PAUL PHELAN

It is what happens in the final 10s that determines whether a landing is smooth

Calculated landings

Some simple geometry could help pilots make smoother and safer landings

PAUL PHELAN/**CAIRNS**

ACCORDING TO David Jacobson, a training captain on Qantas' Boeing 737 domestic fleet, in this age of "...technical precision, the manual landing flare manoeuvre has remained imprecise. Conventional techniques have relied upon an inconsistent, critical estimation of height above the landing surface, and are subject to a number of variable factors. They are inadequate, inappropriate, imprecise, complex, hazardous, and frustrating; yet we have stayed with them. We have attempted to teach judgement and perception."

Jacobson asserts that the answer lies in a simple geometric calculation by which any pilot, of any aeroplane, can identify a visual fix on the runway at which the aircraft's wheels are at exactly the correct height above the surface for the initiation of the landing flare. He says: "Without an adequate framework, there is no simple way to teach perception and judgement to those to whom it does not come easily. We have always attempted to teach *what* we do, but we have failed in our collective attempts to explain *how*. Ask any pilot *how* he lands – he won't be able to tell you. Surprisingly, there has been no acceptable, quantifiable technique in the history of aviation, nor any recognition of the need for one."

Following an "unusually firm landing" 15 years ago in a Boeing 727, Jacobson has researched the final approach and landing sequence, seeking a solution to such random events. He now attributes them to "a glaring and almost universal flaw in the development and understanding of defined landing flare techniques" which, he insists, leaves a similar unfilled gap in pilot training at all levels:

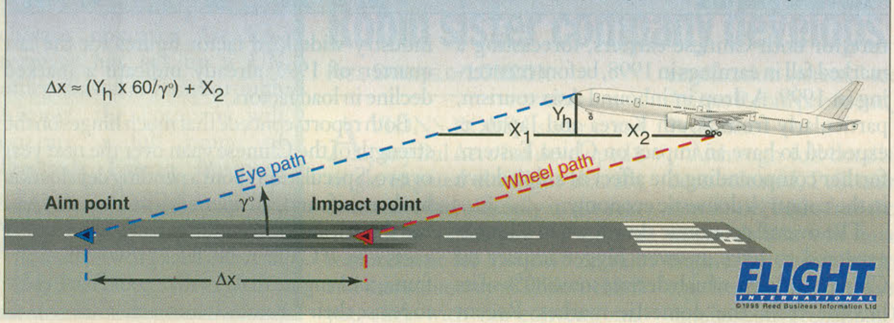
"Current methods rely heavily on skill, memory, perception, familiarity and practice. Student pilots, without those resources, rely on trial and error to develop the judgement necessary to practise them. So do pilots moving from one aircraft to another, generally larger, type," says Jacobson.

CONSISTENTLY SAFE

More importantly, where rapid economic growth and determined nationalism in pilot employment policies is propelling relatively inexperienced pilots into large aeroplanes, it is almost imperative that new initiatives be developed to improve their landing skills to a point where they can achieve a consistently safe result.

Jacobson's solution, now known as "the Jacobson flare", is based on simple triangulation, inspired by the technique the Second World War "dam busters" used to lob their bombs with precision between a protective boom net and the dam wall; or the principle adapted to position airliners precisely at aerobridges. His technique is already being taught at the Australian Aviation College, which trains

The distance between aim point and impact point (simplified version)



cadets for several major international carriers including Qantas.

China Southern's Perth (Western Australia) flying college has now also formally confirmed plans to adopt the Jacobson flare as part of its standard training techniques.

Proponents assert that it will reduce wasted training time, relieve unnecessary stress on pilots (and passengers), provide standardisation, stability and predictability, offer solutions to immediate problems which will also carry over to larger types, arm trainers with an ability to troubleshoot and to critique landings sensibly and constructively and diminish the number of landing accidents – which represent a high proportion of all safety events.

The solution is derived by Jacobson from a practical and error-tolerant technique based on simple geometry to establish a visual fix for flare initiation. He stresses that he is not promoting any radical departure from current practice, he has merely defined it with simple mathematics, to establish a methodology by which a pilot on approach can accurately locate the "flare cutoff point". (Any pilot who is daunted by geometry could probably plot the whole process with a protractor on a large sheet of graph paper.)

The method begins with the recognition, which is now the baseline of most jet airliner pilot training, that a stable, constant-angle approach – a "path descent"– is required. The technique is, however, equally suitable for light aeroplanes. "Speed descent techniques are not essential for light aircraft, despite commonly held views to the contrary, and they are not suitable for larger or high performance aircraft. Interestingly, the advocates of the speed-descent dogma are then quite inconsistent in recommending a path-descent technique to maintain an ILS [instrument landing system] glide-slope," says Jacobson.

