

Flight Analysis using Flight Recorders.

Flight recorders are great for proving flights have been completed for the purpose of competitions and badges but they have the ability to tell us a lot more than. “Task not completed.” There is an enormous amount of information that can be gleaned from the flight recorder. Let’s look at a number of pieces of information one by one. I have used SeeYou as this is certainly the most common flight analysis program being used.

Thermalling rule number 1. Maintain a constant angle of bank and speed so that your position is fixed in space until you choose to move it.

If you want to use your logger to give you some decent analysis it is important to set the logger to record at a suitable intervals. If the recording interval is too long you will get traces like the one in Figure 1, and you will learn nothing from your logger as to how you are thermalling. The best setting to put your logger on is one that will give you a regular shape Square, Pentagon or Hexagon when thermalling at the correct angle of bank and speed. Fig 2 indicates that if we have a glider flying at 45° angle of bank the time to turn will be 15 seconds at 45 knots, 16.5 seconds at 50 knots and 18 Seconds at 55 Knots. So if we have a logger setting of 3 seconds we will get 5 fixes per turn and so get a pentagon when thermalling dry and Hexagon when thermalling wet. Naturally this depends upon the glider you are flying, but it shows the principle. We should see a thermal as Fig 3 in this case with nice pentagons, assuming the pilot was flying dry! If however we see the geometry changing from pentagons to squares and then to Hexagons we can see that the pilot is flying erratically.

For more accurate examination of a climb look at the time you entered the thermal, and the time you exited. Count the number of turns and calculate the turn rate. And compare to Figure number 4.

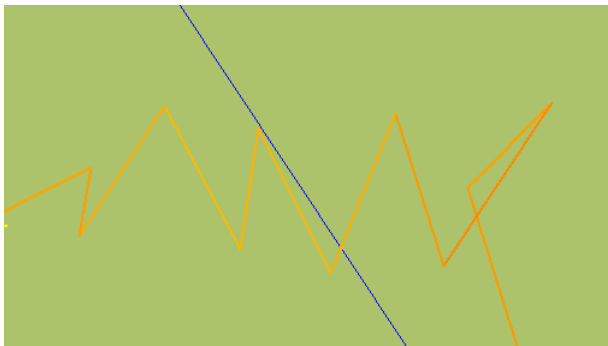


Fig 1

	Speed in Knots		
	45	50	55
45°	15	16.5	18
3 Sec int	5	5.5	6
Shape	Pentagon		Hexagon
Time to turn in seconds 45° v Speed			

Fig 2



Fig 3

Turn time in Time in Seconds	Speed in Knots				
	40	45	50	55	60
25	28.3	31.8	35.4	38.9	42.4
30	22.8	25.7	28.6	31.4	34.3
35	18.8	21.2	23.5	25.9	28.3
40	15.7	17.7	19.7	21.6	23.6
45	13.2	14.8	16.5	18.1	19.8
50	11.1	12.5	13.8	15.2	16.6

Fig 4.

Thermalling Rule 2, never fly in the same bit of sink twice.

The data recorder can help show you how well you are obeying this rule. If your logger recording interval is much more than seven seconds it will smooth out the graph and be of little use. To look at the climb it is necessary to zoom into the thermal so that it is stretched out considerably.



There are two examples below, one where the pilot has the thermal cored, the other not. Fig 5

