Deturbulators: Fact or Fiction

The Johnson Deturbulator Flight Test Data

Introduction

In 2003, I began working with Dr. Sumon K. Sinha to develop his *flexible composite surface deturbulator*, for better wing performance. But, six years later we still do not have a marketable product for aviation. Nevertheless, we have made ground breaking progress by achieving marginally detached flow over nearly all wing surfaces and thereby eliminating nearly all skin friction drag. This has yielded extreme performance when all factors influencing deturbulator behavior are controlled. These included smooth dry air, precise airspeed and appropriate static pressure balance between the flow stream and air trapped between the deturbulator skin and substrate. Correct pressure balance and skin tension (a manufacturing quality control issue) enables interaction modes that coerce turbulence formation, at the flow reattachment point on the top wing surface, to high frequencies, yielding short lived tubules. Reducing turbulent energy in the boundary flow enables slightly detached flow ahead of and behind the deturbulator strip. A thin tape around the wing leading edge influences overall aerodynamics by detaching and accelerating the flow at the tape edge. Instances of extreme performance in the Johnson flight tests of 2006 attest to this achievement. This article examines that evidence. Additional evidence may be seen in oil flow visualizations posted at www.deturbulator.org/Progress-OilFlows.asp . Today we are encouraging academic and industrial R&D efforts to further develop the technology. We are working with ANKER-ZEMER Engineering to use deturbulation in new wind turbine designs. Also, we have an invitation to validate deturbulator performance at a well-known institute in Europe.

Johnson's Flight Test Results

In December, 2006, Dick Johnson put Standard Cirrus serial number 60 through his usual flight test routine. First he tested the glider with deturbulator panels on the upper wing surfaces located at the 50 KIAS flow reattachment chord position as well as very thin 49 mm wide tape around the leading edges. Four flights were flown on December 13 and another two on December 14. Flight duties were shared equally by Dick Johnson and Jeff Baird. Their method was to measure sink rates by holding airspeeds long enough for 400 to 500 feet of altitude loss, and noting the beginning and ending altitudes, elapsed time and air temperature. In addition, a Cambridge 302 flight data recorder was logging GPS and pressure altitudes at four second intervals. Later, after cleaning the wings, the standard configuration was measured in three flights without using the flight data recorder. Dick also calibrated the airspeed system. The first indication that Dick had found something came in this amusing message: "*Something awfully good appears to be happening rather consistently at 60[sic] kts. I wonder what it is?*"

Johnson reported two results in an article printed in the May 2007 issue of Soaring magazine. First, he averaged data points from all six deturbulated flights and noted a 13% performance improvement at 50 KIAS. He then discarded flights 2, 3 and 4 that he judged to contain large errors. Averaging the remaining three flights increased the performance boost at 50 KIAS to 18%. Johnson concluded that "*The new Sinha Deturbulator could be the first really significant drag-reducing aerodynamic invention since the development of the now-common laminar-flow airfoils that were developed some 65 years ago*."

The Baseline Data

Fig. 1 shows matched sink rates and glide ratios for the three baseline flights after removing the deturbulator panels and other tapes from the wings. The black dashed curve is a second order fit to the average baseline data. These plots illustrate normal data scatter.

