Knowledge of the deceleration/acceleration forces and human factors involved in rejecting a landing after touchdown — especially on a contaminated runway with significant crosswind — should inform flight crews’ risk assessments before arrival in a regional jet or other turbine-powered airplane, says a U.S. academic researcher.

If communicated via graphs and diagrams in training, aircraft flight manuals and approach briefings, and via aural and graphical alerts from avionics (ASW, 11/09, p. 26, and 8/10, p. 30), imperceptible risks become readily apparent, according to Nihad Daidzic, a professor in the Department of Aviation at Minnesota State University, Mankato.¹

His perspective of when an overrun becomes preferable to a go-around² comes from study of the July 2008 Hawker 800A accident at the neighboring Minnesota airport in Owatonna (ASW, 4/11, p. 16) and hypothetical commit-to-stop scenarios involving typical business jet speeds and accelerations. These scenarios were analyzed that year.
Simulating a Go-Around After Touchdown

TOGA = takeoff/go-around

Notes: Mathematical submodels for each landing phase shown were designed to enable the landing model and a flight simulation program to calculate operational landing distances, including a basis for designating a commit-to-stop point, and to realistically analyze variations in pilot techniques. For educational purposes, the submodels account for effects of a stabilized or unstabilized final approach; variation from main gear threshold crossing height of 35–50 ft; variation from a proper height at flare and touchdown point; variation from 3-second derotation; maximum safe elapsed decision time before decelerating to minimum TOGA action speed; an assumed 1,000 ft (305 m) for configuration change with or without thrust reversers; and no assumed provision for engine failure or departure obstacles while accelerating to safe liftoff speed by the end of the runway.

Source: Adapted from Nihad Daidzic

Figure 1

with a computer simulation that he developed for studies of runway overruns on contaminated runways (for which the Boeing 737–800 was modeled as an example applicable to large commercial jets), and of runway veer-offs (for which a Bombardier CRJ700 was modeled as an example applicable to regional jets). He discussed results at the World Aviation Training Conference and Tradeshow (WATS 2011), April 19–21, in Orlando, Florida.

Overruns and veer-offs have occurred with “stubborn frequency” despite industry initiatives throughout at least 20 years, such as the 2000 and 2010 versions of the Flight Safety Foundation Approach-and-Landing Accident Reduction Tool Kit, Daidzic said.

“Go-around safety is actually a problem for every airplane, although at WATS 2011 I am talking specifically about regional airline operations,” he said. “In 2008, I called this a point of no return [also called a commit-to-stop point] on the runway, referring then to the lowest speed that the airplane can slow down to before the crew initiates the go-around. My objective has been to understand some of the dynamics in pilot response when the airplane has already touched down and the crew is trying to execute a go-around [Figure 1].”

As recently as 2010, a non-U.S. fatal accident with this element reminded government and industry safety specialists of the continued importance of related academic research, policies and pilot education (see “Committed to Stop,” p. 39).

“Operators need to have standard operating procedures [SOPs] and a clear policy on if, how and when to execute a go-around after touchdown,” he said. “For regions or majors, this scenario can be much more hazardous than a V1 cut (action speed),” that is, practicing complete loss of power from one engine at the maximum airspeed in the takeoff at which the pilot must take the first action (for example, apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance (ASW, 7–8/11, p. 23).

“After the point of no return, it is far better to accept the possible overrun than to attempt a go-around,” Daidzic said. “This point on the runway, defined in the model by airspeed,” with its associated minimum takeoff/go-around action speed and maximum safe elapsed time, “is the dynamic location of the last-chance go-around attempt after actual touchdown and landing roll. The exact point in flight operations could depend on any of many factors — airspeed, wind, distance, touchdown location, deployment of thrust reversers, runway contamination condition, engine failure in attempted go-around, and so forth.” Certainty about the exact point — absent a head-up display/head-up guidance system or other equivalent capability in a primary flight display/multifunction display — may not be possible, he indicated, but early recognition of risk factors can be trained (Figure 2, p. 38).

