

Rink or Runway?

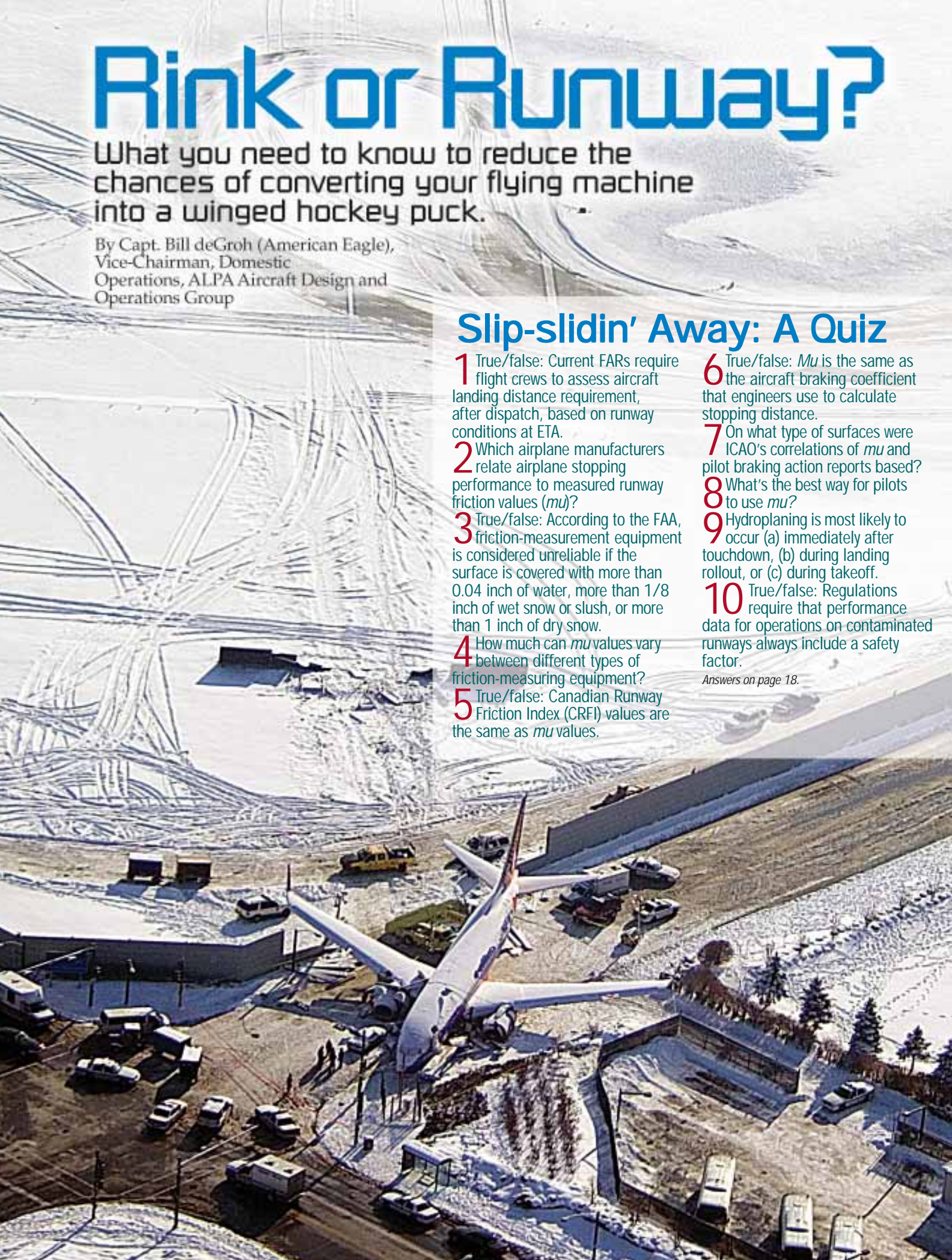
What you need to know to reduce the chances of converting your flying machine into a winged hockey puck.

