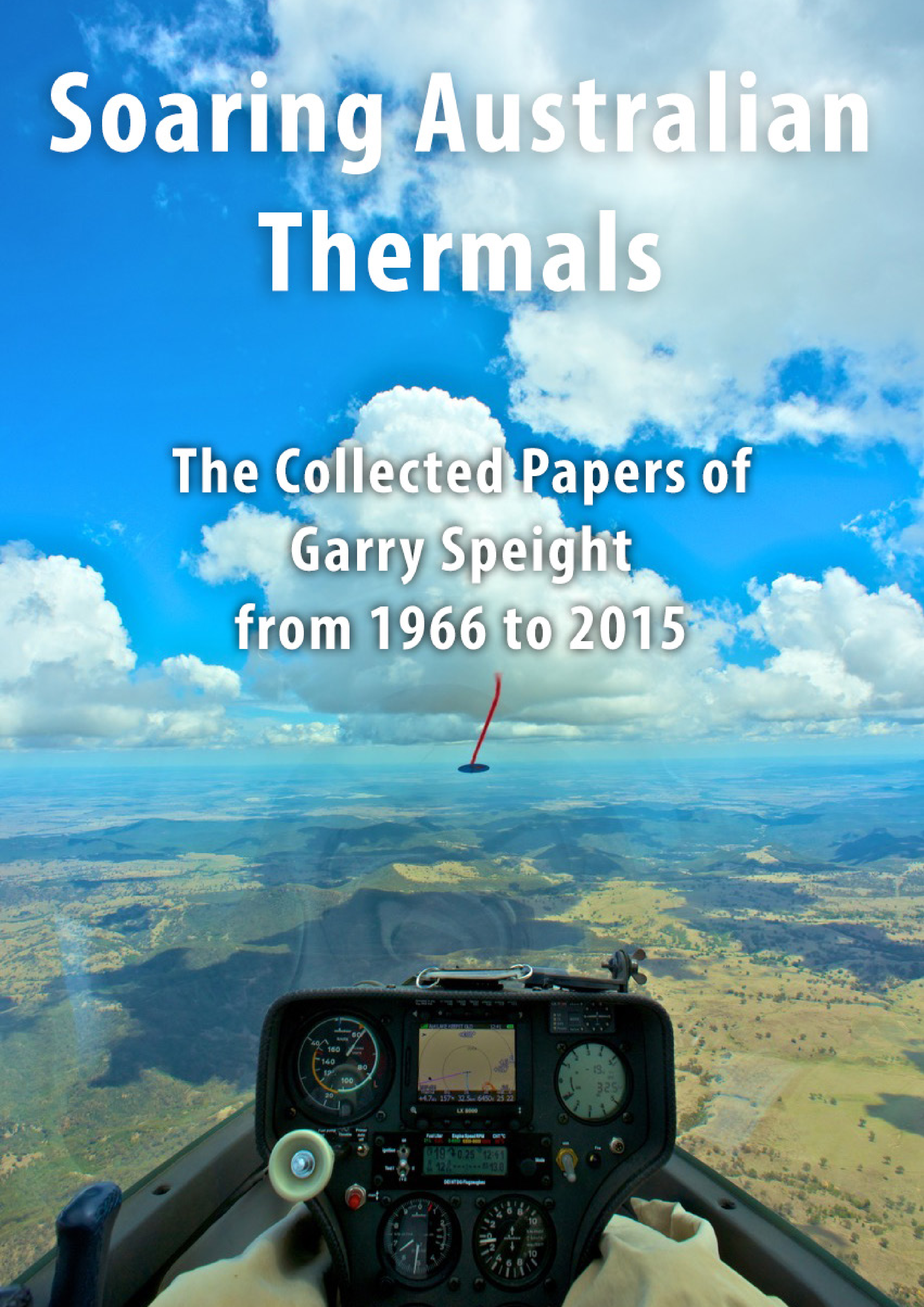
Soaring Australian Thermals

The Collected Papers of Garry Speight from 1966 to 2015



Canopy Marks for Attitude Control

By Garry Speight

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In a turn, the airspeed and the rate of turn have to be kept steady. At the same time, the yaw has to be matched to the bank to avoid slipping or skidding.

