FLIGHT SAFETY FOUNDATION

ALAR

APPROACH-AND-LANDING ACCIDENT REDUCTION

TOOL KIT

FSF ALAR BRIEFING NOTE 6.3

Terrain-Avoidance (Pull-Up) Maneuver

A typical training program to reduce approach-and-landing accidents (ALAs), including those involving controlled flight into terrain (CFIT), includes the following:

- Alert flight crews to the factors that may cause ALAs and CFIT;
- Ensure that situational awareness is maintained at all times;
- Ensure that crews attain proficiency in conducting approach procedures for their aircraft type;
- Provide crews with adequate knowledge of the capabilities and limitations of the ground-proximity warning system (GPWS) or terrain awareness and warning system (TAWS)[1] installed on their aircraft; and,
- Ensure that crews are proficient in conducting the terrain-avoidance maneuver required in response to a GPWS warning or a TAWS warning (as published in the aircraft operating manual [AOM]/quick reference handbook [QRH]).

Statistical Data

The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force found that CFIT was involved in 37 percent of 76 approach-and-landing accidents and serious incidents worldwide in 1984 through 1997.[2]

GPWS/TAWS Training

The rigorous application of standard operating procedures (SOPs) to reinforce situational awareness and the optimum use of automated systems and displays during approach procedures should be incorporated in transition training and recurrent training programs developed by the aircraft manufacturer or by the company's training department.

A training program should include:

- An instructor-led classroom briefing or a self-briefing based on the FSF *ALAR Tool Kit*;
- A complete discussion about the operation of the GPWS/TAWS;
- The FSF *Controlled Flight Into Terrain: An Encounter Avoided* video;
- Exercises to be incorporated in simulator training sessions during transition training/recurrent training (three typical sample exercises are described later); and,
- A simulator briefing for nonprecision approaches to emphasize CFIT risks and the advantages of using a constant-angle nonprecision approach (CANPA) or other type of precision-like approach.

Simulator Requirements

- The flight simulator database should include terrain in the vicinity of the airports selected for training. The terrain database should extend to an area with a radius (centered on the airfield reference point) of 25 nautical miles (nm) to 30 nm (45 kilometers to 55 kilometers). This terrain also should be displayed by the visual system;
- The capability should be available to insert an "electronic mountain" from the instructor's panel at a selected point on the aircraft's projected flight path.

  Inserting an electronic mountain at an airport that does not have such terrain, however, may result in the trainee dismissing the GPWS/TAWS warning as a spurious warning, thus resulting in negative training.

  The slope and height of the mountain should be tailored to a particular aircraft at a representative gross weight (e.g., maximum landing weight [MLW]), so that maximum performance is required to avoid striking the mountain.

The slope of the mountain therefore should be adjustable to match the climb gradients that can be achieved in the pull-up maneuver; and,

- To prevent negative training, the simulator must represent realistically the handling qualities and performance as airspeed reduces to stick-shaker speed or minimum airspeed.

Simulator Exercises

All GPWS/TAWS modes should be demonstrated. The objective should be to ensure an understanding of the capabilities and limitations of the GPWS/TAWS installed on the aircraft type.

These exercises can be conducted in either a fixed-base simulator (FBS) or a full-flight simulator (FFS).

The following scenarios, to be conducted in an FFS, are designed to increase CFIT awareness and to allow the pilot to practice the correct response to GPWS/TAWS warnings without significantly increasing the training time. The scenarios should be modified in accordance with the company's training requirements or operating environment.

Pull-Up in VMC Exercise

Objectives. Demonstrate GPWS/TAWS warnings, *that a pull-up maneuver must be immediate*, the pull-up technique (with special emphasis on pitch force and attitude) and crew coordination.

Briefing. Explain the objectives and emphasize that this is a training exercise. Describe the pull-up technique required for the particular aircraft type.

Initial Conditions. Establish initial approach configuration and airspeed, at or near the MLW, in a shallow descent or in level flight.

Procedure. The instructor inserts an electronic mountain ahead of the aircraft and talks to the flight crew throughout the maneuver, insisting on an immediate and aggressive response.