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Slip-slidin' Away: A Quiz

- 1 True/false: Current FARs require flight crews to assess aircraft landing distance requirement, after dispatch, based on runway conditions at ETA.
- 2 Which airplane manufacturers relate airplane stopping performance to measured runway friction values (μ)?
- 3 True/false: According to the FAA, friction-measurement equipment is considered unreliable if the surface is covered with more than 0.04 inch of water, more than 1/8 inch of wet snow or slush, or more than 1 inch of dry snow.
- 4 How much can μ values vary between different types of friction-measuring equipment?
- 5 True/false: Canadian Runway Friction Index (CRFI) values are the same as μ values.
- 6 True/false: μ is the same as the aircraft braking coefficient that engineers use to calculate stopping distance.
- 7 On what type of surfaces were ICAO's correlations of μ and pilot braking action reports based?
- 8 What's the best way for pilots to use μ ?
- 9 Hydroplaning is most likely to occur (a) immediately after touchdown, (b) during landing rollout, or (c) during takeoff.
- 10 True/false: Regulations require that performance data for operations on contaminated runways always include a safety factor.

Answers on page 18.



On Dec. 8, 2005, Southwest Airlines Flight 1248 slid off the end of Runway 31C at Chicago's Midway Airport while landing amid snow showers. A boy riding in a van was killed when the airplane rolled through the airport perimeter fence and onto the street, crushing the van. This accident grabbed immediate news media attention and renewed FAA and airline industry focus on issues surrounding operations on slippery/contaminated runways. ALPA participated as a witness at the NTSB's public hearing on the accident, and publicly voiced concerns ranging from inaccurate, non-standard reporting of runway conditions to the lack of aircraft performance data available to flight crews.

Current U.S. regulations require operators to determine that the effective runway length for the destination airport meets the landing field length requirements before dispatch to that airport. Operational regulations don't, however, specifically require an assessment of the aircraft's landing distance, after dispatch, based on the runway conditions that exist at the time of arrival. Although aircraft manufacturers have developed performance information for contaminated runway operations, current U.S. operational regulations don't require operators to use that information. However, operators subject to JAR-OPS rules must be provided—and use—performance information for takeoffs and landings on contaminated runways.

In an effort to require turbojet pilots to calculate landing distance based on the actual runway conditions at ETA while enroute, the FAA planned to issue Operations Specification C084 in September 2006. This Ops Spec would have required operators to develop procedures that flight crews would use to assess their landing distance requirements based upon the runway conditions that exist at the time of arrival. These assessments would likely be based upon reliable braking action pilot reports (PIREPs). The subjectivity of such reports is well known and is one reason the FAA held a workshop to discuss runway condition determination, reporting, and report dissemination. Sparse guidance has existed for the braking action terms “good,” “fair,”

“poor,” and “nil.” As part of this workshop, ALPA participated in the Common Terms and Definitions Working Group, which was tasked with defining these braking action terms.

Unfortunately, after intense post-workshop airline industry pressure, the FAA has withdrawn the proposed Ops Spec to pursue the issue through the standard rulemaking process. In the interim, the contents of Ops Spec C084 are contained in a Safety Alert

the fact that the surface being measured is deformed by the very device designed to measure it. Friction-measurement equipment seems to be more reliable on firm surfaces, such as bare pavement, packed snow, or ice.

The Canadian Runway Friction Index (CRFI, pronounced KERR-fee) system avoids some of the variability issues by using one type of device. However, CRFI has similar limitations on its use under certain runway surface



for Operators, or SAFO, that requests voluntary compliance from operators. A link to that document, SAFO 06012, “Landing Performance Assessment at Time of Arrival (Turbojet),” can be found on ALPA's website, Crewroom.alpa.org, under the Spotlight section.

Friction measurement

One way of assessing a runway surface is through the use of friction surveys. However, runway friction values (expressed on some reports as the coefficient of friction—*mu*, pronounced “mew”) have limitations that call into question their usefulness for anything but trend information. In fact, no airplane manufacturer currently relates airplane performance to *mu* values directly. The FAA has stated that friction-measurement equipment is considered unreliable if the surface is covered with more than 0.04 inch of water, more than 1/8 inch of wet snow or slush, or more than 1 inch of dry snow.

