Just a little faster, part II
By John Cochrane

Last month, I presented the basic ideas about how to fly cross-country as fast as possible, given that thermals are uncertain and altitude is limited. This month, we'll consider centering, cruising speeds, course deviations, and final glides.

Centering time

It takes time (and skill!) to center thermals. Managing this centering time crucially affects your flying strategy.

A pretty good pilot can start climbing at the thermal's maximum rate in 4 turns – 2 minutes. Table 1 shows what this does to your achieved climb rate. As you can see, even two minutes of centering time has a dramatic effect on achieved climb rates! The "six-knot thermal" you talk about at the bar can easily net you 3 knots or less. The effect is larger for *stronger* thermals, and for *smaller* height gains.

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

Many modern flight computers include a display of average climb for the whole thermal – from the minute you switch to climb mode or start circling. When I bought one with this wonderful reality-check feature, I was amazed that what I thought of as a "four-knot day" was often really a 1.5- or 2-knot day. I felt a lot better about my seemingly wimpy intrathermal speeds.

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.

Figure 1 summarizes how centering time affects MacCready values. It is worth *staying* in a weaker thermal than you would *stop* for. The difference is strongest higher up, since you have less altitude left in which to climb. The difference is also stronger when lift is stronger: when time is not precious you don't worry so much about centering time. The cruising speed decision is based on the lower MacCready value – the minimum thermal you would *stay in,* once again rationalizing the observation that pilots fly a good deal slower than classic MacCready theory based on peak climb rates. Following the advice of Figure 1 will lead to a deeper height band, with a few long climbs rather than many short ones.

Figure 1 and the resulting height band depend on the weather and the pilot, of course. Thermals are often smoother higher up and harder to center down low. This can pinch the two lines higher up and widen them down low, leading you to stay high in weaker easy-to-center thermals. Thermals are also harder to center on windy days, and when there is a change in wind speed or direction with altitude.

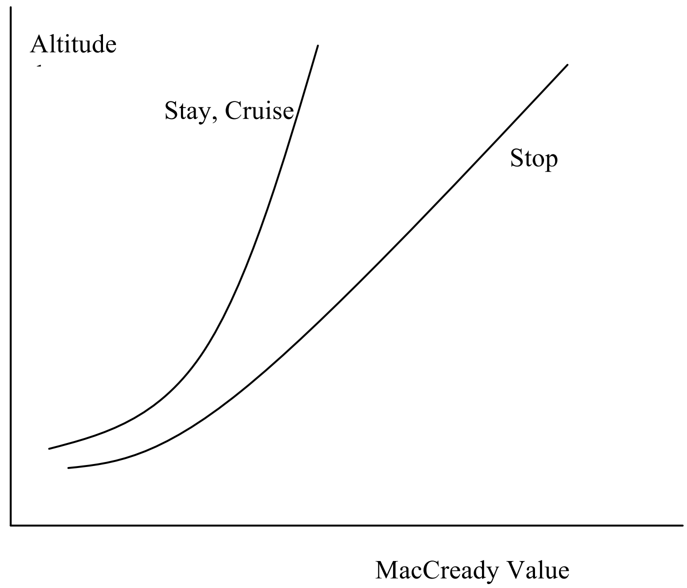

Figure 1. MacCready values when it takes time to center a thermal.

Misconceptions

It is a common misconception that you should "cruise slower than MacCready theory" in order to get more range. It is a mathematical fact that if you are cruising at a MacCready 2 (typically 70-75 kts 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 climb rates, 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.

Conversely, Reichmann criticized pilots for cruising too slowly in an attempt to avoid the need to circle, correctly pointing out that it is better to fly faster and stop to climb in really strong thermals. Again, there is a grain of truth in the error. The correct cruising MacCready value can be a good deal lower than the climb rate *once centered* of the weakest thermal you'd stop for; especially so near cloudbase where the difference between the "stop" and "stay, cruise" lines of Figure 1 is particularly large.

Critics and 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 is not likely to gain you anything. The lags in the variometer, the pilot, and the glider mean that if you try to follow the vario, you're 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 think about average cruise speeds. When desperate, 60 kts (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 ahead, and you can see birds, gliders, corn stalks, small cars, and Dorothy’s house being swept up below, go ahead and slow 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 weak or insisting on thermals one knot too strong will make a huge difference to your speed. *Deciding when to stop and when to leave 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.

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 knots, 3 miles at 30 degrees off course costs you one-third of a minute. At a MacCready setting of 3, this is worthwhile if you gain 100 feet. Now, just about any cloud or haze dome will net you one hundred feet. (You don’t have to climb 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 flying straight.

