MODULE SIX

STRATEGY FOR SOARING

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JUST A LITTLE FASTER, PLEASE

There comes a time that you want to fly just a little bit faster. Maybe you've been to a contest or two and you've seen what amazing speeds the top pilots achieve – and often in surprisingly bad conditions. Maybe you want to go for a badge, or just cover a little more territory in your fun cross-country flying. We are glued to this sport by obsessive self-improvement, and a little more speed soon becomes the focus of that obsession.

Many pilots think that the key to going faster is spending a lot of money on new gliders. They don't go to contests because "I won't be competitive in this old thing." In fact, small differences in pilot technique outweigh huge differences in expensive fiberglass. You see new gliders at the top of the scoresheet only because great pilots tend to put the money and effort into flying the latest gliders. Make no mistake, the top pilots would still dominate if they had to fly 20 year old gliders.

To see what a little thinking and practicing can do, let's set a goal of cutting down 3 circles per hour. This doesn't seem like much, maybe one circle every other thermal. How many of us do not, three times per hour, take a circle that gains nothing; maybe searching for a thermal that isn't there, indecisive about leaving, or centering poorly? That seems like an achievable goal for a season's practice.

Each circle takes about 25 seconds; 3 times 25 seconds divided by an hour is 2 percent or 20 contest points. In Figure 1, I used the current SSA handicaps to plot performance against cost. The graph shows you that *cutting 3 circles per hour is worth about $20,000!* It is like moving up one generation in gliders, for free. And given the choice, wouldn't it be a lot more fun to be a better pilot in a worse glider than to be a poor pilot in an expensive glider?

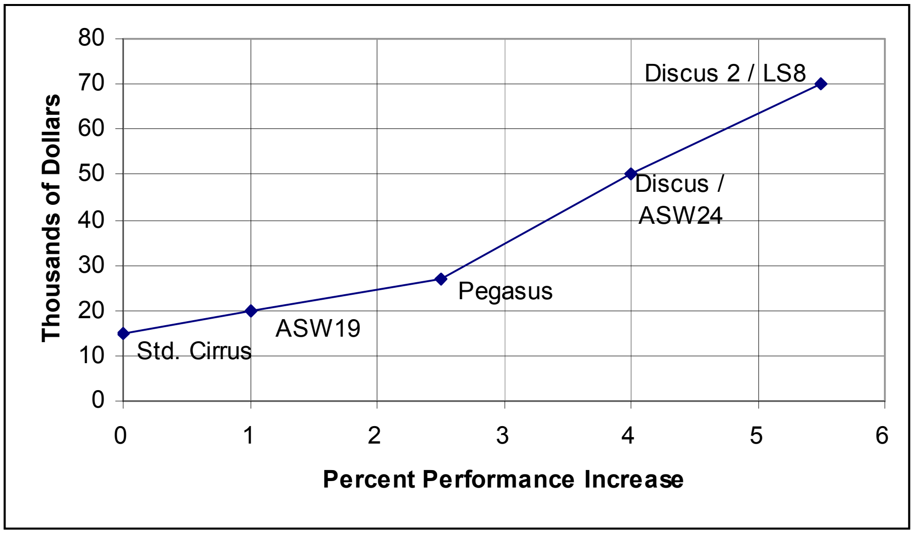

Figure 1. The cost of performance

Now, how to go faster? I am not a fast pilot, but I know some. I have spent a lot of time watching fast pilots, listening to them, reading articles by and about them, and trying to understand what they do and what they say, which are not always the same thing. I have been able to update the classic MacCready theory to take account of the fact that thermals are random and height is limited[1]. This mathematical theory seems to accord well with what fast pilots do. Techniques have changed since the classic writing by Moffat, Reichmann, and the Byars and Holbrook symposia, and I'll point out some of the innovations.

At any point in the flight, you should decide on a general level of confidence or aggressiveness. The quantitative measure of confidence answers the question "how much higher would I have to be in order to finish one minute sooner?" I call the answer to this question the *MacCready value*. A MacCready value of 4 means that you could finish one minute sooner if you were 400 feet higher. Our game is trading altitude for time. The MacCready value is the price of time in terms of altitude.

The MacCready value is the key to all speed-related in-flight decisions. Most easily, if the MacCready value is 4, you should take any thermal greater than 4 kts, and you should refuse or leave any thermal less than 4 kts. If it takes 400 feet to finish one minute sooner, trading one minute for 500 feet is obviously a good deal, and trading one minute for 300 feet is a bad deal. Conversely, I find this rule very helpful for deciding on a MacCready value. What is the minimum thermal I would stop for right now? The answer to that question is the MacCready value.

The MacCready value also determines the right cruising speed – it is the speed ring setting. If you *buy* altitude at 400 feet per minute, then you should *spend* altitude at 400 feet per minute as well. That doesn't mean to fly at the speed that generates a 400 feet per minute sink rate. That means that you should fly at the speed where gaining an *extra* minute of time would cost you an *extra* 400 feet. Almost 50 years ago, Paul MacCready figured out how to compute this speed, and the answer is programmed in to every flight computer and presented in every book on soaring. As you increase speed from 70 kts to 71 kts in a typical glider, each minute that you arrive sooner costs you about 200 extra feet. Thus, if you have decided that you should trade altitude for speed at 200 feet per minute, this decision tells you to cruise at 70 kts in still air.

That's all fine, *given* the MacCready value, but what is the right MacCready value? What *is* the relative price of altitude and time? How aggressive should you be? Now we leave the land of mathematical certainty. This is what that long experience in watching weather and learning what thermals lie ahead tells the experts. But we can work out the answers in some simple and stylized situations, and these parables are useful ways to organize our thinking about the right MacCready value for a real flight.

MacCready.

If you know the strength of the next thermal, and that you can get to it, then this is the MacCready value for the glide to that thermal. If you know that the next thermal will be 4 knots, then you set the speed ring for 4, and fly the appropriate speed to fly. If you should happen on a 6 knot thermal, you should take it, and you obviously should not stop for anything less than four knots. Reichmann.

Reichmann refined this theory. Thermals are often weaker at the top and bottom than in the middle. So which "thermal strength" do you use? Reichmann showed that you should use the weaker "initial" thermal strength as the MacCready value for the preceding glide. If you fly a bit faster, you will have to make up your altitude in that weaker lift, not in the booming lift near the top of the thermal.

Of course, you should always take any thermal greater than the current MacCready value, and Reichmann applied this idea to the last thermal:

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stay in the last thermal until it weakens so much that it equals the initial climb of the next thermal. Thus, Reichmann's rule: Initial climb in the next thermal = MacCready setting = final climb in the last thermal. Reichmann also started thinking about the fact that you have to get to the next thermal. It's worth lowering your MacCready setting even further if you will otherwise land out before you get to the next thermal!

Reichmann's ideas are very useful to understand how top pilots are flying. They fly a good deal slower than "classic" MacCready theory, based on the best part of the climb. Gaining range and recognizing that the initial climb is often in weak lift are two good reasons to turn down the MacCready setting substantially.

Classic final glides

Classic final glides are another simple calculation of the right MacCready value. If you are about 30:1 away from the finish with no lift or sink ahead, in a typical standard/15 meter glider, a MacCready 4 setting will just exhaust your altitude. In this situation, a thermal that lifted you 400' higher would allow you to fly faster, and finish one minute earlier. If you find a stronger thermal, you should stop and then finish faster.

Random lift and finite altitude.

