Flight Safety Foundation

ALAR

Approach-and-landing Accident Reduction

Tool Kit

FSF ALAR Briefing Note 7.2 — Constant-angle Nonprecision Approach

Planning and conducting a nonprecision approach are challenging tasks that involve:

- Decision making on strategies and options;
- Task-sharing;
- Crew resource management (e.g., crew coordination, cross-check and backup); and,
- Controlled-flight-into-terrain (CFIT) risk awareness (e.g., awareness of the requirement for immediate response to a ground-proximity warning system [GPWS] warning or a terrain awareness and warning system [TAWS][1] warning).

Nonprecision approaches have common features but require approach-specific techniques, depending on the navaids being used or on the strategy being used for:

- Lateral navigation and vertical navigation;
- Descent from the final approach fix (FAF) to the minimum descent altitude/height (MDA[H]); and,
- Decision making before or upon reaching the MDA(H).

Note: The charted MDA(H) is referenced either to the touchdown zone elevation (TDZE) or to the airport elevation, which is the highest point in the landing area. The International Civil Aviation Organization (ICAO) defines MDA(H) as: obstacle clearance altitude/height (OCA[H]) plus 30 feet.[2]

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, and that 57 percent of the CFIT accidents and incidents occurred during step-down nonprecision approaches.[3]

The task force recommended expedited implementation worldwide of constant-angle nonprecision approach (CANPA) procedures and training flight crews to properly use such procedures.

Definition

A nonprecision approach is an instrument approach that does not incorporate vertical guidance (i.e., no glideslope).

This discussion will include nonprecision instrument approaches that use the following navaids: nondirectional beacon (NDB), very-high-frequency omnidirectional radio (VOR), localizer (LOC), VOR-DME (distance-measuring equipment), LOC-DME and LOC back course (BC).

Instrument approaches normally include three approach segments:

- Initial approach:

– Beginning at an initial approach fix (IAF) and ending at the intermediate fix (IF), if defined; and,

– With obstacle clearance of 1,000 feet;

- Intermediate approach:

– From the IF to the final approach fix (FAF); and,

– With obstacle clearance of 500 feet; and,

- Final approach:

– From the FAF to the MDA(H), visual descent point (VDP) or missed approach point (MAP); and,

– With obstacle clearance of 250 feet.

During the intermediate approach, the aircraft is configured for the final approach as follows:

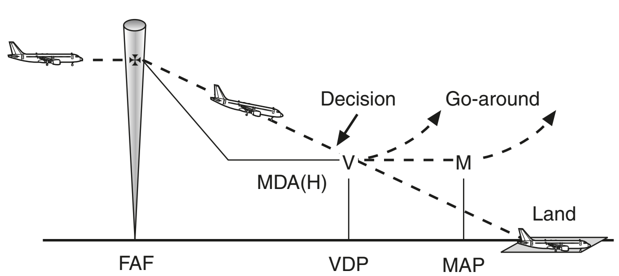
- Configuration established (landing flaps and landing gear extended);
- Airspeed stabilized at the final approach speed;
- Aircraft aligned with the final approach course; and,
- Landing checklist and briefings completed.

The CANPA final approach features *a constant-angle descent* using the vertical-speed mode or the flight-path vector (as available), with altitude-distance checks.

VDP Concept

The VDP is the location at the MDA(H) where the aircraft can be flown on approximately a three-degree glide path to the runway (Figure 1).

Visual Descent Point Provides Normal Descent to Runway



FAF = Final approach fix
MDA(H) = Minimum descent altitude/height
VDP = Visual descent point
MAP = Missed approach point

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

Figure 1

The VDP location is defined by:

- Distance from a VOR-DME or LOC-DME; or,
- Time from the FAF.

The VDP should be considered the last point from which a stabilized approach can be conducted (Table 1).

CANPA Benefits

Traditional step-down approaches are based on an *obstacle-clearance profile*; such approaches are not optimum for modern turbine aircraft and turboprop aircraft.

Table 1
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)

Flying a constant-angle approach profile:

- Provides a more stabilized flight path;
- Reduces workload; and,
- Reduces the risk of error.

