FLIGHT SAFETY FOUNDATION
ALAR
APPROACH-AND-LANDING ACCIDENT REDUCTION
TOOL KIT

FSF ALAR BRIEFING NOTE 7.1

Stabilized Approach

Unstabilized approaches are frequent factors in approach-and-landing accidents (ALAs), including those involving controlled flight into terrain (CFIT).

Unstabilized approaches are often the result of a flight crew who conducted the approach without sufficient time to:

- Plan;
- Prepare; and,
- Conduct a stabilized approach.

Statistical Data

The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force found that unstabilized approaches (i.e., approaches conducted either low/slow or high/fast) were a causal factor[1] in 66 percent of 76 approach-and-landing accidents and serious incidents worldwide in 1984 through 1997.[2]

The task force said that although some low-energy approaches (i.e., low/slow) resulted in loss of aircraft control, most involved CFIT because of inadequate vertical-position awareness.

The task force said that the high-energy approaches (i.e., high/fast) resulted in loss of aircraft control, runway overruns and runway excursions, and contributed to inadequate situational awareness in some CFIT accidents.

The task force also found that flight-handling difficulties (i.e., the crew's inability to control the aircraft to the desired flight parameters [e.g., airspeed, altitude, rate of descent]) were a causal factor in 45 percent of the 76 approach-and-landing accidents and serious incidents.

The task force said that flight-handling difficulties occurred in situations that included rushing approaches, attempts to comply with demanding air traffic control (ATC) clearances, adverse wind conditions and improper use of automation.

Definition

An approach is stabilized only if all the criteria in company standard operating procedures (SOPs) are met before or when reaching the applicable minimum stabilization height.

The stabilized approach criteria recommended by the FSF ALAR Task Force are shown on the next page.

Note: Flying a stabilized approach that meets the recommended criteria discussed below does not preclude flying a delayed-flaps approach (also referred to as a decelerated approach) to comply with ATC instructions.

The following minimum stabilization heights are recommended to achieve a stabilized approach:

- 1,000 feet above airport elevation in instrument meteorological conditions (IMC); or,
- 500 feet above airport elevation in visual meteorological conditions (VMC).

At the minimum stabilization height and below, a call should be made by the pilot not flying/pilot monitoring (PNF/PM) if any flight parameter exceeds the established criteria.

Any time an approach is not stabilized at the minimum stabilization height or becomes unstabilized below the minimum stabilization height, a go-around should be conducted.

Benefits of a Stabilized Approach

Conducting a stabilized approach increases the flight crew's overall situational awareness, including:

- Horizontal awareness, by closely monitoring the horizontal flight path;
- Vertical awareness, by monitoring the vertical flight path and the rate of descent;
- Airspeed awareness, by monitoring airspeed trends; and,

Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 ft above airport elevation in instrument meteorological conditions (IMC) and by 500 ft 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 kt 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 fpm; if an approach requires a sink rate greater than 1,000 fpm, 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 ft 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 ft above airport elevation in IMC or below 500 ft above airport elevation in VMC requires an immediate go-around.

Source: FSF ALAR Task Force

- Energy-condition awareness, by maintaining the engine thrust at the level required to fly a three-degree approach path at the target final approach speed (or at the minimum groundspeed, as applicable). This also enhances go-around capability.

In addition, a stabilized approach provides:

- More time and attention for monitoring ATC communications, weather conditions and systems operation;
- More time for monitoring and backup by the PNF/PM;
- Defined flight-parameter-deviation limits and minimum stabilization heights to support the decision to land or to go around; and,
- Landing performance consistent with published performance.

