

— Flight path of Embraer Legacy
— Flight path of Boeing 737

Manaus

✦ Accident site

Brasilia

São José dos Campos

BY MARK LACAGNINA

The airplanes converged nearly head-on, striking their left wings first. The business jet lost most of its left winglet and the tips of the left horizontal stabilizer and elevator, but it remained controllable and was landed without injury to the seven people aboard. The airliner initially lost about a third of its wing and then broke up during a spiral dive into the Amazon rain forest; all 148 passengers and six crewmembers were killed.

The 282-page final report by the Brazilian Aeronautical Accident Investigation and Prevention Center — the Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA) — concludes that loss of situational awareness by the Embraer Legacy 600 pilots and by the air traffic

Midair over the Amazon

Controversial Brazilian report cites loss of situational awareness by pilots and controllers.

Amazon



The Legacy pilots experienced control difficulties after the collision but were able to land the airplane. The 737 descended out of control after losing the outer portion of its left wing.

controllers handling the flights were among several factors that led to the business jet proceeding out of radar and radio contact — and with a nonfunctioning transponder and traffic alert and collision avoidance system (TCAS) — at a flight level that placed it in conflict with the Boeing 737-800.

The report's findings and conclusions have been questioned by organizations that include the U.S. National Transportation Safety Board (NTSB), a party to the investigation. NTSB said, for example, that although the report acknowledges air traffic control (ATC) safety deficiencies, it does not provide sufficient analysis of the deficiencies or include them in conclusions about the cause of the accident.

The collision occurred in visual meteorological conditions at Flight Level (FL) 370 (approximately 37,000 ft) the evening of Sept. 29, 2006. Both airplanes were nearly brand-new. The Legacy, N600XL, had been purchased by Excel-Aire Services, a U.S.-based charter and aircraft management company, and was en route from the Embraer factory at São José dos Campos to Fort Lauderdale, Florida, U.S., with an overnight technical stop at Manaus, Brazil. The 737, PR-GTD, had entered service with Gol Transportes Aéreos the month before the accident and was

on a scheduled flight from Manaus to Rio de Janeiro, with a technical stop at Brasília.

Partial Clearance

The report said that because of their haste to depart — to avoid flying over the Amazon at night — the Legacy flight crew did not have adequate knowledge of the flight plan that had been prepared for them by Embraer personnel. It also concluded that transmission of an incomplete departure clearance by the ground controller at the São José dos Campos airport “favored the understanding by the pilots that they had to maintain FL 370 all the way to Manaus.”

The Brasília Area Control Center (ACC) had given the ground controller a clearance that specified three flight levels: FL 370 on Airway UW2 to the Brasília VHF omnidirectional radio (VOR), FL 360 from the VOR to an intersection on Airway UZ6, and FL 380 thereafter. When the ground controller relayed the clearance to the Legacy pilots, he included only the initial flight level, saying, in part, “clearance to Eduardo Gomes [the Manaus airport], Flight Level three seven zero.”

“As a result, the pilots understood that FL 370 was cleared up to Manaus,” the report said. “In an interview ... the pilots of N600XL confirmed this understanding.”

The Legacy departed at 1751 coordinated universal time (1451 local time). The airplane was on Airway UW2, which has a centerline track of 006 degrees, and 52 nm (96 km) south of the VOR about one hour later when it was handed off by the Brasília ACC Sector 5 controller to the Sector 7 controller. The Sector 5 controller did not tell the Sector 7 controller or the pilots that a change from FL 370 to FL 360 was to be made before the airplane crossed the VOR and began navigating on the 335-degree centerline track of UZ6.

Noting that the Brasília VOR is well within Sector 5 airspace, NTSB said that the hand-off was made “unusually early” and that it was the Sector 5 controller’s responsibility to instruct the crew to descend to FL 360. “Alternatively, he should have either changed the data [shown on the ATC radar displays] to accurately reflect the

clearance [i.e., the assigned altitude] or advised the Sector 7 controller of the actual clearance.”

