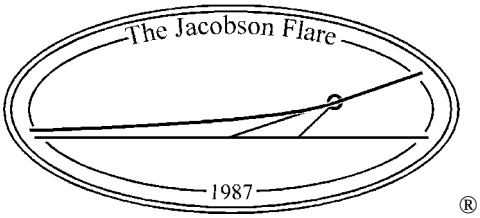
CASA 1997 Flight Safety Seminars
Landing Techniques Presentation



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The Jacobson Flare ®

Accompanying Text 29 April 2008

Please read this first

These notes are the basis of the presentations made by the author in all Australian capital cities and Cairns at the CASA 1997 Flight Safety Seminars. They present, in bullet-point form, the various aspects and arguments raised and emphasised in the accompanying visual PowerPoint and video presentation. See "*The Jacobson Flare CASA 1997 Flight Safety Seminar Series Presentation*".pdf file. It may assist to print these pages first so that they may be available while viewing the above presentation.

While running the video clips, please note the following:

- The video clips contain a couple of built-in freezes of 5 seconds each at key points.

- While the video clips are of a Cessna Conquest and a Cessna 172, the pilot was flying a 1000ft aim point on CBR 35. This means that the flare point for **any** aircraft using this aim point may be displayed by pausing the video action at the appropriate cut-off point, for example, the beginning of the 500ft point for the B737-400, or 500 + /- 20 ft, respectively, for the B737-300 / -800.

- Selecting the enter/return key should pause the action; selecting this key again should play it once again.

- While paused, the right and left cursor keys should advance and rewind, respectively, the action.

This presentation provides a simple introduction to the Jacobson Flare. For specific detail please refer to the other files included on the CD.

Fig 1 *Title*:Landing Techniques The "Jacobson Flare"

INTRODUCTION

We've all had some questions about our landings from time to time. **Let me pose a few that I'm sure we have all wondered about:**

1. Why is the landing **so difficult to learn, and to teach?**
2. Why do **student pilots,** after commencing circuit training, **double their hours before first solo?**
3. Why does our **technique not work** on the **next, bigger aircraft?** Or at **night?**
4. Why is it that **we can land beautifully one time,** and **mess it up on the next?**
5. Why is different with a **different flap setting**?
6. Why can't I land them when they are **light**?
7. Why does a **30 metre** wide runway throw me?
8. What did we **do right that time?...**What did we **do wrong this time?**
9. Are we truly **confident** about our **next landing?**
10. **Why** are there **so many landing accidents?** 55% **is too high.**

Fig 2 *Title*: Existing Techniques

- To begin answering these questions, **let's look at what has usually been taught** all these years.

Fig 3 Airspeed controlled by elevators

- Today **this is called a speed descent.** It **evolved from full glide approaches in the earliest days of aviation** and **is** certainly **applicable when thrust is fixed**, such as when **gliding**.

- However, we normally make **powered approaches, not glide approaches.**

Fig 4 Rate of descent controlled by power

- This is what we are taught, but **it is an over-simplification. Thrust does not control rate of descent**. The application of **additional thrust increases airspeed**; the **pilot pitches up** slightly to hold the required airspeed, the **flight path angle reduces** and the **rate of descent reduces as a consequence of the reduced flight path angle**. It is **a result, not a contributor**. This important point has been **lost in the translation** over many years.

- **Look at the resulting flight path**! After a **roller coaster** ride like that, we try and...

Fig 5 Flare using trial and error

- **Much trial** and **many errors.** The **landing problem** is **common** to **all aeroplanes.** The **size** is **irrelevant** and **so is** the **experience level of the pilot.**

Fig 6 When?, How much?, How fast should we flare?