ESTABLISHING AIM

For any aeroplane, the aim point is established as a point along the runway which will provide the required wheel clearance and undershoot protection at the runway threshold. The location of the aim point along the runway then depends on the height of the pilot eye point above the main wheel path. The distance between the aim point and the "impact point" (assuming no flare) of the main wheels is easily calculated. The desired position of the aim point in the windscreen is a simple function of the pilot's eye level in relation to the top of the glareshield. This relationship is modified by the aircraft attitude, as a consequence of flap configuration and airspeed. The flare is initiated when a predetermined cutoff point along the runway centreline is overtaken by the glareshield.

Once on a stable approach, and having done the calculations for their aircraft type, pilots have all the necessary tools to locate the flare cutoff point. The method differs slightly according to whether the eye height at the flare point (Ye) is known or not. In either case, the mathematics are relatively simple. "The flare is initiated when, on a stable approach, the predetermined cut-off point is overtaken by the aircraft cockpit lower cut-off angle (κ°). In practice, it is the simplest of tasks to notice the aircraft glareshield, at the base of the windscreen, and superimpose the cut-off point while flying an approach using standard path techniques," says Jacobson✎

Because a 20ft error in identifying the flare point makes only a 1ft error in height, the method is error tolerant. Also, the geometry makes it self-compensating for non-standard landing configurations such as the flapless case, where an aircraft with a higher body angle would require a higher flare point to accommodate the reduced clearance for the main wheel. The higher attitude self-compensates because the lower cut-off angle is reached earlier in the approach, providing an earlier flare cue; and the reverse applies in any configuration producing a nose low attitude. The same self-compensation applies for sloping runways. Flare rate is varied with experience to accommodate heavy or light landing weights, and strong headwinds or tailwinds. The technique is also completely portable between aircraft types.

Jacobson says that pilots converting to new types report notably improved landings as a result of its application. Users affirm that it is in no way a radical departure from current practice – it defines what they are already doing, making it more precise. The Jacobson flare enhances traditional techniques, just as global positioning systems and radio navigation enhanced dead-reckoning navigation. ❑

WHERE THE FLARE HEIGHT (Ye) IS KNOWN

WHERE THE REQUIRED flare height (Ye) is nominated by the manufacturer (and for most widebodies it is), an accurate flare cutoff point (Δf) can be calculated using the formula:

(f = Δe (cot γ - cot κ°).

For the low angles involved, the "one in 60 rule" can be substituted for cotangents with negligible loss of accuracy (eg, the cotangent of 3° is 19.08ft, but use of the 1:60 rule derives 60/3, or 20ft).

The values in the formulae and calculations are:

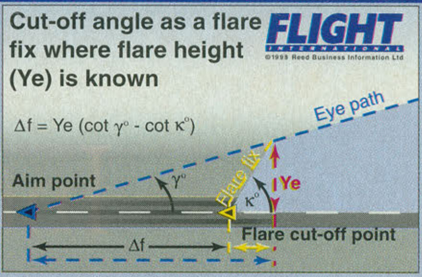
Yh: the vertical elevation of the pilot's eye above the level of the main wheels in approach configuration;

Yw: main wheel height at the flare point;

Ye: the eye height at flare point (Yh + Yw)

γ°: flight path inclination angle - (3° for a standard ILS.)

κ°: cockpit lower cutoff angle - the lower limit of pilot vision through the windshield For example in a Boeing 747, where Yh = 43 feet, Yw = 30ft and κ = 16°, the calculation is:



Δf = Ye (cot γ - cot κ)
= (43 + 30) x (19.08 - 3.49)
= 73 x 15.59
= 1,138.07ft = 346.88m (say 350m)

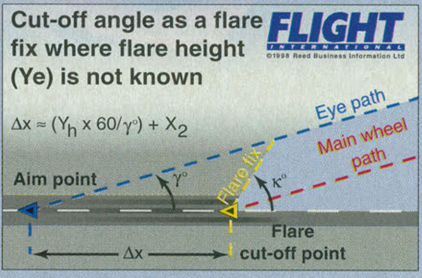
Available runway markings are then used to identify that point. Aim point for a 747 is the 450m marker, so the flare cutoff point identified on the runway is 450m minus 350m, or 100m from the threshold. That distance corresponds with the farther end of the first centreline marking, so you are at the flare cutoff point when that point vanishes under your glareshield. Rotate to the flared attitude at the appropriate rate at that point.

WHERE THE FLARE HEIGHT (Ye) IS NOT KNOWN

WHERE THE manufacturer does not provide a value for Ye and Yw, for example a Boeing 737-300, Jacobson details an alternative method of determining the flare point. "A suitable approximation for the flare cutoff point (Δx), based on aircraft and approach geometry and through practical testing, has provided a simple and effective alternative technique, with near-universal application." (x2 is the distance of the pilot's eye forward of the main wheels – in this example, for a 737-300, x2 = 40 ft):

Δx = (Yh cot γ) + x2, which using the 1:60 rule, is expressed more simply as:

= (16.3 x 60/3) + 40



= 16.3 x 20 + 40 = 366ft (112m, rounded to 110m).

Identified on runway at the aim point - Δx = 1,000 - 370 = 630ft (192m) from threshold; very close to the beginning of the third runway centreline marking stripe.