FLIGHT SAFETY FOUNDATION

ALAR

APPROACH-AND-LANDING ACCIDENT REDUCTION

TOOL KIT

FSF ALAR BRIEFING NOTE 8.2

# The Final Approach Speed

Assuring that a safe landing can be conducted requires achieving a balanced distribution of safety margins between:

- The computed *final approach speed* (also called the *target threshold speed*); and,
- The resulting landing distance.

## Statistical Data

Computation of the final approach speed rarely is a factor in runway overrun events, but an approach conducted significantly faster than the computed target final approach speed is cited often as a causal factor.

The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force found that "high-energy" approaches were a causal factor[1] in 30 percent of 76 approach-and-landing accidents and serious incidents worldwide in 1984 through 1997.[2]

The FSF Runway Safety Initiative (RSI) team found that fast approaches and/or touchdowns were factors in 30 percent of 329 runway-excursion accidents worldwide in 1995 through March 2008.[3]

## Defining the Final Approach Speed

The final approach speed is the airspeed to be maintained down to 50 feet over the runway threshold.

The final approach speed computation is the result of a decision made by the flight crew to ensure the safest approach and landing for the following:

- Gross weight;
- Wind;
- Flap configuration (when several flap configurations are certified for landing);
- Aircraft systems status (airspeed corrections for abnormal configurations);
- Icing conditions; and,
- Use of autothrottle speed mode or autoland.

The final approach speed is based on the reference landing speed, $V_{REF}$.

$V_{REF}$ usually is defined by the aircraft operating manual (AOM) and/or the quick reference handbook (QRH) as:

*1.3 x stall speed with full landing flaps*
*or with selected landing flaps.*

Final approach speed is defined as:

$$V_{REF} + corrections.$$

Airspeed corrections are based on operational factors (e.g., wind, wind shear or icing) and on landing configuration (e.g., less than full flaps or abnormal configuration).

The resulting final approach speed provides the best compromise between handling qualities (stall margin or controllability/maneuverability) and landing distance.

Some manufacturers and operators use the term $V_{APP}$ to designate the final approach speed.

## Factors Affecting the Final Approach Speed

The following airspeed corrections usually are not cumulative; only the highest airspeed correction should be added to $V_{REF}$ (unless otherwise stated in the AOM/QRH):

- Airspeed correction for wind;
- Airspeed correction for ice accretion;
- Airspeed correction for autothrottle speed mode or autoland; or,

- Airspeed correction for forecast turbulence/wind shear conditions.

### Gross Weight

Because $V_{REF}$ is derived from the stall speed, the $V_{REF}$ value depends directly on aircraft gross weight.

The AOM/QRH usually provides $V_{REF}$ values as a function of gross weight in a table or graphical format for normal landings and for overweight landings.

### Wind Conditions

The wind correction provides an additional stall margin for airspeed excursions caused by turbulence and wind shear.

Depending on aircraft manufacturers and aircraft models, the wind correction is defined using different methods, such as the following:

- Half of the steady head wind component plus the entire gust value, limited to a maximum value (usually 20 knots);
- One-third of the tower-reported average wind velocity or the gust velocity, whichever is higher, limited to a maximum value (usually 15 knots); or,
- A graphical assessment based on the tower-reported wind velocity and wind angle, limited to a maximum value (usually 15 knots).

The gust velocity is not used in this graphical assessment, but the resulting wind correction usually is very close to the second method.

Usually, no wind correction is applied for tail winds.

On some aircraft models, the wind correction can be entered on the appropriate flight management system (FMS) page.

### Flap Configuration

When several flap configurations are certified for landing, $V_{REF}$ (for the selected configuration) is defined by manufacturers as either:

- $V_{REF}$ full flaps plus a correction for the selected flap setting; or,
- $V_{REF}$ selected flaps.

In calm wind conditions or light-and-variable wind conditions, $V_{REF}$ (or $V_{REF}$ corrected for the selected landing flap setting) plus five knots is a typical target final approach speed.

### Abnormal Configuration

System malfunctions (e.g., the failure of a hydraulic system or the jamming of slats/flaps) require an airspeed correction to restore:

- The stall margin; or,
- Controllability/maneuverability.

For a given primary malfunction, the airspeed correction provided in the AOM/QRH usually considers all the consequential effects of the malfunction (i.e., no combination of airspeed corrections is required normally).

In the unlikely event of two unrelated malfunctions — both affecting controllability/maneuverability or stall margin — the following recommendations are applied usually:

- If both malfunctions affect the stall margin, the airspeed corrections must be added;
- If both malfunctions affect controllability/maneuverability, only the higher airspeed correction must be considered; and,
- If one malfunction affects the stall margin and the other malfunction affects controllability/maneuverability, only the higher airspeed correction must be considered.

### Use of Autothrottle Speed Mode

Whenever the autothrottle system is used for maintaining the target final approach speed, the crew should consider an airspeed correction (typically five knots) to $V_{REF}$ to allow for the accuracy of the autothrottle system in maintaining the target final approach speed.