The report said that the Sector 7 controller assumed that the crew already had been instructed to descend to FL 360 even though the copilot reported that they were maintaining FL 370 when they established radio communication with him. After the controller told the crew that the airplane was in radar contact and the copilot acknowledged the information, there was no further communication between the crew and ATC until after the collision.

‘Bad System Design’

NTSB said that a change on the controller’s radar display when the airplane neared the VOR at 1855 likely contributed to the controller’s misunderstanding of the assigned flight level. The aircraft data blocks on Brazilian ATC radar displays show two flight levels, side by side and separated by a symbol. On the left is the Mode C flight level transmitted by the aircraft’s transponder; next to it is the “cleared flight level” that has been issued, and entered in the data block, by a controller. Normally, the symbol “=” appears between the two flight levels.

However, the cleared flight level automatically changes to the “requested flight level” about two minutes before the aircraft crosses a navigation fix at which a level change should be made. Thus, when the Legacy neared the Brasília VOR, the flight level information displayed in its data block changed from “370=370” to “370=360.” Nevertheless, the controller did not notice that the airplane was “flying at a flight level that was different from the flight level requested in the active flight plan,” the report said.

Noting that the report did not fault the flight level display itself, NTSB said that “a design in which two distinctly different pieces of information — that is, requested altitude and cleared altitude — appear identical on the display is clearly a latent error.” A similar opinion was expressed by the International Federation of Air Traffic Controllers’ Associations, which called the flight-level-display feature “non-error-tolerant ... and a bad system design” that was

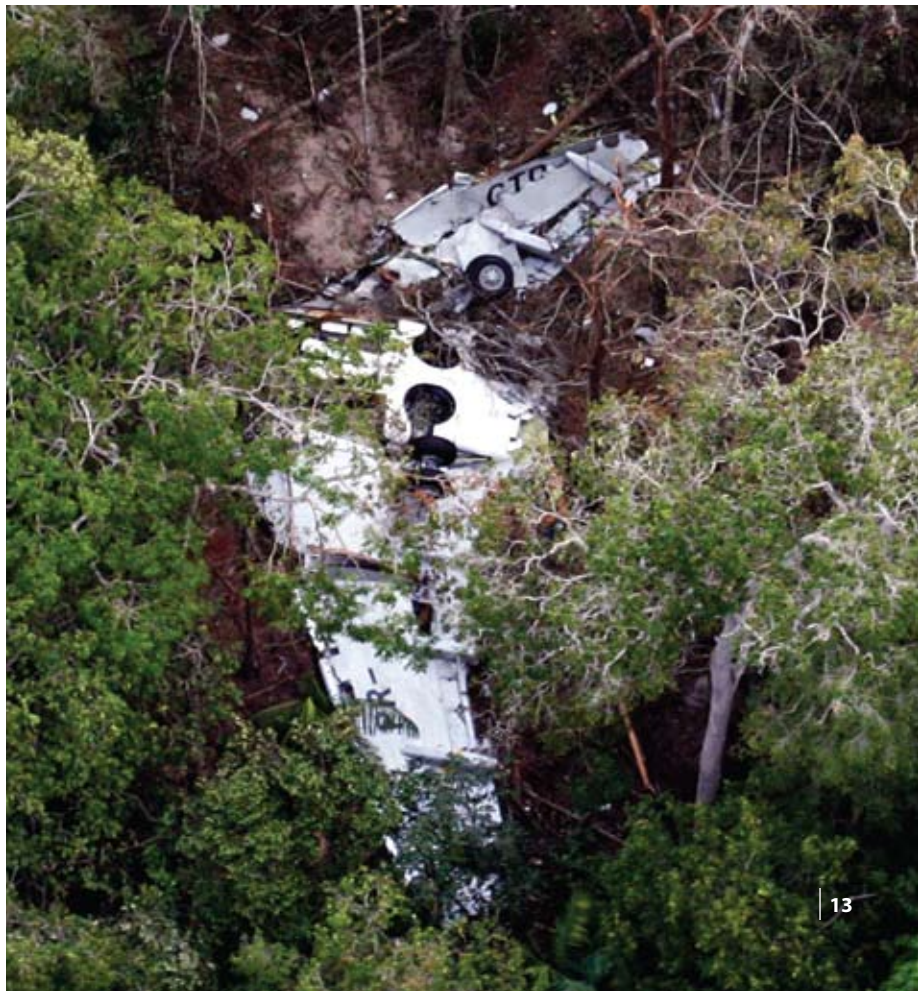
not adequately addressed by the report (see “Missed Opportunity,” p. 14).

