U.S. National Oceanic & Atmospheric Administration (NOAA)

CFIT in Queensland

Metro pilots lost the big picture during a difficult approach.

BY MARK LACAGNINA

An experienced pilot with a history of noncompliance with standard operating procedures (SOPs), an inexperienced and nonassertive copilot, excessive airspeeds and descent rates during a nonprecision approach in bad weather, and the operator's disregard of its own rules and training standards were found to have played roles in the May 7, 2005, crash of a Fairchild Metro 23 in Queensland, Australia.

In its final report, the Australian Transport Safety Bureau (ATSB) said, "The accident was almost certainly the result of controlled flight into terrain [CFIT] — that is, an airworthy aircraft under the control of the flight crew was flown unintentionally into terrain, probably with no prior awareness by the crew of the aircraft's proximity to terrain." Both pilots and all 13 passengers were killed in the accident, which occurred near Lockhart River.

The Metro 23 and eight other aircraft were operated by Transair from its main base in Brisbane and ancillary bases in Cairns, Grafton and Inverell.[1] The company employed 21 full-time pilots.

The morning of the accident, the flight crew had flown the Metro from Cairns to Lockhart River and Bamaga. The accident occurred on the return trip to Cairns, on the leg from Bamaga to Lockhart River (Figure 1).

Accident Flight Route

Source: Australian Transport Safety Bureau

Figure 1

Exceeding the Limits

The pilot-in-command (PIC), 40, held an airline transport pilot license and had 6,072 flight hours, including 3,249 flight hours in Metros. He was employed by Transair as a line pilot in March 2001, promoted to supervisory pilot in September 2002 and to Cairns base manager in August 2003.

The report said that there were no records indicating that the PIC had received training on crew resource management (CRM), as required by the *Transair Operations Manual*.

The PIC had a history of noncompliance with SOPs. A previous employer had placed him on probation for not following company procedures. Flight data recorder (FDR) data from the accident aircraft indicated that descent rates and airspeeds had exceeded those specified by Transair's SOPs during two previous instrument approaches conducted by the PIC. Several Transair copilots had expressed concern to a supervisory pilot that the PIC did not follow company procedures, including airspeed limits. One copilot said that the PIC would slow down only if asked to do so by a copilot he respected. Another copilot said that he had to be assertive to prevent the PIC from descending below the minimum sector altitude.

"The chief pilot [of Transair] reported that he could not recall ever receiving any specific

Fairchild SA-227DC Metro 23

@ Craig Murray/Airliners.net

Designer Edward J. Swearingen's Merlin corporate/business aircraft first flew in 1965 with Pratt & Whitney Canada PT6A-20 engines. All subsequent versions of the Merlin and its longer-fuselage, 19-passenger regional airline derivative, the Metro, have had Garrett, now Honeywell, TPE331 engines.

The original SA-226TC Metro was introduced in 1969 and was replaced in 1974 by the Metro II, which has larger windows and improved systems. The SA-227AC Metro III, introduced in 1981, has longer wings, a higher useful load and more powerful engines. Maximum takeoff weight was increased from 14,500 lb (6,577 kg) to 16,500 lb (7,484 kg) with the introduction of the more powerful SA-227DC Metro 23 in 1990.

The Merlin/Metro series was produced by Swearingen Aircraft Co., Fairchild Aircraft Corp. and Fairchild Dornier. Production was terminated in 1999.

Source: *Jane's All the World's Aircraft*

complaints about the operational performance of the PIC," the report said. The chief pilot was the managing director of Transair and also served as training director and as one of the company's two check pilots.

The copilot, 21, held a commercial pilot license and had 655 flight hours, including 150 flight hours in Metros. He had no experience in turbine aircraft or multi-pilot operations before being employed by Transair in March 2005. "A family member reported that the copilot was given a training manual to study and was not provided with any formal classroom training during his ground school," the report said. His records indicated that he had passed aircraft ground training despite earning a score of 77 percent on a test of aircraft systems and operating limitations; the company operations manual required a minimum score of 80 percent. The copilot also was not checked by a check pilot, as required by the manual, before he began line operations.

"Pilots who flew with the copilot reported that he was keen to learn," the report said. "The copilot's flying ability and systems knowledge were generally reported as being consistent with his flying experience." The copilot also was described by colleagues as quiet, shy and nonassertive.

The PIC and copilot previously had flown together on 10 days, completing 27 flight sectors. The copilot had told other Transair pilots that the PIC was difficult and authoritarian, and that he did not provide effective instruction and did not comply with SOPs.