These calculations are enlightening, but obviously simplified. The most important problem is that you really don't know where the next thermal will be and how strong it will be. We want to know, given the *chances* of finding thermals of various strengths, what is the right MacCready value?

Figure 2 presents an answer to this question, for typical East Coast conditions in a Discus. I specified that thermals extend from 500 to 5000 feet. I specified the probability of finding thermals shown in Table 1. For example, reading the second column, you have a 20% chance in each mile of finding a 1 kt thermal, a 10% chance of finding a 2 kt thermal, and so on. There are a few 4 and 6 kt thermals, but they are rare so you'd better not go barreling around counting on them. Still, you want to adjust your strategy so that if you find one, you can take advantage of it.

Thermal	Miles		
Strength	1	5	10
1	20	90	99
2	10	61	84
4	5	30	52
6	2	10	18

Table 1. Probability of finding a thermal at least this strong in the indicated number of miles

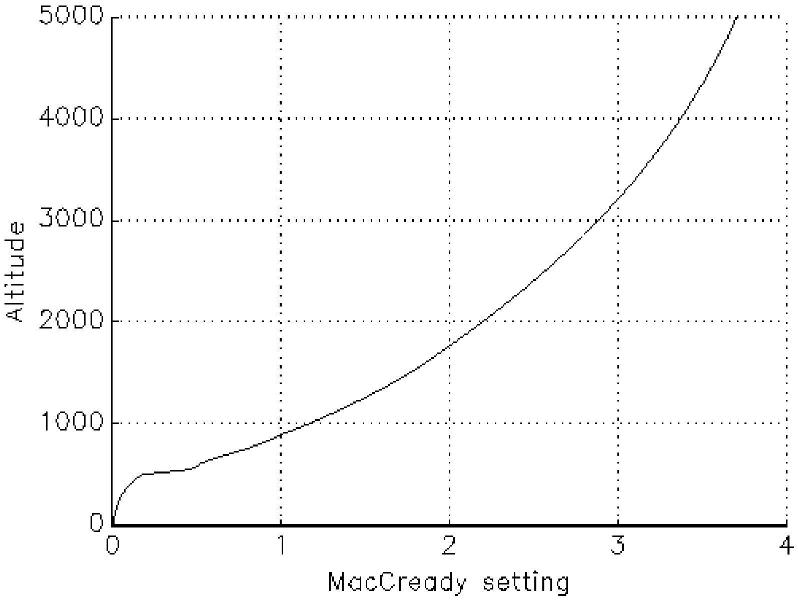


Figure 2. MacCready value vs. altitude, for a Discus facing the thermals of Table 1.

You can read several rules from Figure 2.

1. *Steadily reduce the MacReady setting as you get lower -- fly more slowly and take weaker thermals.*

The MacCready value rises from less than 1 at 1000 feet to nearly 4 at 5000 feet. The reason is simple: *range*. If you stop for nothing less than 4 knots at 1000 feet, you are soon going to be an outstanding pilot – out standing in Farmer Brown's field.

We knew this of course. Even the earliest explanations of MacCready theory added advice such as "take anything if you're below 2000 feet." Clearly, if you're going to take anything below 2000 feet, and you're not stop for anything less than 6 knots at 8000 feet, you should smoothly interpolate these two ideas in between –you shouldn't set the MacCready to 6 as you pass 2001 feet.

2. Vice versa, you should *leave weak thermals to go find better lift as you get higher.*

Many books warn of the danger that after a low save, it's important to recharge your psychology and not work your saving two-knot thermal all the way to cloudbase. Once you're past 2000 feet on this nice day, you should move on and try to find something better.

Combined with the tendency of some thermals to work in bubbles and have multiple cores, and perhaps with the tendency of the pilot to blunder out of lift, following Figure 2 can lead to a stairstep climb. You might get low, and find a 3 knot thermal. You take it. Around 3000 feet, though, you should start getting impatient. Following the advice of Figure 2, you leave and find something better. You might find that thermal right next door in a better core (this happens to me more often than I'd like to admit), or you might glide a bit and then find a 4 knot thermal further on. Of course you might not, but the heart of the calculation is that at 3000 feet you are more likely to find something better than you are likely to have to accept something worse. And when you do find that something better, you'll have the altitude to use it. Cloudbase is in one sense the *worst* place you can be. If you run in to an 8 knot thermal at cloudbase, you can't take it anywhere!

3. MacCready settings are substantially lower than best climb in best thermal of the day.

In my calculation, the best thermals of the day are 6 knots. Yet the MacCready setting never goes over 4, and will be more like 3 through the typical range of the flight. Again, the calculation confirms what we hear from pilots all over the world: reduced MacCready settings let you fly faster, since you cover more range.

The basic principle behind the calculations in Figure 2 is this:

4. The MacCready value now should be the same as you expect it to be farther ahead.

If you know you are going to be desperate up ahead, you should start conserving altitude now. Suppose that you are at 3000 feet. Looking ahead 5 miles, you think there is half a chance you will find a 4 kt thermal. However, there is half a chance that you will not find a thermal, wind up at 2000 feet and be willing to take a 2 kt thermal. *Your MacCready value now should be 3 kts*. This is a good principle to use in thinking about what MacCready value to set. I used this principle to ask the computer to work back from the finish to find the right MacCready values for any combination of altitude and distance to go.

Figure 3 shows more intuitively how you get range without being too slow. The bottom pilot is straight from the 60s. He knows there are 5 knot thermals out there, so he sets his MacCready at 5. He goes fast, and will win the day if he does find 5 knot thermals. But he is quite likely to run in to the ground before he finds those good thermals, or, more often, wind up low and waste a lot of time scratching up again. The top pilot sets his MacCready at 2. By flying slower, he glides further, and so raises his chance of finding a good thermal. But if he does find that good thermal, he is slow.

The middle pilot finds the happy medium between these two paths. When high, he flies fast. Starting at 6,000 feet and following his plan, he is quite likely to find a 6 knot thermal, and if not 6 he will very likely find 4. Thus, he sets his MacCready at 5, like the fast pilot. But as he gets lower, he is less likely to find that really good thermal with the altitude available, and is increasingly likely to have to take something weaker. Thus, he steadily reduces his MacCready setting as he gets lower, flying slower and taking short climbs in weak thermals. If the middle pilot does find good thermals, he gets most of the speed of the fast pilot. If he does not find good thermals, he gets most of the range of the slow pilot.

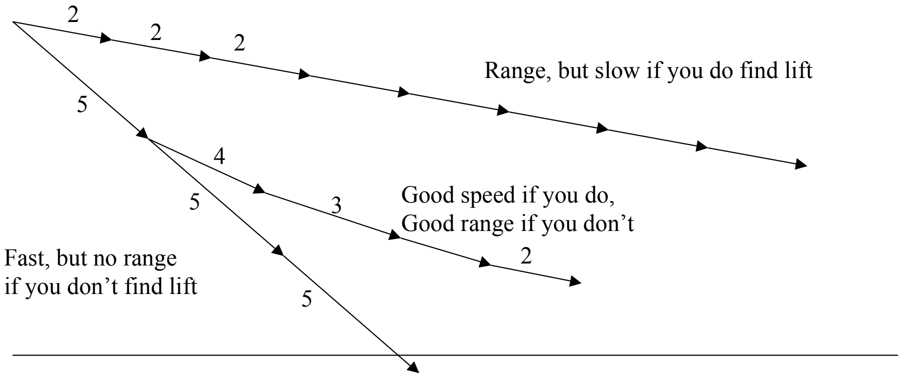


Figure 3. Speed and Range

The location of the curve in Figure 2 is not fixed in stone, but moves around according to the weather, the glider, and the pilot. Any calculation depends on its inputs, and as you vary the inputs to this calculation, it gives different answers.