In some cases, *mu* values have varied as much as 40 percent between different types of friction-measuring equipment. Some of these problems are the result of improper maintenance of the equipment; some are the result of

conditions. It's important to understand that CRFI values may not be equivalent to *mu* values. A link to more information on CRFI, including the CRFI Recommended Landing Distance Tables, can be found in the Spotlight section of Crewroom.alpa.org. Canadian pilots can find the CRFI tables in the Canadian Aeronautical Information Manual; those tables are intended to be used at the pilots' discretion. Currently, it's unclear whether FAA approval is required to allow U.S. operators to use the CRFI system when flying in Canada.

The *mu* values determined by friction surveys are not the same as the aircraft braking coefficient that engineers use to calculate stopping distance. This has been the crux of the problem—no direct, reliable correlation exists between runway *mu* values and the aircraft braking coefficient. Determining this relationship has been the goal of the Joint Winter Runway Friction Measurement Program (JWRFMP) since the early 1990s. Results of this research activity seem to indicate that harmonizing all the different friction measurement devices to a common standard may provide the consistent

reliability needed for correlation to aircraft braking coefficient. Harmonized friction measurements would become the International Runway Friction Index (IRFI). No implementation date for deploying IRFI has yet been set.

Because a direct, reliable correlation between *mu* values and aircraft braking coefficient doesn't exist, aircraft manufacturers have resisted presenting performance data as a function of *mu*. This forces an attempt at correlating *mu* values to something in common use—i.e., braking action. ICAO presents a table that gives *mu* value ranges for each of the braking action terms in its Annex 14, Aerodromes publication. Many pilots have this table, or one similar to it, in their manuals.

However, according to Annex 14, “The table with associated descriptive terms was developed from friction data collected **only in compacted snow and ice** and should not therefore be taken to be absolute values in all conditions.” This seems to substantiate the notion that the reliability of friction-measurement devices is better on firm surfaces than on loose snow or slush or in standing water. The ICAO table also does not have an equivalent correlation to the U.S. term “nil,” nor does it differentiate between friction-measuring device types. In addition, because of the many issues surrounding friction measurement, a pending ICAO Notice of Proposed Amendment may remove this table from ICAO Annex 14.

The Common Terms and Definitions Working Group in the most recent FAA workshop agreed that “*Mu* values **can vary significantly** for the same contaminant conditions due to measuring techniques, equipment calibration, effects of contamination on the friction-measuring device, and the time since the last survey. **Do not** base landing distance assessments solely on runway *mu* values. If *mu* is the only information provided, attempt to ascertain the depth and type of runway contamination to make a better assessment of actual conditions.” Historic *mu* information can also be helpful in showing runway condition trend information. Increasing *mu* may indicate an improvement in runway conditions, depending on when the runway was treated versus when the friction survey was taken.

Table 1: Braking Action

Term	Definition	Estimated runway surface condition correlation	ICAO Code
Good	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	<ul style="list-style-type: none"> • Water depth of 1/8 inch or less • Dry snow less than 3/4 inch in depth • Compacted snow with OAT at or below -15°C 	5
Good to Medium			4
Medium (fair)	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be slightly reduced.	<ul style="list-style-type: none"> • Dry snow 3/4 inch or greater in depth • Sanded snow • Sanded ice • Compacted snow with OAT above -15°C 	3
Medium to Poor			2
Poor	Braking deceleration is significantly reduced for the wheel braking effort applied. Potential for hydroplaning exists. Directional control may be significantly reduced.	<ul style="list-style-type: none"> • Wet snow • Slush • Water depth more than 1/8 inch • Ice (not melting) 	1
Nil	Braking deceleration is minimal or nonexistent for the wheel braking effort applied. Directional control may be uncertain. <i>Note: Taxi, takeoff, and landing operations in nil conditions are prohibited.</i>	<ul style="list-style-type: none"> • Ice (melting) • Wet ice 	—

Note: The ICAO term “unreliable” (SNOTAM code of “9”) indicates contamination is outside the approved operational range for the friction-measuring equipment in use. Use PIREPs and the depth and type of runway contaminants to assess actual braking conditions.

