VISUAL APPROACHES

Based on a review by F. H. LORENZ

A surprising number of aircraft accidents have occurred during visual approaches or during the visual segment following an instrument approach. An interesting review initiated by Captain Fred H. LORENZ has been published sometime ago…

ACCIDENTS

Case Nr. 1

During approach over water, the aircraft touched down 200 feet short on a soft coral clearway. As it crossed a ditch 60 feet short, the left gear separated. The aircraft continued to the runway, traveled 2400 feet on the right gear and Nr. 1 engine. At this point the engine separated and the aircraft continued another 340 feet, coming to stop 2700 feet from the threshold and 65 feet to the left of the runway. The runway is 5248 feet long.
There was no report of fire or injuries to passengers or crew. Aircraft damage was limited to the gear, nacelle, strut, wing tip and flaps.

Case Nr. 2

Aircraft was on a scheduled domestic passenger flight. Following a routine approach the aircraft touched down 12 feet short of the runway. Impact with the runway edge/lip by the landing gear caused the aircraft to veer right and depart the runway. The right main landing gear and Nr. 2 engine separated and the left main landing gear collapsed under the trailing edge flaps. After coming to rest a fuel fire caused extensive damage to the right wing. No passenger or crew injuries were reported. During removal of the aircraft to a secondary location, leaking fuel ignited and the aircraft was consumed by fire.

Case Nr. 3

The aircraft approached the destination at about 5:00 PM., in clear weather. The VASI system was in operation. The approach was at a higher than normal speed and, as it became apparent that the touchdown would be well down the runway, the first officer suggested to the captain, who was flying the aircraft, that a missed approach and go-around be executed. The captain did not concur and the aircraft touched down about 2000 meters past the threshold. Thrust reversers were deployed and power was advanced to 1.4 EPR. The captain considered the reversers to be ineffective and placed both their control levers in the forward (idle) position.
The aircraft departed the left side of the runway near the end of the 3000 meter strip. It stopped approximately 30 meters beyond and 30 meters left of the end of the runway. The right main landing gear, nose gear and Nr. 2 engine separated. There was extensive lower fuselage damage from the migrating parts and the subsequent fire.

After reading these case histories, one has to ask the questions; *What happened? Why did these accidents occur?* The answers in most cases are quite complex and it is not my intent in this article to address the exact causes of each accident which I have given as examples.

They only serve to illustrate that accidents do occur during visual landings. Rather, I would like to address factors that might affect how a pilot perceives his approach path during a visual approach, factors which might affect that perception, and recommended procedures for avoiding incidents during a visual approach.

OPTICAL ILLUSION DURING LANDING APPROACH

When a pilot makes a visual approach, he subconsciously judges his approach path for a combination of his apparent distance from the runway and his apparent height above the terrain. Through continuous exposure to precision glide path, VASI or other modern approach aids, he also becomes conditioned to the 3° glide path to the touchdown point irrespective of the runway gradient, or surrounding terrain.

In the normal case, when the approach terrain and runway have zero slope, the pilot would become accustomed to seeing a 3° relationship between the runway and himself (see figure 1). He should also develop a knowledge of reference rate of descent values for his aircraft for quick reference.

Not all approaches will be made over terrain or into runways that meet the nominal zero slope criteria.

The following is a brief discussion of illusions that may occur with some of the more common approach terrain/runway slope combinations. The angular relationships in these figures are exaggerated for clarity.

When there is an upslope in either the approach terrain or runway, the pilot will experience an *above glide path* illusion (see figures 2 and 3).

In the first case, the pilot's visual reference to the approach terrain will give the illusion that the aircraft is too high. In the second case, angular reference to the runway gives the illusion that the approach path is too steep, implying that the aircraft must therefore be too high. In both cases, correcting for the apparent illusion of the aircraft being *too high on the approach path will result in a flat approach* which may result in landing short. There may be a tendency to fly a low, flat approach which must be avoided by maintaining the proper speed and power control.

When there is a down slope in the approach or runway, the pilot will experience a *below glide path* illusion (see figures 4 and 5).

In the first case, the pilot's visual reference to the approach terrain will give the illusion that the aircraft is too low. In the second case, angular reference to the runway gives the illusion that the approach path is too shallow, implying that the aircraft must therefore be too low. In each case, correcting the apparent illusion of being *too low on the approach path* will result in a steep approach which may result in landing long. Power and airspeed control must be maintained and the tendency to fly steeper approach paths must be avoided.

