The traditional difficulties associated with learning, teaching and making an approach would be simplified if we could just adopt a constant approach angle — and the simplest way to maintain a constant approach angle is to maintain a constant lift/drag ratio throughout the approach. If the lift/drag ratio remains constant, the approach angle must remain constant.

What affects the lift/drag ratio of the aircraft?

- the aircraft body angle — the attitude of the aircraft as it moves through the air,
- the power setting — thrust, affecting lift and drag,
- the aircraft's configuration — undercarriage position and the setting of flaps or other devices which alter the camber of the wing.

No mention of airspeed — because airspeed is a product of these three. Thus, the lift/drag ratio (and the approach angle) can be maintained by three pilot-controlled variables: attitude, power, and configuration.

Now the object of our endeavours has been to minimise the number of variables the pilot must recognise and manipulate during the approach. Bearing in mind the relationship between attitude, power and flap setting, it becomes obvious that the only two variables that will affect the approach angle, once the attitude has been established, are power and flap.

During a normal approach we lower flap, so the wing configuration varies. How do we compensate for a variation in wing configuration and thus a change in the approach path? — by simultaneously adjusting the power. As the wing lift/drag ratio decreases, the aircraft begins to move down a steeper approach path. To maintain the initial approach path, we restore the lift/drag ratio by an increase in power. Nothing else is required.

It's that simple. For a change in flap, we use balancing power and the aircraft continues along the required approach path at a reduced airspeed.

Throughout the approach, the aircraft acts as its own approach computer. By maintaining a constant attitude, any requirement for more or less power (compensating for changes in weight, temperature, pressure, headwind etc.) will become obvious by the movement of the pilot's approach path away from the desired aim point. The pilot makes automatic adjustments for the above variables using one control — the power lever.

What could be simpler and safer? Using this method of approach, any pilot, after a suitable period of training, can make a safe, consistent and confident approach and landing. What more could we ask? □

A flare for landing

Captian David Jacobson is a training captain on DC-9s with Australian Airlines and is a Grade 1 instructor at the RAAF Point Cook Flying Club. His system sounds complicated at first but in reality is delightfully simple. It works for little aircraft too.

OF ALL THE manoeuvres performed in fixed-wing aircraft, the landing flare is an enigma. It is critical to the safe and satisfactory conclusion of flight and yet, despite international research, remains more an art than a science. The way the pilot judges the flare is still not fully understood.

Student pilots and experienced pilots alike find it at times alternatively satisfying and frustrating, simple and complex, safe and hazardous.

In *Digest 129* the Bureau of Air Safety Investigation identified improper landing flare as the third most significant of thirteen factors in instances where pilot factors were assigned to accidents involving private pilots.

In an age of technical precision, this critical manoeuvre remains imprecise.

This proposal discusses a practical technique for establishing a consistant flare point which does not rely on the pilot's perception of vertical height. It embraces the physical principle of motion parallax to provide a simple cue for commencement of the flare. No device or modification is required and therefore no costs are incurred. Safety is enhanced and the technique is 'pilot-portable'.

Current practice

The landing flare is one of the last critical phases of flight to which the term 'seat-of-the-pants' may still be applied. The vast majority of landings, worldwide, are practised by pilots utilising highly developed qualities of judgment, co-ordination, experience and skill.

Existing flare techniques involve a critical estimation of height above the landing surface. This is very difficult to achieve because the estimation of height and the particular height are subject to many variables, such as:

- Aircraft type.
- Aircraft size.
- Aircraft configuration.
- Glide path angle.
- Pilot total experience.
- Pilot recent experience.
- Pilot experience on type.
- Pilot seating position.
- Pilot performance or skill.
- Landing surface.
- Day versus night.
- Visibility.
- Wind and turbulence.

Historically, instruction in determining a suitable and consistent flare point has been inadequate to say the least. We are attempting to recognise and extract one flare point from a range of acceptable flare circumstances. Generally, the best that instructors have been able to manage is to demonstrate a suitable flare point for a particular aircraft as being 'about here'.

The student pilot has no proper model except in his memory, and that in itself is inconsistent. Trial and error are the arbiters in determining the soundness of his developing judgment. Unfortunately, even after the basic skills are mastered, the problem still exists because every aircraft type requires a different flare height. As a pilot converts to successive aircraft types, he faces the same problem over and over. He has no proper model at the very time he needs one most, and there lies a clue.