Obviously, the curve shifts to the left in weak weather and to the right in strong weather. Less obviously,

- The shape of the curve depends on how good thermals are lower down. If thermals are weaker lower down, you become more conservative sooner, and accept weaker lift to stay in the good band. Thermals tend to be weaker down low in wind, in mountains, at the end of the day, and when there is a wind shift with altitude.

- The curve depends on how high thermals go and how far apart they are. As thermals become further spaced, you have to use a lower setting.

- The same pilot flying the same weather in a lower performance glider must fly more conservatively. The same calculation for a Schweitzer 1-26 gives a MacCready setting of only 3 at the top rather than 4. There is art to flying a 1-26: you must take weaker thermals to stay aloft. Classic MacCready calculations, which assume that everyone will be able to get to the same thermals, understate the advantages of higher performing gliders.

- A less skilled pilot should fly more conservatively, shifting the curve to the left. If you are less skilled than the top pilot is, *you* will increase *your* points by following a more conservative strategy than he follows. Top pilots will find a thermal that you and I will miss. We need to give ourselves a little more room as a result.

> **Experienced pilots will often invite newcomers to "follow me and see how it's done." This is generous and well-intentioned advice, especially when you think of the lengths they go to in order to keep their competitors from following them! A less experienced pilot should thank them generously and ignore the advice. (That is, unless they are explicitly going to stop and wait and show you around. Then, by all means take this rare and exceptionally useful lesson!) The fast pilot will start at the absolute last moment. Once you take two extra turns in a thermal, you will never see him (or her) again, you get to struggle home all alone as the day dies. Worse, the fast pilot will, rightly for him, push on hard even as he gets low in poor terrain. Your leader may know that there is a field around the bend up ahead, and he has the skill to get his glider in there. You don't know about the field and may not be able to land in it. When he finds that last thermal and you don't, you'll be in real trouble.**

- The right policy depends on how you value speed versus landing out. If you want to minimize the probability of landing out, you set the MacCready to zero always. This is really slow. To fly any faster at all, you must accept some larger probability of landing out. In Figure 2, I valued landouts according to the distance points in U.S. contest rules. If you're flying in a contest that gives more distance credit, fly more aggressively. If your personal dislike of landing out goes beyond contest points, fly more cautiously, especially as you get low.

This completes the basic ideas of how to fly a bit faster, given that thermals are uncertain and that you need altitude to get them. We need to think about the fact that it takes time to center thermals. Managing this centering time is one of the most important parts of flying for speed, and it affects how you fly considerably. I start with that topic next month, and I also update cruising speeds, course deviations, and final glides.

Just a little faster, part II

Last month, I presented the basic ideas of how to fly faster, given that thermals are uncertain and you need altitude to get to them. To recap,

1. At any point in the flight, figure out the right level of confidence or aggressiveness. Quantitatively, this answers the question "how much higher would I have to be in order to finish a minute sooner?" It is the MacCready value
2. Take any thermal greater than the MacCready value; leave any thermal below the MacCready value. The MacCready value is the *weakest* thermal you would take at any point in time.
3. Fly the speed ring setting corresponding to the current MacCready value.
4. The MacCready value is the weakest thermal you would take for one circle. It is substantially less than the peak climb in the best thermal of the day.
5. As you get lower, fly more conservatively – take weaker thermals and fly slower. As you get higher, get more aggressive – leave weak thermals, stop only for stronger ones, and fly faster.

Figure 2 of last month's article, reproduced below, gives a computer calculation of the right MacCready value for each height in typical East coast conditions.

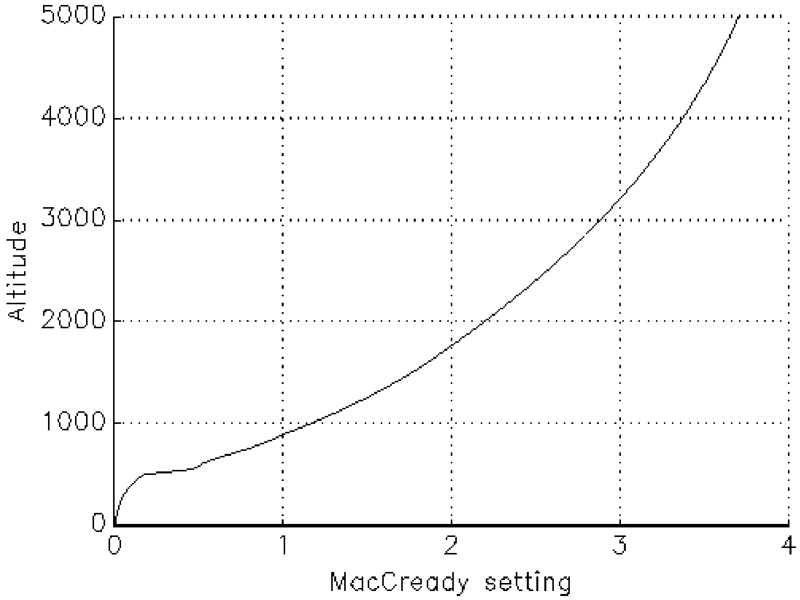


Figure 2. MacCready value vs. altitude, for a Discus in typical East Coast conditions.

This month, we do some extensions of the basic ideas. Most importantly, the fact that it takes time to center thermals crucially affects flying strategy. We'll also think about cruising speeds, the surprisingly large course deviations you can take, and how to do final glides given that lift and sink are random, and I'll address some common misconceptions.

Centering time

On most flights, it takes at least a couple of turns to center the thermal. A pretty good pilot can start climbing at the thermal's maximum rate in 4 turns – 2 minutes. Table 2 shows what this does to your achieved climb rate.

Height	Thermal strength in knots			
gained (ft)	1	2	4	6
500	0.7	1.1	1.5	1.8
1000	0.8	1.4	2.2	2.7
2000	0.9	1.7	2.9	3.8
5000	1.0	1.9	3.4	4.8

Table 2. Actual climb rate if it takes 2 minutes to center a thermal.

As you can see, a few minutes of centering time has a dramatic effect on achieved climb rates! The effect is larger for *stronger* thermals, and for *smaller* height gains. Managing this centering time is a crucial piece of flying strategy.

Many modern flight computers include an average climb for the whole thermal – from the minute you switch in to climb mode or start circling. These reality meters are wonderful checks on your enthusiasm. When I bought a flight computer with this feature, I was amazed that what I thought of as a "four knot day" was often a 1.5 or 2 knot day once you factor in the centering time. I felt a lot better about my seemingly wimpy intrathermal speeds. This is one more reason that pilots now use MacCready settings much lower than they used to, based on an optimistic reading of the 20 second averager.

For many thermals, the decision to stop doesn't depend so much on *how strong* you think the thermal is, as *how easy it will be to center.* If you feel the right kind of surges and can roll right in to a 4 knot thermal for a 2000 foot climb, that is as good as having to center a 6 knot thermal.

Centering time affects even classic calculations such as Reichmann's, that presume you know what the next thermal will be like and where it will be. The *lower* of average climb and initial climb (after centering) determines the MacCready setting. The initial climb rule considers how much lower will you arrive at the next thermal if you fly a little faster. The average climb rule considers how many more thermals will you have to center if you fly a little faster. The price of altitude is the lower of the two climb rates.