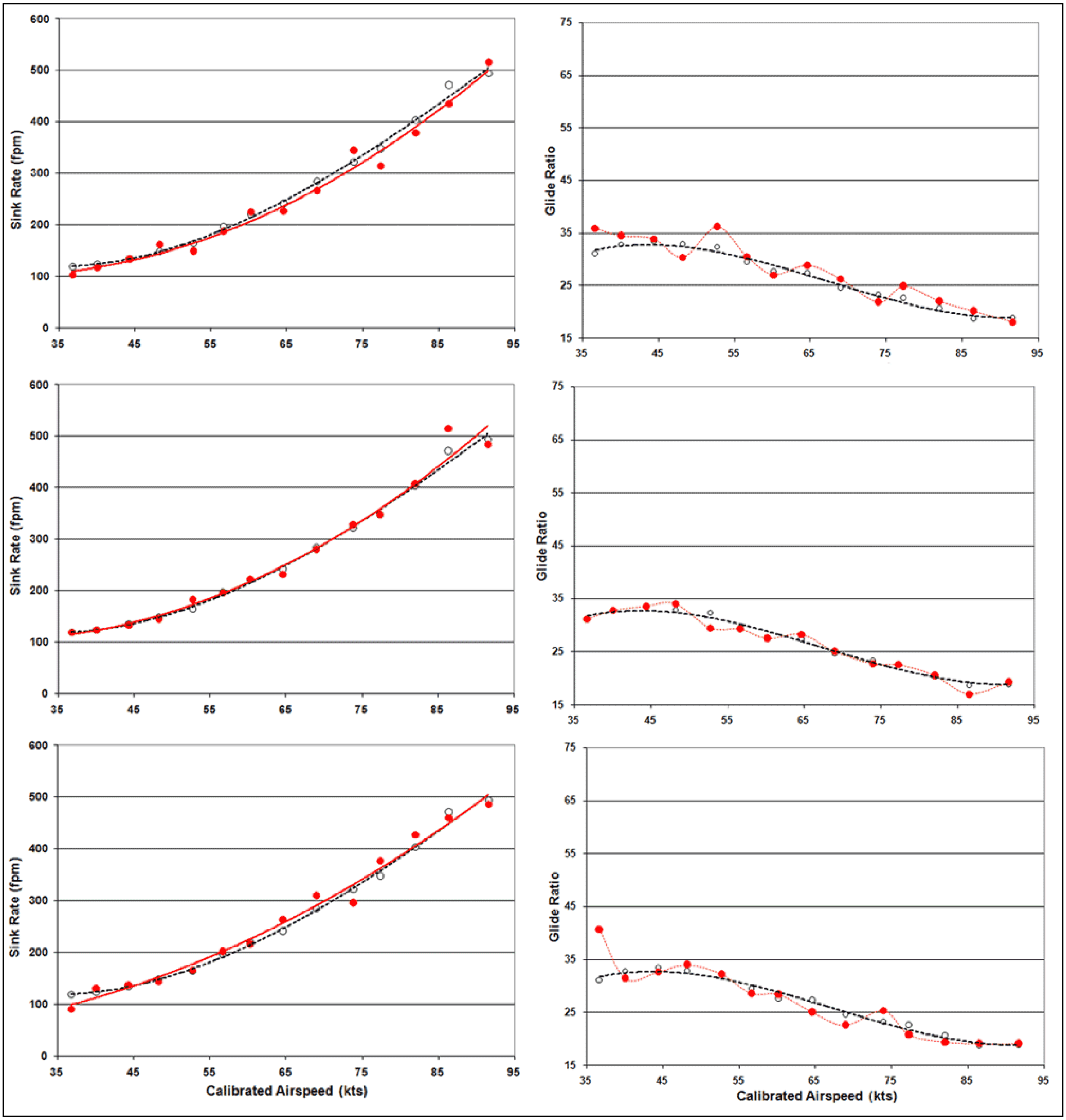

Figure 1 – Sink Rates and Glide Ratios for Baseline Flights

The Deturbulated Data

Fig. 2 shows similar plots for the three most interesting deturbulated flights. The baselines are in black, the IGC log data are in red and the manually acquired data is brown. Of course neither the log nor the manual data are exact, but showing them together increases confidence that the truth is somewhere in the neighborhood. It also eases concerns about human errors. In fact, the log data reveal large errors in three of the 84 manual data points. Two are shown in Fig. 2.