Just as the student pilot consolidates his flare-height judgment, so does the experienced pilot after conversion to another aircraft type. After a time, he becomes comfortable with his aircraft (if he consolidates and flies regularly), and can land it as well as any flown previously. Probably, this is a subconscious recognition of something visible to the pilot through his windshield that is providing a useable cue for flare. Obviously, to achieve consistency some recognition and quantification is necessary.

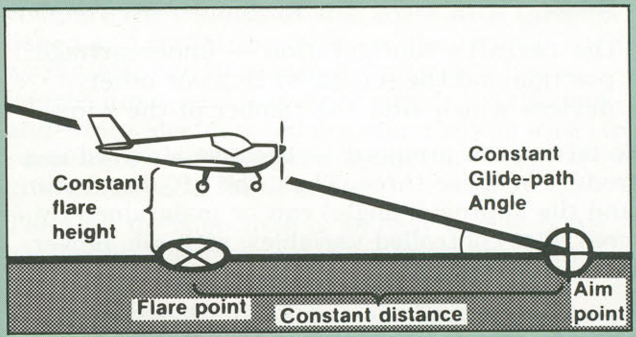
Vague terms such as the height of a double-decker bus, 20 feet, when the individual blades of grass are discernible, when the ground starts to 'rush', when you feel that your feet are just about to reach the threshold or 'about here' are too imprecise or inconsistent. And for a student they are almost incomprehensible.

We need to bring this 'something' out into the open so that we know exactly what we are looking for, what works for us, and what to use in the future.

Another way

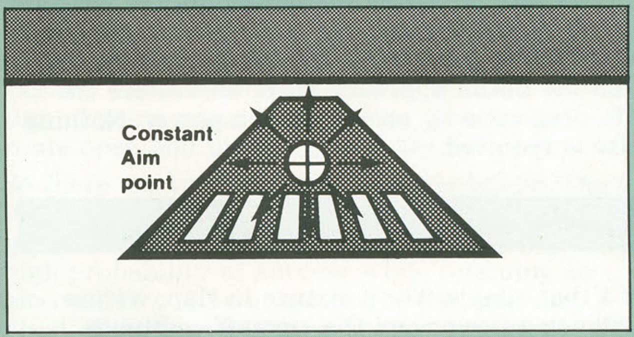
When properly taught, pilots have little difficulty with the concept of selecting and flying an approach to a nominated aim point on the landing surface. With or without glide-slope guidance, pilots can learn to fly a consistent and stable approach angle to the aim point.

Accepting that the glide-path angle may be fixed within reasonable tolerances, it follows that any point located longitudinally on the approach path, short of the aim point, will correspond with a particular vertical height (simple triangulation).



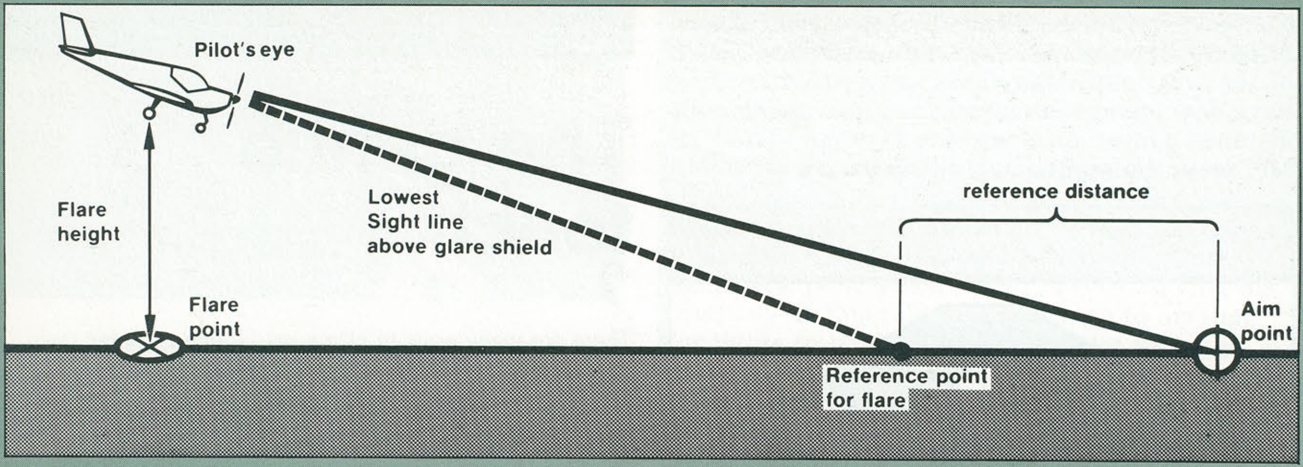
Therefore, a flare-height of greater consistency than is possible using mere perception could be provided by a suitably chosen point along the approach path and overflown by the aircraft.