Bad Weather

Before departing from Bamaga at 1107 local time, the PIC told a ground agent that the weather was bad at Lockhart River and that they might not be able to land there.

The forecast winds were from 130 degrees at 15 kt, gusting to 25 kt. The crew elected to conduct the area navigation/global navigation satellite system (RNAV/GNSS) approach to Runway 12, which had a minimum descent altitude (MDA) of 1,040 ft — or 120 ft lower than the MDAs for the RNAV/GNSS approach to Runway 30 and the nondirectional beacon (NDB) approach.

The airport did not have a control tower. The automatic weather station at the airport recorded only wind direction and velocity, temperature and rainfall data. A meteorological observer performed observations three times a day but did not have the capability to communicate directly with pilots. The observation performed at 1200 the day of the accident did not include information on visibility or cloud bases.

The report said that Australian Bureau of Meteorology estimates indicated that "the cloud base was probably between 500 ft and 1,000 ft above mean sea level, and the terrain to the west of the aerodrome, beneath the Runway 12 RNAV/GNSS approach, was probably obscured by cloud."

The PIC likely was the pilot flying because recorded radio transmissions were made by the copilot. There was no record of communication between the pilots because the cockpit voice recorder (CVR) had malfunctioned and provided no usable data for the last 30 minutes of the flight.

The copilot had an endorsement on his instrument rating to conduct NDB approaches, but he was not endorsed for RNAV/GNSS approaches. There was no record that he had received company-required training on the use of global positioning system (GPS) equipment as the sole source of navigation information.

"The crew commenced the … RNAV/GNSS approach, even though they were aware that the copilot did not have the appropriate endorsement and had limited experience to conduct this type of instrument approach," the report said.

Complex Procedure

The approach procedure was relatively complex, and the crew's workload during the approach likely was very high (*ASW*, 2/07, p. 46). The aircraft was not equipped with an autopilot.

"There was a significant potential for [CRM] problems within the crew in high-workload situations, given that there was a steep trans-cockpit authority gradient and neither pilot had previously demonstrated a high level of CRM skills," the report said. "A steep gradient between a dominant PIC and a submissive copilot may result in the PIC not listening to the concerns of the copilot and/or the copilot being less willing to communicate important information to the PIC."

The report also said that the copilot's lack of training and experience in conducting RNAV/GNSS approaches might have made it difficult for him to detect deviations during the approach.

At 1139, the copilot announced on the airport's common traffic advisory frequency (CTAF) that the Metro was over "Whiskey Golf" — the LHRWG waypoint, an initial approach fix — and was inbound to "Whiskey India" — LHRWI, the intermediate fix, which was 12.5 nm from the runway threshold (Figure 2).

Unstabilized Approach

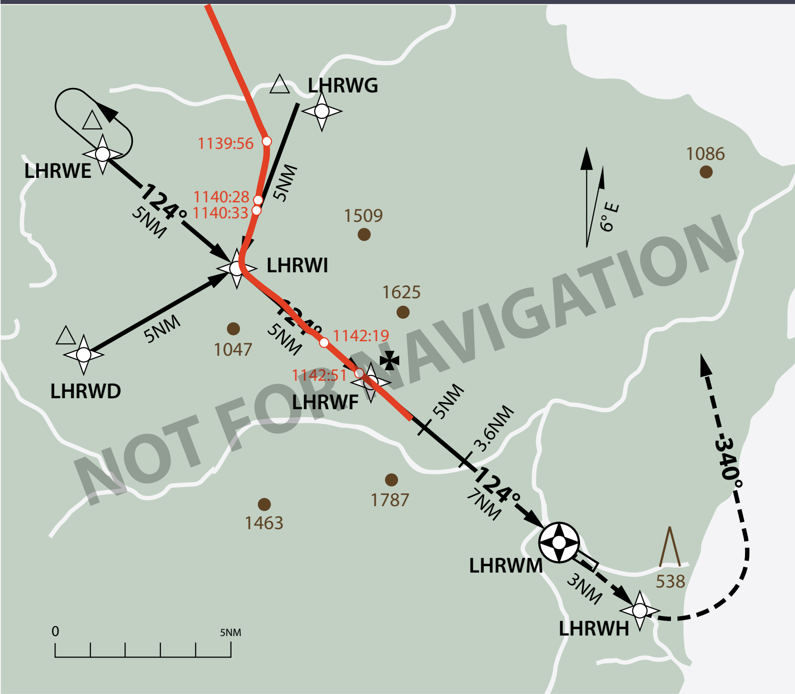
FDR data indicated that the aircraft accurately tracked the final approach course. However, airspeeds and descent rates exceeded those specified in the *Transair Operations Manual* and those appropriate for a stabilized approach, the report said. The company operations manual did not provide specific guidance for conducting a stabilized approach.