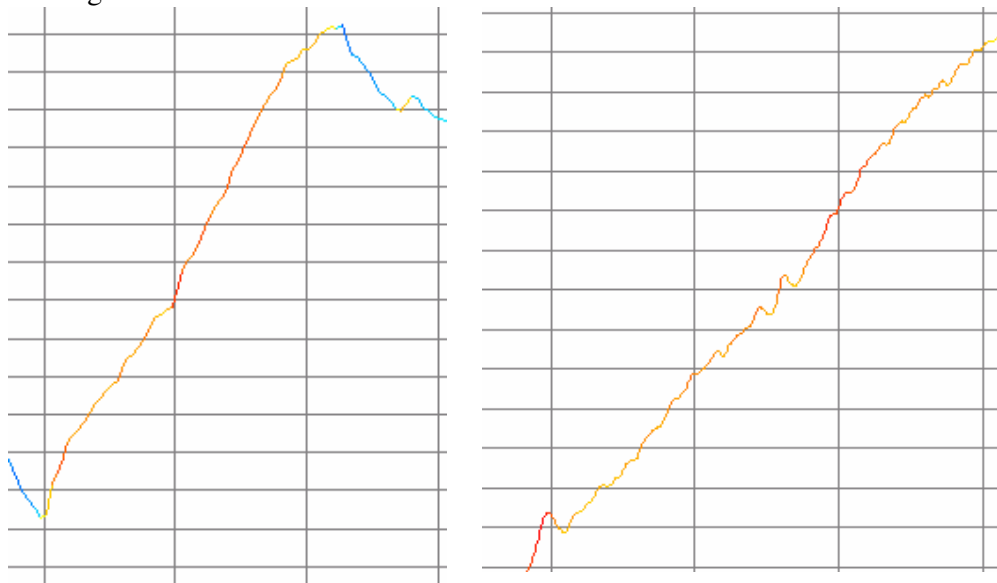


Fig 5

Rule 3. Leave the thermal when it becomes the strength of the next thermal that you will climb in.

What so often happens with novice pilots is that they stay in a thermal until it reaches the top. Rather than when it begins to loose its strength. Again we can look at a couple of traces in Fig 6

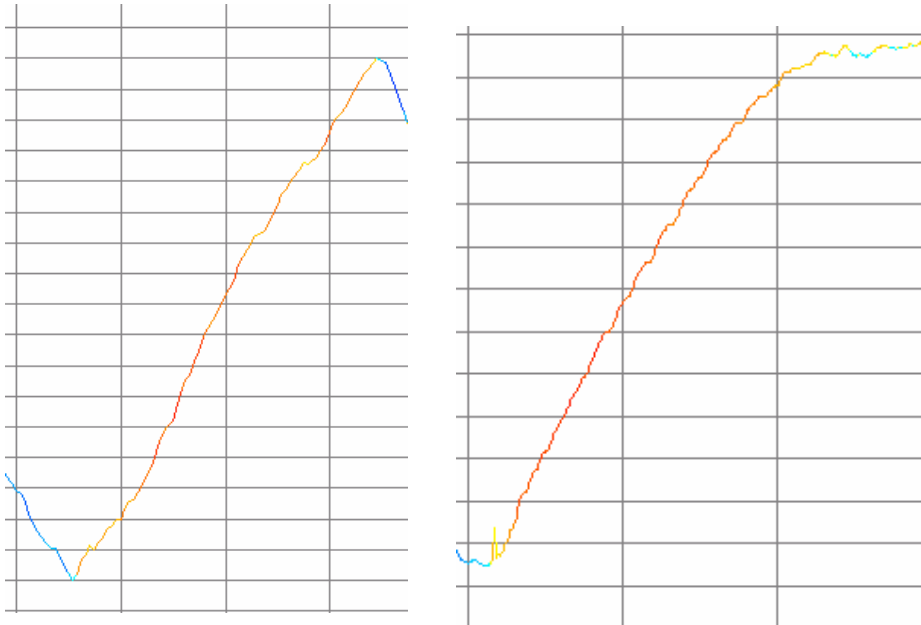


Fig 6

The climb on the left is what we are looking for but the pilot on the left needs some improving and we will detail the aspects of his climb. In this climb the pilot averaged 5.7 knots for the bulk of the climb but by the time he had left the climb it averaged 3.9 knots. So how did we work out these figures and is there anything we can examine to see why the pilot did what he did. Let's look at the map view of the pilots on the right's flight in Figure 7. We can see that many pilots climb well in the thermal but then think that they have lost the core so start looking around for "The lost core" rather than moving on, this is clearly seen by looking at this view. To get the figures for the climb rate within the thermal we go to the map and pressing the shift key we click the mouse on the start of the climb a blue marker will show we keep the shift key held down and move the mouse to the point that we want to measure to and release the shift key, the red end marker is created. If we go to the statistics page and click the statistics tab we can read the data from the selected period, as shown in Figure 8. Using this technique we can further examine other sections of the climb.



Fig 7

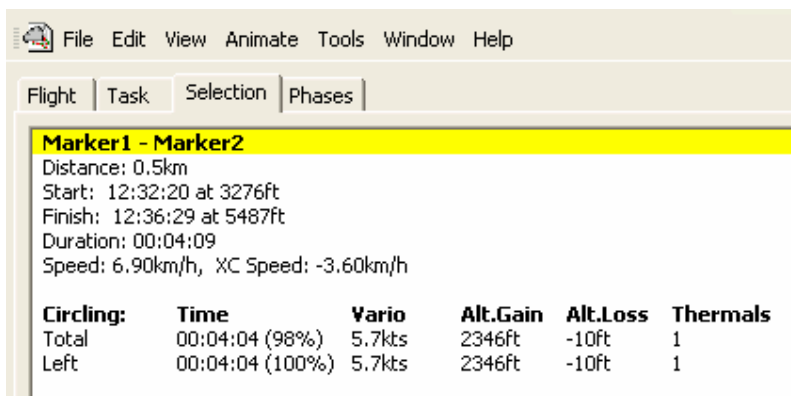


Fig 8

Diversions?