Much has been written on the subject of the aim point being the centre of expansion of a flow pattern, providing the pilot with a visual illusion as points surrounding the aim point accelerate radially outwards as the aircraft approaches the ground (motion parallax).



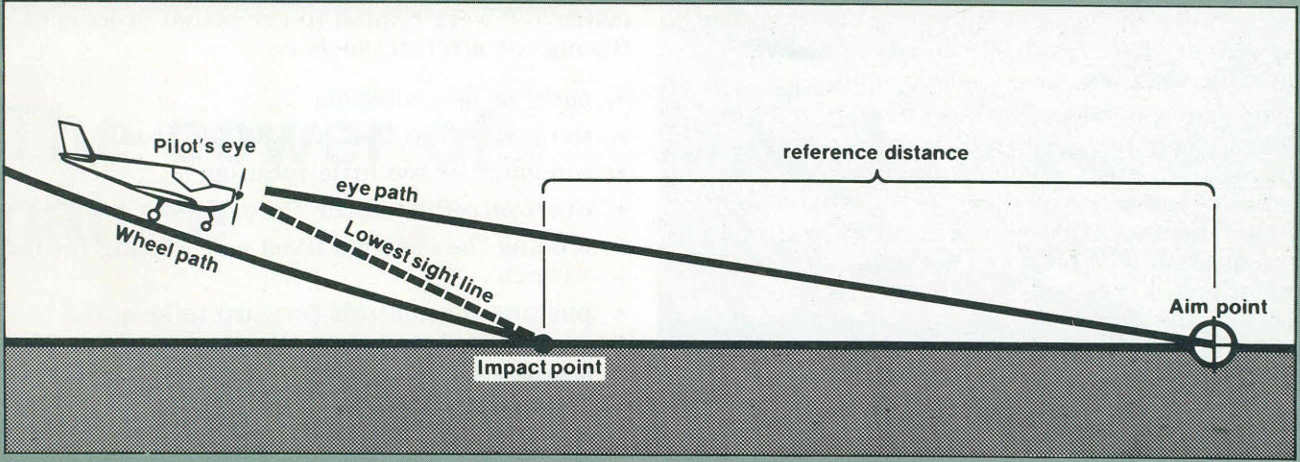
Points beyond the aim point will appear to move upward from the aim point, while points short of the aim point will appear to move downward. It is a point in this 'six o'clock' sector of the pilots' view which has proven useful.

If such a point were selected and could be simply identified, a consistent longitudinal fix for the flare point for a given aircraft could be obtained as the preselected point appeared to move down the windshield (due to increasing depression angle) to the point where it reached the lower vision or cut-off angle (limit depression angle) of the cockpit. This angle is dictated by the geometry of the pilot's seating position in relation to the aircraft structure, where, within limits, some design consistencies exist between aircraft types.



Calculation of this distance from the aim point to the flare cut-off point involves energy/geometry considerations, quickly determined in practice but complicated to derive by analysis. However, a suitable approximation, based on aircraft/approach geometry, and thorough practical testing, has provided a simple and effective alternative technique with near universal application.

For a given aircraft type, the distance between the aim and impact points has provided suitable quantification for the flare-point estimate. This distance accommodates the critical variables of glide angle, eye height above mainwheels and horizontal distance between the mainwheels and the pilot's eye — when the aircraft is on a stable approach in the landing configuration and attitude.



The Jacobson Flare

On final approach, the aircraft occupies space vertically, in practical terms between the pilot's eye and the main wheels. Two parallel paths may be traced down the approach path: the pilot-eye path which intersects the landing surface at the aim point; and assuming, no flare, the lower mainwheel path which would intersect the landing surface at a point called the impact point.

