Australian Government
Australian Transport Safety Bureau

Publication Date: June 2009 ISBN 978-1-921602-81-8

ATSB TRANSPORT SAFETY REPORT
Aviation Safety Issue Investigation AI-2007-010
Final

Ground proximity warning events on the Lockhart River Runway 12 RNAV (GNSS) non-precision approach

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
Australia
1800 020 616
www.atsb.gov.au

INFRA-08557

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Abstract

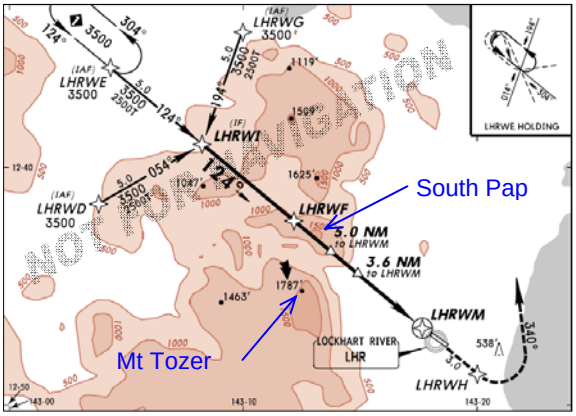
During the Australian Transport Safety Bureau investigation into the accident at Lockhart River, Qld on 7 May 2005, involving the Metro 23 aircraft registered VH-TFU, it was established that it was possible to receive ground proximity warning system (GPWS) warnings while conducting the Runway 12 RNAV (GNSS) non-precision approach, even when the aircraft was on the correct profile and track. After several reports of crews receiving such warnings, an investigation into the potential safety implications of these 'nuisance' warnings' was commenced. It was found that nuisance warnings could condition flight crews to ignore the warnings in order to complete the approach procedure, rendering the warning system ineffective in preventing controlled flight into terrain.

The safety issue identified as a result of this investigation related to the generation of 'nuisance' GPWS warnings while conducting the Runway 12 RNAV (GNSS) non-precision approach at Lockhart River. Airservices Australia have commenced designing a revised approach using new approach design criteria, and the Civil Aviation Safety Authority has undertaken to flight validate the revised approach when available.

Safety issue

The Lockhart River Runway 12 area navigation global navigation satellite system (RNAV (GNSS)) non-precision approach procedure tracked aircraft directly over the 'South Pap' ridge line approximately 5.3 NM (9.8 km) from the missed approach waypoint, LHRWM (Figure 1). In aircraft equipped with a ground proximity warning system (GPWS) and particular terrain awareness and warning systems (TAWS)[1], this can result in nuisance alerts and warnings. Those nuisance alerts and warnings could condition crews to ignore them in order to complete the approach procedure, rendering the warning device ineffective in preventing controlled flight into terrain (CFIT).

Figure 1: Lockhart River Runway 12 RNAV (GNSS) non-precision approach procedure with terrain contours



Source: Jeppesen Sanderson, Inc

Background

On 7 May 2005, a Fairchild Aircraft Inc. SA227-DC Metro 23 aircraft, registered VH-TFU, impacted terrain during the Runway 12 RNAV (GNSS) non-precision approach to Lockhart River, Qld, fatally injuring all 15 occupants. The Australian Transport Safety Bureau (ATSB) investigation (ATSB

1 See page 3 for an explanation of ground proximity warning systems and terrain awareness and warning systems

occurrence 200501977) into the accident found that, although it was on the published approach track, the aircraft had descended below the prescribed descent profile. The ATSB investigation determined that the accident was almost certainly the result of a 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 their proximity to terrain.

During that investigation, the manufacturer of the GPWS that was installed in VH-TFU, carried out a series of computer simulations. Those simulations predicted that the GPWS equipment should have provided approximately 5 seconds warning before the aircraft impacted terrain at South Pap. There was no indication that the aircraft's rate of descent was corrected prior to impacting the ridge. The investigation found that it was probable that the crew either did not perceive the GPWS warning, or did not respond to the warning.