When it takes time to center thermals, it is worth *staying* in a thermal somewhat weaker than you would *stop* for, and it is not worth stopping and centering a thermal that you would stay in if perfectly centered. The curve of Figure 2 breaks into two curves. The difference is strongest higher up, since you have less altitude left in which to climb. The speed decision is based on the lower value – what thermal would you *stay in,* once again rationalizing the observation that pilots fly a good deal slower than classic MacCready theory.

Many pilots follow rules such as "don't stop unless you can gain at least 1,000 feet." Like any rule, this one is meant to be broken, but it contains a grain of truth. It's worth stopping at any altitude if the thermal is strong enough, and especially if it feels smooth so that you will not have to center it. But it is not worth stopping and centering a normal thermal if you can't amortize the centering investment in a decent climb.

You can think about centering time strategy in terms of a height band. If it takes time to center thermals, then your height band will be larger, as it is better to have a few long climbs than many short ones. On the other hand, thermals are often smoother higher up, making it worth staying high in weaker thermals than going low where you will waste a stronger thermal by having to work too hard to center it.

Thermals are harder to center down low, on windy days, when there is a change of wind speed with altitude or direction. Quickly centering thermals, and feeling which thermals will be easy to center before you turn are crucial skills of expert pilots on which the rest of us can always use more practice.

It is a common misconception that you should use MacCready settings that are systematically lower than the worst thermal you would take, in order to get more range. It is a mathematical fact that if you are cruising at a MacCready 2 (70-75 dry or 75-80 wet), you will always do better by stopping for a 3 knot thermal, at least for a short climb until you can cruise faster. However, the misconception contains a grain of truth. When you add up the effects of low initial climbs, centering times, and the fact that the *average* thermal you will climb in is stronger than the *weakest* thermal you would take, the correct MacCready value is a lot less than you would have thought based on the averager readings that you brag about in the bar after the flight. A "3 knot thermal" means an achieved average climb of 3 knots after any centering; it often takes a "5 knot thermal" at the bar to do that, and if you have any luck at all, you will stumble into a "7 knot thermal" a few times during the day.

Cruising speeds

Speed to fly theory is loudly criticized by some pilots. There is a point in this criticism: Following the ups and downs of the vario around is not likely to gain you anything. The lags in the variometer, the pilot, and the glider mean that if you try to fly faster every time the vario shows sink and slower every time it shows lift, you're most likely to get completely out of phase – like turning the hot water on when the shower gets cold and turning the cold water on when it gets hot.

Most pilots now fly a "modified constant speed." They do use MacCready theory and settings to determine the average cruise speed. When desperate, 60 (MacCready 1), when worried 70 (MacCready 2) when happy 80-85, and 5-10 more for water are good rules of thumb. Even the loudest MacCready critics fly a lot faster at Uvalde than they do at Ionia, and they fly a lot faster at 9000 feet than they do at 1000 feet. However, pilots ignore most of the vario's chirping and beeping. They porpoise only when they can tell what's happening *ahead*—that the lift or sink will be there for a while. If you feel the characteristic bumps of the edge of a thermal, your vario starts to chirp, there is a huge well-formed cumulus is ahead, and you can see birds, gliders, corn stalks, small cars, and Dorothy's house being swept up below, go ahead and slow up! If you see that you are in sink that's going to last a while, go ahead and speed up.

Pilots also criticize MacCready theory, noticing that the exact speed you fly isn't that crucial. 5 knots one way or the other will not make a great deal of difference to overall speed. That is true of 5 knots, but it isn't true of 10 knots. More importantly, while *gliding* at a MacCready setting one knot too high or low won't make much difference, *choosing thermals* one knot too slow or insisting on thermals one knot too strong will make a huge difference to your speed. *Deciding when to stop and when to leave, and achieving the best average climb rate, are the most important determinants of cross-country speed.* This decision is as much a part of "MacCready theory" as is the decision of what speed to fly.

Standard class gliders have a kink in the polar around 80 knots dry that makes speed to fly decisions particularly easy. For anything between MacCready setting (plus sink) between about 2.5 and 7, just fly at the kink speed.

Course deviations

It is surprising how far off course you should go. Think about a 30 degree course deviation. By going 30 degrees off course, you have to fly 15% further. Cruising at 80 kts, 3 miles 30 degrees off course costs you one third of a minute. At a MacCready setting of 3, this is worth it if you gain 100 feet. Just about any cloud or haze dome will net you one hundred feet. (You don't have to *gain* 100 feet, you just have to gain 100 feet over the guy who flies straight.) If it nets you 150 feet, constantly zig zagging 30 degrees off course from cloud to cloud will give you a much better speed than going straight. As an extreme, going a mile perpendicular to the courseline will cost about a minute. It's worth it at MacCready 3 if it nets you 300 feet.

As you can see from the examples, the MacCready value also tells you how far off course to go. If the MacCready value is low, it's worth trading a lot of time for a little altitude by larger course deviations. If the MacCready value is high, time is precious so you should bomb straight ahead. Of course in stronger lift you will gain more by flying through thermals, so the two effects can cancel. Pilots at Uvalde, where lift is strong, close together and well-marked often take as much as 45 degree course deviations to hop from cloud to cloud with little circling.

The late 70's saw a big increase in cross-country speeds, and there was a lot of talk about the new "dolphin flying" technique, brought on by netto varios that showed pilots how to exploit large areas of light lift. Yet we know that dolphining by following the variometer or using artificially low MacCready settings doesn't help. The real change may well have been that pilots started to make much larger course deviations in order to "dolphin" in the thermals.

Netto variometers also caused, or at least accompanied, a change in thermalling technique. Writers in the 60s and early 70s encouraged you to keep your speed up, and describe a perfect zoom and wingover into a thermal. They then described artful thermal exit techniques where you cut right through the hot core at high speed to bash through the surrounding sink. When pilots got netto variometers, they quickly discovered that the big sink surrounding thermals isn't always there. Thermals tend to cluster, strung out up and down wind if there is any. (See Tom Bradbury's wonderful articles on thermals in recent issues of *Soaring*.)

Given this fact, pilots now often follow a different technique. When you feel the characteristic bumpiness of the edges of a thermal, slow up to 70 or so; you can't sniff out lift at 90 knots. Then sniff around, feeling the air for the big core. I have seen some experts curve this way and that, sniffing the air for two miles before dipping in and circling. Similarly, after the thermal weakens or you get impatient, you can often milk the lift flying straight for another few hundred feet, especially upwind. Sometimes you even blunder into a really strong big core and thermal again.

Final glides

The standard final glide calculation assumes no lift and sink. How should you approach a final glide given that thermals are random? There are two schools of thought on this.

First there is the "start the glide early and low" school. Doug Jacobs has offered this advice, and seems to start his glides one thermal before everyone else. Bill Bartell advises you to start thinking about the final glide when you hit MacCready 0. You can often do better than the still air glide by course deviations and porpoising in thermals. If so, save time by anticipating this fact and starting the final glide low. Starting a final glide low also keeps alive the option of stopping in a superb thermal if one comes along. How many of us have struggled to make "final glide" in a 3 knot thermal, only to blunder in to a now useless 6 knots while bashing home! If that happens often enough, if you find yourself often slowly gaining on your glide, maybe you should start lower the next time.