In all cases, the pilot must not allow visual illusions to disorientate him. Thrust, airspeed and rate of descent control must be maintained, and the aircraft must be controlled and flown to the touchdown target to prevent approach path deviations that may compromise the landing.

Crosscheck the IVSI for the desired rate of descent for the approach speed corrected for known headwind or tailwind component to maintain the proper profile to touchdown (see Table 1).

Combinations of slope may modify the illusion. Also, the length of the runway or hazardous terrain at either end of the runway may add psychological effects. A desire to touch down near the approach end could increase the hazard.

VISIBILITY RESTRICTIONS

Under conditions of haze, smoke, dust, glare or darkness, expect to appear higher than you actually are.

Shadows are one of the key factors in depth perception. Their absence, when due to visibility restrictions, unknowingly confuses the pilot. Since he cannot discern the shadows he normally sees given height, he interprets his altitude as being higher than it actually is. This effect is also encountered during night landings. Another serious case is encountered in a smoke or dust layer blowing low across the threshold. The effect varies with individuals and is modified by the intensity and clarity of runway lighting. It is best exemplified by the tendency, when on a precision approach, to reduce power and drop below glide path as soon as the runway is seen.

Moisture on the windshield interferes with visibility and may cause an *off glide path* illusion. Light rays will refract as they pass through the layer of moisture on the windshield. Depending upon the particular aircraft and pattern of ripples across the windshield, you can appear to be above or below the glide path or left or right of the centreline. This can be as much as a 200-foot error at one mile from the runway which, when combined with the effect mentioned above, could result in a touchdown three to five thousand feet short of the runway.

Crosscheck IVSI for rate of descent and fly to the touchdown target.

RUNWAY LIGHTING

Expect to appear higher and farther from the runway when the lights are dim.

On a straight-in, clear night approach, you may actually be farther from or closer to the runway than you appear to be.

When runway lights are on bright, the runway will appear to be closer. When the runway lights are dim, it will seem farther away. Or, more simply, bold colors advance, dull colors recede. An approach to a brightly lit runway on a dark, clear night has often resulted in touchdown far short of the runway when the pilot ignored instrument crosscheck and relied only on visual cues. The effect is greatly increased in clear desert air or when approaching over an unlit desert or water surface. An approach over an area where there are houses or other surface lights will decrease the contrast of high intensity lights. The absence of approach zone lighting increases the hazard.

RUNWAY CHARACTERISTICS

During approach, expect to be higher than you appear when approaching a wide runway and be lower than you appear to a short, narrow runway.

A pilot bases part of his judgment on a mental comparison with the runway to which he is accustomed. If his experience is with landing on a 12,000-foot by 300-foot runway, he may touch down well short on a 4800-foot by 120-foot strip which has the same relative proportions.
On the final approach, he will judge himself farther out and therefore higher above the ground than he actually is. Again the reminder, continue instrument crosscheck until touchdown.

Irregularities in -runway surfaces especially on rolling terrain, can also cause a runway to appear much shorter when you lose sight of the far end after touchdown due to a hump between the aircraft and the far end. This sudden *shortening* of the runway could result in more abrupt than necessary stopping, excessive reversing and end with a problem of keeping the aircraft on the runway.

RUNWAY CONTRAST

Be alert for problems in depth perception when runway color approximates the surrounding terrain.

The snow covered runway and night landing on a dimly lit runway are extreme examples. But even lesser conditions present severe problems in depth perception, resulting in over- and under-shoots. The concrete runway on a sand surface in bright sunlight or the macadam strip surrounded by dark jungle foliage will give similar difficulties. Water on the runway in either of the two latter examples will heighten the effect. Haze or other visibility restrictions will serve to further reduce runway terrain color contrast.

If the visual approach that a pilot is flying turns out to be something less than perfect, the pilot must make an assessment of the situation and determine if it is safe to continue the landing. Obviously, it is not acceptable to land short of the runway and as such, immediate corrective action is required if that appears to be imminent. However, the situation is less clear cut when a long landing and/or touchdown at a higher speed than intended appear to be unavoidable.

Is it safe to do this or is it not ? We cannot directly answer that question since each case is individual and many factors might affect the outcome. What we can do is discuss some of those factors which affect actual landing distance and which might also affect the pilot's decision to continue the landing or to go around.

