



When flight crews are aware and in control of a situation, they are able to make effective and timely decisions to ensure a safe landing.

Reducing Runway Landing Overruns

Working with industry, Boeing is implementing a combination of procedural improvements, flight crew knowledge, and flight deck enhancements to mitigate runway overrun excursions during landing.

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Runway overruns during landing are a top safety focus for Boeing, regulatory agencies, and the entire commercial aviation industry. Boeing is working with the industry to develop a comprehensive runway safety strategy — called Situational Awareness and Alerting for Excursion Reduction (SAAFER) — that is based on a data-driven consensus of root causes, risk factors, and interventions.

This article explores the strategy in terms of near- and long-term recommendations to airlines and flight crews to address the causes of runway overruns as well as flight deck design solutions currently under development.

CAUSES OF RUNWAY OVERRUN EXCURSIONS

Boeing event data shows that there are numerous contributors to runway overruns. Causes of landing overruns may begin as early as the approach briefing or occur once the airplane is on the ground and decelerating (see fig. 1). Understanding the root causes of runway excursions is fundamental to mitigating them.

Event data, analyzed collectively from 2003 to 2010, shows the factors contributing to landing overruns occur at these frequencies:

- 68 percent occurred after stable approaches.

- 55 percent touched down within the touchdown zone.
- 90 percent landed on an other-than-dry runway.
- 42 percent landed with a tailwind of 5 knots or greater.

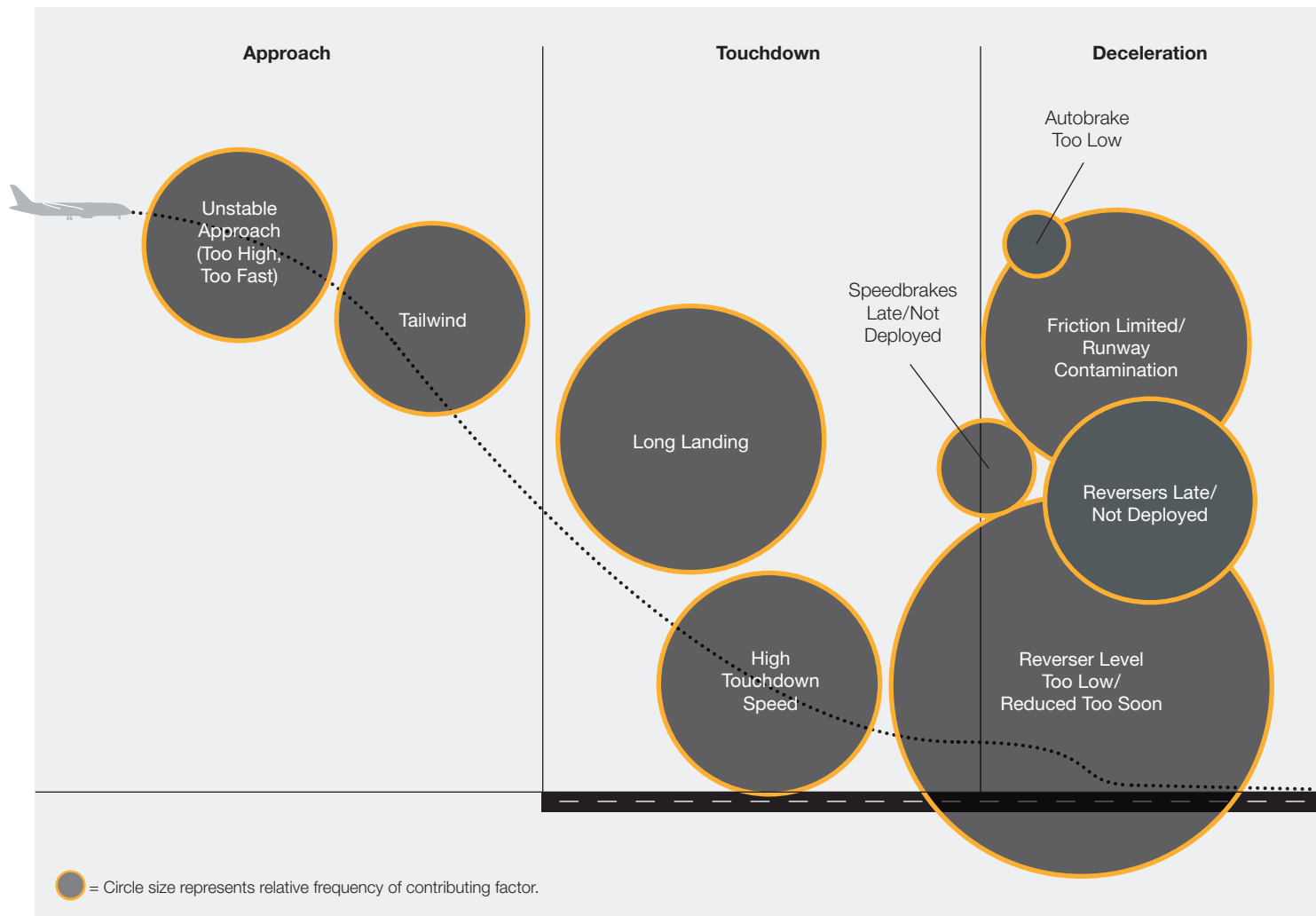
This event analysis was the key driver for developing Boeing's runway safety strategy.

