Flight Safety Foundation

ALAR

Approach-and-landing Accident Reduction

Tool Kit

FSF ALAR Briefing Note 5.2 — Terrain

Terrain awareness can be defined as the combined awareness and knowledge of the following:

- Aircraft position;
- Aircraft altitude;
- Applicable minimum safe altitude (MSA);
- Terrain location and features; and,
- Other hazards.

Statistical Data

The Flight Safety Foundation Approach-and-landing Accident Reduction Task Force found that controlled flight into terrain (CFIT) was involved in 37 percent of 76 approach-and-landing accidents (ALAs) and serious incidents worldwide in 1984 through 1997.[1]

The task force said that among these CFIT accidents/ incidents:

- Sixty-seven percent occurred in hilly terrain or mountainous terrain, and 29 percent occurred in areas of flat terrain (the type of terrain in which the remainder of the CFIT accidents/incidents occurred was unknown);
- Fifty-seven percent occurred during nonprecision approaches; and,
- Seventy percent occurred in poor visibility or fog.

The absence or the loss of visual references is the most common primary causal factor[2] in ALAs involving CFIT. These accidents result from:

- Descending below the minimum descent altitude/height (MDA[H]) or decision altitude/height (DA[H]) without adequate visual references or having acquired incorrect visual references (e.g., a lighted area in the airport vicinity, a taxiway or another runway); and,
- Continuing the approach after the loss of visual references (e.g., because of a fast-moving rain shower or fog patch).

Navigation Deviations and Inadequate Terrain Separation

A navigation (course) deviation occurs when an aircraft is operated beyond the course clearance issued by air traffic control (ATC) or beyond the defined airway system.

Inadequate terrain separation occurs when terrain separation of 2,000 feet in designated mountainous areas or 1,000 feet in all other areas is not maintained (unless authorized and properly assigned by ATC in terminal areas).

Navigation deviations and inadequate terrain separation are usually the results of monitoring errors.

Monitoring errors involve the crew's failure to adequately monitor the aircraft trajectory and instruments while programming the autopilot or flight management system (FMS), or while being interrupted or distracted.

Standard Operating Procedures

Standard operating procedures (SOPs) should emphasize the following terrain-awareness items:

- Conduct task-sharing for effective cross-check and backup, particularly mode selections and target entries (e.g., airspeed, heading, altitude); and,
- Adhere to the basic golden rule: aviate (fly), navigate, communicate and manage, in that order.

Navigate can be defined by the following "know where" statements:

- Know where you are;
- Know where you should be; and,
- Know where the terrain and obstacles are.

Terrain-awareness elements of effective cross-check and backup include:

- Assertive challenging;
- Altitude calls;
- Excessive parameter-deviation calls; and,
- Task-sharing and standard calls for the acquisition of visual references.

Terrain awareness can be improved by correct use of the radio altimeter. The barometric-altimeter bug and the radio-altimeter decision height (RA DH) bug must be set according to the aircraft manufacturer's SOPs or the company's SOPs.

Altimeter-setting Errors

The following will minimize the potential for altimeter-setting errors and provide for optimum use of the barometric-altimeter bug and RA DH bug:

- Awareness of altimeter-setting changes because of prevailing weather conditions (temperature-extreme cold front or warm front, steep frontal surfaces, semi-permanent or seasonal low-pressure areas);
- Awareness of the altimeter-setting unit of measurement in use at the destination airport;
- Awareness of the expected altimeter setting (using both routine aviation weather reports [METARs] and automatic terminal information system [ATIS] for cross-checking);
- Effective pilot flying-pilot not flying (PF-PNF) cross-check and backup;
- Adherence to SOPs for:
  - Resetting altimeters at the transition altitude/flight level;
  - Use of the standby altimeter to cross-check the primary altimeters;
  - Altitude calls;
  - Radio-altimeter calls; and,
  - Setting the barometric-altimeter bug and RA DH bug; and,
- Cross-check that the assigned altitude is above the MSA (unless the crew is aware of the applicable minimum vectoring altitude for the sector).

Table 1 shows examples of SOPs for setting the barometric-altimeter bug and the RA DH bug.