FACTORS AFFECTING LANDING DISTANCE

Actual stopping distances for a maximum effort stop are approximately 60% of the field length requirement on a dry runway. Some factors that affect stopping distance are altitude and speed at the threshold, glide slope, use of thrust reversers, speedbrakes and brakes. Floating just off the runway surface before touchdown must be avoided, as this procedure uses a large portion of the available runway. The aircraft should be landed as near the normal touchdown point as possible rather than be allowed to float to bleed off speed. Aircraft deceleration on the runway is about three times greater than in the air.

Height of the aircraft over the end of the runway also has a very significant effect on total landing distance. For example, flying over the end of the runway at 100 feet altitude rather than 50 feet could increase total landing distance by 950 feet on a 3° glide path. This change in total landing distance results primarily because of the length of the runway used up before the aircraft actually touches down. Glide path angle also affects total landing distance. Even while maintaining proper height over the end of the runway, total landing distance is increased as the approach path becomes flatter.

Stopping distance will also vary with wind conditions and any deviation from recommended approach speeds.

Reverse thrust and Speedbrake drag are most effective at high speeds. Make the Speedbrake actuation and reverse thrust lever manipulation rapidly, with as little time delay as possible. Boeing pilots could find in their Boeing Operations Manual how some of these factors may affect landing distances.

SUMMARY AND RECOMMENDATIONS

In summary, a visual approach in good weather conditions or the visual segment of an instrument approach is not the time to relax and be lulled into a false sense of security. Many factors exist which can affect your visual perception of your flight path. You should be aware of them and compensate for them. The following are some recommended procedures which might be helpful in accomplishing that task.

- Use all available airport aids when conducting a visual approach. Accept radar vectors to the final approach if available. If an ILS or MLS is available for the runway of intended landing, by all means tune it in and use it as a primary reference during the approach and landing. If some form of visual approach monitor (Visual Approach Slope Indicator [VASI] or Precision Approach Path Indicator [PAPI]) is available, use that as a secondary reference in conjunction with the ILS/MLS or a primary reference if an ILS/MLS is not available.

- Know the terrain surrounding the aircraft, the width and length of the runway, and the field conditions and be alert for any visual illusions such as those outlined in this article.

- Use normal call-outs and crew co-ordination procedures in the same manner as on an instrument approach to enhance altitude and general situation awareness. Fly the proper speed for the flap configuration and avoid excess speed on final approach.

- If an instrument approach procedure exists for the runway of intended landing, brief that approach, have the approach plate available for use, and consider flying at least the final approach portion of that approach as illustrated. This should ensure proper terrain clearance during that segment of the approach and landing.

- On FMC and EFIS-equipped aircraft, use the map mode to display airport information such as the runway of intended landing and any significant waypoints or navigation aids. Use the extended runway centreline and distance to go to the runway end for lateral and vertical position of the aircraft. If nothing else is available, a good rule of thumb for vertical positioning is to be at 900 to 1 000 feet AGL at three miles out, 600 to 700 feet AGL at two miles out, and 300 to 40 feet AGL at one mile out on final. This approximates a 2.50 to 30 descent path. Cross check the vertical speed indications on

- Last, but by no means least, if you end up high, fast, or otherwise out of position to make a normal landing, do not hesitate to make a go-around or missed approach. This is also true any time that visual contact with the airport is lost during the visual descent segment following an instrument approach. If it is not right, do not continue. Do not be proud, go around and try it again.