Nearly all glider pilots learn how vital these things are in their first hour in the air. Then they spend the next thousand hours or more trying to get them right!

A glider pilot must be much more aware of flying errors in turns than the pilot of a light aeroplane. Once the glider pilot allows the aircraft to stray from its proper attitude, a stall or spin may be only seconds away.

Most turns in gliders are thermalling turns. They are made at airspeeds slow enough for gusts to have a big effect. The margin above the stall is only 5 or 10 knots. This compares with a margin of 30 to 60 knots for typical turns in a light aeroplane.

This problem is not likely to go away. Thermals are not big enough for high-speed circling, and the stalling speed of gliders is not going to get less while glider pilots want to go further and faster.

Even turns in the circuit are made within 20 knots of stalling speed. Higher circuit speeds would reduce the time available for looking, thinking, and correcting, and could mean arriving at ground level with too much energy to get rid of within the length of the field.

Speed control at low speeds is not easy. Thermalling turns are made at speeds below the speed for best glide angle. This is the speed for minimum drag.

Pitch correct for 50 knots, roll correct (45˚), yaw wrong (slipping)

Canopy Marks for Attitude Control

Pitch wrong (nose too high) , roll correct (45˚), yaw wrong (slipping)

Pitch correct, roll wrong (only 40˚), yaw correct

Canopy Marks for Attitude Control

At thermalling speeds, any momentary decrease in speed due to turbulence or clumsiness increases the drag, which lowers the speed even more.

Conversely, increasing the speed decreases the drag, causing the speed to increase further. That is to say, the glider's speed is unstable.

At speeds above the best glide speed the glider speed is stable, because more speed brings more drag and less speed brings less drag.

At such high speeds there is no problem with speed control. The glider will "fly itself". This is just as well, for it takes a much smaller change in pitch angle to go from 90 kt to 95 kt than it does to go from 40 kt to 45 kt.

At slow speeds, gliders may be unstable not only in airspeed but also in roll and in yaw. Furthermore, the control surfaces all have less effect than they do at higher speeds. It is no wonder that skilful turning comes only with hours of practice.

When the glider stalls or spins, the pilot is likely to realise that there has been some error. Short of such alarming events, if the glider is not under proper control, climbing is largely a matter of luck.

The pilot can hardly learn much about thermals. A clear picture of the pattern of lift emerges only when the glider is doing almost-perfect circles at a steady speed.

The key to controlling a glider is **perception**, being able to notice the glider's attitude in the sky.

The aim of holding a steady speed and a steady rate of turn is achieved only by checking errors in the attitude of the glider: the height of the nose, the angle of bank and the presence of slip or skid, in other words, one checks the **pitch**, the **roll**, and the **yaw**.

Control in pitch

It is very difficult to control the speed by using the airspeed indicator (ASI) alone. The airspeed jumps about so wildly in thermal gusts that there is no point in trying to correct for them.

More important, the airspeed is slow to respond to errors in pitch attitude. If the nose is too high the speed will only slowly fall off.

When the airspeed error is noticed, the stick can be held forward until the airspeed returns to normal, but by that time the nose will be very low and the speed will continue to increase, becoming far too high. Then the stick will have to be pulled back, and so on.

If one has to fly in cloud on "limited panel" (i.e. with no Artificial Horizon), pitch attitude must be controlled using the ASI alone.

Then one must learn through long practice how to avoid these "pilot induced oscillations". For visual flight it is far better to look out at the horizon, glancing at the ASI only now and then to confirm that you have the airspeed value that you want.

In any case, having one's eyes glued to the ASI, or any other instrument, is bad. There may be other aircraft nearby, or the airfield may be passing out of range.

To control the airspeed, first control the pitch angle. Control of pitch is best achieved by relating the height of the nose of the glider to the horizon.

Control in roll

The banking or rolling of the glider is also most easily controlled while looking at the horizon in front of the nose. One learns to notice how much the horizon is tilted compared to parts of the glider.

Looking sideways along the wing is little use. One knows that the angle between the wing and the horizon is the angle of bank, but the wing and the horizon cannot both be seen at a glance, being some 30° apart.

Control in yaw

When the glider flies sideways we call it **slip** or **skid**. Slipping is sliding sideways towards the lower wing and skidding is towards the higher wing.