- Ask yourselves "**how** do I land an aeroplane?" Can **you** answer that one? The **text books** and the **training manuals can't**, not one of them. They only **tell "what", not "how?"** Here is a small selection:

- "Many students have difficulty in mastering the approach and landing. This is a **matter of judgement** and there is **no simple way of teaching judgement** to those to whom it does not come easily. **Proficiency is attained mainly through practice**.... **Errors** are **likely to be** of a **random** nature. **Only by seeing and retaining a mental picture of this exercise can the student learn to land the aeroplane**. The **aim is** to **develop judgement** as rapidly as possible by **repetition.**"

- **"A landing is similar to a power off stall..."** I hope not**.**

- **"If sinking,** apply more back pressure**; if moving away from the ground,** relax the back pressure. **The airspeed will be decreasing to a very low figure, but this is of no concern to you."** I love that one.

Do these explain "how?" No, they do not! **Are landings really so difficult** or **have training techniques been inadequate**? **My long-held view is the latter**:

Part of the problem has been that **for nearly 100 years instructors have attempted to teach judgement, perception and feel.** This is **near impossible.**

- These are **only acquired by repetition - by trial and error,** and **they wear off** when we are **out of practice.** They are **useless when conditions change.**

- If you are **hoping that it gets better with more experience, it doesn't! Even professionals have off days.** We all do!

- **There are many examples** of this **hit and miss** technique **in other fields**. An **experienced carpenter** occasionally bends a nail. **Greg Norman** has been known to miss a sure putt and **Mark Taylor** had some difficulty with a cricket bat, a few years back.

- They are using the **same judgement, perception and feel.**

- **Another real problem is our exaggeration in depicting the glide path angle - more on this later.**

- There has **never been a recognised, quantifiable landing technique**, **nor any recognition of the need for one. (It's as if it's a taboo subject, like politics, religion and sex.)** We've just accepted the **rhetoric** and the **ritual and ("I won't comment on your performance if you don't comment on mine!").**

- **Without a proper model,** instructors and students have had **no hope of any consistency, predictability or portability** between aircraft types**.**

- **There had to be a better way to explain** the landing manoeuvre**, to enhance** the traditional techniques we've been using for nearly 100 years, just as **GPS now enhances DR navigation.** There **had to be a consistent thread** to all landings**.**

- While instructing on **both** light aircraft **and** DC-9's, that **commonality became apparent.** My **original inspiration** came from the **RAF Dambusters of 1943.**

- **Right now I shall introduce a visible model for the landing manoeuvre**. It is **simple to use** and it **can be applied to any circumstances. I regard the landing**

not as an art or a science, but as an exciting skill that can be **taught well** and **learned easily.**

- **You have the required knowledge** already, **such as the primary effects of controls, simple triangulation and the "1:60 rule**." The **only distinction** here is the **application** of this knowledge, and **a willingness to think laterally**.

Fig 7 ***Title*:** **Jacobson Flare**

- **Now let's look at something different**

Fig 8 Approach path controlled by pitch attitude

The **full glide approach requires** a **speed descent** - there is **no alternative.**

A **constant-angle powered approach** is **different.** It **demands a path descent.**

The **primary pitching** effect of elevators provides **direct control** of flight **path angle** for both **visual and instrument** (ILS) **approaches** in conjunction with:

Fig 9 Airspeed controlled by thrust...a variable.

- This proven technique has long been used by the military, and the airlines, but **is not exclusive to large / high performance aircraft.**

- **Ideal for just about any aeroplane** because it is **simple, stable, safe and certain. Compare this** path **with** the **roller coaster** ride from a speed descent**.**

- Some **instructors insist on the speed descent** technique for **visual** approaches, and **then recommend a path descent** technique **to maintain an ILS** glide-slope! No wonder their students are confused!

Fig 10 Commence flare at a pre-determined visual fix

- I shall introduce **two points** on the runway centre-line...the **first an aim point**.

- The **second** is a **pre-determined cut-off point**, ultimately **superimposed** by the aircraft glareshield. This **visually fixes** the **flare point**.

