PERFORMANCE TESTING OF RNR'S SBXC USING GPS

By John Ellias

SBXC BY RNR 1

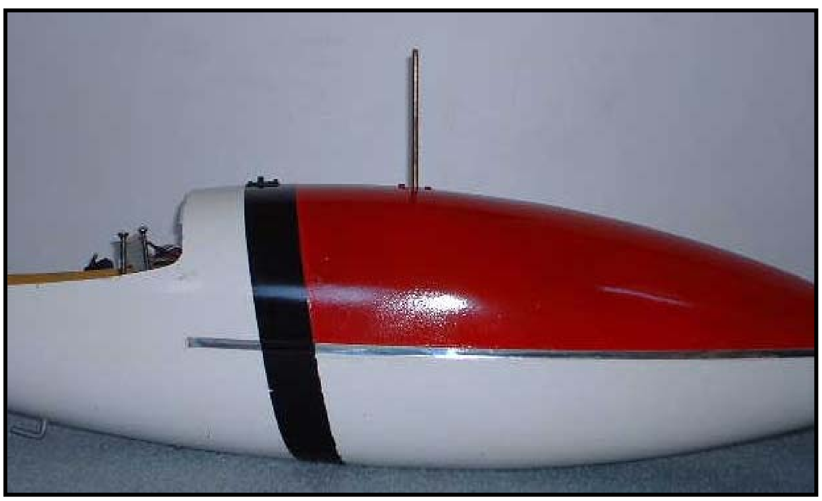
The development of R/C sailplane design and construction has advanced greatly over the past decade. The airfoil research by Selig, Donovan and others have given designers the data needed to select the most efficient airfoil for a particular design. The use of hollow core molded wings has allowed the manufacturer's to consistently and accurately copy these airfoils. A typical pilot with average building skills can now assemble a glider with performance equal to the best available. While we know the performance of these gliders are excellent, it has been very difficult to quantify the performance of an R/C glider. However, with the introduction of small and very accurate GPS units, it is now simpler to make accurate performance measurements.

During the California Valley cross-country race in September of 2001, Dean Gradwell mentioned that he had installed a GPS unit in his glider. After talking with Dean about what type of GPS unit would be best, I decided to purchase one with the intention of recording my flights and hopefully obtaining accurate performance information. I have always found the performance testing articles in "Soaring" magazine very interesting and often wished such information was available for RC sailplanes.

Test Equipment

SBXC Specifications	
Airfoil:	SD-2048
Span:	170.0 in.
Wing Area:	1656 Sq.-in.
Flying Wt. :	158 oz.
Aspect Ratio:	19.8 : 1
Wing Loading:	13.6 oz/Sq.-ft.
Stab Span:	36.5 in.
Stab Area:	135 Sq.-in.

The SBXC glider manufactured by RnR Products is currently the most popular sailplane used by cross-country pilots. In my opinion it combines excellent penetration, very docile handling and good thermalling characteristics. The wing uses separate flaps and ailerons, which can be combined with a computer transmitter for full trailing edge camber control. It has the added benefit of a very large fuselage that has more than enough room to carry the GPS unit. This is the glider I use for all my cross-country flying and is the subject of these flight tests. My SBXC is a completely stock model that is almost three years old. It does not have root flap fillets that many of the pilots are now installing on their SBXC's. As a result there is a gap of about ¼" where the flaps meet the fuselage. This is typical of a stock built SBXC. The left wingtip was damaged in a ground loop accident, but has since been repaired with only a few ripples in the upper skin still evident. The weight of the glider with the GPS installed is 9.8 pounds.



Installed in the SBXC is a multiplex variometer, modified with total energy compensation by Tom Hoopes. As part of the modification a brass pitot tube has been installed in the forward section of the fuselage. The brass tube is 3/16" in diameter and protrudes 3.5" vertically above the top of the fuselage.