Factors in Unstabilized Approaches

Unstabilized approaches are attributed to:

- Fatigue;
- Pressure of flight schedule (making up for delays);
- Any crew-induced or ATC-induced circumstances resulting in insufficient time to plan, prepare and conduct a safe approach. This includes accepting requests from ATC to fly higher/faster or to fly shorter routings than desired;
- ATC instructions that result in flying too high/too fast during the initial approach;
- Excessive altitude or excessive airspeed (e.g., inadequate energy management) early in the approach;
- Late runway change (lack of ATC awareness of the time required by the flight crew to reconfigure the aircraft for a new approach);
- Excessive head-down work (e.g., flight management system [FMS] reprogramming);
- Short outbound leg or short downwind leg (e.g., because of traffic in the area);
- Late takeover from automation (e.g., because the autopilot [AP] fails to capture the glideslope);
- Premature descent or late descent caused by failure to positively identify the final approach fix (FAF);
- Inadequate awareness of wind conditions, including:
  - Tail wind component;
  - Low-altitude wind shear;
  - Local wind gradient and turbulence (because of terrain or buildings); or,
  - Recent weather along the final approach path (e.g., wind shift or downdrafts caused by a descending cold air mass following a rain shower);
- Incorrect anticipation of aircraft deceleration characteristics in level flight or on a three-degree glide path;
- Failure to recognize deviations or failure to adhere to the excessive-parameter-deviation limits;
- Belief that the aircraft will be stabilized at the minimum stabilization height or shortly thereafter;
- Excessive confidence by the PNF/PM that the pilot flying (PF) will achieve a timely stabilization;
- PF-PNF/PM too reliant on each other to call excessive deviations or to call for a go-around; and,
- Visual illusions.

Deviations in Unstabilized Approaches

One or more of the following deviations often are involved in unstabilized approaches:

- Entire approach flown at idle thrust down to touchdown, because of excessive airspeed and/or excessive altitude from early in the approach;
- Steep approach (above desired flight path with excessive vertical speed). Steep approaches are conducted typically twice as often as shallow approaches;
- Shallow approach (below desired glide path);
- Low-airspeed maneuvering (energy deficit);
- Excessive bank angle when capturing the final approach course;
- Activation of the ground-proximity warning system (GPWS) or the terrain awareness and warning system (TAWS)[3]:
  - Mode 1: "sink rate";
  - Mode 2A: "terrain" (not full flaps); or,
  - Mode 2B: "terrain" (full flaps);
- Late extension of flaps, or flaps-load-relief-system activation resulting in the late extension of flaps;
- Excessive flight-parameter deviation when crossing the minimum stabilization height:
  - Excessive airspeed;
  - Not aligned with runway;
  - Excessive bank angle;
  - Excessive vertical speed; or,
  - Flight path above glideslope;
- Excessive bank angle, excessive sink rate or excessive maneuvering while conducting a side-step maneuver;
- Speed brakes remain extended on short-final approach;
- Excessive flight-parameter deviation down to runway threshold;
- High at runway threshold crossing (i.e., more than 50 feet above threshold); and,
- Extended flare and extended touchdown.

Company Accident-Prevention Strategies and Personal Lines of Defense

Preventing unstabilized approaches can be achieved by developing recommendations for the early detection and correction of factors that contribute to an unstabilized approach.

The following strategy is recommended:

- Anticipate;
- Detect;
- Correct; and,
- Decide.

Anticipate

Some factors likely to result in an unstabilized approach can be anticipated. For example, pilots and controllers should avoid situations that result in rushing approaches.

The approach briefing provides opportunities to identify and discuss factors such as nonstandard altitude, airspeed restrictions and energy management. The flight crew should agree on the management of the descent, deceleration and stabilization. This agreement will constitute a common objective for the PF and PNF/PM.

Detect

The purpose of defined excessive-parameter-deviation limits and minimum stabilization heights is to provide the PF and PNF/PM with a common reference for effective monitoring (early detection of deviations) and backup (timely and precise calls for effective corrections).

To ensure monitoring and backup, the following should be avoided:

- Late briefings;
- Unnecessary radio calls (e.g., company calls);
- Unnecessary actions (e.g., use of airborne communications addressing and reporting system [ACARS]); and,
- Nonpertinent conversations on the flight deck (i.e., breaking the "sterile cockpit rule"[4]).

Reducing workload and flight deck interruptions/distractions also allows the flight crew to:

- Better cope with fatigue;
- Comply with an unexpected ATC request (e.g., runway change);
- Adapt to changing weather conditions; and,
- Manage a system malfunction (e.g., flaps jamming or landing gear failing to extend).