Table 1
Barometric-altimeter and Radio-altimeter Reference Settings

Approach	Barometric Altimeter	Radio Altimeter
Visual	MDA(H)/DA(H) of instrument approach or 200 feet above airport elevation	200 feet*
Nonprecision	MDA/(H)	200 feet*
ILS CAT I no RA	DA(H)	200 feet*
ILS CAT I with RA	DA(H)	RA DH
ILS CAT II	DA(H)	RA DH
ILS CAT III with DH	DA(H)	RA DH
ILS CAT III with no DH	TDZE	Alert height

MDA(H) = Minimum descent altitude/height
DA(H) = Decision altitude/height
ILS = Instrument landing system
CAT = Category
RA DH = Radio altimeter decision height
TDZE = Touchdown zone elevation

* The RA DH should be set (e.g., at 200 feet) for terrain-awareness purposes. The use of the radio altimeter should be discussed during the approach briefing.

Note: For all approaches, except CAT II and CAT III ILS approaches, the approach "minimum" call will be based on the barometric-altimeter bug set at MDA(H) or DA(H).

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force

Use of Radio Altimeter

Radio-altimeter calls can be either:

- Announced by the PNF (or the flight engineer); or,
- Generated automatically by a synthesized voice.

The calls should be tailored to the company operating policy and to the type of approach.

To enhance the flight crew's terrain awareness, the call "radio altimeter alive" should be made by the first crewmember observing the radio-altimeter activation at 2,500 feet.

The radio-altimeter indication then should be included in the instrument scan for the remainder of the approach.

Flight crews should call radio-altimeter indications that are below obstacle-clearance requirements during the approach. The radio altimeter indications should not be below the following minimum heights:

- 1,000 feet during arrival until past the intermediate fix, except when being radar-vectored;
- 500 feet when being radar-vectored by ATC or until past the final approach fix (FAF); and,
- 250 feet from the FAF to a point on final approach to the landing runway where the aircraft is in visual conditions and in position for a normal landing, except during Category (CAT) II instrument landing system (ILS) and CAT III ILS approaches.

The following cross-check procedures should be used to confirm the barometric-altimeter setting:

- When receiving an altitude clearance, immediately set the assigned altitude in the altitude window (even before readback, if appropriate because of workload);
- Ensure that the selected altitude is cross-checked by the captain and the first officer (e.g., each pilot should announce what he or she heard and then point to the altitude window to confirm that the correct altitude has been selected); and,
- Ensure that the assigned altitude is above the applicable MSA.

Training

Altitude Awareness Program

The altitude awareness program should emphasize the following:

- Awareness of altimeter-setting errors:
  - 29.XX inches of mercury (in. Hg) vs. 28.XX in. Hg or 30.XX in. Hg (with typical errors of approximately 1,000 feet); or,
  - 29.XX in. Hg vs. 9XX hectopascals (hPa) (true altitude [actual height above mean sea level] 600 feet lower than indicated); and,
- Awareness of altitude corrections for low outside air temperature (OAT) operations and awareness of pilot's/controller's responsibilities in applying these corrections.

Pilot-Controller Communication

The company should develop and implement an awareness and training program to improve pilot-controller communication.

Route Familiarization Program

A training program should be implemented for departure, route, approach and airport familiarization, using:

- High-resolution paper material;
- Video display; and/or,
- Visual simulator.

Whenever warranted, a route familiarization check for a new pilot should be conducted by a check airman or with the new pilot as an observer of a qualified flight crew.

CFIT Training

CFIT training should include the following:

- Ground-proximity warning system (GPWS) modes or terrain awareness and warning system (TAWS)[3] modes (the detection limits of each mode, such as inhibitions and protection envelopes, should be emphasized clearly); and,
- Terrain-avoidance (pull-up) maneuver.

Departure Strategies

Briefing

Standard instrument departure (SID) charts and en route charts should be used to cross-check the flight plan and the ATC route clearance. The FMS control display unit (CDU) and the navigation display (ND) should be used for illustration during the cross-check.

The takeoff-and-departure briefing should include the following terrain-awareness items, using all available charts and cockpit displays to support and illustrate the briefing:

- Significant terrain or obstacles along the intended departure course; and,
- SID routing and MSAs.

If available, SID charts featuring terrain depictions with color-shaded contours should be used during the briefing.

Standard Instrument Departure

When conducting a SID, the flight crew should:

- Be aware of whether the departure is radar-monitored by ATC;
- Maintain a "sterile cockpit"[4] below 10,000 feet or below the MSA, particularly at night or in instrument meteorological conditions (IMC);
- Monitor the sequencing of each waypoint and the guidance after waypoint sequencing (i.e., correct

direction of turn and correct "TO" waypoint, in accordance with the SID), particularly after a flight plan revision or after conducting a "DIR TO"; and,

- In the event of incorrect sequencing/lateral guidance, the crew should be alert to conduct a "DIR TO" [an appropriate waypoint] or to revert to selected lateral navigation.