In the context of Figure 2, the early and low school moves the curve to the right as they get closer to home. Near the end of the task, you might be 50:1 from home. That's not enough to start a bare bones 40:1 glide, and really not enough to start a sensible 30:1 plus 500 feet glide. But if you start being just slightly more aggressive at any altitude, being choosier about thermals and gliding a bit faster between them, you will, on average, slowly descend. If you average a 50:1 descent, then you just use up your altitude as you get home. Of course, if you start to lose altitude you still get more conservative, and you still get more aggressive as you gain.

Second, there is the "make sure you don't blow the contest by landing out" school. Dick Johnson has offered this advice. If there is lift there is also sink. How many of us have not also set up a nice 30:1 plus 500 feet final glide, only to have it all evaporate and either end up struggling low, or landing on the way home? A landout is aggravating, and it costs at least 400 points, sending you far down the scoresheet. Being a little more conservative than the standard calculation – say climbing in a 3 knot thermal to a MacCready 4 glide – might cost a minute, but it buys good insurance against this kind of disaster.

Who is right? To get a handle on this question, I went back to the computer, and Figure 4 gives the computer's answer.

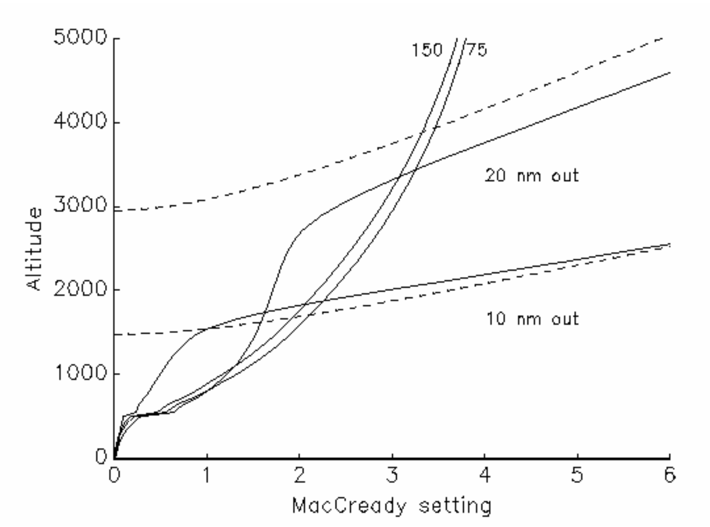


Figure 4. MacCready values on final glide

The 150 mile out line is the same line shown in Figure 2. The 20 mile out and 10 mile out lines show how the calculation advises you to fly the final glide. The dashed lines give the standard still air calculation. For example, at 4,000 feet, the 20 mile out dashed line gives a MacCready value of 4. This means that the glide corresponding to a MacCready 4 will just exhaust 4,000 feet in 20 miles in still air.

Over 3,000 feet, the 20 mile out line is about 500 feet below the corresponding dashed line – you fly about 500 feet below final glide. There is lift that you can use to porpoise in. If you do not find lift, you can still glide in at a lower setting, and there is a good chance of finding a weak thermal save the flight. This line verifies the advice of the low and fast school.

However, the 10 mile out line is slightly more conservative than the still air calculation. At 10 miles out, the program trades the slight advantage of a few knots more speed for 10 miles against the small probability of a disastrous landout, and advises a cautious final glide. In sum, this calculation balances the two schools of thought: *start final glides aggressively, but finish them conservatively*.

Below 1,500 feet, the 20 mile out line looks just like the 100 and 150 mile out lines. If you're 20 miles out at 1,500 feet, it's just like being on course; forget about final glide! The 20 mile out line is very interesting between 1,000 and 3,000 feet. Here, the calculation advises you to be *more* conservative on final glide than you would be on course – the final glide calculation is to the left of the 150 mile out calculations. Why this seemingly crazy advice? In these situations, the out-on-course MacCready setting would not get you home, but the slightly lower MacCready settings will practically guarantee a glide home if you should not happen to find a thermal along the way. The program trades off the small loss in points from flying slowly for a few miles against the scoresheet disaster of landing out if you don't find a thermal up ahead. Giving up 2 or 3 points to avoid a small chance of a 400 point loss is a good deal.

The calculations are far from the last word, but the curious way they come out make clear the tradeoffs you have to think about. On final glide, you balance large chances of a small speed increase against small chances of a costly landout. Managing this tension correctly wins contests. Final glide strategies are a particularly fertile area for quantitative analysis. As with safety issues, which trade similar probabilities, it is hard to learn this balance from personal experience since the disasters are infrequent.

Weather is especially important on final glides. Even the most aggressive pilots take high final glides when they have to go through rain on the way home! The chance of sink is just as important as the chance of lift. You fly more conservatively if the weather is more *uncertain*. (I learned this sharp lesson from Liz Schwenkler when she beat me home on a MacCready 1 final glide that I had taken too slowly. "No lift means no sink," she said, and she was right.) Porpoising may be harder down low than when up high, and the presence of frequent 1-2 knot thermals with which to save the flight are crucial for the low and early calculation. Glides into the wind seem to work out less well than glides downwind, even after accounting correctly for the wind speed.

Final glide safety

Before thinking about conventional final glides, to say nothing of a low and porpoise up final glide, a pilot has to be very clear about the special safety issues involved in final glides. *Off-field landings close to the airport are extremely dangerous.* The areas around airports are littered with glider wreckage from misjudged final glides.

To see why, think about how you do an off-field landing on course. As you get lower, you steer towards a good area. By 2,000 feet you have several good fields picked. By 1,500 feet, you stop trying to make forward progress, and you look for thermals while checking out the fields. By 1,000 feet you have picked a main and alternate. By the time you commit to a pattern and landing from say 600 feet, you have been directly above good fields, looking for wires, slope, ditches, planning approach and so on for a good 10 minutes.

Final glide landings are totally different. At 2 miles out, 40:1 is 300 feet, and 400 feet is enough to blast home at 90 knots. *Everything* happens below 300 feet. More importantly, you didn't *get* to 2 miles out and 250 feet the same peaceful way you got to the on-course landing. At 5 miles out, 40:1 is 750 feet. The bare minimum of 1,500 for decent field selection is 10 miles out. Think hard about being 5 or 10 miles out on a MacCready 0 glide, or even a bit below. You've read all those great articles about pilots who popped over the fence and rolled in. If in a contest, you're also thinking about losing 450 points or more if you don't make it. One bitty thermal will give you 100 feet and you'll scream home. Tell your spouse otherwise, but you will find it almost impossible not to keep going.

Therefore, unlike a landing on course, field selection, checking for wires, slope, ditches, fences and alternates, *will*, inevitably, all happen from a 35:1 or lower angle, straight in, while intensely watching the airport and glide computer. The final decisions will be made in seconds, from 300 feet or less. There is just *no way* to do a good off field landing in this situation. This isn't just theory. I looked at a lot of GPS traces from contests with 2-5 mile out landings. All of them flew *straight* toward the airport until below 300 feet, took at most one turn into the wind and landed.

What can we do about this danger? For a new contest pilot, recognize the trap and keep a very conservative margin. On a decent day, it will cost no more than 3 minutes to gain an extra thousand feet.

As you want to go faster, the options narrow. An ambitious pilot cannot give up 3 minutes per day. The standard answer is that you must carefully check out the fields around the airport before you do a final glide. If you know where fields are 2-5 miles from the airport, meaning you have completely checked them for crops, wires, slopes, obstructions, ditches and fences, and you have picked approaches and landing spots, then it is not ridiculously unsafe to glide straight into them. Many pilots *say* they do this, but few actually do. A glance down while milling around at the start is not nearly enough.