To detect slip and skid, some genius invented the yaw string. This is sensitive and accurate, and can be placed just where the pilot should he looking: in line with the horizon ahead.

A slip ball, as used in aeroplanes, is less sensitive, and is kept down in the "office" with the ASI. The only problem with the yaw string is that it can go soggy and lifeless when above cloudbase or in rain.

The yaw string shows **errors** in yaw, rather than yaw itself. Every turn should have the right amount of yaw. Yaw can be perceived directly as the sideways movement of the nose against the horizon.

When thermalling one learns to correct for sideways gusts by using the rudder to keep the nose moving around the horizon at a steady rate. In a spin the very fast sideways movement of the nose can be perceived so strongly as to produce vertigo.

Canopy marks

If attitude control is best achieved by relating the glider to the horizon ahead , how can we tell just where the glider is pointing? The horizon is easy to see, but the glider is not, because we are inside it.

While we have a rough idea of the sense of "straight ahead", it helps to have something to take aim with — something well out in the nose of the aircraft, such as the front of the canopy frame, the compass, or the instrument panel cover.

An aiming mark should be far enough from the pilot's head so that the eyes don't need to be re-focussed, and so that movements of the head don't have much effect. The farther away it is, the better the aim can be.

Instructors in back seats have always had more distant objects to use as aiming marks than their unfortunate pupils in the front.

Naturally enough, the canopy area through which one looks at the horizon ahead is usually kept clear of any features within the glider, to allow the pilot an unobstructed view! Yet that part of the canopy is clearly the place where aiming marks should be put. In modern gliders with fully-faired canopies this surface is far enough away from the pilot's eyes.

Because I felt I needed an accurate reference for attitude in a turn, I tried putting various marks on the inner surface of the canopy to line up with the horizon ahead in a thermalling turn. The marks showed my attitude control to be very poor indeed. I was letting the angle of bank change by 10° from moment to moment, and I was failing to notice the difference between 30° and 40° angles of bank. By using the marks I have managed to improve.

In the course of trials on my Astir CS I managed to place the mounting point of the yaw string just on the horizon for thermal turns.

On the inside of the canopy I then stuck small pieces of coloured sticky paper in two lines at 45° to the plane of the wings.

These lines mark the correct position of the horizon in a turn at 50 knots with 45° of bank. The photos show the pilot's view of the marks in relation to the horizon.

One can clearly see small errors in pitch, roll and yaw, and correct them before they get any worse.

Pitch error is shown by the line of marks being above or below the horizon. Roll error shows as an angle between the horizon and the line of marks. Yaw error is made very clear by the way the yaw-string is not pointing at the zero mark on the centre-line of the canopy.

Canopy Marks for Attitude Control

I have since replaced the paper marks with slivers of red plastic insulating tape, and I have changed the angle of bank shown by the marks to 40°. I find that 40° suits most thermals, flown with or without ballast.

I very seldom see Standard Class pilots banking more steeply than that, although some open class pilots thermal at 50° — a great sight to see!

If I want to, I can keep the bank steady at 5° steeper or shallower than the line of canopy marks. For different speeds I can keep the marks just above or below the horizon.

I feel that more than one line of marks would not be useful enough to justify the extra clutter.

To know where to put the marks, one should find where the horizon cuts the centre-line of the canopy at normal gliding speed, say best glide speed.

Usually there is a yaw string already fitted, and one can note where it sits in relation to the horizon.

