FLIGHT SAFETY FOUNDATION

ALAR

APPROACH-AND-LANDING ACCIDENT REDUCTION

TOOL KIT

FSF ALAR BRIEFING NOTE 7.3

Visual References

The transition from instrument references to external visual references is an important element of any type of instrument approach.

Some variations exist in company operating philosophies about flight crew task sharing for:

- Acquiring visual references;
- Conducting the landing; and,
- Conducting the go-around.

For task sharing during approach, two operating philosophies are common:

- Pilot flying-pilot not flying/pilot monitoring (PF-PNF/PM) task sharing with differences about the acquisition of visual references, depending on the type of approach and on the use of automation:
  - Nonprecision and Category (CAT) I instrument landing system (ILS) approaches; or,
  - CAT II/CAT III ILS approaches (the captain usually is the PF, and only an automatic approach and landing is considered); and,
- Captain-first officer (CAPT-FO) task sharing, which usually is referred to as a *shared approach, monitored approach* or *delegated-handling approach*.

Differences in the philosophies include:

- The transition to flying by visual references; and,
- Using and monitoring the autopilot.

Statistical Data

The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force found that flight crew omission of action/inappropriate action was a causal factor[1] in 25 percent of 287 fatal approach-and-landing accidents worldwide in 1980 through 1996 involving jet aircraft and turboprop aircraft with maximum takeoff weights above 12,500 pounds/5,700 kilograms.[2] The task force said that these accidents typically involved the following errors:

- 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).

Altitude-Deviation and Terrain Avoidance

During the final-approach segment, the primary attention of both pilots should be directed to published minimum approach altitudes and altitude-distance checks prior to reaching the MDA(H) or DA(H).

An immediate pull-up is required in response to a ground-proximity warning system (GPWS) warning or a terrain awareness and warning system (TAWS)[3] warning in instrument meteorological conditions (IMC) or at night.

Definition

Whenever a low-visibility approach is anticipated, the approach briefing must include a thorough review of the approach light system (ALS) by using the instrument approach chart and the airport chart.

Depending on the type of approach and prevailing ceiling and visibility conditions, the crew should discuss the lighting system(s) expected to be observed upon first visual contact.

For example, U.S. Federal Aviation Regulations (FARs) Part 91.175 says that at least one of the following references must be distinctly visible and identifiable before the pilot descends below DA(H) on a CAT I ILS approach or MDA(H) on a nonprecision approach:

- "The approach light system, except that the pilot may not descend below 100 feet above the touchdown zone elevation using the approach lights as a reference unless the red terminating bars or the red side-row bars are also distinctly visible and identifiable;
- "The [runway] threshold;
- "The threshold markings;
- "The threshold lights;
- "The runway end identifier lights;
- "The visual approach slope indicator;
- "The touchdown zone or touchdown zone markings;
- "The touchdown zone lights;
- "The runway or runway markings; [or,]
- "The runway lights."

The International Civil Aviation Organization says that *required visual reference* "means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position in relation to the desired flight path."

When using external references, the visual references must be adequate for the pilot to assess horizontal flight path and vertical flight path.

After adequate visual references have been acquired to allow descent below the MDA(H) or DA(H), the different elements of the various ALSs provide references for position, drift angle, distance and rates of change for the final phase of the approach.

Visual References

The task sharing for the acquisition of visual references and for the monitoring of the flight path and aircraft systems varies, depending on:

- The type of approach; and,
- The level of automation being used:
  - Hand flying (using the flight director [FD]); or,
  - Autopilot (AP) monitoring (single or dual AP).

Nonprecision and CAT I ILS Approaches

Nonprecision approaches and CAT I ILS approaches can be flown by hand with reference to raw data[4] or to the FD commands, or with the AP engaged.

The PF is engaged directly in either:

- Hand flying the airplane, by actively following the FD commands and monitoring the raw data; or,
- Supervising AP operation and being ready to take manual control of the aircraft, if required.

The PNF/PM is responsible for progressively acquiring and calling the visual references while monitoring flight progress and backing up the PF.

The PNF/PM scans alternately inside and outside, calls flight-parameter deviations and calls:

- "One hundred above" then "minimum" (if no automatic call) if adequate visual references are not acquired; or,
- "Visual" (or whatever visual reference is in sight) if adequate visual references are acquired.

  The PNF/PM should not lean forward while attempting to acquire visual references. If the PNF/PM calls "visual" while leaning forward, the PF might not acquire the visual reference because his/her viewing angle will be different.