The GPWS simulations also predicted that the equipment should produce 'excessive closure rate to terrain' ground proximity warnings during an approach that was accurately following the published approach (both step-down and constant angle descent profiles)[2].

Since that accident, the ATSB has received several flight crew reports regarding the activation of GPWS (and TAWS) at about 5 NM (9.3 km) from the Lockhart River runway 12 RNAV (GNSS) approach missed approach point (LHRWM). The position described in those reports was the approximate location of the accident involving VH-TFU.

ATSB Occurrence No: 200502286

On 10 May 2005, the ATSB received a report from an operator stating that:

> We cannot conduct the Lockhart River Runway 12 RNAV approach without the GPWS (Ground Proximity Warning System) announcing 'Terrain Terrain Pull Up Pull Up'. This happens in both our Hawker 800XP and Kingair 350. The occurrence is always just after passing LHRWF [the final approach fix] inbound.

The operator also reported that, in all instances, the aircraft was on the constant angle approach path and, in most cases, with the autopilot coupled to the flight management system.

ATSB Occurrence No: 200703363

On 29 May 2007, the crew of a Beechcraft B300 Super Kingair reported that a Lockhart River Runway 12 RNAV (GNSS) non-precision approach was being conducted, via the LHRWD waypoint, in instrument meteorological conditions (IMC), with the flight management system coupled to the autopilot:

> At a point 5nm from the MAPT [LHRWM] the Enhanced Ground Proximity and Warning System (EGPWS)[3] gave aural and visual alerts of 'Terrain Terrain Pull Up Pull Up' which lasted for 1 cycle of approximately 3 seconds. No amber or red terrain indications appeared on the EGPWS display. At the time of the warning, the airspeed was 130 KIAS and a rate of decent of 700 fpm in IMC at an altitude of 2150 ft. The RADALT indicated approximately 1600 ft just prior to the event and decreased to 1000 ft during the event.

The crew responded to the alert, established a positive rate of climb and conducted a missed approach. The crew then made a second attempt via the LHRWG entry waypoint and reported:

> During the second approach, in the same configuration and, at the same position as the first approach, the same alerts were produced by the EGPWS.
>
> The terrain map showed only blue and green terrain and the aircraft was again accurately on both azimuth and glide path. The flying pilot noted the RADALT height reduce from 1600' to 1000' over a period of less than 1 second before returning to 1600'. The alert continued for 1 cycle before ceasing. The aircraft was confirmed on FMS glide path and a decision to continue was made...

The approach continued normally and the aircraft landed safely after the crew made visual contact

2 ATSB Transport Safety Investigation Report 200501977, *Collision with Terrain 11 km NW Lockhart River Aerodrome, 7 May 2005, VH-TFU,* Australian Transport Safety Bureau, page 68 and Appendix F.

3 EGPWS is a proprietary name for the TAWS system produced by Honeywell.

before the minimum descent altitude was attained.

Ground proximity warning systems and terrain awareness and warning systems

Ground proximity warning systems were designed to prevent CFIT accidents[4]. The GPWS monitors the height of the aircraft above the terrain immediately below it and provides warnings under a range of potentially hazardous flight conditions. The system was not designed to be used for navigation, but to provide a 'last-ditch'[5] warning to crews about the hazardous situation.

Terrain awareness and warning systems were designed as an enhanced form of GPWS, by utilising global positioning system (GPS) and terrain database technologies. By comparing the aircraft position and projected flight path, the TAWS computer can predict possible terrain conflicts and provide flight crews with a graphical terrain hazard depiction and warnings when required. TAWS can increase the warning time provided to a crew by 'looking forward', rather than just straight down as in the case of a GPWS.

Nuisance warnings

Nuisance warnings are those that are produced by a terrain warning system that is capable of normal operation but that, due to a combination of operational procedures and terrain features (particularly rapidly-rising terrain under an approach track), produces a warning when the aircraft is not actually at risk of conflict with terrain.

