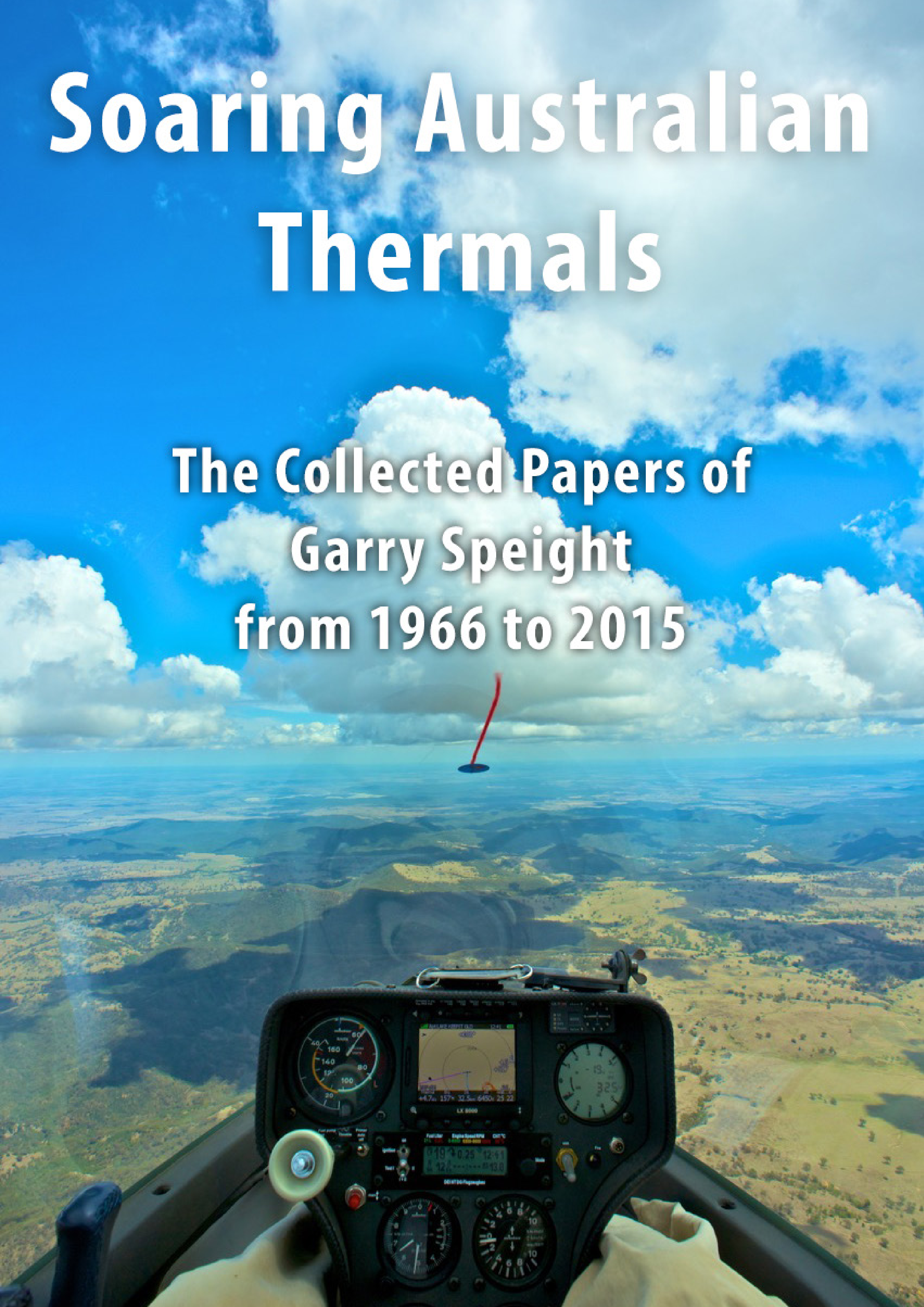
Soaring Australian Thermals

The Collected Papers of Garry Speight from 1966 to 2015



Best Use of Thermals

By Garry Speight

This is a new article. It gathers together lecture material published in the on-line newsletter "Keep Soaring": "Finding and centring strong lift" (April 2010), "Accepting and rejecting lift" (July 2010), and "Fly fast and stay high with the threshold theorem" (March 2014)

Most cross-country soaring in Australia is done by gliding along tracks that are almost straight, and pausing to gain height by circling in thermals. The speed over the course depends mainly on the rate of climb in the thermals. Flying through lift or reduced sink while on track adds to the speed. However, it is rare to complete a course without stopping to circle. Even that case shows that the pilot has judged that there were no thermals strong enough to repay the time to be spent in circling. Deciding when to stop and circle, and when to move on, are key actions in high speed soaring. Some top pilots rely on intuition: the rest of us can do better by using what is known about these decisions.