I think it helps to prepare yourself psychologically to make a *very* quick decision, as you do for PTT emergencies. 10 seconds of indecision has killed. I rehearse congratulating myself for making the safe decision, not to criticizing myself for landing out and blowing the contest. When you're at MacCready 0 and 5 miles out, an alarm bell should go off *–this is how people get hurt.*

This danger is entirely a creation of the rules. If the rules specified a 1,000 foot finish altitude for speed points, then a pilot at 800 feet, 5 miles out will calmly either stop to thermal or do a good pattern into a well-inspected field. He gains almost nothing by stretching a glide into the airport. A safety finish is particularly easy to implement with GPS rules: pilots must clear a 1,000 foot barrier two miles out.

We have crash after crash within 5 miles of the airport, including totalled gliders, serious injuries and fatalities. Most pilots take a “right stuff” attitude to these crashes – “well, he must have been a bozo, any real pilot wouldn’t do that.” Safety in flying comes when you get over this attitude, and recognize that we all can do silly things on rare but costly occasions. I hope we do not have to wait until another prominent pilot dies to eliminate this needless danger, as we seem to finally to have done with similarly preventable assembly mistakes.

What’s next?

When you learned to follow the towplane, you and your instructor analyzed the task. Then you flew to learn to do in the air things you understood on the ground. By the time you got your license, following the towplane became automatic, and you probably would have trouble explaining how to do it to a beginner.

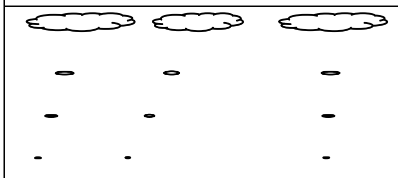
Cross-country flying works the same way. You start with the basics, thermaling and navigation. This article is about the intermediate stage, getting up to speed on course. You have to think about and analyze these decisions on the ground, and then use your flying time to learn to make them, and then to make them subconsciously, in the air. This is not easy, and requires dedicated practice. I know this from experience; I write articles on theory, yet from lack of practice I still end each flight with a list of “coulda shoulda woulda’s” if I could only make in flight the decisions advocated by my own articles.

Advanced pilots have made this all automatic. They often have trouble describing what they do as you might have trouble describing how to follow the towplane. They fly thinking about weather, psychology, and contest tactics. Our job is to get to that stage!

For technical types, I have only scratched the surface of what the mathematical technique – dynamic programming – can do to advance the theory of soaring flight. Centering time, thermals whose strength and character changes with altitude, better thermal models, upwind and downwind turnpoints, objectives other than expected value of contest score, comparing the program solutions to flight recorder data of top pilots’ decisions, and many more questions only await enough wintertime programming to be solved.

A STRATEGY FOR ALTITUE AND SPEED

The following is a strategy to guide pilots who are new to cross-country flying or are out of practice.

Altitude	**Priority**	**Action**
50% -100% Cruise level		Aim to fly in cruise level
	⇒⇒⇒ Speed	Stay in lift by using cloud streets If sky overcast, over-convected, or broken stay in top 30%
	⇒⇒⇒Speed ⇑ Lift	Move on when climb rate reduces to 2/3
25%-50% Insurance level	⇒⇒⇒speed ⇑⇑ climb	Aim to return to cruise level
	⇒⇒⇒speed ⇑⇑ climb	Cloud and ground read. Stay out of sink
	⇒ speed ⇑⇑⇑ climb ⇓ land	If cloud cover >6/8s be cautious. Use optimum glide to reach sunny spots
	⇑⇑⇑⇑ climb ⇓⇓ land	Ground read
0 %-25% Survival Level	⇑⇑⇑⇑ climb	Look for heat sources, trigger points, check wind. Use dams
	⇑⇑⇑⇑ climb	Forget about the task, concentrate finding lift
	⇑ climb ⇓⇓⇓⇓ land	Paddock should be selected
0% Ground Level	Land Safely	Check for slope, surface, obstructions, wires, and wind indications

The following speeds are applicable to sailplanes with a L/D of approximatley1/40. If the average lift strength is 2kts or greater it is assumed the water ballast is being carried.

Lift	Mc Cready Average	Speed to Fly
Excellent	3 kts	90kts
Good	2 kts	80kts
Below Average	1 kt	65kts
Poor	>1kt	55kts

MODULE SEVEN

TASK SETTING

TASK SETTING

There are a number of logistical things to sort out before setting off on a badge or long distance flight from Benalla, with task setting possibly taking the greatest time. The factors affecting route selection, task distance and map marking should all be considered. When task setting, try not to limit yourself to any one particular direction, or only set for one type of weather conditions.

In Victoria and Southern New South there are three main factors that affect the size and shape of tasks, weather, terrain and airspace. The task areas can be large, and cover some remote and sparsely populated areas.

> [a]Weather. The dominate feature of the weather during the soaring season December/January/February are the high-pressure systems, which track across the continent, and it is the trajectory of the air mass surrounding the high which determines the convection room and the length of a soaring day. This will impact on the length of the task.
>
> [b]Terrain. This may enhance or limit the prospects for soaring, the mountainous Great Dividing Range offers good prospects but if the convection room is limited in height the transit speeds are generally lower than speeds achieved over the plains. On the other hand as the height of convection rises soaring prospects improve and cross-country speeds increase. The irrigation areas surrounding Shepparton, the rice growing areas of the Southern Riverina and the lake shadows of Makowan and Mulwalla should also be considered**.**
>
> [c] Airspace. Compared to many countries there is freedom for soaring out of Benalla. Providing the height of convection does not exceed 8500 feet QNH, controlled airspace does not generally impact on cross-country flight. However, once convection is expected to exceed the 8500 feet level, planning should accommodate this. High convection rooms are reached at the back of a high pressure system with the advection of hot northerly winds supported by a weak trough this gives rise to high base cumulus offering the prospects of long distance and record flights

Airways.

The impact of controlled airspace is Albury to the north east and Melbourne to the south.Controlled airspace classified C associated with Albury and Melbourne can only be entered with a clearance. If you have an RT license or have a GFA clearance and wish to enter class C airspace then you must,

[a] Contact the ATC unit eg Albury TWR 124.2 and give details of position, altitude and proposed track.
[b] Obtain entry clearance.
[c]Listen out on that frequency until you are clear.
[d]Comply with ATC instructions.
[e]Remain in VMC conditions throughout. This is that a glider must remain 1000ft vertically and 1.5 km horizontally clear of cloud with a flight visibility of at least 8km>10,000feet, 5km< 10,000feet

The lower levels of class C and E airspace will be [QNH], based on feet above sea level.

When above 5000 feet sailplane pilots are encouraged to listen out on the area frequency.

MBZ and CTAFs

MBZ. Mandatory Broadcasting Zones are at Wagga and Dubbo and Cooma. Radio is mandatory and must be used. The dimension is a radius of 15 nm and an upper limit of 5000 feet AGL

CTAF are Common Traffic Advisory Frequencies. Sailpanes transiting should advise on the appropriate frequency. The standard CTAF is 5nm radius with an upper limit 3000 feet agl. Non-standard CTAFs are promulgated and annotated on the chart with a #. Benalla and Tocumwal are non-standard CTAFs.