Some pilots fly in a straight line to the next turning point whereas others divert a lot with the aim of picking up as much energy as possible on the way to the next turning point. It is very difficult to put a rule how much diversion should be done. Perhaps the best way to see how much diversion should be done is to look at other pilot's flights on the same day. But how do we work out how much diversion has been flown? On the top left of the screen is the distance between the two marked points 260 k in this case Fig 9. Further down is the column Dis Done in this case 285.8 k, an increase in

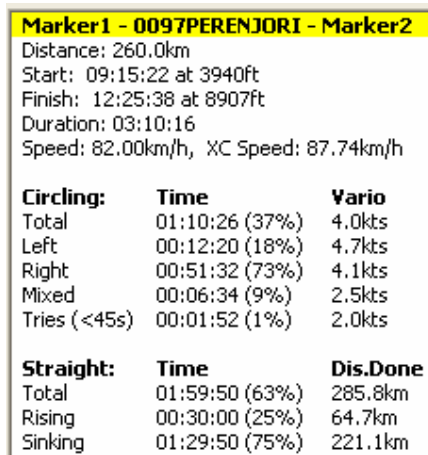


Fig 9

distance of 9.9%. So what does this mean when it comes to degrees of diversion? The chart Figure 10 shows the angle of diversion from track against the extra distance flown. So we can see up to 15° diversion gives virtually no extra distance to fly but once we start to divert any more we need to start to be expecting to get a thermal that will increase the cross country speed by that amount. But remember that sometimes a diversion is necessary to just to stay in the air.

0	0.00%
5	0.38%
10	1.54%
15	3.53%
20	6.42%
25	10.34%
30	15.47%
35	22.08%
40	30.54%
45	41.42%
50	55.57%
55	74.34%
60	100.00%

Fig 10

General information from the Logger.

We can see from the data the date of the flight and basic self explanatory details, but in addition we can see that this flight is legal in that the landing took place before sun set and certainly before last light. We can of course see our flight time for our log book.

General information
Date of flight: 10/01/2004
Pilot name: James Cooper
Glider type: C0VL55
Competition class: Unknown
Registration: Unknown
Competition number: XIF
Takeoff: 09:33:52 at 1010ft (Sunrise: 05:16:22)
Soaring begin: 09:33:52 at 987ft
Soaring end: 19:27:12 at 1036ft
Landing: 19:27:12 at 1031ft (Sunset: 19:20:46)
Duration: 09:53:20

Fig 11

In addition we can confirm that the task has been completed but we have additional information like the speed for each leg with the additional information as to the height that each turn point was rounded, so from this chart we can see that Pithara and Alderside were both rounded at the same height, what a coincidence, and so the speed of 92.13 kph down that leg was a true speed whereas the next leg all be it a bit slower could perhaps be compensated by the fact that the turning point was rounded somewhat higher. In addition it can be seen that the third turning point has no town name just a number that has given to it, we no longer have to turn specific points on the ground when using flight recorders. We should consider that if there was a wind blowing did we turn the turning point at the most efficient height.

Declared Task - FAI Triangle, Start on leg - (669.2km)							
Declaration is valid.							
Date/Time: 10/01/2004 8:17:14 AM							
Type: FAI Triangle, Start on leg - (669.2km)							
Task distance: 671.6km							
Takeoff point: 0000TAKEOFF							
Landing point: 0000LANDING							
Points:	Latitude/Longitude	Dis.	Alt.	Time	Duration	Speed	
1) 0001CUNDERDIN AI	531°37.390' E117°12.989'	---	3507ft	09:42:25	---	---	
2) 0074PITHARA	530°23.239' E116°40.040'	147.0km	5869ft	12:24:00	02:41:35	54.60km/h	
3) 01171000T2	530°28.000' E118°39.999'	191.9km	5869ft	14:28:58	02:04:58	92.13km/h	
4) 0025ALDERSIDE	532°22.190' E117°16.490'	249.4km	7414ft	17:13:42	02:44:44	90.85km/h	
5) 0001CUNDERDIN AI	531°37.390' E117°12.989'	83.2km	7851ft	18:27:54	01:14:12	67.28km/h	
All reached turn points rounded ok. Task completed.							
Distance: 671.6km, Duration: 08:45:29, Speed: 76.68km/h, Speed over triangle: 76.41km/h							

Fig 12.

