Parallel-Flight Testing With Your Flight Data Recorder

If you haven't spoken a number, you haven't said anything at all. (1)

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Introduction

An inexpensive, convenient and enjoyable way of measuring the effectiveness of performance modifications to your glider is by flying parallel with another glider before and after the change.

Vertical movement in the air corrupts sink rate measurements, making it necessary to take multiple measurements in different atmospheric conditions in order to average scatter out of the numbers.

Flying parallel versus a reference glider cancels the scatter since both gliders experience the same perturbations in the air. If you calculate the sink rate difference between the two gliders at a given airspeed, before and after a modification, the constant sink rate of the reference glider will subtract out, leaving only the change in the test glider. This can be seen in the following equation:

$$Ct = (Sta - Sr) - (Stb - Sr) = Sta - Stb$$

where

Ct = change in sink rate of test glider
Sta = sink rate of test glider after mod
Stb = sink rate of test glider before mod
Sr = sink rate of reference glider

For this to work, the two gliders must be close enough laterally and vertically so that, for all practical purposes, they see the same atmospheric perturbations.

This technique has been honed to a fine point by European aerodynamicists. They carefully measure the reference glider, and then fly it always at the same gross weight and condition. Absolute sink rate data may then be obtained by analyzing photographic evidence or log data. When high quality data acquisition equipment is used together with sophisticated processing algorithms, very accurate results are possible.

But the lack of these resources does not prevent you from using your IGC logger to take meaningful measurements of your performance modifications.

You can arrange to meet up with your reference pilot for a parallel flight test as part of a normal soaring flight. This may happen when you return from a cross country flight at the end of the day when the air is smooth and you have excessive altitude to burn off before landing.

Obtaining meaningful L/D values requires calibrating your airspeed system, a process that involves special instrumentation and skills. However, as long as you are only interested in sink rate differences, before and after a modification, then calibrating the airspeed system is not necessary. However, your sink rate measurements cannot be compared accurately to other gliders, since the airspeeds will not match.

Concept

The basic idea is for the test and reference gliders to fly as close as practical for extended periods of time at precisely the same airspeed. The sink rate of the test glider relative to the reference glider (St - Sr) may then be taken from the two IGC logs by matching the appropriate segments in time. A spreadsheet may be used for the numerical analysis and/or graphing the log segments.

It is not necessary to fly against another glider if the same type. In fact, if you are measuring a substantial performance improvement it is advantageous to fly against a newer glider too minimize the altitude differential that develops over long periods of time. This is because, if the vertical separation becomes too great, the two gliders may no longer be flying through the same perturbations. An easy way to check this, after the fact, is to simply study the two matched log segments. If the two gliders go up and down together and match each other bump for bump then the gliders were close enough.

A legitimate object is to compare performance differences in rough air as well as smooth. After all, everyone knows that the pristine performance figures that are published for gliders is seldom realized in real soaring conditions. You really want to know how your ship has been improved in turbulent as well as smooth air.

You should extend the speed runs as long as possible. The longer, the better. Five minutes is not as convincing as 10 or 20 minutes. This may necessitate course changes and relative elevation adjustments.

Preparation

It is difficult to communicate procedures in-flight to another pilot that you happen to meet. More often than not, they do not understand the concept, so they fail to come in close enough and hold formation, precisely matching your airspeed. Instead they instinctively try to maintain your altitude by slowing down and speeding up in lift and sink.

Therefore, it is best to hold "ground school" beforehand. Nothing is lost, however, if you chance to meet a newbie and give it a try. It may just work out.

Procedure

It is important that you, as the test pilot, set the speed and course since you are the one who knows the airspeeds, durations and conditions you want to test.

Use your radio to coordinate changes so that you never surprise the reference pilot.

The gliders must manoeuvre into a wing tip formation, one wing-span apart, and maintain the course and speed that you select. The reference pilot must hold his fore/aft position relative to yours and not be concerned that one glider is sinking faster than the other.

You should choose a preferred side for the reference glider. If you have a camcorder or camera mounted for wing tip shots that should be the side of choice. This must be understood beforehand.

Manoeuvring into position is not easy. First, you should set a course line that puts the higher glider behind. Then the lower glider should fly at minimum sink speed while the higher glider speeds up to approach one side from behind, using the spoilers as necessary to arrive at about the same altitude. If the gliders meet with excess altitude difference, then the higher glider should descend into formation position using spoilers.

If the test glider is expected to outperform the reference glider, then the reference glider should start a little higher than the test glider, and vice versa. This will extend the time before an elevation adjustment may become necessary.

The reference glider should end up beside the test glider, one wing span away, to avoid its wing tip vortex, and far enough behind to eliminate the possibility of a collision and so that the reference pilot can easily judge and maintain his fire/aft position. The reference pilot then has one purpose in life...to fly in formation precisely.