Prohibited, Restricted, Danger areas.[PRD]

These are annotated with the one of the letters PRD its number with the maximum height in thousands of feet above msl. A restricted area may be crossed by a glider depending on the restriction, but a prohibited area may not. The restricted areas affecting flights out of Benalla are to the north within the Benalla CTAF, Pukapunyal to the south west, Yarrawonga and Oaklands to the north and to the west of Wagga Wagga.

Parachute drop zones

These are zones 1.5 or 2nm in diameter and extend up to 10,000 feet and above parachutists that are freefalling are almost impossible to spot so always assume these sites are active. Listen on the appropriate frequency before transiting theses area and if possible plan to avoid them. Parachuting takes place at Corowa, Euroa, Nagambie, and Bridgewater

NOTAMS

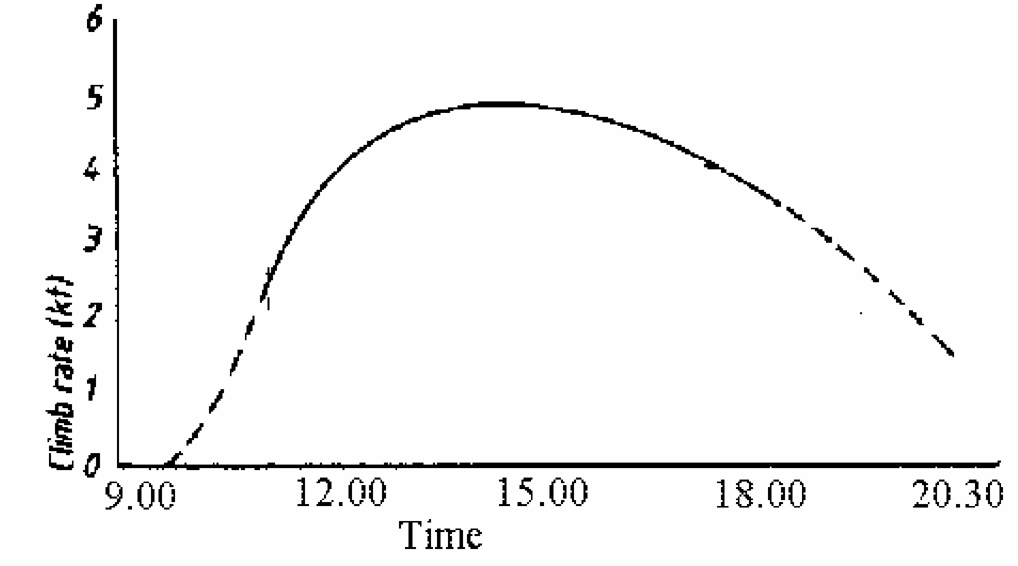
Not all airspace that needs to be avoided is printed on the map, as it may only be active for a few days. Such airspace is notified by NOTAM, Copies of relevant notams are downloaded from the airservices website and displayed at morning briefing. These must be checked before you intend to fly. The active sites give date, height, description of activity and a precise location.

Time Available for Task

At the 0900 hours briefing the time of convection to 4000 feet, average thermal and maximum thermal strength will be given. These will give a guide to the distance that can be achieved and helping in planning a badge or long distance flight. Thermal activity will be dependent on the stability of the environment, surface heating, time of year, cloud cover and how dry the ground is.

Thermals are not of a continuous strength throughout the day, being fairly weak in the early morning, then rapidly building in strength towards midday and reaching a peak at about mid to late afternoon. At the end of the day the thermals rapidly become weaker and widely spaced. At Benalla if the wind is from the south convection is likely to be curtailed early, conversely with a wind from the north convection will continue well into the evening.

It can be seen from the following diagram on a good summer day thermals may start towards 1100 hrs and go on to 2000hrs giving a soaring day of 9 hours. Looking at this graph then it can be seen that the average thermal strength over this time period works out to be 3kts, but on hot high days with high cloud base this will be exceeded.



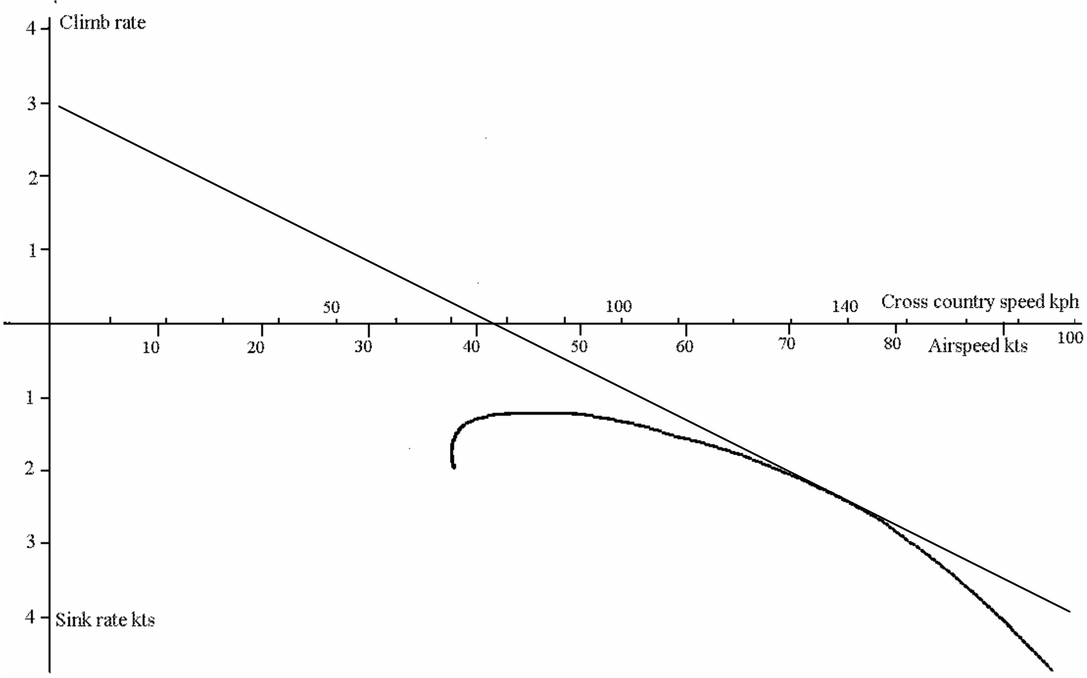
Wind strength

An important figure to consider is the wind speed, because unfortunately the reduction in cross-country speed on a leg into wind is normally greater than the extra speed gained on the downwind legs. Therefore the greater the wind speed then the slower your speed around a closed circuit task will be

Glider performance.

Obviously, the greater the performance of the glider then the faster and therefore further you are going to be able to fly. To find out exactly how fast your cross-country speed is likely to be for a given set of conditions, in any particular type of glider, then the polar curve for that glider must be consulted.

One of the useful pieces of information that can be extracted from the polar curve is the maximum theoretical cross country speed for that glider. To do this the climb rate for the day must be plotted on the positive Y axis, and a line drawn from this point to a point on the polar curve such that the line is a tangent to the polar curve. The place where this line intersects the X axis gives the maximum theoretical cross country speed.



In the above diagram the polar curve for an LS 4 has been used at a wing loading of 33kg/sqr m, and the average climb rate is assumed to be 3kts. If the glider flys at 75kts between thermals, this situation shows us that the maximum possible speed is 77kph.

Once again it must be stressed that this speed is the maximum theoretical possible with the assumption that all thermals average 3kts and the air is still between climbs. With this information and the the fact that the day lasts 9 hours from the previous diagram, the maximum theoretical distance can be calculated.