En Route Strategies

Navigation

The en route charts should be accessible if a total loss of FMS navigation occurs or any doubt arises about FMS lateral guidance.

Flight Progress Monitoring

The flight crew should:

- Monitor and cross-check FMS guidance and navigation accuracy;
- Monitor instruments and raw data[5];
- Use all information available (flight deck displays, charts); and,
- Request confirmation or clarification from ATC if any doubt exists about terrain clearance, particularly when receiving radar vectors.

Descent Strategies

Management and Monitoring

When entering the terminal area, FMS navigation accuracy should be checked against raw data.

If the accuracy criteria for FMS lateral navigation in a terminal area and/or for approach are not met, revert to selected lateral navigation with associated horizontal situation indicator (HSI)-type navigation display.

Standard Terminal Arrival

When conducting a STAR, the flight crew should:

- Be aware of whether the arrival is radar-monitored by ATC;
- Maintain a sterile cockpit;
- Monitor the sequencing of each waypoint and the guidance after waypoint sequencing (i.e., correct direction of turn and correct "TO" waypoint, in accordance with the STAR), particularly after a flight plan revision or after conducting a "DIR TO"; and,
- In the event of incorrect sequencing/lateral guidance, the crew should be prepared to conduct a "DIR TO" (to appropriate waypoint) or to revert to selected lateral navigation.

Changes in ATC clearances should be understood before they are accepted and are implemented.

For example, an ATC clearance to descend to a lower altitude should never be understood as a clearance to descend (prematurely) below the MSA or an approach-segment minimum altitude.

When receiving ATC radar vectors, ensure that:

- The controller has identified your radar return by stating "radar contact";
- The pilot-controller confirmation/correction process (communication loop) remains effective at all times;
- The flight crew maintains situational awareness; and,
- The pilot requests confirmation or clarification from the controller without delay if there is any doubt about a clearance.

During the final approach segment, the attention of both pilots should be directed to any required altitude restriction or altitude/distance check prior to reaching the MDA(H) or DA(H).

Unless the airport is near high terrain, the radio-altimeter indication should reasonably agree with the height above airport elevation (obtained by direct reading of the barometric altimeter if using QFE or by computation if using QNH).

In IMC or at night, flight crews should respond immediately to any GPWS/TAWS warning.

Approach Strategies

Briefing

The approach briefing should include information about:

- Descent profile management;
- Energy management;
- Terrain awareness;
- Approach hazards awareness;
- Elements of a stabilized approach (Table 2) and approach gate[6];
- Readiness and commitment to respond to a GPWS/TAWS warning; and,
- Missed approach procedures.

Table 2
Recommended Elements
Of a Stabilized Approach

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC). *An approach is stabilized when all of the following criteria are met:*

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 knots indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force (V1.1 November 2000)

If available, approach charts featuring terrain depictions with color-shaded contours should be used during the approach briefing to enhance terrain awareness.

A thorough briefing should be conducted, regardless of:

- How familiar the destination airport and the approach may be; or,
- How often the pilots have flown together.

The briefing should help the pilot flying (conducting the briefing) and the pilot not flying (acknowledging the briefing) know:

- The main features of the descent, approach and missed approach;
- The sequence of events and actions; and,
- Any special hazards.

The flight crew should include the following terrain-awareness items in the approach briefing:

- MSAs;
- Terrain and man-made obstacles;
- Applicable minimums (ceiling, visibility or runway visual range [RVR]);
- Applicable minimum stabilization height (approach gate);
- Final approach descent gradient (and vertical speed); and,
- Go-around altitude and missed approach initial steps.

The following is an expanded review of the terrain-awareness items to be included in the approach briefing — as practical and as appropriate for the conditions of the flight.

ATIS

Review and discuss the following items:

- Runway in use (type of approach);
- Expected arrival route (standard terminal arrival [STAR] or radar vectors);
- Altimeter setting (QNH or QFE [setting that causes the barometric altimeter to indicate height above the QFE reference datum (i.e., zero feet at touchdown on the runway)], as required); and,
- Transition altitude/level (unless standard for the country or for the airport).