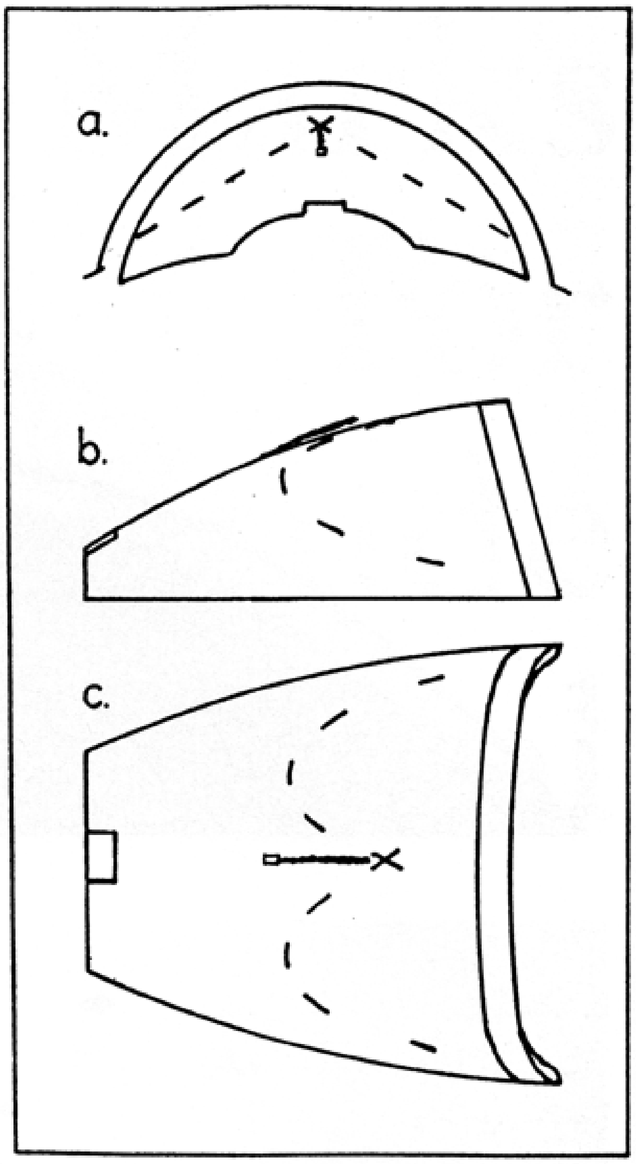
Then one end of the yaw string, the front end for choice, is shifted to the point where it will sit on the horizon. Then one must construct two sloping lines passing through this point.

A Douglas protractor can be set up on top of the instrument panel, with a ruler placed against it to give a line at the correct angle. If the panel is curved, some other way must be found to get a base-line that is in the plane of the wings.

A person sitting in the cockpit can direct a helper to draw the lines with a grease pencil on the outside of the canopy. Then, little rectangles of insulating tape (about 20 mm x 7 mm) are stuck at intervals along the lines on the inside, and the grease pencil marks are wiped off.

I use the canopy marks myself to improve and maintain my level of flying skill. I believe that they may also have a role in basic training.

If a pupil has a clear and certain "foresight" to line up with the horizon, he may not have to put up with so much nagging from the back seat: "You've let it bank too much! Now the nose is too low! We're skidding! Don't let it stall!" etc. etc.



Canopy marks for a Blanik for 30° banked turns; (a) seen from the pilots seat, (b) side view, (c) plan view

I have sketched the layout for canopy marks in a Blanik in the drawing. Clearly, the canopy bow badly obstructs the forward view of the front seat pilot. There is no room for the yaw-string above the horizon.

These marks are arranged to show a 30° bank angle. This angle is steep enough for thermalling, because the Blanik has a lower stalling speed than a Standard Class glider.

Canopy Marks for Attitude Control

It is also a useful bank angle for turns in the circuit area, although some pupils don't like to bank so steeply as 30°!

Depending on the speed, the marks may appear above or below the horizon, but they are close enough to the horizon to relate to it.

The idea is to keep them parallel to the horizon and a constant distance above or below it for the duration of the turn.

The height of the pilot's head in the cockpit has two effects. First, the marks may appear higher or lower for the same aircraft attitude. Second, due to the curve of the canopy, the marks will not form a straight line unless the pilot's head is in the right position.

This should not be a problem because all pilots heads should be at the same height! Pilots should sit as high as they can, so as to get the best view out of the glider.

I have found that pupils having trouble with landings are often seated too low. They improve dramatically when raised up on higher cushions.

A limit is set by the canopy over the pilot's head. Too close is dangerous and causes costly repairs. About two fingers (40mm) gap between the scalp and the canopy is best, so long as the harness is properly tight.

I have been concerned that people might find the canopy marks distracting but this does not seem to happen. On the contrary, when they are installed some pilots don't even see them for several flights!

I cannot say for sure that anyone has learnt more quickly or flies more accurately as a result of having canopy marks in our club Blanik. All the same, I think they must help towards better and safer flying.