-out situation.

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