Squawk Stopped

Seven minutes after the airplane crossed the VOR — its transponder stopped replying to ATC radar interrogations. The report said that neither the pilots nor the controller noticed this, and that cockpit voice recorder data indicated that the attention of both pilots was focused on conducting performance calculations for the landing and takeoff at Manaus. “With adequate planning, this task should have been finished on the ground before departure,” the report said, noting that the pilots had found after they were under way that the preflight paperwork assembled by Embraer included a notice to airmen about a reduction of the available runway length at the Manaus airport.

Investigators were unable to determine conclusively how the transponder had been switched to the standby mode, which requires pressing the transponder/TCAS button — one of 12 buttons on the sides of a radio management unit (RMU)

All 154 people aboard the 737 were killed when the airplane broke up during descent and crashed in the rain forest.



‘Missed Opportunity’

The final report on the midair collision failed to provide “clear conclusions” about known problems in the Brazilian air traffic control (ATC) system and how they contributed to the accident, said a position statement issued in January by the International Federation of Air Traffic Controllers’ Associations (IFATCA).

“Whereas the inquiries in regard to the events in the cockpit of the Legacy private jet seem to have received a lot of attention and were done with rather detailed care by CENIPA [the Brazilian Aeronautical Accident Investigation and Prevention Center], the same cannot be said for investigations on the ATC side,” said the federation, which represents more than 50,000 controllers in 130 countries.

For example, IFATCA noted a “non-error-tolerant” ATC software feature that occasionally changes the flight level shown on the controller’s radar display, with no input by the controller. The federation called this a “bad

system design” that created a trap for the pilots and controllers involved in the collision. The accident report discusses this feature but includes no recommendation about it.

“IFATCA thinks the identified shortcomings in the CENIPA report are a missed opportunity for the Brazilian aviation authorities to restore trust and safety in the national aviation system. This final accident report could have served as the starting point for an extensive and desperately needed healing process. ... This has unfortunately not occurred, as CENIPA — an integral part of the same Brazilian Air Force that is responsible for the provision of air traffic control — has chosen to put the main responsibility for the midair collision of 2006 on the front-line operator only. This CENIPA decision appears driven by a reluctance to expose staff and departments situated in its own organization.”

— ML

the flight level display in the data block would have changed from “370=360” to “370Z360,” to indicate that the airplane was being tracked by primary radar with an altitude sweep. This system is intended to be used only for military aircraft in emergency or air-defense situations. However, the “Z” also is automatically displayed when a civil aircraft stops replying to radar interrogations.

“Although the system presented the prescribed indications for the loss of the N600XL transponder, they did not draw the attention of the controller to the need for changing the flight level,” the report said. It also said that during the 57 minutes preceding the collision, the Legacy pilots failed to notice a transponder “STANDBY” indication on the RMUs and a “TCAS OFF” indication on the primary flight displays.

At 1926 — 34 minutes after the last radio communication — the Sector 7 relief controller made the first of seven calls to the Legacy, which had by then flown beyond the area covered by the last assigned radio frequency. The controller’s calls were made simultaneously on six radio frequencies. However, NTSB said that he “never attempted to try a relay through other flight crews, the emergency frequency or any other means to treat the flight under lost-communication procedures.” The board said that the controller also failed to inform the Amazonic ACC, which was handling the 737, about the loss of radio and radar contact with the Legacy.

At 1948, the copilot began using the five Sector 7 frequencies shown on his navigation chart in an attempt to re-establish radio communication with ATC; he made 19 calls. However, only one of the frequencies shown on the chart actually was usable. Two of the frequencies had not been selected at the controller’s console, one was erroneous,

— twice within 20 seconds. The report said that the most likely explanation is that the pilot inadvertently switched the transponder to standby while using other RMU features for the performance calculations.