Strategies and Options

Planning for a nonprecision approach requires several decisions on the following strategies and options:

- Lateral navigation:
  - Use of selected modes (heading or localizer); or,
  - Use of the flight management system (FMS) lateral-navigation (LNAV) mode down to MDA(H) or until LOC interception;
- Vertical navigation:
  - Use of selected modes (altitude hold and vertical speed); or,
  - Use of the FMS vertical-navigation (VNAV) mode down to the FAF (or beyond, as applicable in accordance with the aircraft operating manual [AOM]/quick reference handbook [QRH]), and use of the vertical-speed mode down to the MDA(H); and,
- Final descent from the FAF:
  - Constant-angle descent with the decision made before or upon reaching MDA(H).

    The requirement to make the final-descent decision before or upon reaching the MDA(H) depends upon applicable operating regulations about descent below the MDA(H) during a go-around maneuver. The CANPA MDA(H) may be considered a DA(H) only if the approach has been surveyed and approved by the appropriate regulatory authorities.

A nonprecision approach may be conducted using either:

- Lateral-navigation guidance, with monitoring of raw data[4];
- Raw data only;
- Flight-path director, with or without the autopilot (AP) engaged; or,
- Raw data supported by the flight-path vector (as available on the primary flight display [PFD] or head-up display [HUD]).

A nonprecision approach may be conducted with the AP engaged.

The autothrottle system should remain in the “speed” mode.

CFIT Awareness

During the final descent to the MDA(H), both pilots must monitor the flight path to ensure that descent is not continued through a charted step-down altitude before reaching the associated charted fix (DME distance or other reference).

A GPWS/TAWS warning in instrument meteorological conditions (IMC) or night conditions demands an immediate pull-up maneuver.

Descending Below MDA(H)

During a nonprecision approach, the pilot flying (PF) is either hand-flying the aircraft or supervising AP operation; the pilot not flying (PNF) is responsible for acquiring and calling out the visual references.

Continuing the approach below the MDA(H) is permitted only if at least one of the required visual references is distinctly visible and identifiable by the PF.

A nonprecision approach is completed visually with a hand-flown landing, or a go-around is conducted.

SOPs and Standard Calls

Task-sharing, standard calls and altitude-deviation and parameter-deviation calls are especially important during a nonprecision approach.

The following overview outlines the actions and standard calls required by standard operating procedures (SOPs) and illustrates the typical phases of the approach and the sequence of decisions involved in a nonprecision approach.

Descent/Approach Preparation

- Anticipate and confirm the runway in use and the type of approach to be conducted;
- Define the approach strategy for lateral navigation:
  - Select heading mode and raw data (or VOR mode, if allowed for navigation in terminal areas); or,
  - Select FMS LNAV mode with monitoring of raw data, provided that the approach is defined in the FMS navigation database and that FMS navigation accuracy meets the criteria for approach;
- Define the approach strategy for vertical navigation:
  - Vertical-speed mode; or,
  - FMS VNAV mode down to the FAF (or beyond, as applicable, in accordance with the AOM/QRH), then vertical-speed mode down to the MDA(H);

- Insert the desired standard terminal arrival (STAR) and approach (from the database) in the FMS flight plan;
- Enter the descent winds and surface winds on the appropriate FMS page, as applicable;
- Enter the landing configuration and wind correction on the appropriate FMS page, as applicable;
- If the VNAV mode is authorized after the FAF, enter the MDA(H) on the appropriate FMS page, as applicable;
- Set up navaids (identify, as required); and,
- Plan the descent to reach the IAF at the prescribed altitude and planned airspeed.

Approach Briefing

- Check FMS navigation accuracy (usually by ensuring that the FMS bearing/distance to a tuned VOR-DME and the radio magnetic indicator [RMI] raw data agree according to criteria defined in SOPs) and confirm strategies for lateral navigation and vertical navigation (i.e., FMS or selected guidance);
- Review terrain features, location of obstacles and obstacle clearances;
- Confirm the minimum safe altitude (MSA);
- Review the approach procedure (altitudes, bearings and headings);
- Review the approach vertical profile (step-down altitudes) and MDA(H);
- Set and check the MDA(H) on the barometric-altimeter bug;
- Review the expected visual references (approach lighting and runway lighting);
- Review the missed approach procedure;
- Confirm the timing from the FAF to the MAP or to the VDP, or confirm the DME reading for the VDP;
- Confirm the navaids (frequencies, courses and identifications);
- Compute the expected groundspeed;
- Confirm the published vertical speed or computed vertical speed for the final descent; and,
- Confirm use of the flight director (FD) or the flight-path director (as applicable).