The exact formula for computing the position of the impact point is simplified as follows:

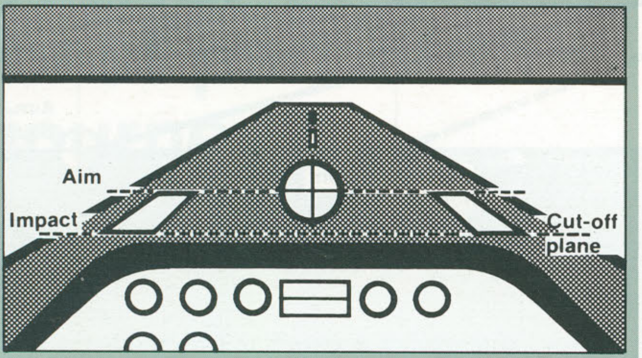
The flare is initiated when, on a stable approach, the pre-determined impact point, appearing to move downward from the aim point, reaches the cockpit cut-off angle and disappears from view under the aircraft. In practice, it is the simplest of tasks to notice the aircraft overtake the impact point while flying an approach using standard techniques. It does not detract from the pilot's attention because the point in question is on the approach centreline in the pilot's *normal* field of view.

$$\text{Distance short of aim point (Reference distance)} = \left(\frac{60}{\text{glide-path angle}} \times \text{vertical height of eyes above mainwheels} \right) + \text{horizontal distance of eyes from mainwheels}$$

For example: a light aircraft with the pilot's eyes 5 feet above the mainwheels and no significant horizontal distance between them -- on a 3^0 glide-path angle;

Reference distance $= \frac{60}{3} \times 5 = 100$ feet (i.e. flare reference point is 100 feet short of the approach aim-point and when that point disappears below the coaming, it is time to start the flare.)

The next important step is to locate the calculated impact point on the landing surface, short of the aim point. Many aviation authorities have developed runway surface markings as distance guides, often at 500, 1000 and 1500 feet from the approach threshold.



Simple interpolation of these markings by the pilot satisfies the practical requirements for a visual fix along the approach axis. Where distance markers do not exist on a landing surface, the pilot can estimate the position of the impact point using variations in surface colour or texture for identification. For night operations from these surfaces, calculations based on the known distance between runway-edge lights provide the pilot with a similar cue.

This flare-point concept is extremely tolerant when compared with traditional perception techniques. For a standard 3° glide path, any error of judgment of flare height will, within limits, be magnified approximately 20 times, longitudinally. In marked contrast, any longitudinal inaccuracy will be reflected as only 5 per cent of the figure, vertically. The expanded scale of the approach axis (approximately 20 times the vertical dimension), together with a visual fix, provides a model that is *visible* and which provides unparalleled consistency of judgment for student and experienced pilot alike.

Non-standard approaches

The impact point calculated for a normal approach also serves for non-standard landing configurations, with their likely variations in aircraft attitude. An aircraft on approach at a higher attitude (body angle) than normal would require a higher flare point to accommodate the reduced mainwheel clearance. The higher attitude self-compensates because the lower cut-off angle is reached further back up the approach path, providing an earlier cue to flare, as would be expected. The converse also applies.

Conclusions

This technique is simple, practical and extremely effective. It was developed and tested over a period of three years in many aircraft types, ranging from single-engine light aircraft to large jet transports, by civil and military pilots of varied ages, abilities and experience — and it works □

The gentle touch

There are many ways to skin a cat — and it seems there are just as many ways to land an aeroplane. Many of us have our pet theories. This is mine.

by David Robson

WE HAVE discussed the control of the aircraft. I have mentioned the constant attitude approach technique that I favour. Warren Wilk's article modifies that technique to include the use of power to offset the drag of the flap — without changing attitude further. Captain David Jacobson has described his novel and successful cue for initiating the flare. Well we are almost on the ground — but not quite.

The major problems that I observed as an instructor were related to the actual process of flaring the aircraft, such as:

- early or late rotation,
- too fast or too slow an attitude change,
- too much or too little rotation,
- overcontrolling in the flare,
- holding the controls fixed and waiting for the 'crunch',
- pushing the controls forward to keep the runway in sight or to get the landing over with.

It was my feeling that the reason for all of these problems was that the pilot didn't have a reference point to aim for. There was a tendency to gaze at the approach aim-point, the far horizon, the expected touchdown point, some other part of the runway or even the nose of the aircraft.

I would now like to introduce a way of controlling the aircraft in the flare that has helped me and my students to land safely and consistently.

The flare is initiated by raising the nose attitude to reduce the rate of descent and to change the flight path. The power is reduced to cause the speed to decay, either ahead of, during or after the attitude change. The timing of this power reduction is largely a matter of whether the threshold speed was slightly high, low or spot-on, whether the descent angle was steep or shallow and what the shear and turbulence is like.

But let's consider the reference point a little further.

We can all fly visually — fly the aircraft so that it will actually hit an aim-point. So why not use the same technique for landing the aircraft?