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Safety recommendation: AIC 19-R17/18-1004

Addressed to: Federal Aviation Administration

Date issued: 20th May 2019

Investigation link: AIC 18-1004

Action status: Issued

Introduction

On 28th September 2018, the Federated States of Micronesia, Department of Transportation, Communications and Infrastructure (DTC&I) was notified of the aircraft accident referenced in this safety recommendation. DTC&I commenced an investigation and deployed investigators to Chuuk and invited the Papua New Guinea Accident Investigation Commission (AIC) to join the investigation in the capacity of the State of Registry and also a State providing experts and facilities for the investigation. The AIC team is comprised of an Accredited Representative and Technical Advisers. The US National Transportation Safety Board (NTSB) as the State of Manufacture of the aircraft and in response to FSM National Government's request for assistance also sent a team comprised of an Accredited Representative and Technical Advisers from the Federal Aviation Administration (FAA) and Boeing. Technical Advisers from the US National Weather Service are assisting the US Accredited Representative.

The Transportation Safety Board of Canada (TSBC) as the State of Manufacture of specific components appointed an Accredited Representative and Technical Advisers to download the data from the AFIRS.

On 14th February 2019, the Government of the Federated States of Micronesia delegated the whole of the investigation to the PNG Accident Investigation Commission, in accordance with *Para 5.1 of ICAO Annex 13 to the Convention on International Civil Aviation*.

The PNG AIC has identified a safety deficiency, which if not rectified could result in an inadvertent ditching accident, resulting in injury or loss of life.

Occurrence

On Friday 28th September 2018, a Boeing 737-8BK aircraft, registered P2-PXE, was being operated by Air Niugini Limited, on a scheduled passenger flight from Pohnpei to Chuuk, Federated States of Micronesia.

At 23:17:19 UTC1 (09:17:19 local time) the aircraft impacted the water of Chuuk Lagoon about 1,443 ft (440 m) short of the runway 04 threshold, during its approach to runway 04 at Chuuk International Airport.

¹ The 24-hour clock, in Coordinated Universal Time (UTC), is used in this report to describe the local time as specific events occurred. Local time in the area of the accident, Pacific/Chuuk Time is UTC + 10 hours.

As the aircraft settled in the water, it turned clockwise through 210° and drifted 460 ft (140 m) south east of the runway 04 extended centreline, with the nose of the aircraft pointing about 265°.

There were 12 crew members and 35 passengers on board. Six passengers were seriously injured, and one passenger was fatally injured.

The 12 crew members and 34 passengers exited the aircraft and were promptly rescued and brought to shore by Chuuk State Government boats, Red Cross, Transco, and more than twenty privately-owned boats, and U.S. Navy divers (who were the first on scene). Local divers located the fatally injured passenger in the aircraft 3 days after the accident.

The aircraft was being flown on a RNAV (GPS)² approach to runway 04. The aircraft flew a stabilised approach on auto-pilot, tracking 041° from FIGBI 2,500 ft, passing FASPO at 1,700 ft. The PIC disconnected the auto-pilot at 627 ft and flew the aircraft manually.

During the approach at 23:23:53, when the EGPWS Advisory alert (altitude callout) “*Minimums*” sounded, the aircraft was passing through 470 ft with a vertical speed (rate of descent) of 1,344 ft per minute. The MDA(H)³ was 420 ft.

The missed approach required a left turn to track 306° with a minimum climb of 375 ft / NM to 960 ft to the Missed approach fix DAMAY.

The aircraft was progressively flown below the glideslope, and from 23:24:00 to the time of impact at 23:24:19 the EGPWS issued eight *Glideslope*⁴ Alerts (aural alert), and nine *Sink rate*⁵ Alerts (aural alert). The first *Sink rate* Alert was issued at 23:24:00 when the aircraft was at a Radio Altitude of 367 ft with a vertical speed (rate of descent) of 1,616 ft per minute. The last *Sink rate* Alert occurred 2 seconds before impact at a Radio Altitude of 13 ft and a vertical speed (rate of descent) of 848 ft per minute. The Caution alerts (aural alerts) were ignored by the crew.

A storm cell situated immediately after the missed approach point was “painting⁶” on the weather radar on the PIC’s Navigation Display. The crew continued past the missed approach point and flew into the heavy rain. The aircraft immediately entered instrument meteorological conditions (IMC).

Safety deficiency description

During the approach, the crew lost situational awareness, with their attention channelised and the aircraft entered the storm cell with heavy rain after passing the *MDA/Missed Approach Point*. The PIC never arrested the excessive rate of descent, and flew the aircraft increasingly below the *Glideslope*.