This airspeed correction ensures that an airspeed equal to or greater than $V_{REF}$ is maintained down to 50 feet over the runway threshold.

### CAT II/CAT III Autoland

For Category (CAT) II instrument landing system (ILS) approaches using the autothrottles, CAT III ILS approaches and autoland approaches (regardless of weather minimums), the five-knot airspeed correction to $V_{REF}$ — to allow for the accuracy of the autothrottle system — is required by certification regulations.

### Ice Accretion

When severe icing conditions are encountered, an airspeed correction (typically five knots) must be considered for the possible accretion of ice on the unheated surfaces of the aircraft and on the wing surfaces above and below fuel tanks containing cold-soaked fuel.

### Wind Shear

Whenever wind shear is anticipated based on pilot reports from preceding aircraft or on an alert issued by the airport low-level wind shear alert system (LLWAS), *the landing should be delayed or the crew should divert to the alternate airport.*

If neither a delayed landing nor a diversion is suitable, an airspeed correction (usually up to 15 knots to 20 knots, based on the expected wind shear value) is recommended.

Landing with less than full flaps should be considered to maximize the climb gradient capability (as applicable, in compliance with the AOM/QRH), and the final approach speed should be adjusted accordingly.

Wind shear is characterized usually by a significant increase of the head wind component preceding a sudden change to a tail wind component. Whenever wind shear is expected, groundspeed should be monitored closely to enhance wind shear awareness.

## Combine Airspeed Corrections

The various airspeed corrections either are combined or not combined to distribute equally the safety margins of the following objectives:

- Stall margin;
- Controllability/maneuverability; and,
- Landing distance.

When a system malfunction results in a configuration correction to $V_{REF}$, the final approach speed becomes:

$V_{REF}$ *+ configuration correction + wind correction.*

The wind correction is limited usually to a maximum value (typically 15 knots to 20 knots).

The configuration correction is determined by referring to the AOM/QRH.

The configuration correction and wind correction are combined usually according to the following rules (as applicable, based on the AOM/QRH):

- If the configuration correction is equal to or greater than a specific limit (e.g., 20 knots), no wind correction is added; or,
- If the configuration correction is lower than a given value (e.g., 20 knots), then the configuration correction and wind correction are combined but limited to a maximum value (e.g., 20 knots).

The five-knot airspeed correction for the use of autothrottles and the five-knot airspeed correction for ice accretion (as applicable) may be disregarded if the other airspeed corrections exceed five knots.

Some manufacturers recommend combining the configuration correction and the wind correction in all cases. (When a system malfunction requires a configuration correction, autoland is not permitted usually.)

## Summary

Data provided by the manufacturer in the AOM/QRH are designed to achieve a balanced distribution of safety margins between:

- The target final approach speed; and,
- The resulting landing distance.

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

- 7.1 — Stabilized Approach;
- 8.1 — Runway Excursions;
- 8.3 — Landing Distances; and,
- 8.4 — Braking Devices.

### 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]."
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. Flight Safety Foundation. "Reducing the Risk of Runway Excursions." Report of the FSF Runway Safety Initiative, May 2009.

### Related Reading From FSF Publications


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

Lacagnina, Mark. "Idle Approach." *AeroSafety World* Volume 4 (August 2009).

Werfelman, Linda. "Safety on the Straight and Narrow." *AeroSafety World* Volume 3 (August 2008).

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

Lacagnina, Mark. "Thin but Deadly." *AeroSafety World* Volume 2 (May 2007).

Lacagnina, Mark. "Streaking Into Vegas." *AeroSafety World* Volume 2 (April 2007).

Rosenkrans, Wayne. "Knowing the Distance." *AeroSafety World* Volume 2 (February 2007).

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

Flight Safety Foundation (FSF) Editorial Staff. "Fast, Low Approach Leads to Long Landing and Overrun." *Accident Prevention* Volume 63 (January 2006).

FSF Editorial Staff. "DC-10 Overruns Runway in Tahiti While Being Landed in a Storm." *Accident Prevention* Volume 62 (August 2005).

FSF Editorial Staff. "Crew's Failure to Maintain Airspeed Cited in King Air Loss of Control." *Accident Prevention* Volume 61 (October 2004).

FSF Editorial Staff. "Airframe Icing, Low Airspeed Cause Stall During Nonprecision Approach." *Accident Prevention* Volume 61 (September 2004).

FSF Editorial Staff. "B-737 Crew's Unstabilized Approach Results in Overrun of a Wet Runway." *Accident Prevention* Volume 60 (July 2003).

FSF Editorial Staff. "Business Jet Overruns Wet Runway After Landing Past Touchdown Zone." *Accident Prevention* Volume 56 (December 1999).

Lawton, Russell. "Moving Power Levers Below Flight Idle During Descent Results in Dual Engine Flameout and Power-off Emergency Landing of Commuter Airplane." *Accident Prevention* Volume 51 (December 1994).

## 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.


601 Madison Street, Suite 300, Alexandria, VA 22314-1756 USA
Tel. +1 703.739.6700  Fax +1 703.739.6708  www.flightsafety.org