77kph for 9 hours = 693km.

This is good day and a well prepared and practiced pilot would have a good chance of achieving a 750 km flight in a standard class sailplane. However, in practice the actual achieved cross country speed is likely to be less due to detours on route, wind factors and the skill level of the pilot. On the other hand by using cloud streets, thermal streams, staying out of sink and locating climbs above average the theoretical speeds can be exceeded. The only way to find out what your achieved cross country speed is for any set of conditions is to time yourself around tasks, or if you have a logger, then you can also acurately assess the thermal strenghts, work out the maximum possible speed and then look at the difference.

The following method of working out cross country speed is only valid for nil wind conditions, and the chart has been produced for maximum speed using the McCready model.

The speed that can be achieved will be dependant on the sailplane performance and the wing loading. These are offered as a guide for planning.

Climb rate kts		1	2	3	4	5	6	7	8
				Speed	Kph				
STD class	Light	37	56	68	78	87	93	98	104
	Heavy	-	-	74	84	93	100	106	111
FAI class	Light	43	65	78	89	98	106	113	117
	Heavy	-	-	83	95	104	112	119	125
Open class	Light	48	69	83	93	102	109	117	122
	Heavy	-	-	89	100	110	117	124	130

Route selection.

The following advice for route selection is for badge and long tasks using the most of the soarable day.

[a]The first part of the task.

During the early part of the day thermals will start over dry well drained ground first. High ground is normaly drier than the plains and also has the advantage that any north easterly facing slopes will heat up particulary quickly and produce good thermals early on in the day. The first leg of a cross country flight should ideally have as much of a downwind component as possible, as any attempt to fly into wind in the first weak thermals of the day will be very hard work as well as being very inefficient. If you are to fly downwind first then you will be surprised at how much progress can be made. If this is not possible then consider an abeam wind.

[b]The middle of the day.

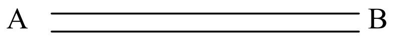
Towards the middle of the day the conditions will be at their best and should allow the highest cross country speeds, For this reason any into wind component of the task should be planned to be done at this time. If there is any significant wind, then it is likely that thermals will be streeting and the into wind leg should lie along the lines of any expected streets. The reason for this is, that when flying into wind any turning drifts the glider back down track, flying down a cloud street allows long into wind glides where turning is not required and is therefore more efficient.
As the day goes on, the cloudbase will start to rise and probably reach its peak at about mid afternoon. Any airspace that restricts your height limit now can significantly slow you down during the best part of the day. This can be a particular problem if the airspace is so low as to keep forcing you to operate below the thermals' best height bands. When flying a task leg it is sometimes advantageous to detour 30 degrees off to one side or the other in order to fly in better conditions. By restricting your search area to one side of the track line then you reduce your ability to find better conditions by 50%.

[c]End of the day.

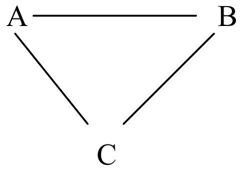
Around 1600 hours on good day it is worth reviewing the flight,calculate the average thermal strength and the speed achieved thus far against the distance remaining and the liklihood of achieving the task. Around 1830 hours will probably be the last good climb, take this as high as possible and adjust your speed to the expected lift in the next thermal.High ground may come in handy as westerly slopes often produce thermals until late in the day. Forests also release their heat at about this time. The terrain should also be taken into consideration as the possibility of an outlanding will be at its heighest at this time. A long marginal final glide at the end of the day is not pleasant when there are few places to land.

Task shape. Below are several suggestions for task shapes.

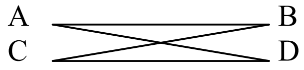
Out and return.

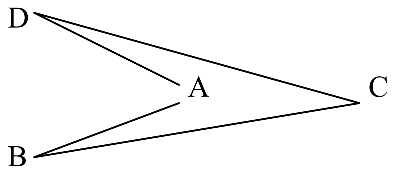


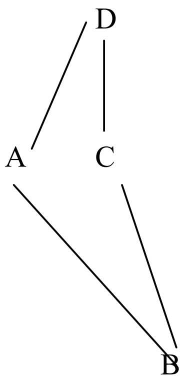
Triangle



3 Turning points



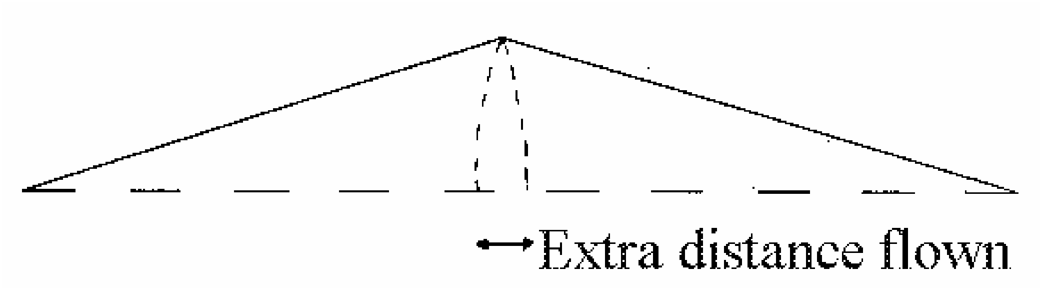




Route deviations.

Quite often it is not possible to fit your desired task round all the obstacles in your path and there is a reluctance to bend a task leg around whatever is in the way. The actual increase in total task length is normaly smaller than most people imagine. To find out how much further you have to fly for a given deviation simply mark backwards with a pair of dividers from the point of maximum deviation to the original track line from both turning points, and the overlap is the extra distance to fly.

The extra distance flown when making a detour (solid lines) from a chosen track (dashed line).



Map marking.

In the age of GPS it’s tempting to skimp on map marking. Unfortunately no electronic gadget can be relied on one hundred percent, however, a piece of paper normally can. If in the event of an electronic failure or indeed you still use a map and compass as your only navigation aid then you will find that a map that is clearly marked and un cluttered much easier to use than one that is covered in an illegible scrawl. It is an essential tool at the planning stage revealing hills and ridges and wet areas.A map helps with orientation, particularly when cruising under high based cumulus over featureless terrain.

The first thing that you must mark are your track lines along the task. These are done simply by drawing a line around your course. Writing the heading on the map has little purpose other than to clutter up the map. Gliders rarely fly on a specific heading down a track because the thermals are not normally that co-operative.

Marking the turning point sectors clearly is of great importance as not doing so often leads to confusion. The actual turning point should not be covered with pen scribble, but the boundaries of the turning point sector should be clearly marked. As should any positioning targets along the turning point bisector.

On the last leg it is well worth while marking the final glide heights at 500ft intervals in radiating from the airfield. If, for instance your glider glides at 5nm per 1000ft into the predicted head wind, then you would mark out every 2.5nm.

Somewhere out of the way it is a good idea to mark on the predicted wind strength and direction.

One last point that is often forgotten is the fact that chinagraph pencil will rub off during the flight. Water resistant pen is more durable and can be removed later either with meths or hairspray.

The weather.

This is by far the most important factor when it comes to task setting but often the least remembered. The direction of the task must be into the best weather in order to achieve the maximum distance for the day or best chance of completion. It is no good following the other advice for task setting if you fly straight into the back of a weather system, or the last turning point has to be flown under 8/8 cover due to an approaching front. So set tasks into the soarable weather, note the highest forecast temperatures, and use the other rules if you can, not the other way round.