Solving the excursion problem also requires acknowledgment that:

- Excursions are caused by multiple factors.
- Mitigating any one factor will not fix the bigger runway overrun excursion problem.
- More than one type of solution is necessary.

Figure 1: Causes of landing overrun excursions

The circle size represents the relative frequency that the item was a contributing factor to a runway overrun. Frequently, a runway overrun is the result of more than one contributing factor occurring simultaneously.



THE RUNWAY SAFETY STRATEGY

The Boeing SAAFER strategy implements a combination of procedural and flight deck enhancements along with additional crew education (i.e., training aids) to mitigate runway landing overruns. Components of this approach — procedural enhancements, training aids, and existing flight deck technology — are already available to operators. Boeing recommends implementing these excursion mitigations immediately.

Boeing’s runway safety strategy provides flight crews with enhanced awareness,

guidance, and alerting tools from the approach-planning phase through landing rollout and deceleration. The strategy’s goal is to keep pilots aware and in control of this phase of flight and enable them to make correct and timely decisions that will ensure a safe landing.

This approach is considered a strategy because it encompasses more than just flight deck enhancements. It’s designed to improve cognition and pilot decision-making during this high workload phase of flight without overloading the pilot.

RECOMMENDED APPROACH AND LANDING PROCEDURES

Boeing recommends that airlines consider modifying their approach and landing procedures to incorporate runway safety recommendations. Augmenting existing landing procedures is a currently available solution that can mitigate runway overrun excursions in the near term without waiting for future technological flight deck enhancements.

- **Calculate required runway length.** As the flight crew prepares its approach briefing, it should use real-time

information to analyze how much runway is required relative to runway available. Performing a landing distance calculation using the real-time airplane and actual runway data (e.g., contamination, wet, grooved, or ungrooved surface) can mitigate runway overrun excursions caused by inadequate runway length.

- **Determine go-around point.** Calculating and briefing a go-around point or the latest point on the runway by which the flight crew must touch down during the approach briefing also has potential to reduce overrun excursions. This go-around distance calculation can mitigate the approximately 44 percent of runway overrun excursions that are attributed to long landings.
- **Add thrust reverser callout.** Boeing has added a mandatory thrust reverser callout to the flight crew training manual and the flight crew operating manuals for all Boeing models. It is intended to increase the flight crew's situational awareness of thrust reverser deployment in conjunction with the speed brakes during the landing rollout. This callout, along with using the reversers until the stop is assured (no early stowage), provides a runway excursion mitigation for the approximately 80 percent of excursions where inadequate or late thrust reverser usage was a contributing factor.