The investigation determined that the pilots of P2-PXE were fixated on the task of landing the aircraft and did not notice the steady visual **PULL UP** caution alert at the bottom of their Primary Flight Displays (PFD). Therefore, they (pilots) did not take any positive action to arrest the high rate of descent and avoid landing in the lagoon. In fact, neither of the pilots were aware of the rapidly unfolding unsafe situation.

The investigation into this accident found that although there were numerous cues to the unsafe situation, the Honeywell EGPWS MK V Mode 1 did not provide sufficient aural WARNING alert that required immediate action by the pilots, at very low altitude, with excessively high rate of descent.

- A change of alert either visual or aural, from CAUTION⁷ to WARNING, demanding an immediate action from the crew was necessary to divert the pilots’ channelised attention from the task of landing the aircraft at Chuuk.

2 WENO 1, Federated States of Micronesia RNAV (GPS) Rwy 4 Jeppesen chart dated 26 January 2018 and current at the time of the accident.

3 MDA(H): Minimum descent altitude; sometimes termed minimum decision altitude. (Source Cambridge Aerospace Dictionary.)

4 Glideslope Caution Alert is issued by the EGPWS when the aircraft deviates below the 3° Glideslope.

5 Sink rate Caution Alert is issued when the aircraft penetrates the zone shown on the Honeywell EGPWS MK V Mode 1 Graph (See Fig 2)

6 To create blip on radar display, esp. one giving position of aircraft or other object. (Source Cambridge Aerospace Dictionary.)

7 Definitions excerpted from 14 CFR 25.1322:

- **Warning:** For conditions that require immediate flightcrew awareness and immediate flightcrew response;
- **Caution:** For conditions that require immediate flightcrew awareness and subsequent flightcrew response; and
- **Advisory:** For conditions that require flightcrew awareness and may require subsequent flightcrew response.



Figure 1: Image from PXE cockpit video⁸ showing **PULL UP** on PFD display

A recommendation was issued to Honeywell Aerospace to ensure that the Honeywell EGPWS MK V Computer provides timely and continuous hard aural warning “**WHOOP WHOOP PULL UP**,” simultaneously with the visual display of **PULL UP** on the Primary Flight Displays, which would require immediate action from the crew, when encountering an excessive Rate of Descent at very low Radio Altitude, similar to that encountered by the crew of P2-PXE as shown in Figure 1. (Refer to recommendation *AIC 19-R02/18-1004* to Honeywell Aerospace) on the 31st January 2019.

However, the Honeywell Aerospace response stated that the requested recommendation was unachievable for two reasons:

1. *Boeing and/or operator has chosen to drive a red “**PULL UP**” annunciation on the PFD when the EGPWS triggers a Mode 1 “Sink Rate” caution alert level when another option is available which would not generate the red “**PULL UP**” annunciation with the same caution level alert; and*
2. *If Honeywell were to change the EGPWS Mode 1 Warning curves to generate a “**PULL UP**” aural when a flight profile were to be flown as P2-PXE performed, it would be in violation of TSO-151d (MOPS DO-367) and would be unable to certify the product with the FAA.*

Given the points of this response, Honeywell Aerospace requested that the recommendation be removed from consideration and stated that it would not be feasible nor within Honeywell’s control to accomplish.

The AIC assessed the Honeywell Aerospace response and assigned it an *unsatisfactory not accepted rating*⁹. The PNG AIC conducts investigations for the purpose of improving safety. It would not be appropriate, nor would it be in the wider interest of aviation safety, for the AIC to withdraw a safety recommendation because a TSO would not be in agreement with proposed changes.

Therefore, the AIC cannot remove the recommendation as requested by Honeywell Aerospace, but has re-issued a revised enhanced safety recommendation *AIC 19-R02/18-1004* based on the following research and analysis.

The investigation reviewed specific documentation associated with the design of *Terrain Awareness and Warning Systems (TAWS)* respectively in conjunction with Honeywell’s response and recommends that the FAA should re-assess *TSO-151d* and *RTCA/DO-367, Minimum Operational Performance Standard (MOPS) for Terrain Awareness and Warning System (TAWS) Airborne Equipment* as the certifying authority for the software enhancement of the Honeywell Aerospace product, *EGPWS Mk V computer* (Refer to recommendation *AIC 19-R02/18-1004* to Honeywell Aerospace).