Pilot-reported braking action

Pilot braking action reports have been used for a long time, but they have two problems—they're subjective, and they require a guinea pig as “test” subject.

The problem of subjectivity might be addressed by adopting standard definitions of the braking action terms of “good,” “fair,” “poor,” and “nil.” This was the primary task of the Common Terms and Definitions Working Group.

Table 1 is intended to help pilots assess runway conditions and choose the most appropriate braking action term when providing PIREPs. Pilots should provide a PIREP when braking action conditions are, or are expected to be, less than good and not wait for ATC to solicit a PIREP.

Table 1 uses the term “medium” in lieu of the U.S. term “fair” to harmonize with ICAO terminology. The Working Group mentioned above deter-

mined that “until FAA guidance materials are revised, the terms ‘medium’ and ‘fair’ can be used interchangeably. The terms ‘good to medium’ and ‘medium to poor’ represent an intermediate level of braking action that varies along the runway length. If braking action varies along the runway length, such as the first half of the runway is ‘medium’ and the second half is ‘poor,’ clearly report that in the PIREP (e.g., ‘first half medium, last half poor’).”

In addition, the Working Group recognized that “correlations between different sources of runway conditions are estimates. Under extremely cold temperatures or for runways that have been chemically treated, the braking capabilities may be better than the runway surface conditions estimated [in Table 1].”

Some additional thoughts on each of the braking action terms may fur-

ther help pilots to choose the most appropriate term:

- “Good” braking action could be characterized by no periods in which the anti-skid limit is reached, if the airplane is equipped with anti-skid. The pilot is able to easily exit the runway at the planned runway exit, using normal to slightly higher brake pedal pressure (normal reverse thrust if reverse thrust is installed). Deceleration feels normal despite the runway’s not being dry, and no directional control problems are experienced.

- “Medium” braking action could be characterized by occasional (less than 1/3 of the time) periods in which the anti-skid limit is reached. The pilot is able to exit the runway at the planned runway exit using strong brake pedal pressure (normal reverse thrust if thrust reverse is installed). Deceleration is noticeably degraded, but no directional control problems are experienced.

- “Poor” braking action could be characterized by intermittent (1/3 to 2/3 of the time) periods in which the anti-skid limit is reached. The pilot is able to exit the runway at the planned runway exit only by using maximum

manual brake pedal pressure and full reverse thrust, if the airplane is equipped with thrust reversers. Deceleration is significantly degraded, or directional control is noticeably degraded but doesn’t require discontinuing the use of reverse thrust.

- “Nil” braking may be characterized by a continuous period (more than 2/3 of the time) in which the anti-skid limit is reached. The pilot is unable to exit the runway at the planned runway exit despite using maximum manual braking and full reverse thrust. The pilot has a sense of very little or no deceleration despite use of maximum manual braking; the sensation may actually be that the airplane is accelerating. Pay particular attention to this when discontinuing reverse thrust. Directional control may be degraded to the extent that reverse thrust must be discontinued.

If you experience “nil” braking, report it to ATC immediately. You owe it to the flight crew on approach behind you. Your report will obligate airport maintenance personnel to take action to improve the runway conditions.

Another important aspect of pilot

braking action reports is the notion of what constitutes a “reliable” report. SAFO 06012 defines a reliable braking action report as one submitted by the flight crew of a turbojet airplane with landing performance capabilities similar to those of your airplane. If the reporting flight crew is flying the same type of airplane you are, chances are better that you’ll get a reliable braking action report than if they’re flying a different type of airplane. In deciding whether a report is reliable, consider the weight, landing gear configuration, and approach speed of the airplane flown by the reporting pilot(s), and whether that airplane has thrust reversers.