Before Reaching the IAF/Holding Fix

- Keep the AP engaged with FMS or selected lateral-navigation mode and vertical-navigation mode, as desired;
- Keep both navigation displays (NDs) in "MAP" mode (unless FMS navigation accuracy is greater than one nautical mile [nm], or per applicable SOPs);
- If the FMS LNAV mode is used:
  - Check the FMS navigation accuracy level (e.g., "R/I" or "HIGH" or […], depending on the FMS type and standard);
  - Check the NDs for correct flight plan and for correct "TO WPT";
  - Confirm that the FMS LNAV mode is shown on the flight-mode annunciator (FMA); and,
  - Maintain both NDs in "MAP" mode (in accordance with the AOM/QRH);
- Adjust the descent rate to reach the IAF at the charted/prescribed altitude and target airspeed;
- Establish the desired configuration (clean or slats extended) and airspeed; and,
- Adjust weather radar gain and tilt, as applicable, for optimum use of the system for weather avoidance or enhanced horizontal situational awareness.

Upon Reaching the IAF or Holding Fix

- If the FMS LNAV mode will be used beyond the IAF or holding fix, keep both NDs in "MAP" mode if the FMS is certified as "sole means of navigation for approach" — otherwise, one ND must be used to monitor raw data;
- If selected heading mode or localizer mode will be used to capture and to track the final approach course, set the PF's ND to the arc or horizontal situation indicator (HSI)-type display; and,
- The PNF may keep the ND in "MAP" mode (with display of airspeed and altitude restrictions) for situational awareness.

While Holding or When Appropriate

Configure the aircraft (slats extended only or approach flaps) and establish the associated maneuvering speed.

Exiting the Holding Pattern

Select the holding "EXIT" prompt to allow the correct sequencing of the FMS flight plan.

After Leaving the Holding Pattern

- If the FMS LNAV mode is not used, use the selected heading mode (or the VOR mode, if allowed for terminal area navigation; or the track mode, as available) to intercept the final approach course, as follows:

– For an NDB approach, set the final approach course on the ILS course selector; this will set the ILS course pointer on the ND and provide a course reference;

– For a VOR or VOR-DME approach, set the final approach course on the VOR course selector, but do not arm the VOR mode. Capture and track the VOR course using the selected heading/track mode; or,

– For a LOC or LOC-DME approach, set the final approach course on the ILS course selector and arm the localizer mode; and,

- To prepare for re-engaging the LNAV mode for a go-around, check the correct FMS flight plan sequencing (the "TO WPT" must be the FAF; if not, program a "DIR TO" the FAF).

Before Reaching the FAF

- Align the aircraft within five degrees of the final approach course;
- Extend the landing gear;
- Arm the ground spoilers;
- Set landing flaps;
- Enter the target final approach speed;
- Set the go-around altitude (if the go-around altitude is the same as the FAF crossing altitude, set the go-around altitude only after beginning the final descent);
- Conduct the "LANDING" checklist;
- If the FMS VNAV mode will be used after the FAF, enter the published or computed vertical speed and course;
- If the flight-path vector will be used after the FAF (as available on the PFD or HUD), enter the published or computed flight-path angle and track; and,
- If the VNAV mode is not authorized beyond the FAF, deselect the VNAV mode by selecting the altitude-hold mode or the vertical-speed mode, as required.

Approaching the FAF

Typically 0.3 nautical mile (nm) to 0.2 nm before reaching the FAF, to begin descent at the FAF on profile:

- Engage the VNAV mode and check mode engagement on the FMA;
- Enter the published (or computed) vertical speed, as a function of the groundspeed;
- Select the flight-path vector display (as available);
- Start timing (as required); and,
- Cross-check and call the next fix (or DME distance, as applicable) and crossing altitude.