⁸ Image taken from cockpit video taken by jump seat occupant

⁹ An unsatisfactory not accepted rating applies to situations where, in the AIC’s view, the safety deficiency will continue to put persons, property or the environment at risk and is assigned if the respondent demonstrates that no action will be taken to reduce or eliminate the identified safety deficiency.

The Honeywell EGPWS Mk V Computer was certified by the FAA, in accordance TSO-151b. However, TSO-C151b did not contain clear and precise requirements for caution and warning alerting curves as set out in the newer TSO-C151d and DO-367 (MOPS).

Furthermore, the minimum operational standards set out in DO-367 (MOPS) as depicted in **Figure 1** below shows the DO-367 'Must Not Alert' (Warning) Region, plotted against the Honeywell EGPWS Mode 1 Alerting Envelope. It is precisely in this region, at very low altitude and excessively high rate of descent that PXE was flown.

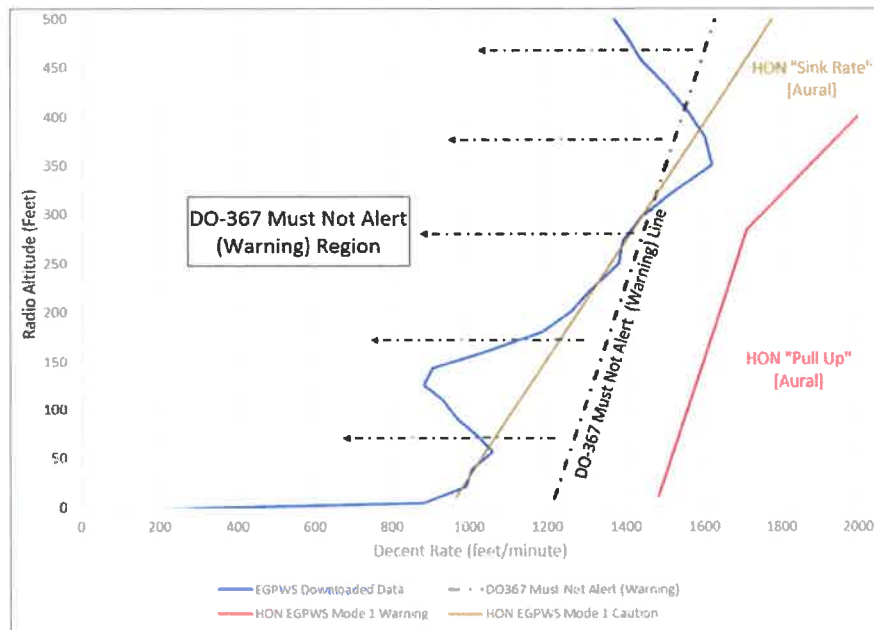


Figure 2. Mode 1 Sink Rate Alert Curves with DO-367 "Must Not Alert (Warning)" requirement¹⁰

Honeywell stated in their response that:

'it is virtually impossible for Honeywell to develop an alerting scheme that would result in a 'PULL UP' aural (Warning envelope) without violating the MOPS standards set forth in DO-367.'

For aviation safety, it is of the utmost importance to determine which aural or visual alerting indications provide the most effective alerts.

The AIC Human Factors investigation determined that an attention-getting hard aural 'WARNING' alert, or a **flashing** visual '**PULL UP**' rather than a steady '**PULL UP**' caution on the PFDs, could have significantly driven the pilots to react positively and decisively, given the severity and significance of a hard warning (see footnote 7 on page 2). It could be the last line of defense for any flight crew who may unknowingly or inadvertently get in a similar fixated situation.

The FAA *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Control Manual Version 2*, Chapter 4, section 4.3.1 – Warnings, Cautions and Advisories states:

Unique visual alert information presented in each pilot's primary field of view is acceptable in place of a master visual alert if it provides immediate awareness and sufficient attention-getting characteristics. However, an aural alert, such as an aural command to "pull up," or another sensory cue, would still be required to meet § 25.1322(c)(2). [AC 25.1322-1, 6.c]

For a time-critical warning, use voice information to indicate conditions that demand immediate flightcrew awareness of a specific condition without further reference to other indications in the flight deck. A second attention-getting sensory cue, such as a visual cue, is still required (§25.1322(c)(2)). [AC 25.1322-1, Appendix 2, 3])

¹⁰ Figure 2 from Honeywell Aerospace response to AIC 19-R02/18-1004

Several visual coding methods can be used to attract attention to specific information on a display, including blinking or **flashing**, reverse video, size coding, color, and location. In non-normal or serious conditions, such coding methods can help the flightcrew distinguish critical information from other information.

