Blurred Approach

Precipitation on your windshield can compromise vision at a critical phase of flight

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It is tempting to think that the hardest part of an instrument approach is the portion conducted solely with reference to the instruments, and that the challenge ends once the runway comes into sight. However, that transition to the visual portion of the approach can pose a new set of challenges resulting from reduced visual cues or visual illusions, and the spatial disorientation that can follow.

Other studies of approach and landing accidents in the air transport industry have found similar trends. Airbus’s analysis of approach and landing accidents found that 30% occur during a visual approach or during the visual segment of an instrument approach. Low visibility caused by precipitation (rain or snow) was a circumstantial factor in more than half of the approach and landing accidents.

During initial pilot training, we formed a mental impression of the “correct” runway orientation during practice landings. Those impressions were based on the airport environment, light patterns, the length of the runway and its projected shape. The location of the runway in the windshield and its relation to the other cockpit structure provides cues that relate to heading, attitude and altitude, and from these the pilot determines when the aircraft is positioned properly in space during an approach. Peripheral light cues, either from the runway environment during the day or from ground lights at night, aid the mental impression of a correct approach.

However, the loss of these peripheral cues due to precipitation reduces the pilot’s ability to assess correctly the aircraft’s position relative to the runway. Anyone who has tried to land when the entire visual field is pretty much a featureless blur of color, shadow and moving shapes knows the difficulty of maneuvering close to the ground. And surfaces that lack texture and color contrasts to help with depth perception and movement detection can make it essentially impossible for the pilot to visually judge height and distance.

Such powerful illusions can cause pilots to unconsciously modify the aircraft’s trajectory to keep a constant perception of the visual references. Failure to monitor the instruments and flight path when processing dubious visual cues makes this a particular challenge for a single-pilot operation or for a crowded flight deck in which neither pilot remains “on the gauge.”

There are other important factors that influence a pilot’s ability to view the runway accurately. These include off-airport lighting, which can range from intense urban lighting to the infamous “black hole” condition. Also on the list are runway slope, runway dimensions, runway lighting and, just as importantly, atmospheric conditions of ceiling, visibility and precipitation. When the ceiling and visibility are down to bare minimums, the slant visibility isn’t sufficient to allow sight of the farther bars of the VASI/PAPI system, thus reducing the available visual clues for the final segment of the approach in reduced visibility.

The perceived brightness of approach and runway lighting directly affects depth perception as well. In general, any visual phenomena — be it rain, haze, mist, smoke, dust or glare — that causes one to perceive being too distant or too high induces a tendency to shallow the glidepath. In addition, “runway foreshortening” occurs when a heavy rain pattern is moving slowly down the runway toward the approach end. This causes the physical dimensions of the runway to appear to decrease, thereby leading pilots to believe that they are high on the approach.

A rain-covered windscreen refracts, or simply distorts, light waves as they pass through the transparency. This refraction can significantly alter the runway’s image, enough to make it exceptionally difficult to accurately perceive its true position and thus the airport’s reference point. In daylight, water on the windshield can make objects appear more distant than true, causing pilots to believe they are too high and far from the planned touchdown point and thus they tend to fly a shallow path to compensate.

Meanwhile, rain increases the apparent brilliance of the approach light system at night, making pilots think they are closer to the runway than true. This tends to induce a pitch-down input and risk landing short of the runway threshold.

When a wet runway surface doesn’t reflect light, it affects a pilot’s depth perception by appearing to be farther away. This usually results in a late flare and firm touchdown. Peripheral vision of runway edge lights should be used to increase depth perception and determine the flare point.

Precipitation can also trick our minds regarding movement. Blowing snow, blowing dust, ripples in water and blowing grass can create the illusion of movement even when we are still. This is called “Optical Flow Rate Confusion.” In general, perception of speed is a function of what we see passing by. The higher we go the less visual information is available to use in assessing forward speed, which is why at FL 400 it is hard to sense speed even though we’re progressing at eight-tenths the speed of sound. Yet do half that speed close to the ground or with big snowflakes whizzing past, and the speed sensation is thrilling.

The rate at which ground disappears beneath the aircraft’s nose gives at least an indirect indication of forward motion. The danger happens when on approach. Without reference to the airspeed indicator, it is easy for a pilot to misperceive the aircraft’s speed. This becomes particularly problematic on dark nights with blowing snow because the aircraft’s bright landing lights reflect from the precipitation in all directions, effectively masking the lighting contrast of the runway approach and landing lights, and leaving an insufficiency of adequate environmental cues. Additionally, the speed sensation caused by blowing snow can lead pilots to believe they are high and fast when they actually are low and slow. Blowing snow across the runway or ramp gives the illusion of aircraft movement opposite of the blowing snow. Knowledge of the absolute altitude and reliance on the altimeter to maintain ground clearance are important in this instance, as well as proper alignment with the runway with reference to the instrument and centerline lighting.

Flight Safety Australia magazine (July-August 2006) describes “flat light” as a condition caused by a combination of overcast skies, snow covered terrain and precipitation. Meanwhile, the NTSB has defined flat light as “the diffusing light that occurs under cloudy skies, especially when the ground is snow covered.” Alpine skiers know this condition well and know how disorienting it can be. It can also occur in dust, sand, mud flaps or on glassy water. Those who have flown in Central Alaska or Northern Canada know this phenomenon can make it impossible to discern where the ground ends and sky begins.