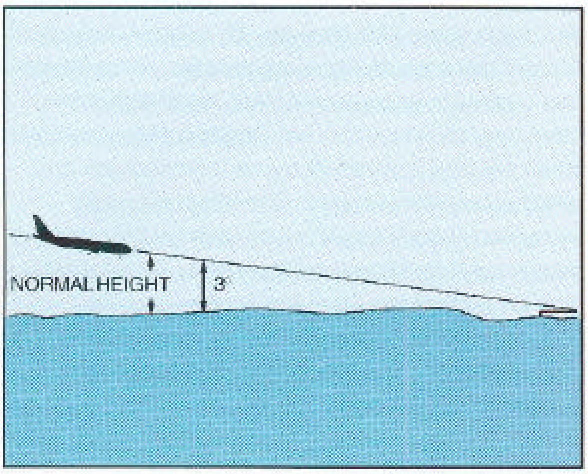

Figure 1. Nominal approach glidepath

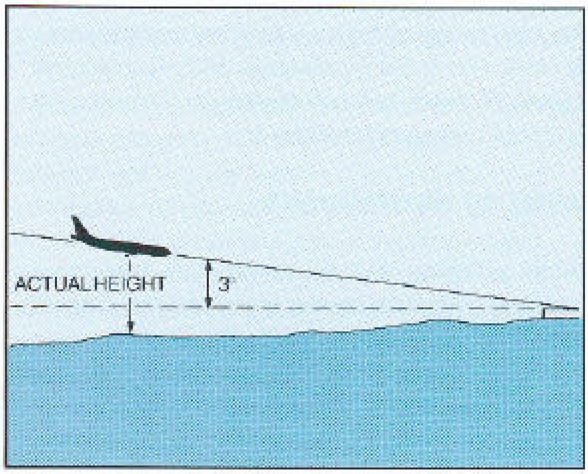

Figure 2. Upslope in approach terrain, zero slope runway

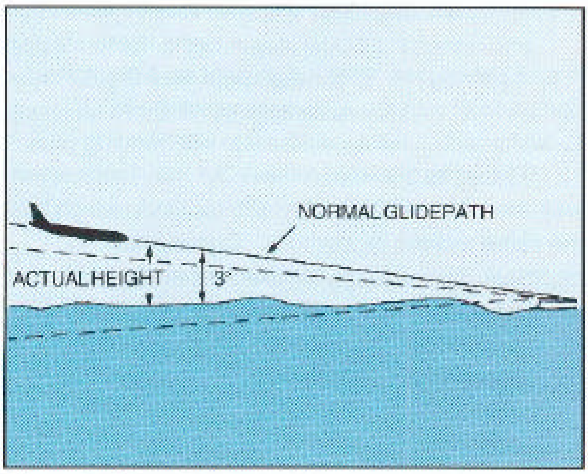

Figure 3. Zero slope terrain, 1° upslope runway

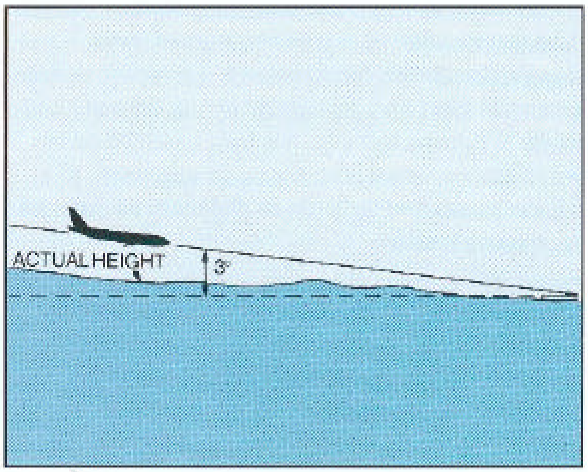

Figure 4. Downslope in approach terrain, zero slope runway

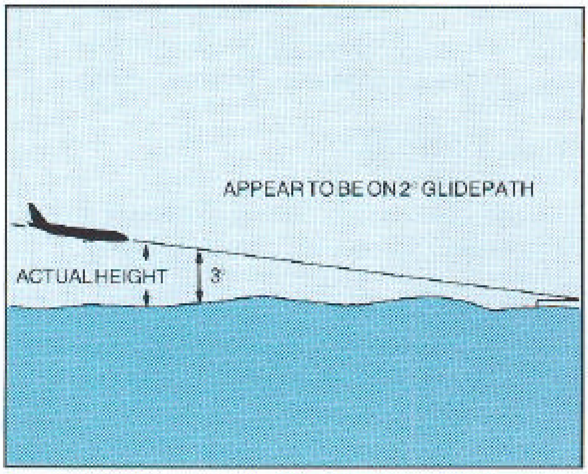

Figure 5. Zero slope terrain, 1° downslope runway

GROUND SPEED (KNOTS)	PROFILE OR GLIDESLOPE (DEGREES)				
V_{REF} ± WIND	2.5	2.75	3.00	3.25	3.50
110	485	535	585	635	680
120	530	585	640	690	745
130	575	635	690	750	805
140	620	680	745	805	870
150	665	730	800	865	930
160	710	780	850	920	990
170	750	830	905	980	1050

Table 1. Crosscheck that desired rate of descent accounts for wind component