Updating approach and landing procedures may not address all runway overrun excursion events that are caused by inadequate runway length when landing long or using inadequate or improper deceleration devices. These runway overrun excursions may require additional pilot situational awareness and involvement. However, these relatively simple, highly feasible, non-equipage enhancements can help reduce runway overrun excursions in the near term.

RUNWAY SAFETY TRAINING AIDS

Runway overrun event data suggests that a number of runway overruns can be avoided if the flight crew has a more thorough understanding of the interrelationship between the landing environment and the potential risks existing that day (e.g., weather, winds, runway conditions, minimum equipment list items, airplane weight).

Pilots need to better understand the relationships among these factors for each flight:

- Flying a stabilized approach.
- Runway contamination, known and accounted for.
- Runway length available versus required.
- Reported conditions compared to actual conditions.
- Approach speed for that flight's approach.
- Energy to be dissipated after landing.
- Speed additives and effect on landing distances.
- Reliability of runway braking action.
- Proper, timely use of all deceleration devices.

A failure or misunderstanding of each of these factors has contributed to runway overrun excursions. For example, many flight crews may not fully understand the importance of using thrust reversers on wet runways. As runway friction decreases due to deteriorating runway conditions, the role of the thrust reverser becomes more important. Additionally, there have been accidents in which the crew had difficulty deploying the thrust reversers and consequently neglected to ensure the spoilers were fully extended during the landing rollout.

Another concern centers on ensuring that the appropriate deceleration devices are used until the airplane is at a stop. This is especially important when there is a known risk of an overrun excursion. It is necessary to ensure all deceleration

devices are utilized fully when facing a runway overrun excursion.

The aviation industry has produced a variety of useful tools to help pilots understand these relationships. The Flight Safety Foundation approach and landing accident reduction toolkit and the International Civil Aviation Organization/International Air Transport Association toolkits are available on the Internet. They provide valuable information flight crews can use to help avoid runway overrun excursions.

Boeing is developing an approach and landing training-aid video intended to be viewed by pilots in order to enhance their understanding of their dynamic landing environment, the day's risk factors, available tools, and desired actions and outcomes relating to runway excursions. This training-aid video is scheduled for release in late 2012.

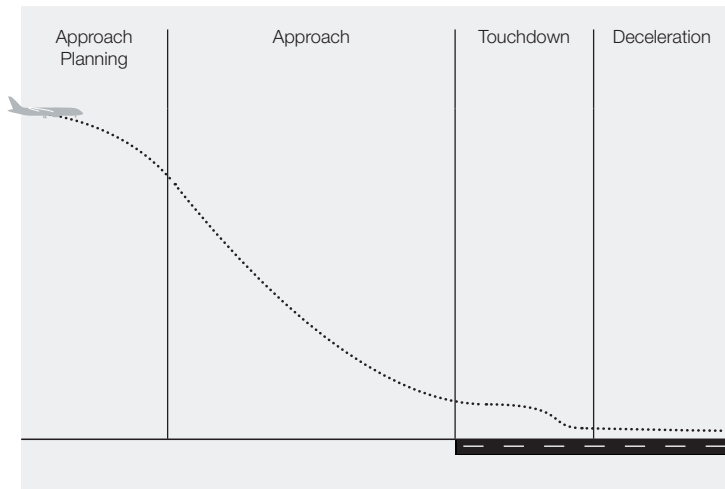
NEW SAFETY TECHNOLOGY

Boeing is focusing on human-factors-driven flight deck design enhancements that are consistent with existing and planned airport, air traffic, and customer operating strategies. These enhancements are targeted at runway overrun prevention through all approach phases: approach planning, approach, touchdown, and deceleration.