Factors modeled in the various simulations have included the pilot indecision time, airplane height and speed above the runway threshold (kinetic energy state/inertia), flare technique, touchdown point (air distance from threshold), friction generated by brake systems, runway surface condition, speed-dependent rolling friction coefficient, stages of ground spoiler deployment/lift dump, thrust-reverser deployment, duration of configuration changes, drag, density altitude and the gravitational effects of an uphill or downhill runway. Slopes of lines on resulting graphs — representing deceleration rates and elapsed time — emphasize the critical importance of a stabilized approach to a safe landing.

“Many experts who studied veer-offs in the past recommended that
Typical Factors Affecting Landing Distance

<table>
<thead>
<tr>
<th>Condition</th>
<th>Distance Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>High approach speed (+10 kt)</td>
<td>170–310 ft (50–95 m)</td>
</tr>
<tr>
<td>Overextended flare (3-second float after flare)</td>
<td>515–775 ft (155–235 m)</td>
</tr>
<tr>
<td>Speedbrakes not extended</td>
<td>420–825 ft (130–250 m)</td>
</tr>
<tr>
<td>High over threshold (100 ft altitude)</td>
<td>950 ft (290 m)</td>
</tr>
<tr>
<td>Speedbrakes not extended and thrust reversers not deployed</td>
<td>640–1,165 ft (195–355 m)</td>
</tr>
<tr>
<td>One-half of full brake pedal pressure</td>
<td>600–1,530 ft (185–465 m)</td>
</tr>
</tbody>
</table>

Notes: These data from the Boeing 737 NG Flight Crew Training Manual were published by the India Ministry of Civil Aviation Court of Inquiry following its investigation of the May 2010 landing accident in which the flight crew attempted a go-around at Mangalore. Distances shown vary with wet or dry runway condition; the data exclude contaminated runway considerations.

Source: Boeing Commercial Airplanes

Figure 2

Pilots get out of reverse thrust and put back in forward thrust,” Daidzic said. “Sometimes pilots do not have time to do that. Then they would be between a ‘hammer and a hard place’ because, if they get out of reverse thrust on a slippery runway, they are going to overrun. So they have to choose between one of these two — it’s going to be an overrun or a veer-off. But with better, accurate models in flight simulation training devices, pilots easily could practice corrective actions in many landing scenarios — slippery runways with crosswind, and so forth.” Effects of unstabilized approaches and the “excessive penalty” imposed by failure to use thrust reversers in slippery or hydroplaning conditions also could be demonstrated.

His own veer-off simulations represented forces acting on a Bombardier CRJ700 with General Electric CF34-8C5 engines landing on a slippery runway in a crosswind, he said. The crosswind force tends to make the airplane slide sideways, and the effect of this lateral force also changes depending on the use of deceleration devices, complicating pilot assessments of go-around feasibility.

These simulations used the CRJ700 performance data set and a 5,500-ft (1,676-m) runway while varying other factors, such as nose-gear touchdown at 1,500, 2,500 and 3,500 ft [457, 762 and 1,067 m] from the threshold; liftoff speed of 120, 130 and 140 kt; and headwind or tailwind. The model calculated minimum safe go-around speed and the elapsed time to decelerate to that speed, in scenarios with and without thrust reverser deployment, at a given runway length. These are a function of the touchdown/lift-off speeds and touchdown point — an air distance from the threshold plus the distance computed with a 3-second derotation factor.

The graph generated by one CRJ700 veer-off simulation represented a case involving a slippery surface (ice-like friction coefficient of 0.08), a 30-kt direct crosswind and no thrust reverser deployment. With the nose gear on the centerline, the downwind main gear normally would be positioned 40 to 65 ft (12 to 20 m) from the runway edge. After about 10 seconds without corrective action, however, the CRJ700 wound up about 13 ft (4 m) from the runway centerline, he said.