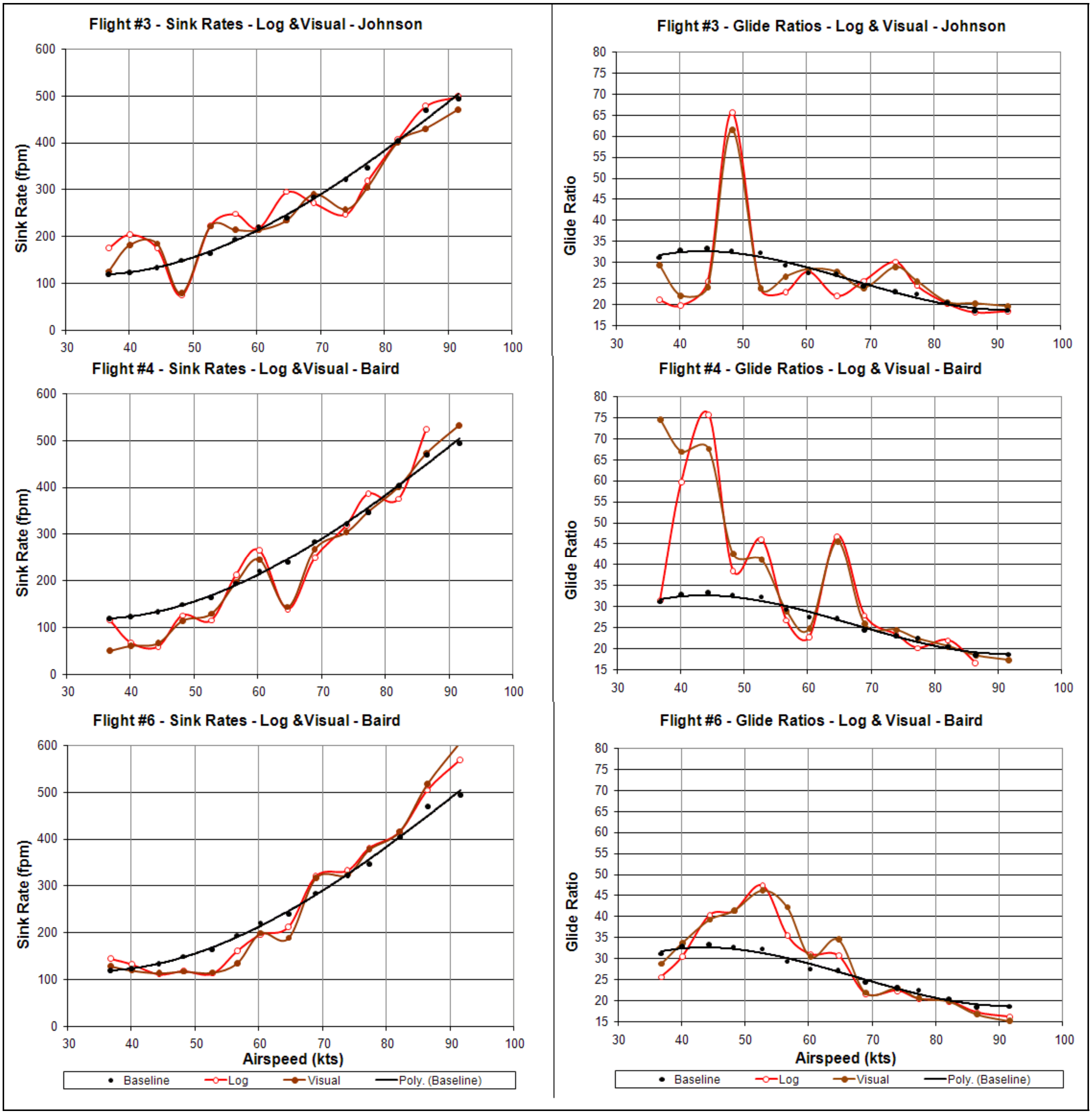

Figure 2 – Three Most Interesting Deturbulated Sink Rate and Glide Ratio Plots

Seeing the Obvious

Compare the overall appearance of the three baseline graphs (Fig. 1) to the deturbulated graphs (Fig. 2). The differences are startling. Normal data scatter is seen in all three of the baseline graphs, but most of the deturbulated graphs show exceptionally large deviations. Furthermore, these deviations are confirmed by agreement between the manually acquired data and the IGC log data. The stark differences between the baseline and deturbulated data indicate that the deturbulator modification has large, albeit inconsistent, effects on performance.