The PF then confirms the acquisition of visual references and calls "landing" (or "go around" if visual references are not adequate).

If "landing" is called, the PF progressively transitions from instrument references to external visual references.

CAT II/CAT III ILS Approaches

CAT II/CAT III ILS approaches are flown using the automatic landing system (as applicable for the aircraft type).

CAT II automatic approaches can be completed with a hand flown landing (although the standard operating procedure is to use the automatic landing capability).

In CAT III weather conditions, automatic landing is mandatory usually.

Consequently, *visual reference* does not have the same meaning for CAT II and CAT III approaches.

For CAT II approaches, visual reference means *being able to see to land* (i.e., being able to conduct a hand-flown landing).

For CAT III approaches, visual references means *being able to see to verify aircraft position*.

FARs Part 91.189 and Joint Aviation Requirements–Operations 1.430 consider these meanings in specifying minimum visual references that must be available at the DA(H).

For a CAT III approach with no DA(H), no visual reference is specified, but recommended practice is for the PF to look for visual references before touchdown, because visual references are useful for monitoring AP guidance during the roll-out phase.

During an automatic approach and landing, the flight path is monitored by the AP (autoland warning) and supervised by the PNF/PM (excessive-deviation calls).

Thus, the PF can concentrate his or her attention on the acquisition of visual references, progressively increasing external scanning as the DH is approached.

When an approach is conducted near minimums, the time available for making the transition from instrument references to visual references is extremely short; the PF therefore must concentrate on the acquisition of visual references.

The PNF/PM maintains instrument references throughout the approach and landing (or go-around) to monitor the flight path and the instruments, and to be ready to call any flight-parameter excessive deviation or warning.

Shared Approach/Monitored Approach/ Delegated-Handling Approach

Shared approach/monitored approach/delegated-handling approach provides an alternative definition of the PF and PNF/PM functions, based on CAPT-FO task sharing.

This operating policy can be summarized as follows:

- Regardless of who was the PF for the sector, the FO is always the PF for the approach;
- The CAPT is PNF/PM and monitors the approach and the acquisition of visual references;
- Before or upon reaching the DA(H), depending on the company's policy:
  - If visual references are acquired, the CAPT calls "landing," takes over the controls and lands; or,
  - If visual references are not acquired, the CAPT calls "go-around," and the FO initiates the go-around and flies the missed approach.

Whatever the decision, landing or go-around, the FO maintains instrument references for the complete approach and landing (or go-around and missed approach).

Depending on the FO's experience, the above roles can be reversed.

This operating policy minimizes the problem of transitioning from instrument flying to visual flying and, in a go-around, the problem of resuming instrument flying. Nevertheless, this operating policy involves a change of controls (i.e., PF-PNF/PM change) and requires the development of appropriate standard operating procedures (SOPs) and standard calls.

Depending on the company's operating philosophy, this technique is applicable to:

- CAT II/CAT III approaches only (for all other approaches, the PF is also the pilot landing); or,
- All types of approaches (except automatic landings where the CAPT resumes control earlier, typically from 1,000 feet radio altitude to 200 feet radio altitude).

Implementation

Implementation of the shared approach/monitored approach/delegated-handling approach requires the development of corresponding SOPs and standard calls.

Of particular importance is that the sequence of planned actions or conditional actions and calls must be briefed accurately during the approach briefing.

Such actions and calls usually include the following:

For the CAPT:

- If adequate visual references are acquired before or at DA(H):
  - Call "landing"; and,
  - Take over flight controls and thrust levers, and call "I have control" or "my controls," per company SOPs;
- If adequate visual references are not acquired at DA(H):
  - Call "go-around," cross-check and back up the FO during the go-around initiation and missed approach.

For the FO:

- If CAPT calls "landing, I have controls" or "landing, my controls":
  - Call "you have control" or "your controls," per company SOPs; and,
  - Continue monitoring instrument references;
- If CAPT calls "go-around":
  - *Initiate immediately the go-around and fly the missed approach*;
- If CAPT does not make any call or does not take over the flight controls and throttle levers (e.g., because of subtle incapacitation):
  - *Call "go-around" and initiate immediately the go-around.*

Standard Calls

The importance of task sharing and standard calls during the final portion of the approach cannot be overemphasized.

Standard calls for confirming the acquisition of visual references vary from company to company.