Flight statistics															
Maximum altitude gained: 8963ft, low point 964ft at 09:33:54, high point 9927ft at 16:06:10															
Circling:	Time	Vario	Alt.Gain	Alt.Loss	Thermals										
Total	03:53:42 (39%)	3.3kts	81631ft	-3366ft	58										
Left	02:24:38 (62%)	3.6kts	54751ft	-1759ft	34										
Right	01:19:12 (34%)	2.9kts	24698ft	-1283ft	20										
Mixed	00:09:52 (4%)	1.9kts	2182ft	-325ft	4										
Tries (<45s)	00:12:10 (2%)	1.5kts	2628ft	-837ft	18										
Straight:	Time	Dis.Done	Alt.Gain	Alt.Loss	Avg.Speed	Glides	Avg.Glide	Mean L/D							
Total	05:59:38 (61%)	828.3km	26621ft	-104836ft	138km/h	58	14.3km	34.7							
Rising	01:01:36 (17%)	128.4km	4.3kts		125km/h			-16							
Sinking	04:58:02 (83%)	699.9km		-3.5kts	141km/h			22							
Vario															
<1.5	2	3	4	5	6	7	8	8.5>	[kts]						
53.2	43.2	44.2	31.4	24.3	17.0	10.1	5.5	4.8	[min]						
1657	9281	12844	13957	12300	10594	7657	4911	5062	[ft]						
Altitude															
<2750	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9250>	[ft]
17.8	21.1	8.2	8.9	9.8	8.1	13.8	15.9	21.5	18.0	29.2	21.6	15.5	14.0	10.3	[min]
1.5	1.4	2.2	2.8	2.2	3.0	3.2	4.4	4.0	4.1	3.4	3.8	4.3	4.0	4.8	[kts]
Speed															
<110	120	140	160	170>	[km/h]										
51.5	98.9	84.6	101.4	23.2	[min]										
90.0	199.2	198.4	271.2	69.5	[km]										
-5164	-14518	-13520	-35515	-9498	[ft]										

Fig 13

Percentage time Thermalling and Cruising.

Flight statistics are worth studying, Figure 13. In this case the pilot spent 39% of his time thermalling and nearly 4% of this time in sink! Perhaps they need some polishing up here.

The percentage can be calculated by taking the Altitude loss / (altitude gain + Altitude loss). In this case $3366/(3366+81631)$

We should question if the 39% of the time thermalling is good or not. Looking at the gliders polar should give us an indication as to what we should achieve on a given day.

Using Figure 14 we can calculate the expected time thermalling. We look at the average thermal strength for the day 3.3knots and then draw a line till it touches the polar of our glider. We can see the average sink rate that we expect whilst gliding between thermals 2.6 knots in this case, in addition to the average inter thermal speed we should have flown at and the cross country speed for the day. If we add the average thermal strength to the average sink rate whilst cruising $3.3 + 2.6 = 5.9$ we can then get the expected percentage of time cruising $3.3/5.9 = 56%$ and climbing $2.6/5.9 = 44%$ so on this day the pilot actually achieved 39% climbing bettering Macready by 5% by using streets and picking up lift in cruise.