Because of the issues surrounding friction surveys, ALPA could not, at the present time, agree to include the ICAO *mu* value ranges in Table 1. Perhaps a more reliable correlation with braking action terms will exist when and if the International Runway Friction Index is implemented. In the meantime, continue to use *mu* values as a trend indicator, but avoid basing decisions about runway suitability solely on these numbers. ☛

So...Should You Land—or Divert?



First, don’t base your decision about the suitability of a runway on runway friction surveys alone. Use all the information available to you to form a picture of expected runway conditions.

Unfortunately, a single, standardized format for reporting runway conditions doesn’t exist yet. Pilots have to rely on ATC, ATIS, NOTAMs, SNOTAMs, AMSCR, company field condition reports, and any other

sources they can find. Until a single, standard format for runway condition reports is developed, consider using the following checklist of items for the runway of intended operation:

- Time since report was made

- Runway condition report
 - Contaminant type, depth, and percentage of coverage
 - Pilot braking action reports
 - Friction survey (μ , or CRFI in Canada)
 - Windrow size and location, if present
 - Cleared width of runway
 - Description of runway treatments (plowing, sweeping, sanding, chemical deicing)
 - Airport weather data
 - Precipitation type and rate
 - Wind direction and speed
 - Temperature trend and proximity to 0 degrees C
- Be conservative in your assessment. For example, if the runway has a mixed braking action report, such as “medium



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to poor,” consider using the more restrictive term of “poor.” Or if the runway report says the runway is covered with packed snow and slush, consider using the more conservative description of slush. With multiple sources of runway information, conflicts are not only possible, but likely. Compare sources to assess their validity.

After you’re comfortable that you know the runway conditions, determine the suitability of that runway for landing. First check that the contaminant depth doesn’t exceed any depth limitations contained in your AOM. Consider both landing and takeoff, because you might be scheduled to take off again before the weather improves. Check that the crosswind component doesn’t exceed the limitations or recommendations in your AOM.

Although current U.S. regulations don’t require operators to use the manufacturer’s advisory data for takeoffs and landings on slippery or contaminated runways, some operators

provide it to their flight crews. However, many flight crews aren’t provided any aircraft performance data with which to assess required runway lengths based upon actual runway conditions that exist at ETA.

If your airline has procedures for determining the required runway length based upon the actual runway conditions existing at ETA, use that information to assess the suitability of the landing runway. Bear in mind that this information may *not* include any extra runway length as a safety margin. Find out if this is the case; if so, consider adding a safety margin to account for potential failure of a thrust reverser, inaccurate runway condition reports, or inaccurate braking action advisories, etc.

If you don’t have approved procedures to determine the necessary runway length for landing on other than dry or wet runways, you will have to use your best judgment to make your own assessment. SAFO 06012 does

include some guidance material in the form of adjustments to the dry runway distances as a function of braking action. However, it is not clear how these multipliers were determined.

Another reference for guidance is the Flight Safety Foundation’s Approach and Landing Accident Reduction (ALAR) tool.

There may be light at the end of the tunnel for those of us without any performance data for operations on contaminated/slippery runways. The FAA has indicated that it will be initiating rulemaking with a goal of requiring all operators to account for actual runway conditions at ETA. Until the rulemaking process is complete, the final form of such a regulation remains to be seen.

Whether you have approved data or not, you still must meet the requirements of FAR Part 121.195—namely, the destination field length must be at least 1.67 times the AFM landing distance for dry runways, or 1.92 times the AFM landing distance for wet or slippery runways. —BdG

Answers to quiz on page 14:

1. False. 2. None. 3. True. 4. As much as 40 percent. 5. False. 6. False. 7. Only on compacted snow and ice. 8. Historic μ information can show the trend in runway condition (improving, worsening, or unchanged). 9. (a). 10. False—current regulations don’t require any operators to include a safety margin for landings on contaminated/slippery runways.