The report cited the elements of a stabilized approach recommended by Flight Safety Foundation that include a maximum speed of V_{REF}, landing reference speed, plus 20 kt and a maximum descent rate of 1,000 fpm.[2]

An appropriate approach airspeed for the Metro under the existing conditions would have been about 130 kt. FDR data indicated that airspeed was about 226 kt when the aircraft crossed the initial approach fix and about 176 kt as it crossed the intermediate fix.

The aircraft then descended from 3,500 ft to 3,000 ft and remained at that altitude momentarily (Figure 3, p. 32). "During this level flight,

Approach Track



Source: Australian Transport Safety Bureau

Figure 2

the aircraft's speed reduced to the maximum half-flap extension speed (180 kt) and the flaps were extended [to half of their travel]," the report said. "The aircraft did not descend below the segment minimum safe altitude (2,200 ft) during this initial descent and leveling."

Soon after the landing gear was extended, about 1.4 nm from the final approach fix, the aircraft began to descend at 1,000 fpm. Airspeed was about 177 kt when the aircraft crossed the final approach fix. Power then was reduced, and the descent rate increased. Airspeed remained about 175 kt and the average descent rate was 1,700 fpm during the last 48 seconds of the flight. The aircraft descended below 2,060 ft, the published minimum altitude for the approach segment, soon after crossing the final approach fix.

"The higher-than-specified speeds and rates of descent reduced the amount of time available to the crew to configure the aircraft for the approach, accomplish the approach procedures and maintain their awareness of their position on the approach," the report said.

Turbulence was encountered during the last 25 seconds of the flight, which further increased the crew's workload. The report said, however, that there was no indication that the aircraft encountered wind shear.

Two GPWS Alerts

The crew likely received two ground-proximity warning system (GPWS) "TERRAIN, TERRAIN" alerts. Postaccident simulations of the aircraft's flight path indicated that the first alert would have occurred about 25 seconds before impact. The second alert would have been followed by continuous "PULL UP" warnings for the final five seconds of the flight. FDR data indicate that the crew did not respond to either alert.

However, the simulations also indicated that a GPWS "TERRAIN, TERRAIN" alert could result during a normal descent on final approach in aircraft with flaps in the approach configuration, even if the aircraft was established on the constant descent angle and/or above the segment minimum safety altitude. The report said that GPWS alerts that occur during normal operations increase the chances that pilots will ignore them in other situations.

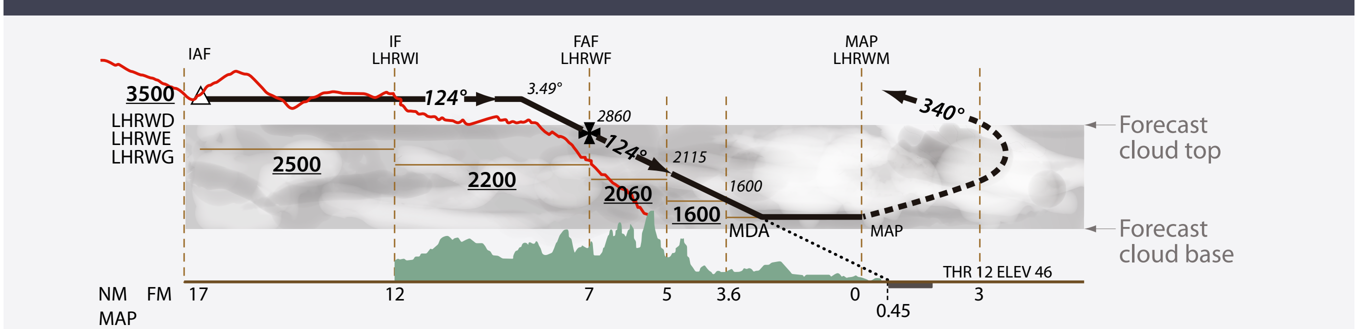
The second GPWS alert came too late. "There would have been insufficient time for the crew to effectively respond to the GPWS alert and warnings that were probably annunciated during the final five seconds prior to impact," the report said.

The accident likely would not have occurred if the aircraft had been equipped with a terrain awareness and warning system (TAWS), which provides predictive terrain-hazard warnings, the report said.

At 1143, the aircraft struck trees at 1,210 ft — about 90 ft below the crest of the northwest slope of South Pap, a heavily timbered ridge in the Iron Range National Park — about 11 km (6 nm) northwest of the airport. This high terrain was not depicted on the approach chart (see sidebar, p. 33). Initial impact occurred 850 ft below the published minimum altitude for the approach segment. "The aircraft was destroyed by the impact forces and an intense, fuel-fed, post-impact fire," the report said.