The exposed brass pitot tube obviously causes additional drag, but this is more than made up for by the accurate information supplied by the a compensated variometer. I find the variometer essential in cross-country flying. It was also beneficial during the test flights as it confirmed that the flights were flown when there was no convection.

The GPS unit used for this testing is a Garmin Etrex Vista. This particular model has certain features, which make it particularly well suited for the performance testing. These feature include:

1. A barometric recording altimeter. Many GPS units determine altitude from satellites; similar to the way they determine the longitude and latitude. This method is not as accurate as a properly calibrated barometric altimeter. With the barometric altimeter, small changes in altitude can be recorded by the GPS unit.
2. A 3000 data point track log capacity. This is larger than most other similarly priced units. This allows the user to record position, altitude, and speed data for 3000 individual points during the flight. The interval between data points can be set for a selected distance traveled or for a selected time interval.
3. It is small and lightweight. The unit easily fits within the fuselage and weighs only 5.3 oz. including batteries.

A box to protect the GPS was fabricated from cardboard and foam. The GPS was installed under the wing just ahead of the center of gravity. It required the removal of a small amount of the nose weight in order to get the CG back to its original location.

The last item needed was software to download and analyze the data collected by the GPS. There are numerous programs available that will link to a GPS. I ended up using three different programs, "GARTIP", "SEEYOU", and "3dTracer". All of them provided the tools required for analysis of the data, but I found "GARTRIP" easiest to use. "GARTRIP" will download the stored tracklog directly from the GPS and then plot location information in two dimensions. It will also display an altitude or speed graph below the plot. Then using the edit track mode, any segment of the flight can be analyzed to determine the distance traveled within that segment, the altitude lost, and the average speed during that segment

Testing Procedure

The GPS is installed in the glider and flights are made at various elevator trim settings. The GPS is set to record location, speed, and altitude every .01 miles or about every 50 feet in distance traveled. The data is then analyzed to determine the sink rate and l/d at each of the speeds. It sounds simple enough but I encountered some difficulties while performing the testing. First, I found that at high speeds and at near stalling speed it was very difficult to keep a constant airspeed. It is important to keep a constant airspeed for a sufficiently long portion of the flight to obtain a segment of usable data. Second, there must essentially no wind. Because the GPS measures ground speed, not airspeed, any wind will skew the data. There was a period of about 3 weeks in which early morning winds made testing impossible. Despite these difficulties it is certainly much simpler to obtain the data with a GPS than with other methods.

The tests were conducted over a period of approximately six weeks on four separate days. I would usually get to the field at about 6:30 am and spend about 30 minutes setting up the glider and the winch. Prior to launching I would wipe the wings down with a cloth because heavy dew would usually form on the top surface of the wings. It was cold enough on the morning of February 18 that the dew that formed on the wings then turned to ice! Test flights were usually performed between 7:00am and 8:30am.

Launches were by 12-volt winch and typically resulted in an altitude of approximately 500 feet above ground. Each individual flight was made at a predetermined trim setting hopefully resulting in a constant airspeed during the entire flight. After each flight, the trim setting was changed and the next flight was flown at a different airspeed. Flights of varying airspeeds were flown ranging from just above stall to a shallow dive. As I mentioned previously flights at either extreme were very difficult to hold a constant airspeed. When trying to fly at stall speed control was weak and unresponsive. At high airspeeds the glider was in a shallow dive and had a tendency to want to pull up.

After the flights for a particular day were completed, the GPS was removed and then serially connected to my PC. I found it was important not to save the tracklog internally in the GPS but rather leave the data as the active log. For some reason that I have not determined, when the tracklog is saved internally, the speed data is lost. This is how I lost the speed data for flights 3, 5, 6, 7, and 8. The active log is then downloaded to the PC using “G7TOWIN” software. This software converts the Garmin tracklog into an “IGC” format. This allows the use of programs like “See you” and “3D tracer” to analyze the data. Both of these are soaring specific programs with many useful tools. The program “Gartrip” was also used. While this is not soaring specific software I found it to be the easiest to use. I ended up using both “See You” and “Gartrip” to analyze each flight in order to confirm the analysis. A segment of each flight was used to obtain data for that particular flight. The segment typically had one, 180-degree turn with equal upwind and downwind legs. Also, the segment chosen was one in which the speed for each leg was fairly constant. The software analyzes each segment and gives the distance traveled, altitude lost, and average speed of the segment.