The sun’s position, atmospheric haze and many forms of precipitation can cause a lack of contrast between obstacles and the runway environment. Certainly anyone who has flown an approach into the Los Angeles haze or the summer haze of the Eastern U.S. knows that “light scatter” effect. These conditions impair the pilot’s ability to accurately determine
depth, altitude and topographical features, thus creating an inability to distinguish distances and closure rates.

One of the difficulties of taxiing at a speed consistent with safety, especially under difficult lighting conditions is that there are few objects to pass by until reaching the ramp area. Assessing speed under such conditions requires looking out the side window to get a direct view of the passage of runway lights, pavement lines or markings, etc.

You will often see safety recommendations that flight crews should be educated and trained on the factors and conditions creating visual illusions and their effects on the perception of the environment and aircraft height, depth, distances and angles. But honestly, I think a lot of us have a hard time remembering, “Oh, the downsloping runway tricks me into thinking I’m too flat...” Pure rote memorization of these effects isn’t an effective countermeasure to these illusions.

Approach hazards should be assessed for each individual approach by reviewing ceiling and visibility; weather, including wind, turbulence, precipitation, fog, smoke, drifting sand or snow, snow-covered terrain, sun height and location; and flight crew experience with the airport environment and landing runway. Preparation should include the type of approach, information for obtaining distance from the runway threshold (i.e., DME not located at the runway threshold), restrictions on glidepath usage (i.e., is it unusable beyond a point on the approach or below a specified altitude?), type of approach light system, and whether it is equipped with a Visual Approach Slope Indicator (VASI) or Precision Approach Path Indicator (PAPI).

A word of caution about VASIs, particularly at night. This comes from NASA Aviation Safety Reporting System reports from a business jet crew landing at an uncontrolled field at night. Unknown to the pilots, the VASI had been knocked askew by a tractor that was mowing the grass. The pilots thought they seemed a bit low but trusted the VASI. They noticed the VASI lights seemed a bit intermittent, and then realized through their landing lights that they were actually skimming the tops of trees. An immediate go-around followed. Upon inspecting the VASI in daylight, it turned out the “on slope” indication put the flight path through the trees.

Procedures at the airlines require pilots to use precision approach aids (glideslope and localizer, if available) even during daylight visual conditions. Pilots are encouraged to choose a runway that is served by a precision approach. Usually runways with precision approaches are also equipped with a VASI, further aiding a pilot for the final portion of the descent to landing.

Absent a precision approach, a non-precision approach supported by VASI/PAPI is preferred, especially if the runway is served by an RNAV approach with an electronic glidepath. If your aircraft’s FMS has the capability for building your own pseudo-glidepath from the runway, that, too, can be an effective aid.

Formally defined task sharing by crews ensures a continued monitoring of the visual and instrument references throughout the transition from instrument flight until touchdown. Altitude and excessive parameter deviation callouts should be the same for instrument and visual approaches, and should be continued for the visual segment. Limits are placed on the variation of speed, vertical velocity, engine spool-up and configuration deviations beyond a certain amount are grounds for immediately executing a missed approach. The single pilot in a light aircraft should do the same. Unfortunately, the single pilot doesn’t have the backup of a copilot to assist.

If performing a step-down non-precision approach, do not descend below MDA before reaching the VDP, even if visual references have been acquired. To prevent going too early to visual references and descending prematurely below MDA, the pilot flying should maintain reference to instruments until reaching the VDP. Maintain a combination of visual flying supported by monitoring of instruments; cross-check instrument indications against outside visual cues to confirm glidepath. It is advisable to use the FMS track distance to runway threshold and the altitude above the airfield (basically the 300-ft.-per-nm technique) to confirm glidepath.

Keep in mind that precipitation can cause lots of trouble beyond visual illusions, but if the final segment to touchdown is blurred, that’s quite enough to handle.

A “monitored approach” is a specific procedure used by the airlines to provide optimum crew coordination with specific cross-checking and monitoring duties to ensure the aircraft remains on a safe trajectory during the high threat portion of an instrument approach transition to the visual segment. It involves one pilot flying (PF) the aircraft on approach exclusively “heads down” by reference solely to the flight instruments. As the aircraft nears the applicable DH/MDA, the pilot monitoring (PM) seeks visual external references. At DH/MDA, the PF makes a call-out. Some air carriers stipulate the call-out of “decide.” If the PM does not believe the aircraft complies with the requirements of FAR Part 91.175 (the lengthy list of requirements that basically say the pilot must be able to see adequate visual references and be in a position to continue using normal maneuvers to land in the touchdown zone as a condition to descend from DH/MDA), the PM will state “Go Around” and the PF will execute the missed approach procedure. At that point the PM shifts back to monitoring the aircraft’s instruments and helps coordinate the aircraft reconfiguration while executing the MAP. If the judgment is the aircraft can safely land, the PM will call “Land” and take over control of the aircraft to now become the PF and continue to the landing.

There are significant advantages to this method, not the least of which is providing explicit crew-coordination procedures during this high threat portion of flight, and it spells out exactly who is heads up and heads down. It highlights the importance of the PF to concentrate solely on accurate aircraft trajectory control while the eyes of the PM can become accommodated. In pilot terms, that means changing one’s focal distance from inside the cockpit to the visual references in the runway environment.

The safety record at the airlines shows the effectiveness of this procedure. But it definitely requires expertise written procedures and practice in the simulator. A change of aircraft control so close to the ground before landing is not a task you should try for the first time in the weather.