Correct

Positive corrective actions should be taken before deviations develop into a challenging situation or a hazardous situation in which the only safe action is a go-around.

Corrective actions may include:

- The timely use of speed brakes or landing gear to correct excessive height or excessive airspeed; and,
- Extending the outbound leg or downwind leg.

Decide

If the approach is not stabilized before reaching the minimum stabilization height, or if any flight parameter exceeds deviation limits (other than transiently) when below the minimum stabilization height, a go-around must be conducted immediately.

The following behaviors often are involved when unstabilized approaches are continued:

- Excessive confidence in a quick recovery (postponing the go-around decision when flight parameters are converging toward excessive-deviation limits);
- Excessive confidence because of a long-and-dry runway and a low gross weight, although airspeed or vertical speed may be excessive;
- Inadequate preparation or lack of commitment to conduct a go-around. A change of mindset should take place from "we will land unless …" to "let's be prepared for a go-around, and we will land if the approach is stabilized and if we have sufficient visual references to make a safe approach and landing"; and,
- Absence of decision making (failure to remember the applicable excessive-deviation limits) because of fatigue or workload.

Achieving Flight Parameters

The flight crew must "stay ahead of the aircraft" throughout the flight. This includes achieving desired flight parameters (e.g., aircraft configuration, aircraft position, energy condition, track, vertical speed, altitude, airspeed and attitude) during the descent, approach and landing. Any indication that a desired flight parameter will not be achieved should prompt immediate corrective action or the decision to go around.

The minimum stabilization height constitutes an *approach gate*[5] on the final approach; a go-around must be initiated if:

- The required configuration and airspeed are not established, or the flight path is not stabilized when reaching the minimum stabilization height; or,
- The aircraft becomes unstabilized below the minimum stabilization height.

Transition to Visual Flying

When transitioning from instrument flight to visual flight, the pilot's perception of the runway and outside environment should be kept constant by maintaining:

- Drift correction, to continue tracking the runway centerline (i.e., resisting the tendency to align the aircraft with the runway centerline);
- The aiming point, to remain on the correct glide path until flare height (resisting the tendency to advance the aiming point and, thus, descend below the correct glide path); and,
- The final approach speed to maintain the energy condition.

Summary

Three essential parameters must be stabilized for a safe approach:

- Aircraft track;
- Flight path angle; and,
- Airspeed.

Depending on the type of approach and aircraft equipment, the most appropriate level of automation, as well as available visual references, should be used to establish and to monitor the stabilization of the aircraft.

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

- 4.1 — Descent-and-Approach Profile Management;
- 4.2 — Energy Management;
- 6.1 — Being Prepared to Go Around;
- 7.2 —Constant-Angle Nonprecision Approach;
- 8.2 — The Final Approach Speed; and,
- 8.3 — Landing Distances.

Notes

1. The Flight Safety Foundation Approach-and-landing Accident Reduction (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.
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.
3. 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.
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.

For the purposes of this section, critical phases of flight include all ground operations involving taxi, takeoff and landing, and all other flight operations below 10,000 feet, except cruise flight." [The FSF ALAR Task Force says that "10,000 feet" should be height above ground level during flight operations over high terrain.]

5. 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."

Related Reading From FSF Publications

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FSF Editorial Staff. "Destabilized Approach Results in MD-11 Bounced Landing, Structural Failure." *Accident Prevention* Volume 58 (January 2001).

FSF Editorial Staff. "Poorly Flown Approach in Fog Results in Collision With Terrain Short of Runway." *Accident Prevention* Volume 52 (August 1995).

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Lawton, Russell. "Steep Turn by Captain During Approach Results in Stall and Crash of DC-8 Freighter." *Accident Prevention* Volume 51 (October 1994).

Lawton, Russell. "Breakdown in Coordination by Commuter Crew During Unstabilized Approach Results in Controlled-flight-into-terrain Accident." *Accident Prevention* Volume 51 (September 1994).

FSF Editorial Staff. "Unstabilized Approach, Icing Conditions Lead to Commuter Tragedy." *Accident Prevention* Volume 49 (December 1992).

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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