

Log 2362



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 21, 1992

In reply refer to: A-92-39 through -44

Honorable Barry L. Harris
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

Ground proximity warning systems (GPWS) supplement flight instrument data and warn the flightcrew when there is danger of unintended controlled flight into terrain (CFIT), accidents in which catastrophic losses of life and property are common. The Safety Board's statistics on U.S. air carrier accidents indicate that GPWS have been effective in reducing the number of CFIT accidents since their introduction more than 15 years ago. Further, there have been many reports¹ by flightcrews of GPWS warnings preventing such accidents.

However, CFIT accidents have continued to occur worldwide, even though onboard GPWS have provided aural warnings to the flightcrew. The Safety Board is concerned that warnings provided by GPWS have not prevented these accidents, and the Board has identified improvements in the current regulations that would enhance the warnings provided to flightcrews by the GPWS in such flight situations.

The performance and environmental requirements for GPWS equipment are defined in FAA Technical Standard Order TSO-C92,² dated May 27, 1976. This document (the TSO) defines the minimum performance standards for equipment on all airplanes operating under 14 CFR Part 121. The standards in the TSO have remained unchanged for more than 15 years, even though substantial improvements have been made in the performance capabilities of GPWS equipment during these years. Further, ground proximity warning systems on

¹The reports are contained in the Aviation Safety Reporting System (ASRS) database maintained by the National Aeronautics and Space Administration. For more detailed information, read "An Investigation of Reports of Controlled Flight Toward Terrain (CFTT), April 6, 1981" written by R. Porter and J. Loomis (Report No. NASA CR 166230).

²The document, entitled "Minimum Performance Standards-Airborne Ground Proximity Warning Equipment, was written by the Radio Technical Commission for Aeronautics, Document DO-161A.

a large portion of Part 121 airplanes currently in service meet only the minimum standards and are not equipped with available improvements.

The Safety Board addressed the need for GPWS equipment to identify the cause of aural warnings in the Board's investigation of a 1978 CFIT accident. On May 8, 1978, a Boeing 727, operating as National Airlines flight 193, crashed into Escambia Bay during its approach to the Pensacola Regional Airport at Pensacola, Florida.³ Three passengers drowned and others on board were seriously injured. The captain and first officer erroneously believed that the aural "pull up" warning provided by the GPWS was caused by an excessive rate of descent; the captain therefore reduced the descent rate, but the airplane struck the water short of the runway. On May 1, 1979, as a result of its investigation, the Safety Board recommended that the FAA amend TSO-C92⁴ so that the GPWS would "...identify with aural messages the cause of the warning being given" (Safety Recommendation A-79-27). The Board further stated:

At least one manufacturer now offers a GPWS with features which specifically announce the reason for each triggered warning, such as "sink rate," "terrain," or "flaps". The Board believes that these features will eliminate ambiguity and will reduce considerably crew reaction time to the warning being given.

A companion recommendation (A-79-28) sought to amend 14 CFR Part 121 to require these aural messages on all newly manufactured airplanes. In its March 31, 1987, response to the recommendations, the FAA stated that "...the present rules provide an adequate level of safety when proper procedures are followed" and that no further action was planned on these recommendations. Based on the FAA's response, the Board classified recommendations A-79-27 and -28 as "Closed--Unacceptable Action" on July 21, 1987.

The need to identify the cause of the aural warning was again made apparent in 1989. On February 8, 1989, a Boeing 707, operating as Independent Air flight 1851, crashed on descent to Santa Maria Island in the Azores, Portugal. Flight 1851 was a charter flight, conducted under the provisions of 14 CFR Part 121. The flight was operating between Bergamo, Italy, and the Dominican Republic, with a refueling stop in Santa Maria. All 144 passengers and crew were killed, and the airplane was destroyed. The airplane was equipped with an early-model GPWS. In accordance with the TSO, this GPWS provided only a "pull up" annunciation for four different types of potentially unsafe airplane operations. The reason to pull up,

³ For more detailed information, read "National Airlines, Inc., Boeing 727-235, N4744NA, Escambia Bay, Pensacola, Florida, May 8, 1978" (Aircraft Accident Report NTSB/AAR-78/13).