"Visual" or the acquired visual reference (e.g., "runway in sight") usually is called if adequate visual references are acquired and the aircraft is correctly aligned and on the approach glide path; otherwise, the call "visual" or "[acquired visual reference]" is followed by an assessment of the lateral deviation or vertical deviation (offset).

The CAPT determines whether the lateral deviation or vertical deviation can be corrected safely and calls "continue" (or "landing") or "go-around."

Recovery From a Deviation

Recovering from a lateral deviation or vertical deviation when transitioning to visual references requires careful control of the pitch attitude, bank angle and power with reference to raw data to help prevent crew disorientation by visual illusions.

The PNF/PM is responsible for monitoring the instruments and for calling any excessive deviation.

Vertical Deviation

A high sink rate with low thrust when too high may result in a hard landing or in a landing short of the runway.

The crew should establish the correct flight path, not exceeding the maximum permissible sink rate (usually 1,000 feet per minute).

A shallow approach with high thrust when too low may result in an extended flare and a long landing.

The crew should establish level flight until the correct flight path is established.

Lateral Deviation

Establish an aiming point on the extended runway centerline, approximately half the distance to the touchdown point, and aim toward the point while maintaining the correct flight path, airspeed and thrust setting.

To avoid overshooting the runway centerline, anticipate the alignment by beginning the final turn shortly before crossing the extended runway-inner-edge line.

Loss of Visual References Below MDA(H) or DA(H)

If loss of adequate visual references occurs below the MDA(H) or DA(H), a go-around must be initiated immediately.

For example, FARs Part 91.189 requires that "each pilot operating an aircraft shall immediately execute an appropriate missed approach whenever [the conditions for operating below the authorized DA(H)] are not met."

Summary

- During nonprecision approaches and CAT I ILS approaches, ensure that both the PF and PNF/PM have acquired the same — and the correct — visual references; and,
- During CAT II/CAT III ILS approaches and during all shared/monitored/delegated-handling approaches, the FO must remain head-down, monitoring flight instruments, for approach and landing or go-around.

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

- 1.1 — Operating Philosophy;
- 1.2 — Automation;
- 1.4 — Standard Calls; and,
- 5.3 — Visual Illusions.

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." Each accident 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 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)."

Related Reading From FSF Publications

Darby, Rick. "Keeping It on the Runway." *AeroSafety World* Volume 4 (August 2009).

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Lacagnina, Mark. "Short Flight, Long Odds." *AeroSafety World* Volume 4 (May 2009).

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Rash, Clarence E. "Flying Blind." *AviationSafety World* Volume 1 (December 2006).

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

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Flight Safety Foundation (FSF) Editorial Staff. "Boeing 767 Strikes Mountain During Circling Approach." *Accident Prevention* Volume 62 (December 2005).

FSF Editorial Staff. "Freighter Strikes Trees During Nighttime 'Black-hole' Approach." *Accident Prevention* Volume 62 (February 2005).

FSF Editorial Staff. "Nonadherence to Approach Procedure Cited in Falcon 20 CFIT in Greenland." *Accident Prevention* Volume 61 (November 2004).

FSF Editorial Staff. "Failure to Comply With Nonprecision Approach Procedure Sets Stage for Regional Jet CFIT at Zurich." *Accident Prevention* Volume 61 (June 2004).

FSF Editorial Staff. "Sabreliner Strikes Mountain Ridge During Night Visual Approach." *Accident Prevention* Volume 60 (April 2003).

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FSF Editorial Staff. "Cargo Airplane Strikes Frozen Sea During Approach in Whiteout Conditions." *Accident Prevention* Volume 59 (January 2002).

FSF Editorial Staff. "Descent Below Minimum Altitude Results in Tree Strike During Night, Nonprecision Approach." *Accident Prevention* Volume 58 (December 2001).

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. "Inadequate Visual References in Flight Pose Threat of Spatial Disorientation." *Human Factors & Aviation Medicine* Volume 44 (November–December 1997).

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

Mohler, Stanley R. "The Human Balance System: A Refresher for Pilots." *Human Factors & Aviation Medicine* Volume 42 (July–August 1995).

FSF Editorial Staff. "Spatial Disorientation Linked to Fatal DC-8 Freighter Crash." *Accident Prevention* Volume 50 (March 1993).

Antuñano, Melchor J.; Mohler, Stanley R. "Inflight Spatial Disorientation." *Human Factors & Aviation Medicine* Volume 39 (January–February 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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