§25.1322(c)(2)¹¹ states:

(c) Warning and caution alerts must:

(2) Provide timely attention-getting cues through at least two different senses by a combination of aural, visual, or tactile indications.

Alerts are intended to attract attention and inform of specific airplane operating conditions and events that require pilot and/or flightcrew awareness. As the number of systems on the flight deck has increased, so too has the number of warnings, cautions, and advisories that can be shown. Failure to standardize alerts within the flight deck and across an aircraft fleet can lead to **confusion and recognition errors**. Different alerting characteristics can prevent the flightcrew from reacting quickly to an alert situation because they are not confident of what the alert is indicating and what action is required. Additionally, it can be more difficult to determine which system generated an alert if alert messages are not easy to interpret.

It is therefore likely that a continuous '**WHOOP WHOOP PULL UP**' hard aural WARNING, or a **flashing** visual display '**PULL UP**' WARNING on the Primary Flight Display, would have been effective in alerting the crew to the imminent danger, prompting a pull up and execution of a missed approach, that would have prevented the accident. A hard-aural WARNING alert or **flashing** visual WARNING, demanding an immediate flight crew response, would clearly be desirable in the interest of aviation safety enhancement.

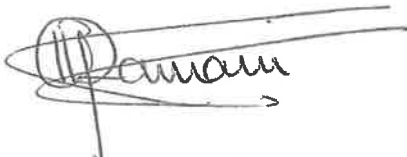
However, if the '**WHOOP WHOOP PULL UP**' hard aural warning is not technically possible on older model EGPWS, a **flashing** '**PULL UP**' warning through software enhancement would achieve the minimum design considerations for alerting as contemplated in the *FAA Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls - Version 2.0, Chapter 4 Considerations for Alerting*.

Recommendation number AIC 18-R17/18-1004 to US Federal Aviation Administration (FAA)

The PNG Accident Investigation Commission recommends that the Federal Aviation Administration should re-evaluate TSO's 151b and 151d and DO-367 related to EGPWS warnings and cautions, and ensure that the Honeywell EGPWS MK V Computer provides a **timely warning** in the form of a continuous **flashing** visual display of '**PULL UP**' at the bottom of the Primary Flight Displays, as an absolute minimum standard. A **flashing** visual display '**PULL UP**' warning, accompanying an aural 'SINK RATE', would require immediate action from the flight crew when encountering an excessive Rate of Descent at very low Radio Altitude, similar to that flown by the crew of P2-PXE.

Action requested

The PNG Accident Investigation Commission requests that the Federal Aviation Administration note recommendation AIC 19-R17/18-1004 and provide a response to the AIC no later than 19th July 2019 (within 60 days of the issue date), and explain, including with evidence, how the FAA has addressed, or proposes to address, the safety deficiency identified in the safety recommendation. Current status **ACTIVE**.



HUBERT NAMANI, LLB
Chief Commissioner

20th May 2019

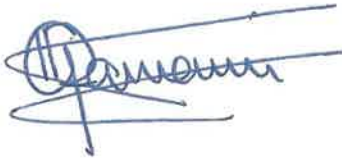
¹¹ Electronic Code of Federal Regulations (e-CFR), Space, Chapter, Subchapter C. AIRCRAFT, Part 25. AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES, Subpart F. Equipment, Subjgrp 113. Instruments: Installation, Section 25.1322. Flightcrew alerting.

PNG Accident Investigation Commission update dated 11 July 2019

During subsequent discussions with Honeywell and Boeing, the AIC was informed that such hard-aural warning might not be an option for older generation EGPWS.

Much more research is required and the AIC is actively working with the US NTSB, FAA, Honeywell, and Boeing. The *Safety Recommendations AIC 19-R02/18-1004* and *AIC 19-R17/18-1004* addressed to Honeywell and FAA respectively will remain Active pending the results of the ongoing research.

Status of AIC recommendation: ACTIVE



HUBERT NAMANI, LLB
Chief Commissioner

20th May 2019

PNG Accident Investigation Commission update

The AIC notes FAA, Honeywell, Boeing and US NTSB commitment to conduct ongoing research to address the AIC's safety concerns with respect to EGPWS warnings and cautions.

The AIC has therefore assigned the stated corrective action plan a *satisfactory intent* rating.

The AIC has recorded the **Status of the Recommendation: CLOSED**



Capt. A Bouraga, MBE
Acting Chief Commissioner

21 March 2022