Potential effect of nuisance warnings

There has been extensive research into the effect of nuisance warnings in the general industrial and aviation fields; of particular note, the role in genuine warnings being ignored. Professor James Reason stated: 'Frequent false alarms[6] cause people to lose trust, and to ignore or disbelieve warnings when they signal genuine emergencies.'[7]

With particular reference to GPWS warnings and air traffic control procedures, Captain Daniel Maurino[8] stated: [9]

> An example of violation-producing conditions are those air traffic control procedures which generate nuisance GPWS warnings. Unless revised, they force crews to ignore warnings, thereby generating violations to operational orders to fulfil such procedures.

These violation-producing conditions apply equally to published approach procedures outside controlled airspace.

Nuisance warning reduction

The design standards for both GPWS and TAWS required manufacturers to minimise the incidence of nuisance warnings when an aircraft purposely comes close to terrain during the final approach sequence for landing. For example, when the flaps are in the landing position (normally fully extended), it is assumed that the aircraft is on the final approach. In that case, the GPWS/TAWS system changes from mode 2A to mode 2B, reducing the warning criteria to prevent nuisance warnings. That functionality was included in both GPWS and TAWS Class A (TAWS-A) systems.

Lockhart River runway 12 RNAV (GNSS) approach design

The Lockhart River Runway 12 RNAV (GNSS) non-precision approach was designed by Airservices Australia and flight validated by CASA in 1999,

4 In the period 1987 to 2005, 24% of the fatal accidents involving the world-wide commercial jet fleet were attributed to CFIT.

5 Robert O. Phillips, *Investigation of Controlled Flight into Terrain – Descriptions of Flight Paths for Selected Controlled Flight into Terrain (CFIT) Aircraft Accidents, 1985-1997*, page 2, Project Memorandum DOT-TSC-FA9D1-99-01, US Federal Aviation Administration, March 1999.

6 False alarms include nuisance alerts and those produced by system faults.

7 James Reason, *Managing the Risks of Organisational Accidents*, 1997, Page 56. Ashgate Publishing Ltd.

8 Secretary, Flight Safety and Human Factors Study Group, International Civil Aviation Organisation (ICAO).

9 International Civil Aviation Organization, Flight Safety Foundation and US Federal Aviation Administration, *Controlled Flight Into Terrain, Education and Training Aid,* Volume 2, section 5.2 'Human Factors and Training Issues in CFIT Accidents and Incidents'. Retrieved from http://www.faa.gov/education_research/training/media/cfit/volume2/pdf/pages/page5_04.pdf on 31 March 2008.

based upon the International Civil Aviation Organization (ICAO) Document No 8168 *Procedures for Air Navigation Services – Aircraft Operations* (PANS-OPS), Vol. 2, Ed 4.

To meet the obstacle clearance requirements of PANS-OPS, the approach was designed with a 5° offset from the runway centreline. This gave the required clearances from Mt Tozer (1,787 ft feature to the south of South Pap in Figure 1), but placed the approach path directly overhead South Pap.

The approach design and flight validation that was carried out prior to the approval of the offset approach, were not required by the PANS-OPS design/approval criteria for non-precision approaches to take into consideration the possibility of GPWS warnings and alerts. The aircraft used for the relevant approach validation flight was not GPWS or TAWS equipped.

On 31 October 2008, ICAO released amendments to PANS-OPS that included changes to the determination of the obstacle clearance areas used in the design of instrument approaches.

ANALYSIS

The ground proximity warning system (GPWS) warnings that the manufacturer's simulation predicted to occur while conducting an on-profile Runway 12 RNAV (GNSS) non-precision approach into Lockhart River, have been validated by a number of incidents reported to the Australian Transport Safety Bureau (ATSB).

The GPWS warnings have been confirmed by both simulation and experience to be nuisance alerts and, as such, do not provide a true warning that the aircraft is in potential conflict with terrain.