The reference pilot should report his vertical position periodically so that you will know how it is going and will be able to decide when an elevation correction is necessary or the speed run should end.

Because the reference pilot sees both gliders, he is in a position to judge whether or not they are following disturbances in the air in a synchronized fashion. When the elevation difference becomes so great that the gliders are no longer synchronized, he should notify you for a decision. In any case, this point is easy to detect later, when the two logs are compared.

When an elevation correction is needed, the higher pilot should open his spoilers fully and close them somewhere below the other glider. The suddenness of the change will be evident when the logs are compared.

When a course change is appropriate, coordinate it carefully with the reference pilot to avoid the possibility of a collision. The turn should be in the direction of the lower glider. That positions the higher glider to fly a longer radius at a higher speed while maintaining the altitude match as closely as possible. If there is no appreciable elevation difference, then turn away from the reference glider to avoid a mid-air.

Finally, you will need thermometer with a probe to take the temperature of the air before and after a speed run. You will need this to estimate an average temperature for use in correcting calculated sink rates to equivalent sea level values.

One last piece of advice, get a firm commitment from the reference pilot to send you his IGC file. Better yet, get it before you leave the airport. You will be surprised how hard it can be to lay your hands on the other log file. Sometimes, it gets left at the airport and sometimes, for whatever reason, it just is not be forthcoming. Not surprisingly, this happens more often when the reference glider is a newer bird that did not match your performance.

Presentation

There are four obvious ways to present the outcome of your flight test.

Post the Video

The easiest is to post your wing tip video clip to a video website. This makes the point graphically, but does not reveal numerical information.

Plot the Log Segments

For this, you will need a text editor with column mode that you can use to copy the time-matched altitude sequences from the two IGC files. You can then paste them into a spreadsheet (contact jim@deturbulator.org for a sample Excel spreadsheet) and plot them together.

IGC files are merely formatted text files. Lines beginning with the letter "B" contain the position fixes. The format of these records is shown in Fig. 1 below.

```
          1        2               3
1 234567 89012345 678901234 5     67890 12345
  time   lat      long      valid p-alt g-alt
B hhmmss DDMMmmmN DDDMMmmmW v     ppppp ggggg
```

Figure 1. Format of a “B” Record

The **time** field runs from the 2nd through the 7th character and has the format **hhmmss**. Use this to match sequences of fixes between the two logs. Don't worry if they do not match to the second. A few seconds difference will not matter.

One issue that you may encounter is that the sample periods of the two loggers may not be the same. For instance, one may space the "B" records two seconds apart and the other four or six. This is not a problem if you plot each glider’s sequence with its own time axis in an XY (scatter) chart. The points from the two gliders do not have to fall on the same time points.

Another problem is the tendency for loggers to drop fixes. Before extracting the altitude column, scan through the **time** fields looking for gaps. When you find one, insert a dummy record with all 9s in the altitude field. Then, in the spread sheet interpolate those altitudes between their neighbours. A simple formula like the one below will do the job:

$$\text{this} = \text{before} + (\text{after} - \text{before}) / 2$$

Finally, some loggers will reduce the sample period to say one second when within a certain radius of a turnpoint. You should be on the lookout for this situation too. This will work out ok in an XY (scatter) chart.

It helps to insert a blank line at the beginning and ending points of the selected speed run to delimit it in an easy to see way.

Next, you will need to locate the **altitude** fields. There are two, **pressure altitude** (columns 26-30), and **GPS altitude** (columns 31-35). Using the column mode of your text editor, copy the **pressure altitudes**, from the beginning to the end of the segment, and paste them into the spreadsheet. Loggers that do not provide pressure altitudes usually substitute the GPS altitude in the pressure altitude field. If that should not be the case, then use the GPS altitudes. It will not matter since your speed runs are on the order of minutes and you will be fitting a linear curve to the points. Beside this column, add a column that counts from zero in sample period steps (e.g., four second steps). Now, do the same for the second glider's log data. After that it is a matter of converting the altitude units from meters into feet and plotting the results. A section from the data entry part of a spreadsheet is shown in Fig. 2 below. Fields highlighted in yellow are manually determined by you. Others are calculated.