Approach Chart

Review and discuss the following terrain-awareness items using the approach chart and the FMS/ND (as applicable):

- Designated runway and approach type;
- Chart index number and date;
- MSA reference point, sectors and altitudes;
- Let-down navaid frequency and identification (confirm the navaid setup);
- Airport elevation;
- Approach transitions (fixes, holding pattern, altitude and airspeed restrictions, required navaids setup);
- Initial approach fix (IAF) and intermediate approach fix (IF), as applicable (positions and crossing altitudes);

- Final approach course (and lead-in radial);
- Terrain features (location and elevation of hazardous terrain or man-made obstacles);
- Approach profile view:
  - FAF;
  - Final descent point (if different from FAF);
  - Visual descent point (VDP);
  - Missed approach point (MAP);
  - Typical vertical speed at expected final approach groundspeed; and,
  - Touchdown zone elevation (TDZE); and,
- Missed approach:
  - Lateral navigation and vertical navigation; and,
  - Significant terrain or obstacles.

Low-OAT Operation

When OAT is below zero degrees Celsius (32 degrees Fahrenheit), low-temperature correction should be applied to the following published altitudes:

- Minimum en route altitude (MEA) and MSA;
- Transition route altitude;
- Procedure turn altitude (as applicable);
- FAF altitude;
- Step-down altitude(s) and MDA(H) during a nonprecision approach;
- Outer marker (OM) crossing altitude during an ILS approach; and,
- Waypoint-crossing altitudes during a global positioning system (GPS) approach flown with barometric vertical navigation.

In a standard atmosphere, indicated altitude is the true altitude above mean sea level (MSL) and, therefore, provides a reliable indication of terrain clearance.

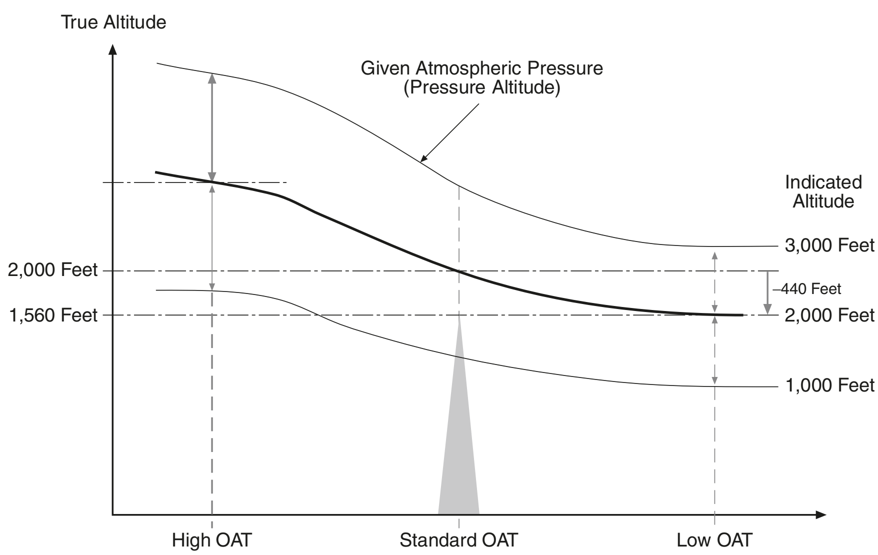
Whenever the temperature is significantly different from the standard temperature, indicated altitude is significantly different from true altitude.

In low temperature, true altitude is lower than indicated altitude, thus creating a lower-than-anticipated terrain clearance and a potential terrain-separation hazard.

Flying into a *low-temperature area* has the same effect as flying into a *low-pressure area*; the aircraft is *lower than the altimeter indicates*.

For example, Figure 1, which is based on low-temperature altimeter corrections published by the International Civil Aviation Organization (ICAO), shows that indicated altitude and true altitude are the same for an aircraft flying at 2,000 feet in an area of standard temperature (15 degrees Celsius [59 degrees Fahrenheit] at the surface); however, for an aircraft flying at 2,000 feet in an area where the surface temperature is –40 degrees Celsius (–40 degrees Fahrenheit), true altitude would be 440 feet lower than indicated altitude.

Effects of Temperature on True Altitude



OAT = Outside air temperature

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force

Figure 1

Airport Charts

Review and discuss the following terrain-awareness items using the airport charts:

- Approach lighting and runway lighting, and other expected visual references; and,
- Specific hazards (such as man-made obstacles, as applicable).

If another airport is located near the destination airport, relevant details or procedures of that airport should be discussed.

Automation

Discuss the intended use of automation for vertical navigation and lateral navigation:

- FMS or selected modes; and,
- Precision approach, constant-angle nonprecision approach (CANPA) or step-down approach, as required.

Preparation for a Go-around

Company policy should stress the importance of:

- Being prepared and committed for an immediate response to a GPWS/TAWS warning; and,
- Being prepared to go around.