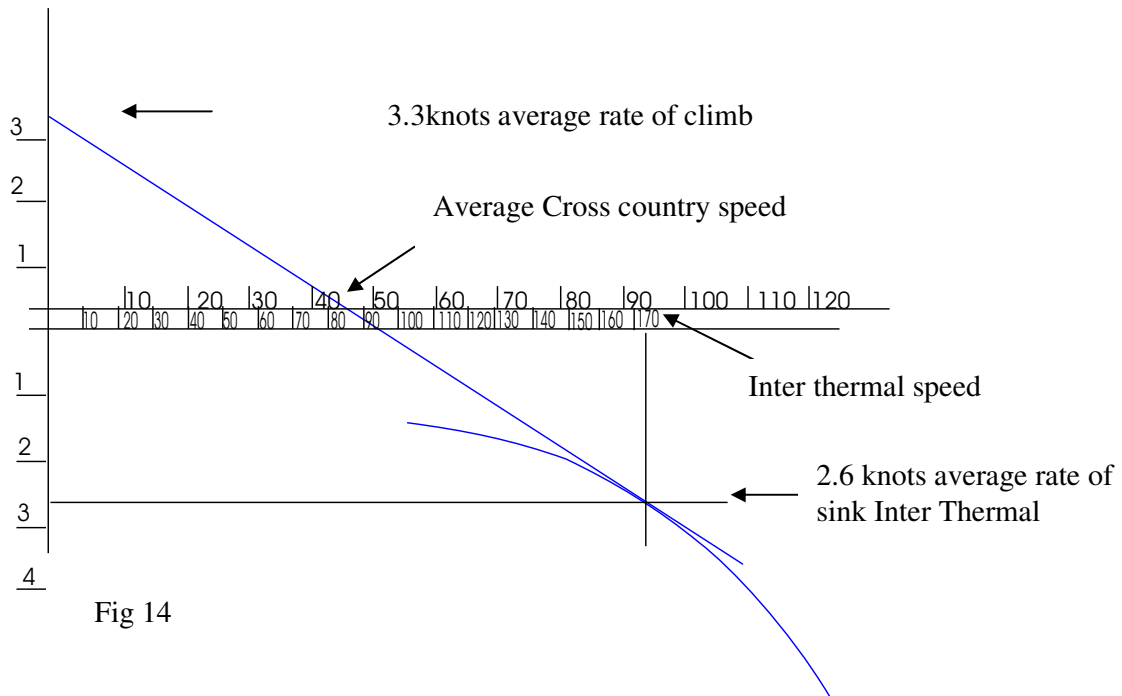
We would expect on a Cu day to be able to better the theoretical cruise percentage by a greater margin than on a blue day. You will find that the stronger the thermal strength the lower the percentage time you will spend climbing.

Let's look at the straight flight. 17% in rising air with an average of 4.3 knots and the rest in sinking air. This statistic is so variable on the weather conditions but try to keep it as high as possible. At least we can see that the pilot flew a little slower in the lift but what does the polar suggest Figure 15. Firstly we can see with the 3.3knot thermal average the pilot should have averaged about 85kph cross country speed, but this would have been affected by the wind speed on the day of 21kph. The recommended glide angle is the angle of the line drawn from the average rate of climb to the point where it touches the polar in the diagram above. We can calculate it as follows. Sink rate in cruise / Interthermal speed. Being in this case $93\text{knots}/2.6\text{knots} = 35.7$ whereas the actual glide angle for the day was 34.7 as shown in the statistics. Don't forget however that this is affected by the wind, a head wind will decrease your glide angle for the leg and a tail wind decrease it. But remember that if some of the flight is into wind and some down wind on average the into wind leg suffers more than the down wind leg gains.

The Polar curve also indicates that the inter thermal speed should have been about 170 Kph on pure Macready, whereas the statistics show that 140 was nearer the speed flown and 170 was the maximum, ok we expect that we should always fly slower than the theoretical Macready setting, but perhaps in this case it was too slow. This could answer some of the reasons why the glide angle was flatter than the theoretical and thus why the overall speed was slower than predicted.

Note that if the statistics are taken over a long flight where the beginning of the day is poor lift and the middle strong followed by poor lift at the end of the day again,

averages are of little use, we need to split the day up into segments of constant strength in order to get some decent figures to work on.



What else can we see on the statistics on Figure 13? The pilot has climbed almost twice as many turns to the left as right, perhaps they need a little more practice going the other way, although there does tend to be logic in turning to the right when for example the headwind track has the wind on the right quarter. I have seen some traces with virtually all the turns in one direction, in these cases the pilot needs to do some major practice at fixing this. Note however not to take into account the percentage of time turning to right or left prior to the start as flights in competition prior to the start will generally be to the right. So we see again the need to break the flight into sections. There were four thermals where the turns were mixed, i.e. the pilot changed direction and looking further we can see that they gained little in height and rate of climb. If you are trying to study thermal rotation and reverse the turn see if it is worthwhile. Just look at those tries 18 in total in reality a waist of 12 minutes for the flight, not only this but using the calculation we did before we can see that 24% of the tries were in sink!