During approach planning, flight deck tools and procedures assist the flight crew in determining the required runway length and where on the runway the airplane is expected to stop, given current conditions (see fig. 2). Boeing already offers a landing distance calculator on electronic flight bags. The new strategy augments this existing technology by adding a more effective way to display this information to the flight crew. By graphically depicting the dry and contaminated stopping location during approach planning, the crew can definitively assess its risk of runway overrun before touching down. The pilot also has

Figure 2: New approach planning technology

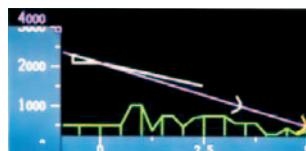
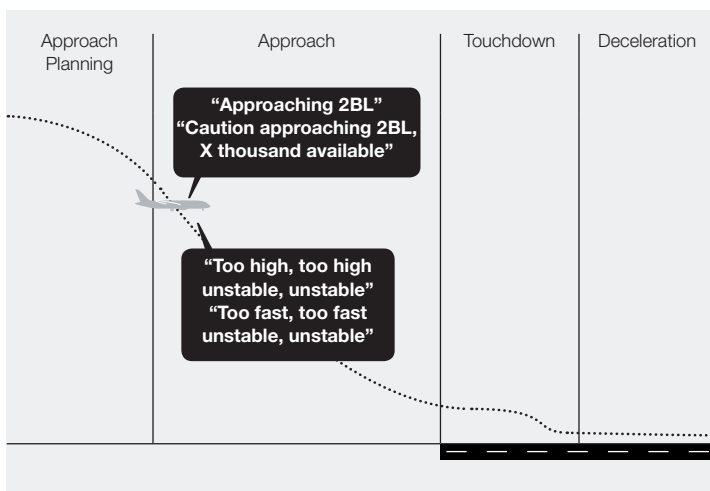
New technology is intended to enhance the existing flight deck during these approach, landing, and rollout phases.



- Display of landing distance for dry/contaminated runways
- Assessment of runway length vs. required

Figure 3: Approach technology

Flight deck enhancements provide aural and visual cues to assist the pilot in flying a stabilized approach.



- Stability (speed, altitude, glideslope) guidance
- Simplified approach technique
- Runway situation awareness and alerting
- Instability alerting

the option of manually entering a reference line. This could be a land and hold short operation, a taxiway exit, or a desired touchdown or go-around point.

During the approach, the airplane's stability and tailwinds are major contributing factors to runway overrun excursions. New flight deck enhancements provide aural and visual cues to assist the pilot in flying a stabilized approach (see fig. 3). Boeing's new runway safety strategy provides a simplified approach technique to reduce workload even in normal conditions. As a final safeguard, the system alerts the pilot to unstable conditions or to a runway that is too short for that landing.

Communication and knowledge sharing in the flight deck are important. For airplanes that are equipped with head-up displays (HUD), the pilot and co-pilot can view the same information on the HUD and on the primary flight display. Even in a single-HUD airplane, both pilots will have the same display of information on which to base their piloting decisions.

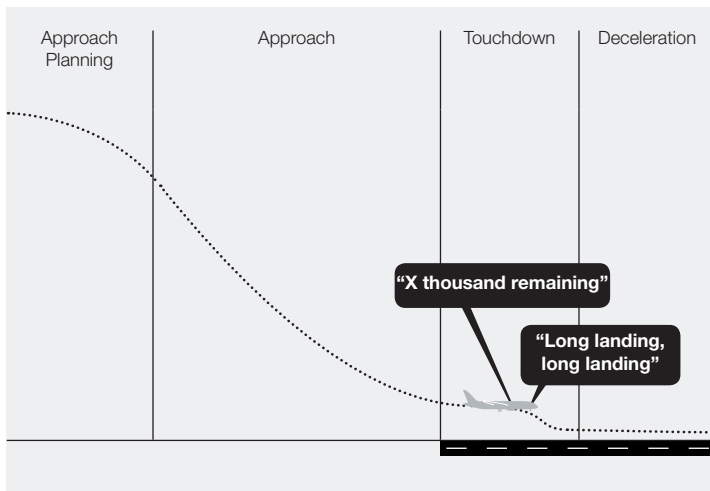
After reaching decision height but before touching down, the primary contributing factor to a runway overrun is a long landing (i.e., airplane that exceeds the touchdown zone). Boeing's new runway safety technology provides landing and flare guidance on the HUD and aural and visual runway positional situation awareness on the HUD

and primary flight display (see fig. 4). Conformal runway edge lines and runway remaining markers assist the crews' positional situational awareness on the runway even in low-visibility conditions.