In The Beginning: "MacCready Theory"

Following Paul MacCready's World Championship win in 1956, pilots who fitted MacCready Rings to the circular dials of their mechanical variometers also won championships. The MacCready Ring advises the best speed to fly to maximise the cross-country speed. It uses performance data, the rate of climb in thermals, the current airspeed, and the current sink-rate. Most people assumed (and still do) that pilots using the Ring did better because their glide speeds were better chosen. This is unlikely: the glide speed has little effect on the cross-country speed. That is shown by a graph in Anthony Edwards' (1963) paper "A stochastic cross-country..." (re-published here in the article "Probability in Cross-country Flying"). The key to their success is not the airspeed values on the Ring, but the arrow that points to the thermal rate of climb. Once the arrow has been set against a number, the pilot's strategy is: "I will circle only if I find lift stronger than the number I have set." Unlike others, a pilot using a MacCready Ring never wastes time circling in weak lift, unless really low.

Critical Rate of Climb (CROC)

The pilot must judge what rate of climb should be set on the MacCready Ring. To set the Ring near the average rate of climb for the day invites an outlanding. There are two reasons for this:

(1.) These stronger thermals may be too far apart;
(2.) The high speeds advised by the ring give a steep glide angle that makes the glide range shorter.

Anthony Edwards' (1963) "Stochastic" graph shows how risky gliding at high speed can be.

It is prudent to set the MacCready Ring rather low. Again, Anthony Edwards (1964) has good advice, which he calls "The Threshold Theorem":

"(In MacCready theory) the "average rate of climb" is to be replaced by the chosen "critical rate of climb"'. The critical rate of climb (CROC) is simply the threshold rate at which the pilot decides to circle in a thermal."

Here Anthony is making it clear that the MacCready Ring should be set in a way that takes account of altitude and thermal spacing as well as thermal strength. Later (Edwards, 1983), Anthony showed that once a MacCready setting has been chosen (for whatever reason) the pilot should not circle in a thermal weaker than the ring setting, and should not fail to circle in a thermal stronger than the ring setting. He proved that either action makes the cross-country speed slower.

When To Leave A Thermal

I devised a rule for when to leave a thermal (Speight, 1984). It is just like the Final Glide rule, so the two can be expressed together:

When thermalling, as soon as it becomes almost certain that one can reach either a stronger thermal or the finish line by cruising towards it with a ring setting equal to the present rate of climb, leave the thermal and fly to that ring setting.

What is new here is the phrase "almost certain". I am insisting that the pilot should think about the odds of success.

Know What Lift You Will Accept!

It is not sensible to have a rule to use only at the moment when one is deciding to leave a thermal. The reasoning that applies to that moment applies to every moment in the flight. The humorist of "Sailplane and Gliding" Mike Bird ("Platypus") showed what should be done: "Always set your speed-to-fly ring to the rate of climb that you would be happy to accept RIGHT NOW." He called this the Minimum Acceptable Instantaneous Rate Of Climb (MAIROC). The MacCready Ring should be re-set at leisure, as circumstances change. It should not be re-set at moments of urgent action.

I express Platypus's idea this way:

At all times you must know what lift is the weakest that you will accept.

(The weakest lift you will accept is Edwards' Critical Rate of Climb (CROC).)

When you know your CROC, set it on the MacCready ring or speed-to-fly instrument.

With CROC set on the MacCready Ring or speed-to-fly instrument, decisions become automatic. The time to leave a thermal is simply the moment when the average rate of climb falls below the CROC and the time to accept a thermal is the moment when the rate of climb rises above the CROC. Your task is to adjust the CROC so that you can be almost certain of finding a thermal as strong as your chosen CROC at all times.

Sensible Odds

One must fly in such a way that there is not much risk of outlanding. In any case one should avoid getting low because it is hard to fly fast when you are low. I suggested in "Rules for Leaving Thermals" that one should think of "almost certain" as being around odds 200 to 1 on, that is, only 0.5% chance of outlanding. If each glide between thermals is flown with 0.5% chance of outlanding, a task using 20 thermals has roughly 10% chance of ending in an outlanding.

To calculate the MacCready setting that will keep the odds of outlanding down to 0.5% calls for a model of how thermals of different strengths are spread around the sky. I did some crude modelling of this sort that resulted in curves relating CROC to height above landing fields. I did not suggest that the strength of any one thermal changed with height, but simply that the chance of finding a strong one was better at a greater height. Models for soaring days with different heights of convection had curves that did not differ much, and I could not find factors other than height that had much effect. Finally, I settled on a very simple formula.

A Simple Formula For CROC

The formula that I use to set the Critical Rate of Climb on a MacCready Ring or a speed-to-fly instrument is:

CROC in knots is height in thousands of feet minus two.