Circling Approaches

When conducting a circling approach, the crew should be aware of and remain within the applicable obstruction clearance protected area.

Factors Affecting Terrain Awareness

The following factors affect situational awareness and, therefore, terrain awareness.

Company accident-prevention strategies and personal lines of defense should be developed to cope with these factors (as practical).

- Aircraft equipment:
  - Lack of navigation display/terrain display/radar display with mapping function;
  - Lack of area navigation (RNAV) capability;
  - Lack of radio altimeter or lack of (automatic) calls; and/or,
  - Lack of GPWS or TAWS;
- Airport environment:
  - Night "black-hole effect"[7] and/or rising or sloping terrain along the approach path;
- Airport equipment:
  - Lack of or restricted radar coverage;
  - Lack of a precision approach, a visual approach slope indicator (VASI) or precision approach path indicator (PAPI); and,
  - Limited approach lighting and runway lighting;
- Navigation charts:
  - Lack of published approach procedure;
  - Lack of color-shaded terrain contours on approach chart; and,
  - Lack of published minimum radar vectoring altitudes;
- Training:
  - Lack of area familiarization and/or airport familiarization; and,
  - Inadequate knowledge of applicable obstacle clearance and/or minimum vectoring altitude;
- SOPs:
  - Inadequate briefings;
  - Monitoring errors (i.e., inability to monitor the aircraft trajectory and instruments while conducting FMS entries or because of an interruption/distraction);
  - Inadequate monitoring of flight progress (being "behind the aircraft");
  - Incorrect use of automation;
  - Omission of a normal checklist or part of a normal checklist (usually because of an interruption/ distraction); and/or,
  - Deliberate or inadvertent deviation from SOPs.
- Pilot-controller communication:
  - Omission of a position report upon first radio contact in an area without radar coverage (i.e., reducing the controller's situational awareness of the aircraft);
  - Breakdown in pilot-controller or crew communication (e.g., readback/hearback errors, failure to resolve doubts or ambiguities, use of nonstandard phraseology); and/or,
  - Accepting an amended clearance without prior evaluation.
- Human factors and crew resource management (CRM):
  - Incorrect CRM practices (e.g., lack of cross-check and backup for mode selections and target entries, late recognition of monitoring errors);
  - Incorrect decision making;
  - Failure to resolve a doubt or confusion;

– Fatigue;

– Complacency;

– Spatial disorientation; and/or,

– Visual illusions.

Summary

Terrain awareness is enhanced by the following:

- SOPs defining crew task-sharing for effective cross-check and backup;
- Correct use of the barometric altimeter and radio altimeter;
- Thorough approach briefings; and,
- Use of GPWS/TAWS.

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

- *1.1 — Operating Philosophy*;
- *1.2 — Automation*;
- *1.3 — Golden Rules*;
- *1.4 — Standard Calls*;
- *1.5 — Normal Checklists*;
- *1.6 — Approach Briefing*;
- *2.3 — Pilot-Controller Communication*;
- *2.4 — Interruptions/Distractions*;
- *3.1 — Barometric Altimeter and Radar Altimeter*;
- *3.2 — Altitude Deviations*;
- *6.1 — Being Prepared to Go Around*; and,
- *6.3 — Terrain Avoidance (Pull-up) Maneuver*.♦

References

1. 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.

2. The FSF ALAR Task Force defines *causal factor* as "an event or item judged to be directly instrumental in the causal chain of events leading to the accident [or incident]." Each accident and incident in the study sample involved several causal factors.

3. Terrain awareness and warning system (TAWS) is the term used by the European Joint Aviation Authorities 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.

4. The *sterile cockpit rule* refers to U.S. Federal Aviation Regulations Part 121.542, which states: "No flight crewmember may engage in, nor may any pilot-in-command permit, any activity during a critical phase of flight which could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as eating meals, engaging in nonessential conversations within the cockpit and nonessential communications between the cabin and cockpit crews, and reading publications not related to the proper conduct of the flight are not required for the safe operation of the aircraft."

5. The FSF ALAR Task Force defines *raw data* as "data received directly (not via the flight director or flight management computer) from basic navigation aids (e.g., ADF, VOR, DME, barometric altimeter)."

6. The FSF ALAR Task Force defines *approach gate* as "a point in space (1,000 feet above airport elevation in instrument meteorological conditions or 500 feet above airport elevation in visual meteorological conditions) at which a go-around is required if the aircraft does not meet defined stabilized approach criteria."