Investigators found no indication in the FDR data that a flight control or power plant problem occurred before impact. "There were no radio transmissions made by the crew on the air traffic services frequencies or the Lockhart River CTAF indicating that there was a problem with the aircraft or crew," the report said.

Approach Profile



ELEV = elevation FAF = final approach fix FM = from IAF = initial approach fix IF = intermediate fix MAP = missed approach point
MDA = minimum descent altitude NM = nautical miles THR = runway threshold

Source: Australian Transport Safety Bureau

Figure 3

Chart Safety Factors

"Safety factors" related to the design and charting of area navigation/global navigation satellite system (RNAV/GNSS) approach procedures were identified by the Australian Transport Safety Bureau (ATSB) in its final report on the Transair Metro 23 accident.[1] The report cited the importance of communicating these factors, even though they were not found to have contributed to the accident.

Among the cited safety factors was the unique method used by Airservices Australia to name waypoints. The report said that the similar, unpronounceable five-letter names cause chart clutter and make it difficult for pilots to distinguish waypoints shown on charts or displayed by on-board global positioning system (GPS) equipment.

"There was also no regulatory requirement for instrument approach charts … to include colored contours to depict terrain, as required by International Civil Aviation Organization (ICAO) Annex 4, to which Australia had not notified a difference," the report said.

The Transair flight crew likely used Jeppesen charts, rather than Airservices Australia charts, during the accident flight. The report said that the Jeppesen chart for the RNAV/GNSS approach to Runway 12 at Lockhart River had several design aspects that "could lead to pilot confusion or a reduction in situational awareness." Examples included limited information on distance to the missed approach point (MAP), nonalignment of information on the plan view and profile view, the typography used for waypoint names and minimum segment altitudes, and the absence of information on the offset, in degrees, between the final approach course and the runway centerline.

As of 2005, more than 350 RNAV/GNSS approach procedures had been designed by Airservices Australia and approved by the Australian Civil Aviation Safety Authority (CASA) based on ICAO criteria.

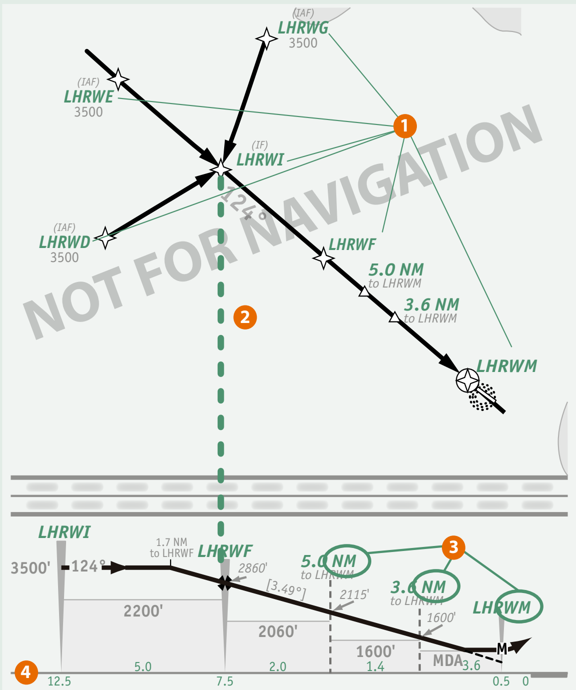
The five-letter waypoints for these procedures are shown on charts in uppercase. The first three letters identify the airport, the fourth indicates the general direction from which the aircraft travels on final approach, and the fifth is a standard letter that identifies the purpose of the fix — for example, "I" for intermediate fix, "F" for final approach fix and "M" for missed approach point (*ASW*, 2/07, p. 47). Thus, the only variation in the waypoint names for a specific approach is the last letter.

"Research has shown that people can automatically (that is, instantly) identify a number among letters, but when identifying a letter among other letters, identification is slower," the report said. "Research also has shown that when searching for a letter in three-letter or five-letter sequences, the time taken to detect the letter increases the further its position is moved from the first letter."

The information alignment factor on the Jeppesen chart resulted from the absence in the profile view of the initial approach fixes — LHRWD, LHRWE and LHRWG. The first waypoint in the profile view is the intermediate fix, LHRWI. This caused LHRWI in the plan view to be aligned vertically with LHRWF in the profile view. The report said that this can cause a pilot to become confused when scanning the chart.