Among other possibilities considered was that a laptop computer accidentally struck the transponder/TCAS button on one of the RMUs when it was passed between the pilots. However, it was determined that the control yoke would have prevented this.

Another possibility is that the button was accidentally struck when the pilot placed a foot on the footrest at the bottom of the panel. However, “the footrest has a metal plate, called a foot protector, designed to keep the foot

away from delicate instruments which could be damaged if contacted inadvertently,” the report said.

NTSB said that misuse of the footrest is another possibility. “In certain forward seat positions, there appeared [during observation flights] to be a very comfortable resting position that involved resting the feet on top of the footrest guards rather than inside the designated footrest areas,” the board said. “This ... located the captain’s right foot in the area of the RMU so it could make unintended contact without the captain’s awareness.”

Warnings Undetected

While briefing his relief controller at 1918, the Sector 7 controller said that the Legacy was maintaining FL 360. At this point,

and one had not been “connected” to the center’s audio equipment, the report said.

The copilot heard part of the controller’s last transmission at 1956. He requested that the controller repeat the message, but his call was not heard. The collision occurred one second later.

The Legacy rolled left and began to descend, but the crew was able to regain control. They used the emergency frequency, 121.5 MHz, to relay a message to Amazonic ACC through the crew of a Polar Air Cargo aircraft that they were declaring an emergency because of flight control difficulties and would conduct an emergency landing at the military airport in Cachimbo, about 100 nm (185 km) ahead.

“After landing, the N600XL crew reported that their airplane had collided in flight with an unknown object,” the report said. “The wreckage of the [737] was found the next day ... in a region of

thick forest in the county of Peixoto de Azevedo, Mato Grosso State.”

Misplaced Blame?

Among the report’s conclusions was that the Legacy crew had not been trained adequately and had not prepared properly for the delivery flight, and that their limited experience with the airplane and its avionics equipment was a likely factor in the inadvertent deactivation of the transponder and TCAS.

NTSB said that the facts do not support these conclusions. “The crew flew the route precisely as cleared and complied with all ATC instructions,” it said. “Although the transponder outage was likely because of an inadvertent action, no evidence in the factual record indicates that a lack of familiarity with the avionics is related to the outage.”

The pilot, 42, had 9,388 flight hours, including 5.5 hours in the Legacy. The

copilot, 34, had 6,400 flight hours, including 3.5 hours in type and nearly 400 flight hours as pilot-in-command of Embraer regional jets, which are similar to the Legacy.

The report also concluded that the pilots were distracted by the performance calculations and lost situational awareness. “Although they were maintaining the last flight level authorized by [ATC], they spent almost an hour flying at a nonstandard flight level for the heading being flown and did not ask for any confirmation from ATC,” it said.

The controllers were faulted for failing to provide proper traffic separation. “The air traffic control units involved ... did not correct the flight level and did not perform the prescribed procedures for altitude verification when they stopped receiving essential information from [the Legacy’s] transponder,” the report said. “The controllers assumed that the traffic was at a different flight level without even being in two-way radio contact with N600XL for confirmation.”

NTSB said that its analysis of the facts led to the conclusion that the probable causes of the accident were “ATC clearances which directed [the pilots of both airplanes] to operate in opposite directions on the same airway at the same altitude. ... The loss of effective air traffic control [resulted from] a combination of numerous individual and institutional ATC factors which reflected systemic shortcomings.”

A separate investigation was conducted by the Brazilian Federal Police and resulted in criminal charges against the Legacy pilots and several of the controllers (see “Investigation Turns Criminal,” p. 16). 🌐

This article is based on Final Report A-00X/CENIPA/2008, available online at <<http://ntsb.gov/Aviation/Brazil-CENIPA.htm>>.

Brazilian investigators considered the possibility that the Legacy’s transponder might have been deactivated when the captain’s foot, when placed on the footrest shown by the arrow, inadvertently touched the radio management unit above and to the right of the footrest.