In SeeYou flight statistics there are four tabs. The first for the full flight the next for the flight, the third for a section that you may have specifically marked out as we did earlier and the last is the Phases as shown in Fig 15. This helps break down the flight for more detailed analysis. Whereas the barograph trace shows the high and low spots,

it also shows the pilot who likes to stay high and the pilot who will risk going low it is difficult to see at a glance the rate of climb, although this can be done by double clicking anywhere on the climb and down the bottom you will get the figures for the rate of climb at that point and the average rate of climb from the top to the bottom. The phases show at a glance the mentality of the flight. We can see at a glance on this flight that climbs of over 6 knots were being achieved by looking in the column AVario. But at the time of 12:22 and 12:26 time was wasted in much lower rates of climb than were necessary 5 minutes in total at less than 2/3 of the expected climb rate and at a good height.

The glides can also be examined and considering the rates of climb being achieved 150 kph is 80 knots perhaps not fast enough for the aircrafts polar shown in Fig 16 that indicates a speed to be flown of 160 Kph, OK no need to fly at Mcready but not that much slower when the conditions look reliable. We can however look at the times that the speed was slowed down to fly through rising air at 116 kph no height lost but still a bit slow 62 kph when there were 6 knot climbs ahead.

Phase	Begin	End	Duration	Start Alt.	End Alt.	dH	AVario	AGsp	DisDone	D/H
Straight	11:54:58	12:04:58	00:10:00	8566ft	6489ft	-2077ft	-2.0kts	149km/h	24.8km	39
Circling - Right	12:04:50	12:06:58	00:02:08	6328ft	7791ft	1463ft	6.8kts			
Straight	12:06:50	12:09:38	00:02:48	7742ft	7306ft	-436ft	-1.5kts	141km/h	6.6km	50
Circling - Right	12:09:30	12:11:28	00:01:58	7122ft	8398ft	1276ft	6.4kts			
Straight	12:11:20	12:22:30	00:11:10	8454ft	5311ft	-3143ft	-2.8kts	148km/h	27.6km	29
Circling - Left	12:22:28	12:24:00	00:01:32	5311ft	5869ft	558ft	3.6kts			
Straight	12:23:58	12:26:22	00:02:24	5869ft	5869ft	0ft	0.0kts	116km/h	4.6km	9999
Circling - Left	12:26:14	12:29:34	00:03:20	5718ft	7122ft	1404ft	4.2kts			
Straight	12:29:26	12:36:30	00:07:04	7148ft	6591ft	-558ft	-0.8kts	136km/h	16.0km	94
Circling - Left	12:36:22	12:41:26	00:05:04	6384ft	9609ft	3225ft	6.3kts			
Straight	12:41:18	12:55:34	00:14:16	9557ft	5974ft	-3583ft	-2.5kts	149km/h	35.3km	32
Circling - Left	12:55:26	13:00:30	00:05:04	5843ft	8736ft	2894ft	5.6kts			
Straight	13:00:22	13:04:54	00:04:32	8704ft	7552ft	-1152ft	-2.5kts	153km/h	11.6km	33
Circling - Left	13:04:46	13:06:06	00:01:20	7388ft	8146ft	758ft	5.6kts			
Straight	13:05:58	13:06:22	00:00:24	8175ft	8343ft	167ft	4.1kts	74km/h	0.5km	-9.6
Circling - Mixed	13:06:14	13:08:10	00:01:56	8228ft	9268ft	1040ft	5.3kts			
Straight	13:07:58	13:12:24	00:04:26	9186ft	8228ft	-958ft	-2.1kts	150km/h	11.1km	38
Circling - Left	13:12:16	13:14:56	00:02:40	8034ft	9301ft	1266ft	4.7kts			

Fig 15

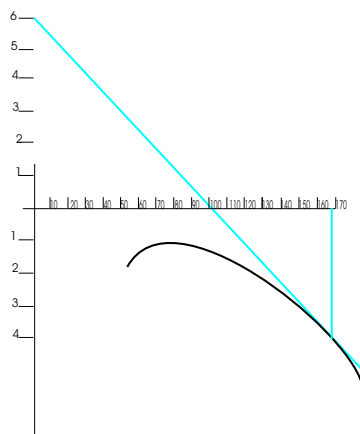


Fig 16

Maggot racing.

This is a term for adding a number of gliders to the view that has a line below the glider indicating its height. When animated they look like little maggots racing round the course. You can add a number of gliders to the screen and synchronise them to all start at the same time, irrespective of their actual start time, using the icon show. Now you can see why the winner won and the loser lost by looking at the critical decisions made.



Perhaps the most important thing that we can achieve with these flight recorders is to examine how we fly, but most important of all it to put into action what we have learnt. There is no point looking at SeeYou and saying look at that great climb that I or you had if you do not learn from the data and put it into action in the future.