Ensure proper crew coordination, with the pilot not flying/pilot monitoring (PNF/PM) calling radio altitudes and trend (e.g., "300 feet decreasing").

Continue the maneuver at maximum performance until the mountain is cleared. The duration of the maneuver should be sufficient for the crew to demonstrate proficiency in maintaining maximum climb performance.

Repeat the exercise, as needed, until crew proficiency is achieved.

Debriefing. Review the exercise, as appropriate.

Pull-Up in IMC Exercise

Objective. Reinforce and confirm correct response to a GPWS/TAWS warning in instrument meteorological conditions (IMC), including pilot technique and crew coordination.

Briefing. Explain the objective. Although the trainees will know that the exercise is to be conducted, explain that it is intended to simulate an inadvertent descent below minimum safe altitude (MSA) because of a loss of situational awareness (e.g., because of a lateral navigation error, an incorrect altitude selection or an incorrect nonprecision approach procedure).

Initial Conditions. Either of the following two scenarios can be used:

- Establish initial approach configuration and airspeed, at or near the MLW, in a shallow descent or in level flight; or,
- Establish landing configuration and approach speed, at or near MLW, on a typical three-degree descent.

Procedure. The instructor inserts an electronic mountain ahead of the aircraft and talks to the flight crew throughout the maneuver, insisting on an immediate and aggressive response.

Ensure proper crew coordination, with the PNF/PM calling radio altitudes and trend (e.g., "300 feet decreasing").

Continue the maneuver at maximum performance until the terrain is cleared. The duration of the maneuver should be sufficient for the crew to demonstrate proficiency in maintaining the maximum climb performance.

Repeat the exercise, as needed, until crew proficiency is achieved.

Debriefing. Review the exercise, as appropriate.

Unexpected GPWS/TAWS Warning

This scenario should be included during a line-oriented flight training (LOFT) session, which normally is programmed at the end of transition training and during periodic recurrent training LOFT sessions.

Objective. To maintain crew awareness of the CFIT hazard and to confirm crew proficiency in responding to a GPWS/TAWS warning.

Briefing. None.

Initial Conditions. Establish either initial-approach configuration and airspeed, or clean configuration and maneuvering speed, at MLW, descending or in level flight.

Procedure. The instructor clears the crew to descend to an altitude below the MSA or provides radar vectors toward high terrain.

If the flight crew takes corrective action before any GPWS/TAWS warning (as expected), an electronic mountain can be inserted at a later stage in the session.

Verify crew response to GPWS/TAWS and crew coordination during the pull-up maneuver.

Debriefing. Review the exercise, as appropriate.

Summary

The following should be emphasized when discussing CFIT awareness and response to a GPWS/TAWS warning:

- Situational awareness must be maintained at all times;
- Preventive actions (ideally) must be taken before a GPWS/TAWS warning;
- Response to a GPWS/TAWS warning by the pilot flying (PF) must be immediate;
- The PNF/PM must monitor and call the radio altitude and its trend throughout the terrain-avoidance maneuver; and,
- The pull-up maneuver must be continued at maximum climb performance until the warning has ceased and terrain is cleared (radio altimeter).

The following FSF ALAR Briefing Notes provide information to supplement this discussion:

- 1.1 — Operating Philosophy;
- 1.2 — Automation;
- 2.3 — Pilot-Controller Communication;
- 3.1 — Barometric Altimeter and Radio Altimeter;
- 3.2 — Altitude Deviations;
- 5.2 — Terrain;
- 7.1 — Stabilized Approach;
- 7.2 — Constant-Angle Nonprecision Approach;
- 7.3 — Visual References; and,
- 7.4 — Visual Approaches.

Notes

1. Terrain awareness and warning system (TAWS) is the term used by the European Aviation Safety Agency and the U.S. Federal Aviation Administration to describe equipment meeting International Civil Aviation Organization standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings. "Enhanced GPWS" and "ground collision avoidance system" are other terms used to describe TAWS equipment.
2. Flight Safety Foundation. "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): 1–121. The facts presented by the FSF ALAR Task Force were based on analyses of 287 fatal approach-and-landing accidents (ALAs) that occurred in 1980 through 1996 involving turbine aircraft weighing more than 12,500 pounds/5,700 kilograms, detailed studies of 76 ALAs and serious incidents in 1984 through 1997 and audits of about 3,300 flights.