“Either the left or right main gear then would be about 30 to 50 ft [9 to 15 m] from one runway edge or the other, but this is not the worst-case scenario,” Daidzic said. “If we look at a case with thrust reversers, the airplane turns into the wind due to directional stability. Unless the pilot uses some aerodynamic controls — such as turning into the skid, which puts the airplane nose downwind with the thrust reversers then counteracting the wind — after landing on the runway centerline, after 10 seconds, the airplane would be about 50 ft off or more and thus already in a ditch.”

If these scenarios had been compounded by inadequate crosswind control during the approach — creating airborne lateral drift of 3 fps (1 mps), for example — the airplane already would have been displaced from the centerline by about 10 ft (3 m) by the time of nose gear touchdown. “In a matter of 10 seconds, this pilot already would have
and that can be fatal,” Daidzic said. “Because of the slippery runway, the airplane would not be slowing as quickly, so the speed generally would be about 100 kt, and that can be fatal.”

Go-Around Window

An example from one table in his commit-to-stop simulation results for a typical business jet, but applicable to any airplane given suitable runway length, showed how brief the opportunity can be to initiate the go-around. The assumptions were a 1,000-ft (305-m) indecision and configuration change distance, hydroplaning surface and maximum thrust after thrust reverser deployment. “Say

Regarding on-board tools, possibly including decision support for go-arounds, the NTSB also recommended that the FAA, “Actively pursue with aircraft and avionics manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed.”

The report also discussed the operator’s inadequate policy, procedures and training, noting, “None of the guidance explicitly states that a go-around should only be conducted before landing or identifies a committed-to-stop point (that is, a point in the landing sequence beyond which a go-around should not be attempted). … The NTSB notes that other recent overrun accidents have not been as catastrophic because the flight crews did not attempt to go around after landing. … [Two other recent U.S. accidents] might have been prevented if the pilots had committed to the landings or better understood where the committed-to-stop point was rather than attempting to go around with insufficient runway available to lift off and clear obstacles.”

Preventing these situations was an objective of international specialists involved in the 2006–2009 runway safety initiative facilitated by Flight Safety Foundation and the International Air Transport Association. Best practices are on the compact disc titled FSF Approach-and-Landing Accident Reduction (ALAR) Tool Kit Update, evidence that the “committed-to-stop” aspect of go-around decisions had received industry attention before the Hawker 800A crash.

Among the ALAR Tool Kit Update’s warnings originating a decade ago, a video says, “A key factor in making the go-around decision is to constantly reassess your decision to land during the approach. Note that there is a time when it is no longer appropriate to go around — for example, when spoilers and thrust reversers have been deployed. Your operational procedures should have appropriate information regarding these situations, and you should follow those procedures.”

Other examples of expert advice appear in “Reducing the Risk of Runway Excursions: Report of the Runway Safety Initiative,” published by Flight Safety Foundation, which says, “Operators should define and train procedures for go-around, including during flare and after touchdown,” and the Runway Excursion Risk Reduction Toolkit, First Edition 2009, which says, “A go-around should be conducted at any time significant deviations are recognized during the flare and touchdown.”

— WR

1. The NTSB could not be certain that these accidents would have been prevented. The board said, “On Oct. 5, 2005, [the pilot of] a Beechcraft 58 overran the runway in Jacksonville, Florida, after attempting a go-around late in the landing roll on a wet, ungrooved runway. … On July 15, 2005, a Cessna 525A collided with a localizer antenna in Newnan, Georgia, after the pilot conducted a go-around late in the landing roll on a wet, ungrooved runway. … As a result of the pilot’s delayed decision to go around, the airplane became airborne only 300 ft [91 m] from the runway end.”

Committed to Stop

Results of a U.S. National Transportation Safety Board (NTSB) performance study during the investigation of the Hawker 800A accident in July 2008 have rekindled concerns about procedures and training regarding go-arounds after touchdown in turbine-powered airplanes (ASW, 4/11, p. 16). “Establishing a committed-to-stop point in the landing sequence beyond which a go-around should not be attempted for turbine-powered aircraft would eliminate ambiguity for pilots making decisions during time-critical events,” said the NTSB’s final report. “If the [accident] captain had continued the landing and accepted the possibility of overrunning the runway instead of attempting to execute a go-around late in the landing roll, the accident most likely would have been prevented or the severity reduced because the airplane would have come to rest within the runway safety area.”