Nuisance warnings occurring while maintaining an approach profile could condition flight crews to ignore such warnings in order to complete the procedure, rendering the warning device ineffective. If an aircraft was below the approach profile, or off-track without the pilot's full awareness, an inappropriate response to a GPWS warning could ultimately lead to a controlled flight into terrain accident.

The incident on 29 May 2007 (ATSB occurrence 200703363) demonstrated that the Lockhart River Runway 12 RNAV (GNSS) non-precision approach can be a violation-producing procedure, as it resulted in a crew intentionally ignoring a terrain warning, in IMC, in order to complete the approach procedure.

SAFETY ACTION

The Australian Transport Safety Bureau (ATSB) expects that the safety issue identified in this investigation should be addressed by the relevant organisation(s). In addressing that issue, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Australian Transport Safety Bureau

On 20 March 2007, the ATSB formally advised Civil Aviation Safety Authority (CASA) of the Safety Issue: 'Based on the available evidence, the Lockhart River Runway 12 RNAV (GNSS) approach design resulted in Mode 2A ground proximity warning system alerts and warnings when flown on the recommended profile or at the segment minimum safe altitudes'.

On 4 April 2007, ATSB safety recommendation R20070008 was released as part of the report into the Lockhart River accident involving VH-TFU, recommending that CASA address that safety issue.

Civil Aviation Safety Authority

On 24 April 2009, CASA advised the ATSB that CASA would support Airservices in the design and approval of the Lockhart River Runway 12 RNAV (GNSS) non-precision approach to the latest revision of ICAO PANS-OPS.

On 12 June 2009, CASA advised that:

- CASA had published a number of articles regarding the use of stabilised approach techniques when flying non-precision approaches. CASA was also in the process of

developing further educational material relating to the operation and use of terrain awareness warning system Class A (TAWS-A) equipment, with particular emphasis on the need for operators to ensure adequate pilot training in the characteristics of the equipment fitted to their aircraft, and operational practices that maximise the benefit of the equipment.

- CASA had purchased a set of TAWS-A equipment that is currently being fitted to a Cessna Conquest aircraft for use in approach validation. The effort will initially focus on revalidating approaches at aerodromes in the vicinity of steep, high terrain to determine the potential for terrain alerts. The information will then be used in the consideration of the priority for the design of approaches with vertical guidance (APV), or for the redesign of an approach where that would be beneficial and feasible.
- The new design for the Lockhart River Runway 12 RNAV (GNSS) approach is expected to be validated in early August 2009 using the TAWS-A equipped aircraft, and will be promulgated as soon as practical after the successful completion of that flight validation.

Airservices Australia

On 24 April 2009, Airservices Australia advised the ATSB that Airservices would redesign the Lockhart River Runway 12 RNAV (GNSS) non-precision approach using the latest revision of the ICAO PANS-OPS procedures that were released on 31 October 2008.

On 13 May 2009, Airservices Australia provided the ATSB with a draft of a revised approach design. The redesigned approach had a final approach path that was aligned with the runway (119° M), which resulted in the approach moving to the south of the South Pap ridge. The revised approach is currently being validated prior to its approval for use.

ATSB assessment of safety action

The ATSB requested that a GPWS/TAWS manufacturer conduct simulations based on the revised approach for both their GPWS and TAWS systems. The manufacturer reported that, in its simulations, the revised approach did not result in any nuisance terrain alerts.

The ATSB assessed that the revised approach will adequately address the safety issue, once it is approved.

SOURCES AND SUBMISSIONS

The sources of information during the investigation included:

- the Civil Aviation Safety Authority (CASA)
- Airservices Australia
- the International Civil Aviation Organization
- the operator of the occurrence aircraft
- Honeywell International.

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

A draft of this report was provided to:

- CASA
- Airservices Australia
- the operator of the 29 May 2007 occurrence aircraft.

Submissions were received from the operator of the 29 May 2007 occurrence aircraft, Airservices Australia and CASA. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.