If the MacCready value is low, altitude is precious, so 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 make deviations as large as 45 degrees to hop from cloud to cloud with little circling.

This art of taking course deviations, rather than speed variation, is the heart of “dolphin flying” which led to a dramatic increase in contest speeds in the late 1970s. Thermal entry and exit technique changed too. Writers in the 60s and early 70s told you to keep your speed up, and described a perfect zoom and wingover entry 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.

But the big sink surrounding thermals isn’t always there. Thermals tend to cluster, strung out up and down the wind line. (See Tom Bradbury’s article in the May 2000 issue of *Soaring*.) Given this, 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 in order to feel the air. Then sniff around, especially upwind, feeling for the big core. Similarly, after the thermal weakens or you get impatient, you can often milk the lift by flying straight for another mile or so, especially up- or downwind. Sometimes you even blunder into a really strong big core worth circling in.

Final glides

The standard final glide calculation assumes no lift and sink. How should you approach a final glide with random thermals and sink? 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 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 into a now-useless 6 knots while bashing home!

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 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 annoying, and in a contest costs at least 400 points. 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 2 gives the computer's answer.

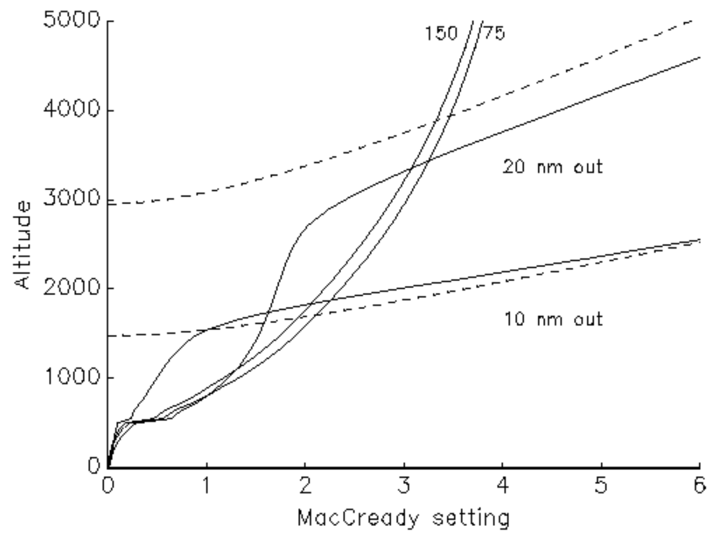

Figure 2. MacCready values on final glide

The 150-mile-out line gives the basic advice how to fly while on course. 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 that your glide computer will report. 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 MacCready 4 will just exhaust 4,000 feet in 20 miles in still air.

Above 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, or, equivalently, you fly at a speed ring setting about a knot too high. There is lift that you can use to porpoise in and extend your glide, or even stop in if it's great. If you do not find lift, you can still glide in at a lower setting – you're above the MacCready 2 still-air dashed line -- and there is a good chance of finding a weak thermal to 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 over 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*.

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. 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 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, and advises a really slow start to this final glide.

The calculations are far from the last word, but the curious way they come out makes 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.

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 lift is more *uncertain*. Porpoising may be harder down low than when up high. 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 toward a good area. By 2,000 feet you have several good fields selected. 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 near good fields, looking for wires, slope, ditches, planning approach and so on for a good 10-20 minutes.

Final glide landouts are totally different. At 2 miles out, 40:1 is 300 feet; 400 feet is enough to blast home at 90 knots. Thus, *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, and the bare minimum of 1,500 for decent field selection happens 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 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 outlandings. 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, and you'll get some of that back as you burn off the extra height at higher speed once you're sure you have the finish line made.

As you try to go faster, the options narrow. An ambitious pilot cannot give up 2-3 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 the fields 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 before 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 (Premature Termination of the Tow) emergencies. Ten seconds of indecision has been fatal. I rehearse congratulating myself for making the safe decision and not criticizing myself for landing out and blowing the contest.

This danger is entirely a creation of the rules. If the rules specified a 1000-foot finish altitude for speed points, then a pilot at 800 feet, 5 miles out will calmly either stop to thermal or do a safe pattern into a well-inspected field. He gains almost nothing by stretching his glide to the airport.

We have crash after crash within 5 miles of the airport, including totaled 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 first analyzed the task. Then you flew to learn to do in the air things you understood on the ground. Eventually, 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. These articles are 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 in the air, and then to make them subconsciously. 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 only I could make in flight the decisions advocated by my own articles!

Advanced pilots have made this automatic. They often have trouble describing what they do, as you might have trouble describing how you 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 change 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.