Not Data Scatter

Should the large deviations be regarded as data scatter from convection in the air and human error? To answer that question, I considered that for 46 years, Dick Johnson has been reading the weather for good flight testing conditions and taking data following a well developed regimen. We have a long record of published flight test evaluations that testify to how well he does. I picked 12 reports and noted the greatest deviation from baseline that Johnson plotted in the mid-speed range and then averaged them. The result was that he normally plots a worst case error of 21 feet per minute. But deviations 4-5 times that great appear in the deturbulated data. One wonders how Johnson and Baird could have accidentally arrived at such large deviations from baseline in the deturbulated flights but not in the baseline flights.

Not Human Error

Overall, there is good agreement in Fig. 2 between the manually acquired data (brown) and log data (red). Only two data points in Fig. 2 differ greatly. In each case, human error can be assumed and the log data (red) should be taken over the erroneous manually acquired data (brown).

Not Convection

The first cry I normally hear from skeptics is "*rising air*!" Let's see if the data concur. First, notice in Fig. 2 the close agreement between the deturbulated (red and brown) and the baseline (black) points at the lowest speed and at high speeds. This argues against a general upwelling of the air mass. Also, since low and high speeds were flown at widely different altitudes, agreement at both ends of the curves argues against differences in upwelling with altitude. It may be argued that small scale perturbations, such as shear waves, resulted in instances of extreme performance. Yes, but, in that case this glider has a strange habit of encountering rising air precisely when it needs it. Fig. 3 shows altitude vs. time profiles from three test flights, one by Dick Johnson, one by Jeff Baird and one by me a year later. Regions of extreme performance are shaded in yellow. Gray regions show very good improvements. KIAS values are noted appropriately. I count 10 clear instances where the profile either begins flattening out when establishing a high performance speed or resumes a steeper angle when leaving a high performance speed. These are amazing coincidences if the improved performance comes from rising air.

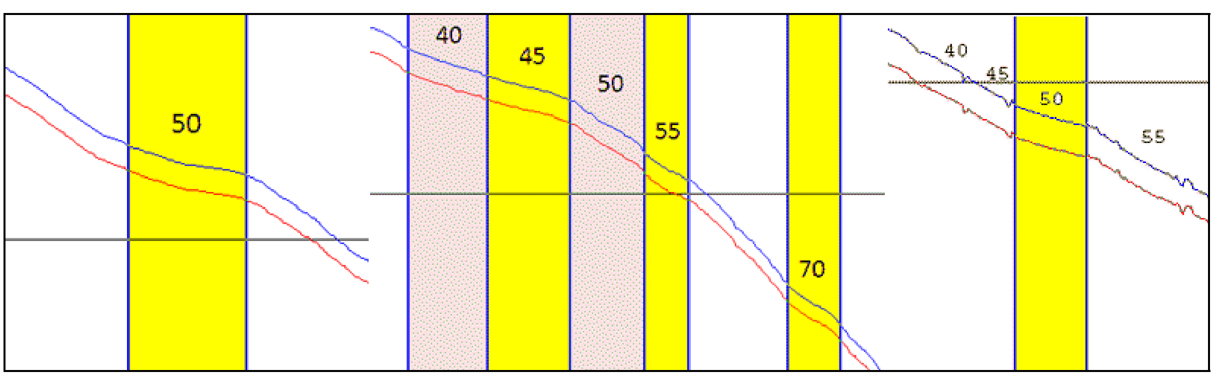

Figure 3– Repeated Abrupt Changes in Sink Rate at Start and End of High Performance Speed Runs

Repeating Johnson's Third Flight

On December 1, 2007, one year after the Johnson tests, with new deturbulators installed, I took measurements including points 2.5 kts on each side of the 50 KIAS point. Fig. 4 shows Dick's measurements (blue) and mine (red). The similarity is striking and obviously confirms a repeat performance. The extreme performance seen in Dick's third flight (Fig. 2) and shadowed in the fourth flight by Jeff Baird occurred for a third time. This third occurrence makes the case that deturbulators really can produce very large positive results repeatedly, though as yet not consistently.

