Table 1

Theoretical average cross country speed Discus, 735lbs

Average climb rate (kts)	Best Speed to Fly (kts)	Theoretical average XC speed (km/h)
0	52 (best L/D speed)	0
1	56	44
2	67	62
3	75	77
4	80	87
5	81	94
6	82	101

MacCready Theory

The classic MacCready construction is used with the glider's polar curve to determine the theoretical optimum speed to fly and average cross-country speed for a range of climb rates *(see* Figure 1, *left).*

Tangents to the polar curve are drawn from average climb rate values on the vertical axis. The point at which the tangent touches the curve is the theoretical optimum speed to fly, and the point at which the tangent cuts the horizontal axis is the theoretical average speed for that climb rate.

Figure 1 illustrates the polar curve for an unballasted Discus with the construction for 2kt average climb rate. By repeating this construction for various climb rates using your own glider's polar curve, it is possible to draw up a table of average climb rate versus theoretical average cross-country speed, as in Table 1, above (again, the example is for an unballasted Discus).

Electronic flight computers basically do the same sum when computing the speed to fly and in still air would direct the pilot to fly at the quoted best speed for any given MacCready setting. Increasing the wing-loading by the addition of waterballast has the effect of increasing the speeds by approximately the square root of the weight increase, so adding 200lbs of water to the Discus increases quoted speeds by about 10 per cent (it's interesting to note that with the Discus at plausible UK climb rates it's almost never worth flying faster than 80kt unballasted). Classic MacCready theory demands that the MacCready is set to the anticipated average climb rate in the next thermal to give the optimum speed to fly towards that thermal. There are also several practical considerations to bear in mind when setting the MacCready.

How fast to fly

A common mistake amongst inexperienced competition pilots is to fly too fast by setting too high a MacCready setting. One reason is over-estimating climb rates.

Consider a typical British day, on which our pilot arrives under a promising-looking cloud, feels a good surge of lift and spends 3 turns, say 1 minute, getting centred and climbing 100ft in the process. Once centred, he climbs for 2 minutes at a settled average of 4kt, 800ft. His total climb so far is 900ft in 3 minutes. The lift then dies off as he approaches cloudbase. He spends another 3 turns (1 minute) climbing a further 100ft trying to recentre the lift before deciding that he has wasted enough time and leaves the thermal. Total height gain is 1,000ft in 4 minutes, so ***the actual average climb rate from entering to leaving the lift is only 2.5kt even though the averager settled at 4kt.***

The achieved climb rate from entering to leaving the thermal will depend very much on how quickly the pilot centres, how decisive he is about leaving as the thermal dies at the top and how deep the operating depth is, but the important point to note is that the actual average climb rate will always be rather less than that indicated by the typical 20-30 second averager found in most variometer systems. It is very easy to over-estimate the average climb rate.

Now consider the effect of flying a little slower than the optimum speed between thermals.

Figure 2 *(above)* illustrates the effect of flying between thermals on an average British 3kt thermal day at best L/D speed instead of the theoretical optimum inter-thermal speed. Theoretical optimum is shown by yellow line 1, tangent to the polar curve from the 3kt point. However, if the glider is flown between thermals at the zero MacCready speed (best L/D) of 52kt, the theoretical cross-country speed in this case is the point where the green line 2 from the 3kt climb point to the polar curve at 52kt crosses the horizontal axis. Incredibly, the theoretical cross-country speed is only 8.5km/h less, a reduction from optimum of just 11 per cent, but with the advantage of achieving a glide angle of 43:1 instead of the 32:1 achieved at 75kt – a 34 per cent improvement in glide angle and therefore search area for the next thermal.

Not only does flying slower significantly reduce your chances of an outlanding or time-consuming low scrape, but by increasing your search area significantly, also increases your chances of finding a better-than-average thermal.

Clearly as speed flown between thermals moves closer to the theoretical optimum, the average speed increases until there comes a point where there is very little difference in average speed, but still remains a significant improvement in glide angle. The theoretical optimum inter-thermal speed for a 1.5kt MacCready setting is 62kt, giving a glide angle of 39:1. If this 1.5kt MacCready speed of 62kt is flown on a 3kt day, the actual average speed will be 74km/h. This is just four per cent less than the optimum, but with 22 per cent better glide angle and search area.

If this 22 per cent better search area yields a thermal just 1kt stronger at 4kt, the average cross-country speed will now increase to 82km/h, as illustrated by the red line 3. This is six per cent quicker than that achieved by flying strictly at theoretical optimum cross-country speed and climbing at 3kt. This assumes that the pilot actually does find a stronger climb as a result of flying a bit slower with a much bigger

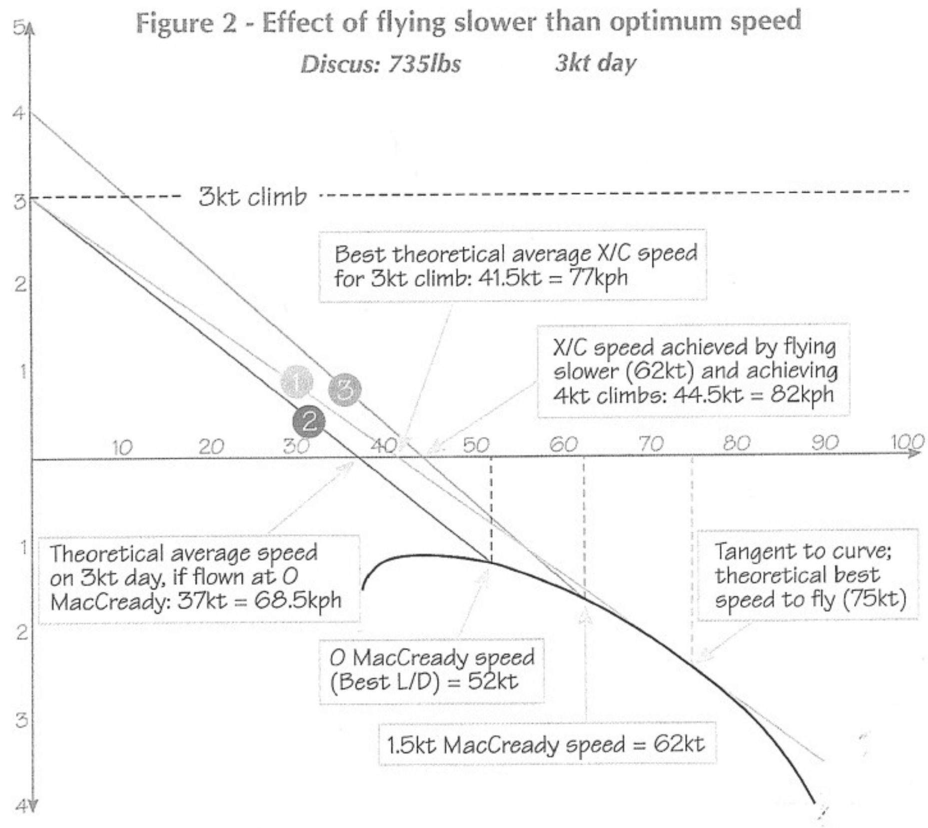

Figure 2: in typical UK conditions, flying a little slower by setting a lower MacCready has little effect on theoretical average cross-country speed but it does increase your search area for the next good thermal (Steve Longland)