7. The *black-hole effect* typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark, featureless terrain where the only visual stimuli are lights on and/or near the airport. The absence of visual references in the pilot's near vision affect depth perception and cause the illusion that the airport is closer than it actually is and, thus, that the aircraft is too high. The pilot may respond to this illusion by conducting an approach below the correct flight path (i.e., a low approach).

Related Reading from FSF Publications

Wilson, Dale R. "Darkness Increases Risks of Flight." *Human Factors & Aviation Medicine* Volume 46 (November–December 1999).

FSF Editorial Staff. "Learjet Strikes Terrain When Crew Tracks False Glideslope Indication and Continues Descent Below Published Decision Height." *Accident Prevention* Volume 56 (June 1999).

FSF Editorial Staff. "B-757 Damaged by Ground Strike During Late Go-around from Visual Approach." *Accident Prevention* Volume 56 (May 1999).

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. "During Nonprecision Approach at Night, MD-83 Descends Below Minimum Descent Altitude and Contacts Trees, Resulting in Engine Flame-out and Touchdown Short of Runway." *Accident Prevention* Volume 54 (April 1997).

FSF Editorial Staff. "Learjet MEDEVAC Flight Ends in Controlled-flight-into-terrain (CFIT) Accident." *Accident Prevention* Volume 54 (January 1997).

FSF Editorial Staff. "Dubrovnik-bound Flight Crew's Improperly Flown Nonprecision Instrument Approach Results in Controlled-flight-into-terrain Accident." *Flight Safety Digest* Volume 15 (July–August 1996)

Enders, John H.; Dodd, Robert; Tarrel, Rick; Khatwa, Ratan; Roelen, Alfred L.C.; Karwal, Arun K. "Airport Safety: A study of Accidents and Available Approach-and-landing Aids." *Flight Safety Digest* Volume 15 (March 1996).

FSF Editorial Staff. "Different Altimeter Displays and Crew Fatigue Likely Contributed to Canadian Controlled-flight-into-terrain Accident." *Accident Prevention* Volume 52 (December 1995).

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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).

Lawton, Russell. "Captain Stops First Officer's Go-around, DC-9 Becomes Controlled-flight-into-terrain (CFIT) Accident." *Accident Prevention* Volume 51 (February 1994).

Regulatory Resources

International Civil Aviation Organization. *Procedures for Air Navigation Services. Aircraft Operations*. Volume I, *Flight Procedures*. Part VI, *Altimeter Setting Procedures*. Fourth edition – 1993. Reprinted May 2000, incorporating Amendments 1–10.

U.S. Federal Aviation Administration (FAA). *Federal Aviation Regulations (FARs)*. 91.3 "Responsibility and authority of the pilot in command," 91.119 "Minimum safe altitudes: General," 91.121 "Altimeter settings," 91.123 "Compliance with ATC clearances and instructions," 91.155 "Basic VFR weather minimums," 91.157 "Special VFR weather minimums," 91.175 "Takeoff and landing under IFR," 91.185 "IFR operations: Two-way radio communications failure," 97 "Standard Instrument Approach Procedures, Subpart C – TERPS Procedures," 121.97 "Airports: Required data," 121.117 "Airports: Required data," 121.135 "Contents," 121.315 "Cockpit check procedure," 121.443 "Pilot in command qualification: Routes and airports," 121.445 "Pilot in command airport qualification: Special areas and airports," 121.542 "Flight crewmember duties." January 1, 2000.

FAA. *FARs*. 121.360 "Ground proximity warning-glide slope deviation alerting system." March 29, 2000.

Notice

The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force has produced this briefing note to help prevent ALAs, 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 (CAST) Joint Safety Analysis Team (JSAT) and the European Joint Aviation Authorities Safety Strategy Initiative (JSSI).

The briefing note has been prepared primarily for operators and pilots of turbine-powered airplanes with underwing-mounted engines (but can be adapted for fuselage-mounted turbine engines, turboprop-powered aircraft and piston-powered aircraft) and with the following:

- Glass flight deck (i.e., an electronic flight instrument system with a primary flight display and a navigation display);
- Integrated autopilot, flight director and autothrottle systems;
- Flight management system;
- Automatic ground spoilers;
- Autobrakes;
- Thrust reversers;
- Manufacturers'/operators' standard operating procedures; and,
- Two-person flight crew.

This briefing note is one of 34 briefing notes that comprise a fundamental part of the FSF *ALAR Tool Kit,* which includes a variety of other safety products that have been developed to help prevent ALAs.

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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