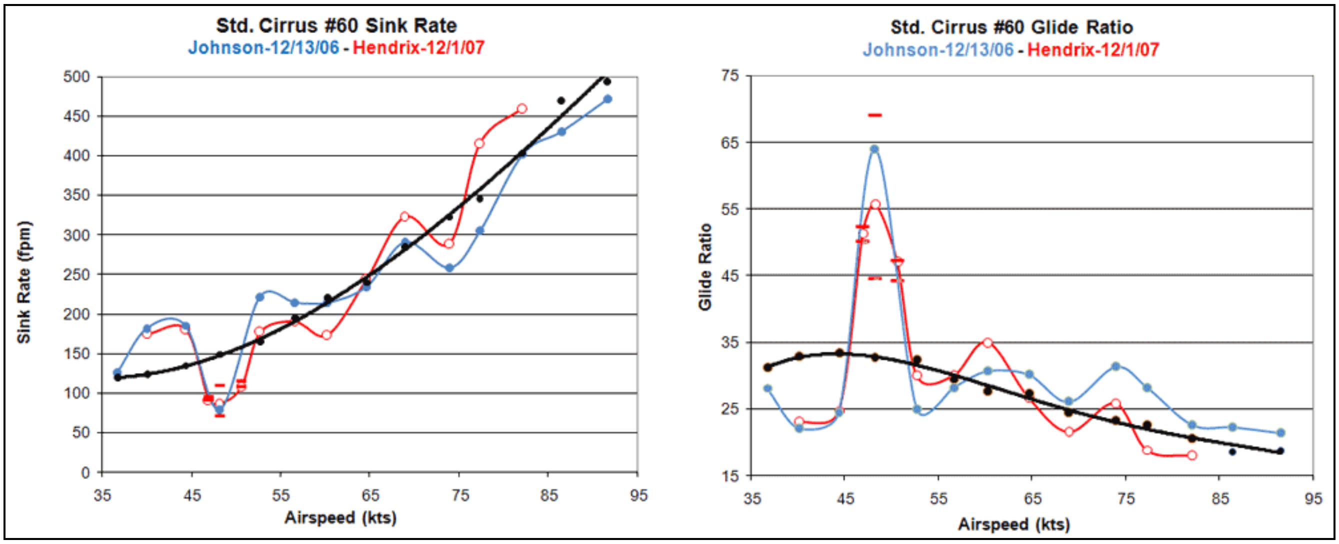

Figure 4 – Two Flights Showing Repeated Instances of Extreme Performance

"Error bars" in Fig. 4 show the best and worst performance that can be found in the log data at 47.5, 50 and 52.5 KIAS. The wide spacing of the bars at 50 KIAS indicates that something was changing during that speed run. Furthermore, the left leaning shape of the glide ratio (red) at 50 KIAS and the higher neighboring point on the left side compared to the right side indicate that I was flying perhaps one knot too slowly for peak performance. I take this as the likely explanation for why my flight yielded less performance than Johnson's. I knew in-flight that I had good data at 50 KIAS, so I took that point a second time.