Another factor specific to the Jeppesen chart is the use of the same typeface and type size for waypoints and the stepdown fixes — 5.0 NM and 3.6 NM — on the final approach segment. The report said that this results in similar appearance of the letter "M" in the stepdown fixes and in LHRWM, and could lead to misidentification of the MAP in high-workload situations.

In addition, the stepdown fixes on the Jeppesen chart are the only specific



1. Similarity of waypoint names may make them more difficult to differentiate.
2. The vertical alignment of two different waypoints may cause confusion.
3. Labels end with the same letter and use the same typeface and size for different information.
4. The lower set of numbers shows the distances to the runway, but not to the missed approach point. The upper set of numbers shows the distance for each segment to the missed approach point, but not the distances from a waypoint to the missed approach point.

Source: Australian Transport Safety Bureau indications of distance to the MAP. The scale at the bottom of the profile view shows distances to the runway threshold. The scale below the profile view on the Airservices Australia chart, on the other hand, shows distances to the MAP.

Because of terrain northwest of the airport, the approach procedure is relatively complex. The final approach course is offset five degrees from the runway centerline because of a mountain northwest of the airport — the 1,787-ft obstacle spot elevation depicted on the plan view (Figure 2, p. 31). The constant descent angle is 3.49 degrees, rather than the optimal 3 degrees. The distance from the final approach fix to the MAP is 7 nm, rather than the optimal 5 nm. The stepdown fixes for the final approach also resulted from terrain considerations. The report said that these factors add to pilot workload and increase the chances for position confusion.

Neither the Airservices Australia chart nor the Jeppesen chart depicts terrain with color contours, as required by ICAO under specific conditions, such as when the final approach gradient is steeper than 3 degrees. The report said that the charts provide no indication of the existence of high terrain under the approach path, such as the ridge struck by the Metro.

ATSB recommended that these safety factors be considered when designing and approving RNAV/GNSS approaches. "There are limited options available to overcome these design problems," the report said. "However, the overall influence that these variations can have needs to be considered by CASA when evaluating and deciding whether to accept the approach."

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Note

1. The Australian Transport Safety Bureau defines safety factor as "an event or condition that increases safety risk" and one that, if repeated, "would increase the likelihood of an occurrence [accident or incident] and/or the severity of the adverse consequences associated with an occurrence."

Deficiencies Uncovered

The report said that factors contributing to the accident included limitations in Transair's safety policies and procedures, and deficiencies in regulatory oversight of the company.

"In particular, [Transair's] flight crew training program had significant limitations, such as superficial or incomplete ground-based instruction during endorsement training, no formal training for new pilots in the operational use of [GPS] equipment, no structured training on minimizing the risk of CFIT and no structured training in CRM (or human factors management) and operating effectively in a multicrew environment," the report said.

The company's SOPs lacked clear guidance on approach speeds, aircraft configuration, elements of a stabilized approach and standard phraseology for challenging another crewmember's decisions and actions.

ATSB made no recommendations regarding Transair, because the company surrendered its air operator certificate and ceased operations in December 2006.

ATSB did, however, recommend improvements to government surveillance of regular public transport operators. The report said that the Australian Civil Aviation Safety Authority (CASA) "did not provide sufficient guidance to its inspectors to enable them to effectively and consistently evaluate several key aspects of [Transair's] management systems. These aspects included evaluating organizational structure and staff resources, evaluating the suitability of key personnel, evaluating organizational change and evaluating risk management processes."

In November 2006, CASA told ATSB that it was recruiting personnel with management and safety management expertise to improve its surveillance of operators. In March 2007, CASA said that it "has [provided] and continues to provide substantial guidance material in all aspects of surveillance." ATSB responded that it still believed that the guidance provided to inspectors "was and is inadequate" and recommended "further work to address this safety issue."

The report noted that CASA was taking action to address other recommendations, including the implementation of regulations requiring regular public transport operators to provide CRM training and to have a safety management system.●

This article is based on Australian Transport Safety Bureau Transport Safety Investigation Report 200501977, "Collision With Terrain, 11 km NW Lockhart River Aerodrome, 7 May 2005, VH-TFU, SA227-DC (Metro 23)." The 532-page report contains illustrations and appendixes.

Notes

1. "Transair" was the trading name for Lessbrook Proprietary Limited, which operated the accident aircraft under its air operator certificate.

2. Flight Safety Foundation (FSF). "Killers in Aviation: FSF Task Force Presents Facts About Approach-and-Landing and Controlled-Flight-Into-Terrain Accidents." *Flight Safety Digest* Volume 17 (November–December 1998) and Volume 18 (January–February 1999).