Late in the day, when thermals are more widely spaced, I use "minus three", not "minus two". This formula suits a Twin Astir or a Hornet, and a pilot at State Championship level. It implies that all soaring days are the same for the purpose of CROC. If convection goes only to 4000 feet, one would not expect many thermals stronger than 2 knots. If convection goes to 10,000 feet, but one is flying at 4000 feet, one should accept 2 knots to avoid getting lower. In fact, at a given height, one should be more cautious on high days than on low days.

Automatic Adjustment Of CROC

With the advent of cheap Pocket Personal Computers, a pilot may have the Critical Rate Of Climb adjusted automatically by a computer during flight. The "glide computer" program "XCSoar" has a routine that does that, using theory developed by John Cochrane (1999).

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The use of this routine is described in the XCsoar Manual, Section 6.7 "Speed to fly with risk" (NOT Section 6.13 "Auto MacCready")

The XCSoar "Speed to fly with risk" uses a MacCready value chosen by the pilot for a height near the top of convection. It automatically reduces the MacCready value as height is lost, down to zero at zero height. The pilot also chooses a "speed-to-fly risk factor". Only the highest risk factor, 1.0, gives a linear reduction with height. (My thousands-minus-two rule is linear, but has a 2000 foot zero-MacCready buffer.) In XCSoar, a risk factor of 0.1 reduces the MacCready value very little until down to 2% of the height of convection (less than circuit height).

Practical Use Of CROC

Many audio speed-to-fly instruments, when in cruise mode, will signal "fly faster" and "fly slower", and will also signal (by "beep") lift that is above the MacCready value.

It is common sense to use these audio signals to make cross-country soaring as efficient as it can be. I do not agree with pilots who simply fly a constant speed between thermals. Nor do I agree with those who use the MacCready setting in ways that conflict with well established theory, or fail to set up their instruments to read as they should. The following practical advice assumes that the pilot is making proper use of well set up instruments.

A cross country flight using thermals should have three distinct phases, repeated many times:

(1.) Glide towards a goal;
(2.) Search for useful lift;
(3.) Circle in useful lift.

Phases (1.) and (2.) may merge into each other. Phases (2.) and (3.) must be distinct, and your decision to circle in the lift must be quite positive. The angle of bank when circling in lift in Phase (3.) is more than three times steeper than it is when searching for lift in Phase (2).

Phase (1.) It pays to fly more-or-less directly towards your next navigation point when you have left a thermal. This stops you from messing about. Having decided on the weakest lift that you will accept (CROC), set that number as the MacCready value in your variometer. Remember to reduce the value of the CROC as you get lower.

Fly a speed that will keep the speed-to-fly audio signal quiet, between the signals for "fly faster" and "fly slower". Always respond promptly to the audio, but never raise or lower the nose more than a slight amount. Deviate somewhat to where there is a better chance of lift.

Phase (2.) Begin an active search for lift when it seems like a good idea.

Search as you get close to a cumulus, and whenever you feel a burble of turbulence, or get persistent audio advice to "fly slower". Weave from side to side at only five degrees of bank. Plan to explore the likely lift area thoroughly so that, if you find nothing, you can be sure there was nothing to be found. When sink increases, bank the other way. When lift increases, steepen up and be ready to circle. Never fly straight in lift: like a tennis player, don't be caught "flat-footed".

I advise keeping the instrument in cruise mode while searching. Do not deviate much from your track, only deviating fifty or sixty degrees when the lift seems the most promising.

Also search for lift when you have planned a circuit for outlanding. In that case, search on every side of the field until you have to commit to a downwind leg. Then complete the FUST check and *stop searching*.

Phase (3.) Commit positively to a tight thermalling circle when the lift is strong enough. That is, when the instrument signals steadily that the lift is above the CROC. Increase the bank to more than forty degrees, and switch the instrument to climb mode. Have a bet with yourself: "I bet I can beat CROC for the whole of this circle!" If you lose that bet, it is likely that a more cautious pilot will catch you up. You need more practice!

Best Use of Thermals

In nearly every thermalling circle there will be a point of weakest lift (or strongest sink). Move away from it! Every time! When learning this, there is a trick taught by Bill Dinsmore of Camden. He said "When the sink is worst, look out to the horizon over the wing that is down. Note some landmark there, and decide to fly towards it." To move the circle does not require flying straight: just smoothly reduce the bank ("Open out!") and increase it again ("Close in!"). Even in a crowded thermal, doing this carefully need not cause conflict. Most pilots want to re-centre in the same direction. Keep a mental record of the direction that you are moving, so you can recognise a shear.

Remember to raise the value of the CROC with every thousand feet. A five-knot thermal that was very welcome when met at 5000 feet becomes barely acceptable at 7000 feet.

If the average lift falls off to a level near the CROC value, do your best to find a stronger core. Leave the thermal the moment the average lift is below the CROC. Then switch the instrument to cruise mode, and track in the direction you have already decided upon, flying at the best speed.

References

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"Keepit traffic, Golf Foxtrot Papa, on final, 14, Keepit traffic"