Related Reading From FSF Publications

Rosenkrans, Wayne. "Helping Hand." *AeroSafety World* Volume 3 (June 2008).

Lacagnina, Mark. "High, Hot and Fixated." *AeroSafety World* Volume 3 (January 2008).

Carbaugh, David. "Good for Business." *AeroSafety World* Volume 2 (December 2007).

Bateman, Don; McKinney, Dick. "Dive-and-Drive Dangers." *AeroSafety World* Volume 2 (November 2007).

Tarnowski, Etienne. "From Nonprecision to Precision-Like Approaches." *AeroSafety World* Volume 2 (October 2007).

Lacagnina, Mark. "Into the Black Sea." *AeroSafety World* Volume 2 (October 2007).

FSF International Advisory Committee. "Pursuing Precision." *AeroSafety World* Volume 2 (September 2007).

Gurney, Dan. "Last Line of Defense." *AeroSafety World* Volume 2 (January 2007).

Berman, Benjamin A.; Dismukes, R. Key. "Pressing the Approach." *AviationSafety World* Volume 1 (December 2006).

Gurney, Dan. "Change of Plan." *AviationSafety World* Volume 1 (December 2006).

Gurney, Dan. "Tricks of Light." *AviationSafety World* Volume 1 (November 2006).

Gurney, Dan. "Wrong Airport." *AviationSafety World* Volume 1 (October 2006).

Gurney, Dan. "Delayed Pull-Up." *AviationSafety World* Volume 1 (September 2006).

Gurney, Dan. "Misidentified Fix." *AviationSafety World* Volume 1 (August 2006).

Gurney, Dan. "Night VMC." *AviationSafety World* Volume 1 (July 2006).

Flight Safety Foundation (FSF) Editorial Staff. "Nonadherence to Standard Procedures Cited in Airbus A320 CFIT in Bahrain." *Accident Prevention* Volume 59 (December 2002).

FSF Editorial Staff. "Preparing for Last-minute Runway Change, Boeing 757 Flight Crew Loses Situational Awareness, Resulting in Collision with Terrain." *Accident Prevention* Volume 54 (July–August 1997).

FSF Editorial Staff. "Unaware That They Have Encountered a Microburst, DC-9 Flight Crew Executes Standard Go-around; Aircraft Flies Into Terrain." *Accident Prevention* Volume 53 (February 1996).

Duke, Thomas A.; FSF Editorial Staff. "Aircraft Descended Below Minimum Sector Altitude and Crew Failed to Respond to GPWS as Chartered Boeing 707 Flew into Mountain in Azores." *Accident Prevention* Volume 52 (February 1995).

Notice

The Flight Safety Foundation (FSF) Approach-and-Landing Accident Reduction (ALAR) Task Force produced this briefing note to help prevent approach-and-landing accidents, including those involving controlled flight into terrain. The briefing note is based on the task force's data-driven conclusions and recommendations, as well as data from the U.S. Commercial Aviation Safety Team's Joint Safety Analysis Team and the European Joint Aviation Authorities Safety Strategy Initiative.

This briefing note is one of 33 briefing notes that comprise a fundamental part of the FSF *ALAR Tool Kit,* which includes a variety of other safety products that also have been developed to help prevent approach-and-landing accidents.

The briefing notes have been prepared primarily for operators and pilots of turbine-powered airplanes with underwing-mounted engines, but they can be adapted for those who operate airplanes with fuselage-mounted turbine engines, turboprop power plants or piston engines. The briefing notes also address operations with the following: electronic flight instrument systems; integrated autopilots, flight directors and autothrottle systems; flight management systems; automatic ground spoilers; autobrakes; thrust reversers; manufacturers'/operators' standard operating procedures; and, two-person flight crews.

This information is not intended to supersede operators' or manufacturers' policies, practices or requirements, and is not intended to supersede government regulations.

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