If you are going to land on a slippery/contaminated runway consider the following:

☐ 1. **Don't carry excess speed over the threshold;** be at your recommended threshold crossing speed. For each 10 percent above this speed, the landing distance increases about 20 percent. For example, if an airplane with an unfactored landing distance of 2,830 feet and a threshold speed of 129 knots crosses the threshold at 142 knots (10 percent above V_{ref}), the estimated landing distance becomes 3,396 feet—a 566-foot increase, the same as landing with a 13-knot tailwind.

☐ 2. **Avoid crossing the threshold** higher than the recommended threshold crossing height. Crossing the threshold at the nominal 50-foot height with a 3-degree descent path will allow touchdown to occur approximately 1,000 feet from the runway threshold. For every 10 feet above the nominal threshold crossing height, the touchdown point moves an additional 190 feet past the runway threshold. Some operations, such as autoland or HGS approaches, will involve touchdown points farther down the runway, but this is accounted for in the performance information for these operations.

☐ 3. **Consider using 1,000 feet beyond the threshold** as a target touchdown point, if a recommended distance to touchdown is not provided. Be on centerline with little or no drift.

☐ 4. **Make a firm and positive touchdown** with thrust at idle. Doing this will assist wheel spin-up for the antiskid system. You should experience little float if threshold crossing speed was not excessive. If touchdown is delayed while trying to decelerate during an extended flare, landing distance could increase as much as 30 percent. Fly the nosewheel onto the runway without delay.

☐ 5. **Confirm spoiler deployment.** Failure to deploy spoilers will decrease stopping force 20-30 percent.

☐ 6. **If the airplane has autobrakes,** use the recommended setting. If the airplane is not equipped with autobrakes, immediately but smoothly apply pedal braking. In both cases, be prepared to use maximum manual pedal braking if necessary. Be aware that patchy runway conditions may make it difficult for the antiskid system to function properly during application of maximum manual braking or with max autobrakes.

☐ 7. **Once the nosewheel is on the ground,** gradually increase forward control column pressure to increase the load on the nosewheel to improve its traction.

☐ 8. **Begin to deploy the thrust reversers** upon touchdown, increasing to maximum reverse thrust. Pay particular attention to directional control. If the airplane begins to weathervane, you will need to come out of reverse to regain the runway centerline; obviously, this will increase the landing distance. This is another good reason to apply a runway distance margin to your estimated required landing distance.

☐ 9. **If necessary, maintain this stopping configuration** until slowed well below your turn-off speed to improve cornering traction.

☐ 10. **As the airplane slows** and rudder effectiveness diminishes, gently begin using nose-wheel steering. Keep in mind that both directional control and braking require tire/ground friction, and they share the maximum friction force the tires can provide. Increasing either will subtract from the other.

When faced with the prospect of landing on a slippery and/or contaminated runway, information, planning, and proper technique will be your best defenses against a runway excursion. This is not an exact science, and may never be, so be conservative.—BdG

...and a few notes On HYDROPLANING

Hydroplaning (skimming over wet pavement with no physical contact between tires and pavement) can double or triple stopping distance. Years ago, NASA developed equations for the minimum dynamic hydroplaning speeds for aircraft tires during wheel spin-up and spin-down.

Wheel spin-down: $V_h = 9 \sqrt{\text{tire pressure in psi}}$

Wheel spin-up: $V_h = 7.7 \sqrt{\text{tire pressure in psi}}$

Many pilots are familiar with the first equation, but it's important to note that hydroplaning occurs at a slower speed during wheel spin-up (the second equation), which is what occurs during landing. Thus *hydroplaning is more likely to occur during landing than during the after-landing rollout or during takeoff.*

Moreover, these equations apply only for smooth-tread tires that don't allow escape paths for water (completely worn tires), or ribbed tires on fluid-covered runways when the depth of the fluid exceeds the groove depths in the tread of those tires (flooded runways). *The importance of having good tire tread depth when headed to an airport with wet runways cannot be overemphasized.* Because of this hydroplaning potential, nearly bald tires that may be serviceable on dry runways may not be safe on wet or flooded runways. Grooved runways do improve the situation, but many runways, such as in Mexico and Canada, aren't grooved.—BdG