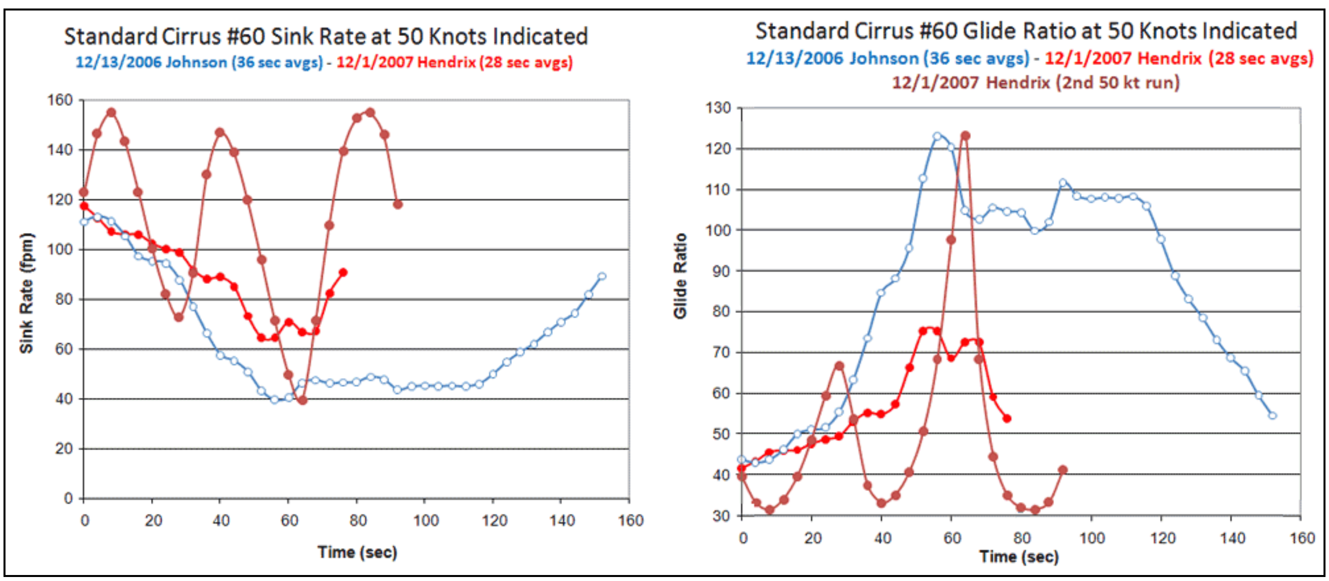

Figure 5 – Moving Average of Three Extreme Performance 50 KIAS Data Points

To see what was happening at 50 KIAS, I calculated moving average sink rates and glide ratios for the three data points. Fig 5 shows the result. The blue curve is Johnson's performance trend. The red curve is the trend from my first measurement and the brown one is from my second measurement. At first sight, one is struck by the similarity of the blue and red curves. They match feature for feature, indicating a repeat of the same dynamic sequence. Two differences stand out, however. My curve (red) runs through the sequence faster and it does not reach the performance level of Johnson's (blue). The explanation for the faster sequence is found in the deeper ridges of the substrate in the new deturbulators. This sped up the ventilation action, affecting the balance of pressures above and below the deturbulator skin, while descending through the atmosphere. The explanation for my lower performance level is found in my failure fly the correct speed, as noted above. This view is bolstered by the brown curve which shows my second 50 KIAS speed run. This curious curve calls for an explanation. First, notice the essential features. Looking at the glide ratio, we see that the curve oscillates at a decreasing rate as performance is ramping up; that the curve bottoms out consistently slightly below baseline performance; and that it peaks at levels matching Johnson's trend line. All of this cannot be coincidence and no pilot could intentionally fly so precisely. Evidently, I approached 50 KIAS with too much pitch momentum which initiated pitchwise oscillations as the flow reattach point moved back and forth over the deturbulator, causing performance to vary. At each performance peak, the pitch momentum carried the AOA past the ideal value. This sensitivity appears to result from the narrowness of the deturbulator strips (about 2 inches).

More Information

For more information, see www.deturbulator.org.

Jim Hendrix lives in Oxford, Mississippi, USA. He holds a master's degree in physics; has written books on the Small C compiler and holds patents in acoustics, aerodynamics and avionics. Jim's professional career spans four decades in computing and now, in retirement, he is developing an inertial/GPS flight data recorder. Jim began flying gliders in 1995 with the Memphis Soaring Society, now at a private field in Cherry Valley, Arkansas where he keeps his Standard Cirrus in a sidewiser hangar of his own design.