After touchdown, the primary contributing factors of runway excursions are the actual runway condition and inadequate or late use of deceleration devices. Boeing's SAAFER strategy provides a visual indication of the predicted stop point on the runway based on real-time deceleration. It also provides a distance-remaining voice callout and alerts the crew when its current deceleration is insufficient and may result in a runway overrun excursion (see fig. 5).

Figure 4: Touchdown technology

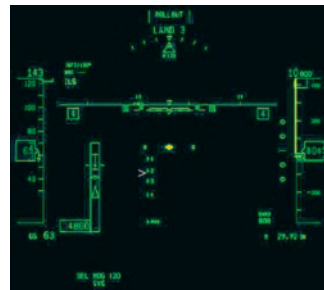
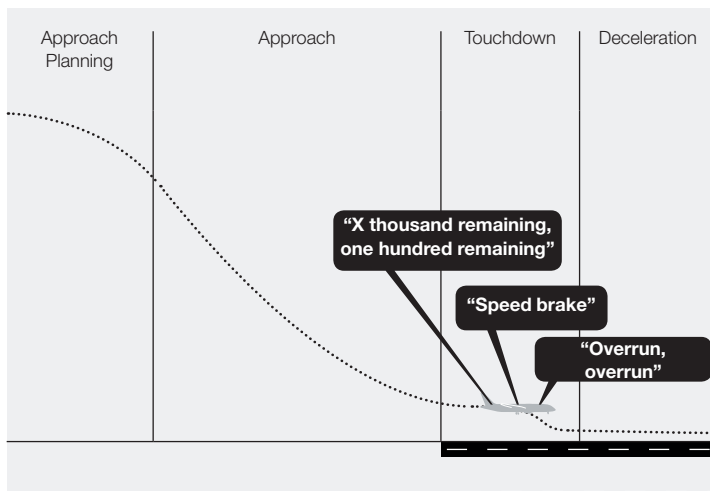
Flight crews receive landing and flare guidance on the head-up display (HUD) and aural and visual runway positional situation awareness on the HUD and primary flight display.



- Landing and flare guidance
- Runway positional situation awareness
- Long landing alerting

Figure 5: Deceleration technology

The system provides a visual indication of the predicted stop point on the runway based on real-time deceleration, as well as a distance-remaining voice callout.



- Runway positional situational awareness
- Display of predicted stop location
- Overrun alerting

The purpose of all these flight deck enhancements is to increase the pilot's situational awareness by providing the guidance and alerting tools during all phases of the approach, landing, and rollout.

AVAILABILITY OF NEW FLIGHT DECK TECHNOLOGY

Advanced flight deck enhancements are in development. Boeing continues to focus on enhancements for in-production and future fleets. It is recognized, however, that the

existing fleet can benefit from enhancements that can be feasibly developed and incorporated, and Boeing is also focused on developing cost-effective, model-specific solutions that build off of the model's existing features and architecture. For the in-production fleet, these enhancements are targeted to start in 2015. Out-of-production retrofit packages will occur afterward.

A number of technologies are already available. Boeing encourages fleet uptake of these equipment mitigations currently available:

- Head-up display.
- Vertical situation display.

- Onboard performance tool.
- Runway awareness and advisory system.

SUMMARY

Boeing's SAAFER strategy combines procedural and flight deck enhancements with additional crew education to mitigate runway overrun excursions. When flight crews are aware and in control of the situation, they will make effective and timely decisions to ensure a safe landing.

For more information, please visit www.boeing.com/saafer. **A**