Fig 11 Visual cues utilised through to touchdown

- A "**real-world head-up display**" is available. This is a **fully visual manoeuvre**.

Fig 11A

- **What's he talking about? Let's have a look.**

- **That's the overview**. Now **let's simplify all this into 3 manageable phases.**

Fig 12 ***Title***: 1 Where to aim? 2 When to flare? 3 How to flare?

Fig 13 ***Title***: Where to aim?

- Let's start to answer all these questions!

Fig 14 Selecting an aim point

- **Visualise** the **main-wheel path** as a **constant-angle concrete ramp (or taxyway)** down to the runway. We can **imagine** the **aeroplane rolling** down this slope. Let us now **assume** the ramp to be **wet concrete**. Only by selecting and aiming at a suitable target, can the **main wheels** be **imagined to be tip-toeing down** the soft wet surface, leaving a **continuous tyre tread impression.** We **can** achieve this **constant flight path angle** by:

Fig 15 Adding an eye path to a suitable aim point

- Like a **rifle sight**...We **cannot sight down the wheel path**, just as you **cannot sight down a gun barrel**. This **makes the hypotenuse visible** and the **path stable**.

Fig 16 Introducing ΔX

Why bother? In selecting a suitable aim point we **must provide for**:

- **Threshold clearance of the gear.**
- **Undershoot protection windshear** and other factors**.**
- **This distance varies with** the **main gear geometry** of the aircraft **and** the **glide-path angle**.

Fig 17 Simplifying the formula

- **Discuss X2. X1** is a function of **eye-above-wheel height** and the **glide path angle.**
- **The 1:60 rule:** For **small angles, cot angle ≈ 60/angle.**

Fig 18 Light aircraft example Assuming 4° flight path angle

Locate suitable impact point on runway: **project forward** to **locate aim point.**

- **Paint marks: 18m** runway **centre-line marks / 30m** runway **fixed distance.**
- **gravel / grass:** use **contrasting colours, marks.**
- **runway edge lighting** at **night: instrument rwy: 60m / non-instrument: 100m**

Fig 19 Large aircraft example Assume 3°

Locate impact point on runway, approximately **≈ 400-500' (TCH 25' x 20)**

- **Aim point** 300m/**1000' up to B727 ...**350m/**1150' A300/B767 ...** 450m/**1500' B747**

standard vasis path **one light high two lights high**

Fig 20 Flying a constant angle path <u>Glareshield</u>

- Where the **Black meets** the **Windscreen**...fairly **consistent**...**Not the nose cowl**.
- This is the **lower limit** of pilot vision, and is called the **lower cockpit cut-off angle. It is a design feature for ground segment after an instrument approach.**

Fig 21 Pilot's sight line (Design Eye Point – refer Vol 2)

- Our **rifle sight. We've used this before, horizon** position in **straight and level**.
- **Commonly stated** as being **1/3 up windscreen...**but **misleading.**
- Determined by (adjusted) **seated eye height, body angle (attitude/flap/airspeed).**

Fig 22 The Aim Point

- The **target for your sight line**.
- **Position your sight line** through windshield **over the selected aim point.**

Fig 23 The Aim Point Constant

When attempting to fly a constant-angle eye path to the nominated aim point, several factors cause **overshooting of the aim point before the flare. The main ones are:**

- **Windshear** overshoot **and** undershoot**.**
- **Ground effect affects aircraft variously, especially large aircraft.**
- **Anticipation** when the **seat of the pants starts functioning like a GPWS!**
- **Wind gradient Reducing headwind, increasing groundspeed.**
- May need to **vary pitch attitude** and **thrust** to **maintain correct eye path**

Fig 24 ***Title*****:** **2 When to flare?**

- **This is the big one!**

Fig 25 Vertical perception of flare height: our first small aircraft

Where's that? We have **no idea** at the beginning. We have **no experience, no judgement**. Our flight instructor probably used phrases like these:

- at the "**height of a tree, wind sock, hangar, double-deck bus, Shell service station on the airport boundary.**"
- when the "**green becomes blades of grass** "
- at "**20 feet**", **"at about 50 feet**", **"<u>about here</u>**", "**<u>about now</u>.**"

What about the **variables?**

- **Aircraft** There are **obvious differences in type, weight, flap angle.**
- **Pilot** The **human factors, experience,** etc
- **Environment** **Day/night, weather conditions, air density, airport**, etc**.**

Fig 26 Our second flare height

- **It all starts again!** We rely on the "**Goldilocks**" technique of flaring " **too high, too low**, and finally, hopefully, **just right**!"..."**Don't worry, you'll get the hang of it**!", said our instructor.

We are **out of our comfort zone, and our previous experience isn't much help.**

Fig 27 Our third flare height

- **Here we go again! Even with** some **experience** it **just doesn't get much better.**
- **Where is** the **perception and judgement when we need them most?**
- **Wait**. Have you **noticed something**?**...**We've **only used two sides** of the triangle...

Fig 28 Aim point remains stationary

- This is the **familiar, visual picture** we have all been using, one way or another.

- **Fig 29** Points on runway **beyond aim point appear to expand upwards**.
- Points on **runway short of aim point appear to expand downwards**.

Instructors have used it in various ways to teach recognition of the flare point:

- when "**your feet reach the runway**"...not as silly as it sounds.
- when the "**ground rush**", "**looming effect**", "**explosive effect**" occurs
- when the "**corners of the runway threshold come up around your ears**"

This effect is **invaluable**. **We have all used it for years.** I have used this effect to finally **quantify the flare point**. It **contains** a **fantastic visual fix**.

Fig 30 Cut-off angle as a fix 1

Let's explore this expansion effect.

- Pilot eye on stable **YELLOW** path to aim point.
- **1st of 3 looks at any chosen point short** of the aim point, the **RED** one.
- **Lower cut-off angle constant, overtakes all points** shown in **BLUE** area**.**

Fig 31 Cut-off angle as a fix 2

- **2nd look: Angle of depression increases**, causing **apparent** downward **movement**
- **Cut-off angle advances. At this height, glareshield superimposes this point.**

Fig 32 Cut-off angle as a fix 3

3rd look: Angle of depression increases and now equals lower cut-off angle.

- This is a **visual fix**. It **provides visible confirmation** of **flare position.**

Fig 33 Where flare height Ye <u>is</u> known

For **every flare eye height**, there is a **corresponding cut-off point** on ground.

- **The accurate calculation Two triangles sharing a common opposite side**
- **Calculate the base length of each: Y - R = B Use formula** to **apply to next a/c.**

Fig 34 Where flare height <u>is not</u> known

- Problem **applicable to all: light aircraft** up to **B737/727/707/DC-8, etc.**

- **Need a substitute for Δf without knowing Ye.**

- When flaring we **accommodate the main-wheel geometry** of the aircraft**. Use Δx, as calculated earlier**. Use **formula to apply to next a/c**. This **provides a ball-park figure** to start with. You **may have to modify** in certain cases.

Fig 35 Aim at the aim point

- Set aircraft up in **landing configuration**.

- **<u>Work cycle</u>:**

- **Centre-line** Check both runway ends, track main gear down centre-line.

- **Aim point** Hold in **constant relationship*** with glareshield.

- **Aspect** Learn to **recognise correct picture**. **Relate to IAS and thrust**.

- **Airspeed** Maintain **correct approach speed* @ approx 1500-1800*rpm**

*** <u>POWER + ATTITUDE + PERFORMANCE = PATH</u>**

Fig 36 On short final

- **Locate flare cut-off point on runway.**

- **Landing check-PUF Landing clearance.**

- <u>The **wide-angle lens**</u>**...Look at** the **big picture. Don't zoom in.**

- **Glareshield approaching runway threshold**

- An **"Amber light"** We're **approaching** the **flare** point.