During the Descent to the MDA(H)

- Monitor the raw data (vertical speed, flight-path vector [as available], course, distances, altitudes) and call the vertical profile for correct slope and track (i.e., at each altitude/distance check):
  – Cross-check and call the altitude deviation;
  – Adjust vertical speed, as required; and,
  – Call the next fix (or DME distance) and crossing altitude; and,
- Set the altitude selector per applicable SOPs (usually, the go-around altitude).

Approaching the MDA(H)

At an altitude corresponding to the MDA(H) plus 1/10 the rate of descent (typically MDA[H] plus 50 feet to 100 feet), anticipate a go-around decision to avoid descent below the MDA(H), as required by applicable regulations.

At the MDA(H)

If adequate visual references are acquired:

- Disconnect the AP and continue the approach visually (the autothrottles may remain engaged in speed mode down to the retard point, as applicable).

If adequate visual references are not acquired:

- Initiate a go-around climb; and,
- Overfly the MAP (to guarantee obstacle clearance during the go-around) and fly the published missed approach procedure.

(ICAO says that although the flight crew should overfly the MAP before conducting the published missed approach procedure, "this does not preclude flying over the [MAP] at an altitude/height greater than that required by the procedure" [as shown in Figure 1].) [5]

Nonprecision Approach Factors

Training feedback and line-operations experience have shown that the nonprecision approach is affected by:

- Incorrect or outdated instrument approach chart;
- Late descent preparation;
- FMS navigation accuracy not checked;
- FMS flight plan not correctly programmed;
- Failure to monitor raw data;
- Navaids not tuned correctly (frequency or course);
- Incomplete briefing;

- Incorrect choice of autopilot modes;
- Incorrect entry of autopilot targets (e.g., airspeed, heading, altitude) or autothrottle targets;
- Inadequate cross-check and backup by the PF/PNF;
- Inaccurate tracking of the final approach course, using the selected heading (or track) mode;
- Late configuration of aircraft;
- Final approach speed not stabilized at FAF;
- Failure to include prevailing head-wind component in computing the vertical speed for the final constant-angle descent;
- No timing or positive identification of the VDP or MAP;
- Inadequate monitoring of raw data;
- Incorrect identification of the FAF;
- Go-around altitude not entered; and,
- Premature descent to the next step-down altitude (if multiple step-downs) or below the MDA(H).

Summary

Successful nonprecision approaches include:

- Determining the type of guidance to be used;
- Preparing the FMS, as applicable;
- Completing an approach briefing;
- Planning aircraft configuration setup;
- Monitoring descent;
- Managing aircraft energy condition during intermediate approach and final approach;
- Not descending below an altitude before reaching the associated fix;
- Determining the correct angle (vertical speed) for the final descent;
- Beginning the descent at the correct point;
- Maintaining the correct flight-path angle (vertical speed) during the final descent;
- Acquiring visual references and making the decision to land; and,
- Preparing for a go-around.

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

- *1.1 — Operating Philosophy*;
- *1.4 — Standard Calls*;
- *1.6 — Approach Briefing*;
- *4.2 — Energy Management*;
- *7.1 —Stabilized Approach*; and,
- *7.3 — Visual References.*♦

References

1. 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.
2. International Civil Aviation Organization (ICAO). *Procedures for Air Navigation Services. Aircraft Operations*. Volume I, *Flight Procedures*. Fourth edition, 1993. Reprinted May 2000, incorporating Amendments 1–10.
3. 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.
4. The Flight Safety Foundation Approach-and-landing Accident Reduction (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)."
5. ICAO. *Manual of All-Weather Operations*. Second edition – 1991.

Related Reading from FSF Publications

FSF Editorial Staff. "Collision with Antenna Guy Wire Severs Jet's Wing During Nonprecision Approach." *Accident Prevention* Volume 54 (October 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).

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).

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

Regulatory Resource

U.S. Federal Aviation Administration. Special Notice to Airmen AFS-420 (11/26/99).

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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