⁴ This document was contained in 14 CFR 37.201 in 1979, but is designated as TSO-C92 in current 14 CFR Part 121 language.

whether because of excessive descent rate, rising terrain, descent after takeoff, or insufficient terrain clearance, was therefore not obvious. The crew of flight 1851 received the "pull up" warning but apparently did not take action immediately; only 6 1/2 seconds after the warning, ground impact occurred. However, the airplane needed to climb only about 100 feet to clear the crest of the ridge on which it crashed. The Safety Board participated in the investigation at the invitation of Portuguese authorities. Although a final report has not been released, the Safety Board believes that an enhanced aural warning, such as "terrain" alternated with "pull up", would have better identified the danger to this crew, thereby prompting their immediate reaction and possibly preventing this accident.

Based on its investigations of CFIT accidents, the Safety Board believes that the FAA should revise the GPWS performance standards in TSO-C92 to require that the warning provided to the flightcrew be enhanced with an aural message that identifies the cause of the warning.

The accident in the Azores also demonstrated the need for longer warning times. The 6 1/2-second warning time provided by the early-model GPWS was so brief that the flightcrew had very little time to react and take corrective action in time to prevent the accident. To increase warning time, modern GPWS include airspeed in their logic. Airspeed considerations, however, are not addressed in the TSO. Flight path and topographical data indicate that if flight 1851 had been equipped with a GPWS that included speed as a part of the system logic, warnings could have started as much as 28 seconds before impact.⁵ This would have allowed the crew significantly more time to react and to take corrective action. The Safety Board believes that the FAA should also revise TSO-C92 to require that airspeed be included in the logic that determines GPWS warning times in order to increase the time for the flightcrew to react and take corrective action.

Another shortcoming in the current GPWS performance standards was demonstrated by a recent CFIT accident in Alaska. On June 2, 1990, a Boeing 737, operating as Markair Airlines flight 3087, crashed during a nonprecision approach to Unalakleet, Alaska. All four crewmembers were injured, and the airplane was destroyed. The airplane was being positioned for a passenger flight and was operating under the provisions of 14 CFR Part 121. In a precision instrument approach, a "glideslope" alert is provided by the GPWS when deviation below the instrument landing system (ILS) glideslope signal and the height above terrain are within a defined envelope. However, the GPWS equipment aboard flight 3087 could not provide a traditional glideslope deviation warning because a nonprecision approach (an approach procedure in which an electronic glideslope is not available) was being flown by the crew.

⁵ Based on the Sundstrand Mark VII GPWS.

Current GPWS technology is capable of providing enhanced altitude awareness during nonprecision approaches by aural annunciations of the radar altitude. Unlike a "talking altimeter" that repetitively calls out altitudes over undulating terrain, these GPWS aural advisories are heard only once for each pre-selected altitude (so-called "smart" callouts) programmed into the GPWS. In its report on the investigation of the Markair accident,⁶ the Safety Board discussed the need for altitude awareness during nonprecision approaches and the radar altitude callouts available on modern GPWS equipment:

...the early model GPWS does not provide a warning after the airplane is configured to land during a nonprecision approach. This lack of warning or alert is cause for concern because there are, and will continue to be, a significant number of nonprecision approaches executed in places such as Alaska, and the majority of controlled flight into terrain (CFIT) accidents occur during the descent/approach phase of flight...Another way to provide callouts of ground proximity when an airplane is configured for landing on a nonprecision approach is through modern GPWS equipment, such as the Sundstrand Mark VII, which provides altitude callouts. Calculations show that [callouts of] "500 feet" and "minimums" (360 feet in this case)...would have been provided by such equipment about 13 and 8 seconds, respectively, before impact. These radar altitude callouts are not a substitute for the barometric altitudes upon which all approaches and go-around decisions should be based. However, these callouts would have occurred prematurely on the accident flight, with the airplane still in IFR [Instrument Flight Rules] conditions about 8 miles from the runway...It is also evident, however, that if this equipment had been installed and if the pilots had interpreted its callouts quickly enough, the accident may not have occurred.

These "smart" altitude callouts are advisory and are typically heard only during the final segment of a nonprecision approach. The Safety Board believes that although these automatic radar altitude callouts do not constitute a GPWS "warning," they would alert the flightcrew to impending danger when the callouts occur unexpectedly. The Safety Board is aware that some air carriers already have GPWS with the "smart" callout feature and have developed operating procedures and training for flightcrews to use these callouts on nonprecision approaches. The Safety Board supports these efforts. However, air carrier operating procedures and training also need

⁶ For more detailed information, read "Markair, Inc., Boeing 737-2X6C, N670MA, Controlled Flight Into Terrain, Unalakleet, Alaska, June 2, 1990" (Aircraft Accident Report NTSB/AAR-91/02)

to emphasize that flightcrews should not rely solely on radar altitude during approaches, because the undulating terrain surrounding many airports makes this a dangerous practice. Approaches and go-around decisions should be based on barometric altitudes. Because flightcrews need to be aware of altitude during nonprecision approaches, the Safety Board believes that the FAA should revise the performance standards in the TSO to require that advisory ("smart") callouts of altitude above terrain be annunciated during nonprecision approaches.