Fig 37 Anticipate the flare point, but maintain the eye path.

- It's **important not to watch it pass under the nose** the effect is **like watching a stick drifting downstream, under a bridge**. By the time you look up, it is all over!

- **Commence flare when glareshield passes cut-off point.**

- Just **observe in lower peripheral field**. This has **been happening for years** while **we were playing "Goldilocks"**. This **visual** cue **self-corrects for most of the variables,** including **flap setting, flight path angle and runway slope**.

- **Do you you recall my mentioning the way we have always exaggerated our depiction of the glide path angle? We should have realised that in using the opposite side of the triangle, all flare height errors** are **compounded by 15 or 20 times, longitudinally,** for **4° ... 1:15** and for **3° ... 1:20** relationship

- **BUT: In using the adjacent side a**ny **longitudinal error is reduced to 1/15 or 1/20** of that error, in vertical terms. So **best of all... this technique is so tolerant of error**....

Fig 38 *Title*:3 How to flare? The Robson "Gentle Touch"

- Many remember **David Robson's "Gentle Touch**" video?

Fig 39 Start lifting the aim point

- **Towards** the **far end of** the **runway over 3-4 seconds**. This is **Aim Point 2**

- **Start thrust reduction** just **after flare commenced** as always**, or vary** if required.

Fig 40 Keep lifting aim point, reducing thrust, (gradually)

- The **eye/glareshield** relationship is not useful now, because the attitude is changing.

Don't worry about how much, or how fast? The **inputs will suggest themselves**.

Fig 41 Find runway end Select as Aim point 2

- **Ideal** point **for: pitch, roll, heading, drift, distance to run.**

- **Provides** an **adjustable optimum** flight path **angle** for gentle touchdown.
- **Reduces** silly **short-term pitch inputs with their resulting excursions, just as looking well ahead reduces the fish-tailing effect when learning to taxy.**

- Check that **thrust is now at idle.**

Continue to fly eyes towards runway end until touchdown

- **When aim point 2** is **moving neither up nor down** in visual field, **hold inputs until touchdown** occurs, **very close to original aim point 1**. QED.

- "**Top Gun**" Analogy: **Visualise 'sight'**. Aim point 2 "**locks on**"...changes to red.

- **Don't prolong the flare unless** for a **three point landing** in a **tail-dragger**.

Fig 42 Finally, a flare for landing

- **How to land** any aeroplane.

- Hold an accurate eye path, **pitching for path,** controlling **airspeed with thrust.**

Fig 43 Commence flare at cut-off point

- Remember, **do not try to watch it pass under the nose**

Fig 44 **Reduce thrust, fly the eyes** progressively **towards runway end** until touchdown.

- Use the controls to **take your eyes where you want them to go. A/c will follow.**

Fig 45 *Title*: Pilot's eye view

Fig 46 / 47 **Video**

- **Cessna Conquest) CBR 35 with T-Vasis 1000'** aim point
- **Cessna 172) CBR 35 without T-Vasis 1000'** aim point

Fig 48 ***Title*****:** **Summary**

Fig 49 The traditional art of landing

- Does not explain how to land.
- Costs time, money and stress.
- Relies on experience and judgement.
- Subject to too many intangibles. **The goal posts keep moving!**
- Remains unpredictable.

Fig 50 The Jacobson Flare

- Explains how to land.
- Faster to learn, **less cost**. The **flare point is consistent and self-compensating.**
- Completely visible. **The goal posts still move but now we can see them!**
- Transferable to any aircraft. **Pilot portable.**
- Extremely tolerant of variables. - **Due to 1:15, 1:20...relationship.**
- Predictable, therefore much safer.

There was, after all**, a consistent thread to all of our landings.** Perhaps we have **all** been doing, **sub-consciously**, for all these years.