		ASW-28					Std. Cirrus	
sec	min	m	ft		sec	min	m	ft
0	0.00	1176	3858		0	0.00	1165	3822
4	0.07	1174	3852		6	0.10	1159	3802
8	0.13	1169	3835		12	0.20	1148	3766
12	0.20	1160	3806		18	0.30	1134	3720
16	0.27	1147	3763		24	0.40	1112	3648
20	0.33	1140	3740		30	0.50	1100	3609
24	0.40	1134	3720		36	0.60	1098	3602
28	0.47	1126	3694		42	0.70	1076	3530

Figure 2. Spreadsheet Data

Fig. 3, below is an example XY (scatter) chart for a four minute speed run. Notice that the spreadsheet's ability to fit a linear curve to each data sequence was used and the option was used to display the linear equations. The constant that multiplies "x" is the slope of the curve in distance units over time units as charted; e.g., feet per minute. This is the overall sink rate of the glider for the speed run.

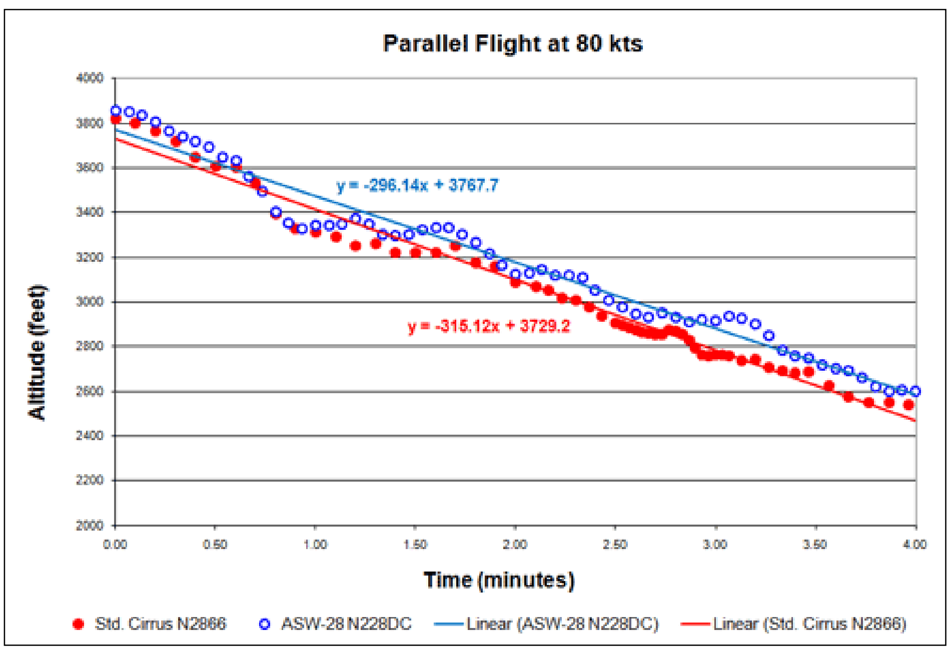

Figure 3. Example Altitude Profile Chart

Calculate Sink Rate Differences

The third option is to go farther and have the spreadsheet calculate the sea level equivalent sink rate differences (St - Sr) before and after your modifications. This can be done by typing in the slope constants from the two linear curve fits and basing the calculations on them.

This will give you a rough comparison to the polar of the reference glider at one speed. Of course, published polars use calibrated airspeeds and you measured indicated speeds on the test glider. So, there will be an error when comparing to a published polar. But, the error falls out when you subtract the before and after differences for a given speed.

Fig. 3 below shows a sample difference calculation.

	Sink Rate ft/min	Avg Alt ft	Avg Alt ft	Temp F	Temp R	Sea Level Correction Factor	Sea Level Sink Rate ft/min	
ASW-28	-296.14	3225					-290.0	=Sr
			3182	75	534.67	0.979		
Std. Cirrus	-315.12	3140					-308.6	= St
						difference	-18.6	= (St - Sr)
						% difference from ASW	6.3%	

Figure 3. Example Calculation

The yellow highlighted numeric fields are determined by you. Enter the slope constants from the chart as the raw Sink Rates. Then enter the average temperature during the speed run. For purposes of calculating the Sea Level Correction Factor, the spreadsheet will figure the Average Altitude of the run for each glider and then average them into a single value. The Temperature you entered will be converted to Rankine units and then used in the Sea Level Correction Factor calculation. This in turn will multiply the two raw Sink Rates to determine the Sea Level Sink Rates. Finally, the difference is taken and a percent difference (test glider compared to reference glider) calculated.

Send Logs to the Deturbulator Project

Finally, the easiest option is to send your log files to jim@deturbulator.org for publication on **The Deturbulator Project** website (www.deturbulator.org).

Conclusion

Measuring performance changes is not difficult, time consuming or expensive and it can be fun and interesting. Parallel flying is the way to do it. You will get useful results for one or two speeds in just two flights and you can do it on any given soaring day. Contact jim@deturbulator.org for a sample spreadsheet.

References

1. Paraphrased from Lord Kelvin: *I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of **Science**, whatever the matter may be*.