Ultimately, a database of worldwide topographical measurements could be linked with airplane position so that a future ground proximity warning system could warn pilots whenever the aircraft is in danger of colliding with terrain. However, storing and utilizing such a large amount of data is a complex undertaking. Fortunately, a less complex "database" feature is entirely feasible using current technology. The Safety Board is aware of efforts by Sundstrand, Inc. (a GPWS manufacturer), to unite an "airport location database" with real-time airplane position to provide a warning whenever the airplane descends too low while outside the vicinity of an airport. Real-time airplane position is currently available from several sources, such as the Global Positioning System (GPS), Loran-C, or onboard inertial navigation system (INS) equipment. Airport positions are simply latitude/longitude coordinates. With this "database" feature, the GPWS would continuously compare positions to provide a warning whenever the airplane descends too low while outside the vicinity of any airport in the database. The database could include all the world's airports that have runways that can accommodate a Part 121 category aircraft. Such an improvement would enable the GPWS to offer effective protection against CFIT during all phases of flight operation. Consequently, the Safety Board believes that the FAA should revise the TSO to require that an airport location database be used in conjunction with real-time airplane position data, when an airplane is equipped with a system that monitors position, so that the GPWS provides a warning whenever the airplane descends too low for terrain while outside the vicinity of any of the world's suitable airports.

The TSO revisions described in this letter will provide greater protection against CFIT accidents for all airplanes equipped with GPWS that conform to the improved performance standards. However, many Part 121 airplanes currently in service are equipped with GPWS systems that meet only the current minimum standards. Consequently, the Safety Board believes that the FAA should amend 14 CFR 121.360 to require that all airplanes in service after an appropriate date be equipped or retrofitted with GPWS that provide aural messages, increased warning times, and advisory callouts required by the improved performance standards. The Safety Board also believes that the FAA should require that all airplanes newly manufactured after an appropriate date be equipped with GPWS that conform to these same improved standards, as well as the use of an airport location data base in conjunction with real-time airplane position data.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

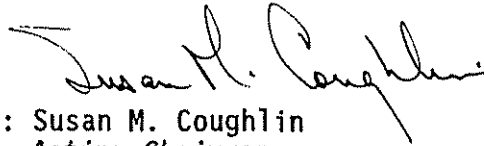
Revise the performance standards for ground proximity warning systems (GPWS) contained in Technical Standard Order TSO-C92 to:

- o Require that each warning provided by the GPWS to the flightcrew be enhanced with an aural message that identifies the reason for the warning. (Class II, Priority Action) (A-92-39)
- o Require that airspeed be included in the logic that determines GPWS warning times in order to significantly increase the time for the flightcrew to react and to take corrective action. (Class II, Priority Action) (A-92-40)
- o Require that advisory ("smart") callouts of altitude above terrain be annunciated during nonprecision approaches. (Class II, Priority Action) (A-92-41)
- o Require that an airport location data base be used in conjunction with real-time airplane position data, when an airplane is equipped with a system that monitors position (such as a global positioning system, inertial navigation system, or Loran-C), so that the GPWS will provide a warning whenever the airplane descends too low while outside the vicinity of any of the world's suitable airports. (Class II, Priority Action) (A-92-42)

Amend 14 CFR 121.360 to:

- o Require that all airplanes in service after an appropriate date be equipped or retrofitted with ground proximity warning systems that conform to Technical Standard Order TSO-C92 as revised according to Safety Recommendations A-92-39 through -41. (Class II, Priority Action) (A-92-43)
- o Require that all airplanes newly manufactured after an appropriate date be equipped with ground proximity warning systems that conform to Technical Standard Order TSO-C92 as revised according to Safety Recommendations A-92-39 through -42. (Class II, Priority Action) (A-92-44)

Acting Chairman COUGHLIN, and Members LAUBER, HART, HAMMERSCHMIDT, and KOLSTAD concurred in these recommendations.

A handwritten signature in cursive script, appearing to read "Susan M. Coughlin". The signature is written in dark ink and is positioned above the typed name.

By: Susan M. Coughlin
Acting Chairman