The most closely related safety recommendation to the U.S. Federal Aviation Administration (FAA) in the NTSB’s March 2011 report said, “Require manufacturers of newly certificated and in-service turbine-powered aircraft to incorporate in their aircraft flight manuals a committed-to-stop point in the landing sequence (for example, in the case of the Hawker Beechcraft 125-800A airplane, once lift dump is deployed) beyond which a go-around should not be attempted.” A companion recommendation said that, upon completion of this manual revision, specific categories of operators and flight training schools should be required to incorporate that information into their manuals and training.
We’re big supporters of some of the world’s smallest things.

With the importance of aviation in the lives of millions of people and the future of the next generations in mind, at Embraer we develop projects for quieter, less polluting and more fuel-efficient aircraft. We’ve already certified the first series airplane powered entirely with biofuels and we are also the first aircraft manufacturer to earn ISO 14001 certification for environmental standards. The commitment of Embraer with a sustainable future is substantiated by our support for the Global Compact (ONU) and it’s recognized by our participation in the portfolios of the Sustainability Index (ISE) and the Dow Jones Sustainability Indexes (DJSI). These initiatives are only a small part of what Embraer is doing already. We pledge to do even more. Because saving some of the smallest things for future generations won’t happen without big ideas from this one.
the groundspeed on touchdown is 120 kt and the nose gear is on the ground by 1,500 ft” beyond the threshold with thrust reversers deployed immediately, he said. “Theoretically, this pilot could slow down to 77 kt in approximately 11 seconds,” then select takeoff/go-around thrust and reconfigure the aircraft, “and still lift off in the 4,000 ft (1,219 m) of runway available after touchdown [Figure 3]. For pilots who do not have an accelerometer telling them their deceleration, however, it is very difficult — especially at high speed in a couple of seconds — to gauge how fast they are slowing down.”

Moreover, if the pilot touched down long at the same speed — for example, more than 3,000 ft from the threshold or beyond the first third of the available runway — he or she could only decelerate about 12 kt in approximately 3 seconds. In the same “generic” business jet scenario with no thrust reversers, the simulation showed that the minimum ground speed for a safe go-around would be about 107 kt and the maximum safe elapsed time to initiate the go-around would be 14 seconds. Landing long without thrust reversers might reduce that time to 4 or 5 seconds.

The above scenario with maximum reverse thrust reinforces calls for specific SOPs, training and discipline. “If you touch down fast and long in this case, you have less than 3 seconds to make a decision to go around,” Daidzic said. “If you pass the point of no return, you have to accept an overrun that can result in an accident because if you try to lift off, the result will be catastrophic.”

Essentially, the simulations show that a go-around, theoretically, can be safely attempted after touchdown only if initiated before the known point of no return, he said. Favorable conditions for a safe outcome ideally would include controllable deceleration-acceleration, a runway far longer than landing calculations require, landing on an appropriate touchdown marker, no obstacles in the departure flight path, a go-around decision before (or not more than three seconds after) main-gear touchdown and at least the calculated minimum go-around speed. “On a contaminated runway — or especially when hydroplaning — the pilots may be would not know that the airplane has no chance of stopping and would be overrunning at 30, 40 or 50 kt,” he said. Visually judging the deceleration rate in darkness also would increase the difficulty in this case.

Notes
1. Daidzic also is an adjunct professor of mechanical engineering, with a doctorate in fluid mechanics, and holds an airline transport pilot certificate and a certified flight instructor–instrument rating, among other pilot qualifications.
4. The captain of a Boeing 737-800 attempted to conduct a go-around at Mangalore, India, in May 2010, after touching down about 5,200 ft (1,585 m) from the landing runway threshold and deploying thrust reversers, resulting in a fatal accident (ASW, 5/11, p. 12).