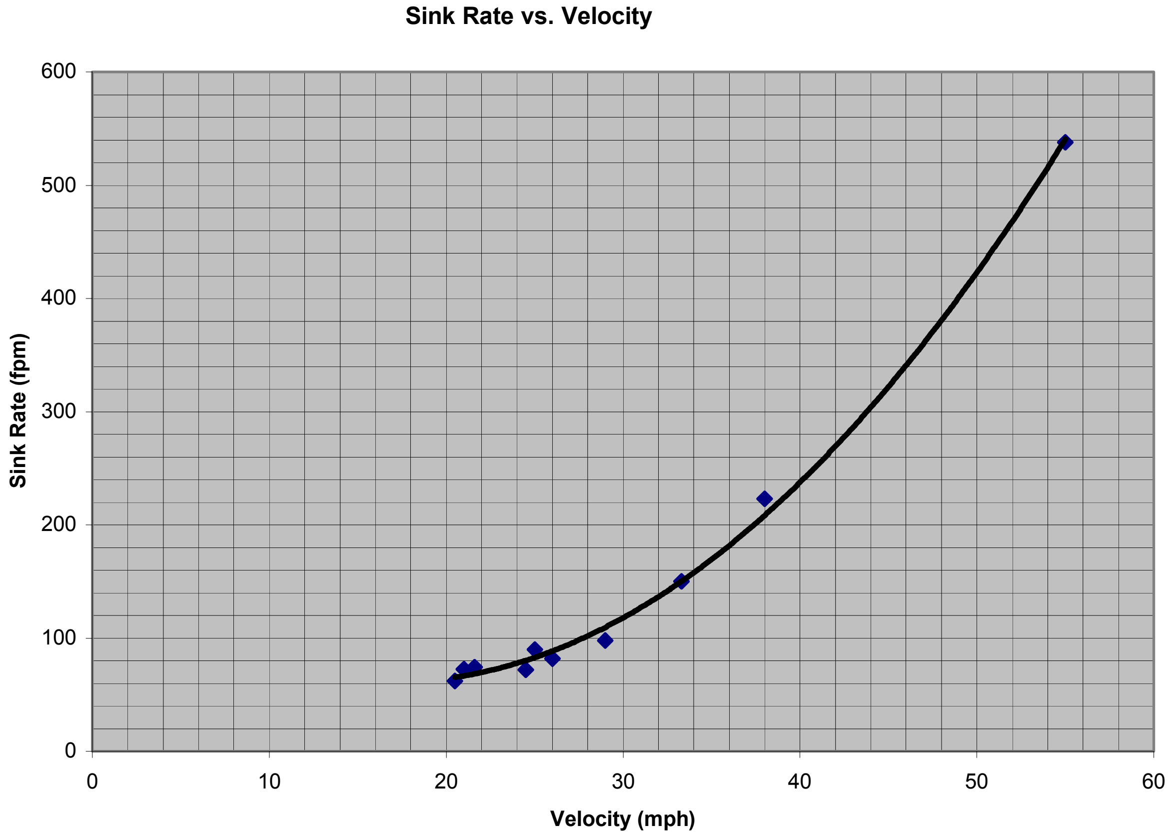
Below is a table that summarizes the data obtained for all the test flights:

SBXC FLIGHT TESTING

Flight #	Date	Trail edge camber	Ground Speed (1) mph	Wind	Best L/D	Sink rate fpm
1	6-Jan-02	neutral	29	0	26	98.2
2	12 Jan 02 - 1	neutral	21	0-3 mph	25.5	72.5
3	12 Jan 02 - 1	neutral	no speed data (2)	0-3 mph	30	N/A
4	12 Jan 02- 2	neutral	26	0-3 mph	28	81.7
5	12 Jan 02- 2	neutral	no speed data (2)	0-3 mph	19.5	N/A
6	12 Jan 02- 3	up 3 deg	no speed data (2)	0-3 mph	11	N/A
7	12 Jan 02- 3	neutral	no speed data (2)	0-3 mph	28.7	N/A
8	12 Jan 02- 3	neutral	no speed data (2)	0-3 mph	23	N/A
9	26-Jan-02	neutral	21.6	3-5 mph	25.5	74.5
10	26-Jan-02	down 5 deg.	20.5	2-4 mph	29	62.2
11	26-Jan-02	neutral	25.5	1- 3 mph	21	106.0
12	26-Jan-02	neutral	33.3	1- 3 mph	19.5	150.3
13	18-Feb-02	nuetral	38	0-1mph	15	222.9
14	18-Feb-02	neutral	55	0-1mph	9	537.8
15	18-Feb-02	down 5 deg.	24.5	0-1mph	30	71.9
16	18-Feb-02	neutral	25	0-1mph	24.5	89.8

Notes:

1. Ground speed based on equal upwind and downwind legs
2. Speed data was lost during download from GPS to PC



By obtaining sinkrate data at airspeeds ranging from just above stall to high speed, a plot can be made with a curve to fit the data. The curve will give sink rates for all speeds. This was the ultimate goal of my testing. Below is the plot using the data from the chart above. The curve was fit to the data points using a second order polynomial function. There are a few things to notice about this chart. There is no data for airspeeds below minimum sink. This is because I could not effectively keep a constant airspeed below minimum sinking speed. The glider would typical stall and drop its nose and then pick up speed.

Minimum sink for this glider is 62 feet/min. or approximately 1 foot/sec. This means with a 500-foot launch, it should be possible to do an 8-minute task in the typical thermal duration contest in completely dead air. Minimum sink was achieved with approximately 6 degrees of trailing edge camber. Flying at very close to the same airspeed with no camber gave a sink rate over 15% higher. Clearly dropping the trailing edge is beneficial while thermaling. Also of note was the fact that dropping the trailing edge did not seem to detract from the max L/D. Flight number 15 shows a max L/D of 30:1 with the trailing edge down which is equal to the best L/D with neutral trailing edge.

One last observation; early on during the testing it became evident that what I had judged to be best L/D speed was actually faster than best L/D speed. What I judged to be minimum sinking speed was closer to best L/D speed.

It should be noted that while I believe this type of testing to be relatively accurate, there are many opportunities for errors to occur. The position accuracy of the GPS ranged from 15 feet to 25 feet. Also, the accuracy of data can be affected by wind, air convection, poor flying techniques, and differences in the way the data is analyzed. My particular glider may not have the same performance of other SBXC's. I have certainly seen SBXC's built with far more precision and care than my model. The total energy pitot tube will cause additional drag. Other gliders do not have the pitot tube or have a smaller one in a different location. Dean Gradwell is trying to get a new fuselage produced that will incorporate drag-reducing features. These include flap root fillets and control horn fairings. It would be interesting to perform further testing on the new fuselage to see what performance gains will be achieved.

The question now arises, is there any practical benefit to be gained by having the information obtained from this testing. In the case of cross-country soaring I believe that accurate polar information can be of significant benefit. As in full size soaring it is beneficial to know at what speed to fly for various conditions. Knowing your approximate glide angle can help you make informed decisions during your flight.

I would like to thank Scott Gradwell for providing me software information he obtained from Mark Mills. Also John Roe for performing some flight analysis and providing software information.