A FLIGHT TEST EVALUATION OF THE DG-600
By Richard H. Johnson, Published in Soaring Magazine, August 1989

The DG-600 is the latest model 15-meter class, high performance sailplane to be produced by the well-known Glaser-Dirks Flugzeugbau Company in Bruchsal, West Germany. It is principally the design of Wilhelm Dirks, their talented young engineer responsible for the successful DG-100, 200, 300, 400 and soon to be produced two-seated DG-500 series of modern composite sailplanes.

Through the use of carbon fiber and epoxy resin construction materials, Wilhelm was able to use one of the newest German HQ airfoil that is remarkably thin in its profile. Our actual thickness-to-chord ratio measurements showed .1293 at the flap roots and about .1283 average over the remainder of the wing panels. As is common these days, the airfoil coordinates are proprietary and, therefore, unavailable to the public in general.

The airfoil is reportedly designed to require spanwise turgulator strips on both its upper and lower surfaces to prevent formation of high drag separation bubbles at the aft ends of its extensive low drag laminar flow regions. Our measurements showed that the factory installed .50 mm (.020 in.) thick zig-zag boundary layer control tape was positioned at .82 chord aft of the leading edges on the wing bottom surfaces and at .68 chord aft of the leading edges on the wing top surfaces and at .68 chord aft of the leading edges on the wing to surfaces.

A three-view outline of the DG-600 is shown in Figure 1. Note that it comes equipped with interchangeable wing tips of three differing designs. One pair are conventional 15M overall span tips, and the second pair are still of 15M overall span, but equipped with well-designed .417 M (16.4 in.) high vertical winglets. The third pair of wing tips are of conventional design, but extended in length to provide an overall wing span of 17M (55.76 ft.). A remarkable feature of the DG-600 is that it was designed to fly at its fully ballasted 525 Kg (1157 lbs.) gross weight, even in its full 17M wing span configuration.

It was decided that all three wing tips would warrant flight testing, and a set of 5 sink rate measurement test flights were, therefore, performed with each of the 3 wing tip pairs. The sink rate test measurement data performed with conventional 15M wing tips are shown in Figure 2, versus calibrated airspeed. Test flight numbers 1 through 4 were piloted by the author, who only slightly exceeds the DG-600’s minimum cockpit weight placard of 74 Kg (163 lbs.) with parachute. Therefore, those flight data were measured with the overall sailplane center-of-gravity near its aft limit. Flight number 14 was flown by Mike Newgard, who weighs about 29.5 Kg (65 lbs.) more than I do, and his additional cockpit weight moved the overall c.g. to near...
its mid-range. The test data taken at Mike’s heavier weight were corrected to the same 348-Kg (767 lbs.) gross weight that I flew by the conventional square-root-of-the-weight-ratio method. Note that the data taken at Mike’s mid-range c.g. compared well with those taken at my near-aft limit c.g.

As usual, some data scatter exists, but the 5 flight averaged data indicates an L/Dmax of about 40.5 at 48 kts., and that was somewhat lower than expected. Also, there appears to exist a higher than-normal-drag knee in the polar between 60 and 70 kts. The reason for that is uncertain, but likely some portion of the wing’s airflow has either transitioned to turbulent flow prematurely or a separation bubble of some sort has formed somewhere.

The next group of high tow sink rate measurement flights were performed with the DG-600’s 17-meter wingspan tips installed. Test flight numbers 5, 6 and 15 were piloted by the author and Mike Newgard performed flights 7 and 8. Again, some data scatter exists but the 5 flights averaged data indicates an L/Dmax of about 46 at 45 kts. and a minimum sink rate of about .48 MIS (95 fpm) at 42 kts.

This time, one of Mike’s mid-c.g. range sink rate data showed higher sink rates in the 45 to 55 kts. airspeed range than did mine, though 3 test data points are not sufficient to warrant much confidence there. Overall, the polar appears to be well shaped, except for an indication of a small higher than normal drag knee in the 70 to 75 kt. region.

The third group of 5 high tow sink rate measurements flights were performed with the 15-meter span winglet tips installed and those test data are shown in Figure 4. Darrel Watson assisted me with those flights. Since his weight was almost exactly equal to my 70 Kg (155 lbs.), our flight c.g:s were essentially equal and near aft limit. Those test data are shown in Figure 4, and they indicate that the winglets significantly improved the DG-600’s performance at airspeeds below 70 kts. with only very small increases in sink rate at airspeeds above 110 kts. In addition, the plain wingtip high drag region shown in Figure 2 disappeared from the polar when the wing-lets were added. Now only a slight drag knee is indicated at 78 kts. in the Figure 4 winglet data.

Darrel Watson performed the airspeed calibration during flight 16, and those data are shown in Figure 5. Here, as with the previous sink rate test flights, the wing flap settings used at each airspeed were those recommended by the manufacturer. Subsequent wing drag probe testing verified that those settings were indeed close to optimum. The DG-600 airspeed system pitot is located at the fuse-
lage nose and inside the cockpit airvent inlet. The airspeed system static sources are located well forward on the sides of the fuselage nose. As the calibration data in Figure 5 shows, the DG-600 airspeed system performs well, although it does appear to under-indicate true airspeed values by about 2 to 3 kts. over the entire flight airspeed range.

Since the basic performance measurement tests were then completed, it was decided that wing profile drag probe tests should be performed to determine if the wing surface turbulator strips were performing as intended. For that testing we installed the wing drag probe system, described in Reference A, to measure the relative profile drag values of the DG-600 wing at a location 1.59 meters (5.22 ft.) outboard from the left wing panel flaperon root.

Test flight number 17 was made with both the top and bottom surface turbulators installed at their factory recommended positions of .68c on the top surface and .82c on the bottom surface, where they were during all the prior testing. Those wing drag data are shown in Figure 6, and they indicate low profile drag values of 11.3 to 12 kts. all the way from 42 to 95 kts. CAS.

The following 3 flights tested the same wing station, but with the bottom, then the top, and finally both turbulator strips removed. The latter case where both turbulators were removed, showed significantly higher profile drag at all test airspeeds as shown in Figure 6. Only the 46 to 54 kt. region showed a slight benefit with removal of the bottom turbulator, as did the greater than 105 kt. region with removal of the top surface turbulator. Overall, the factory-installed turbulators appeared to be functioning as intended.

We considered that possibly the airflow over other portions of our test DG-600 wing may not be as good as those we measured at the single span-station 1.59 meters out on the left wing panel. Therefore, the same +21.2 mm-high drag probe was remounted and tested wise at four additional spanwise wing stations. They varied from .66 meters (2.16 ft.) outboard from the flaperon root to 5.97 meters (19.58 ft.), which is approaching the flaperon tip. Those data are shown in Figure 7, except for the last test station which indicated such low drag values that they were barely readable on our instrumentation (Kollsman helicopter ASI and our +21.2 mm high drag probe).

The Reference A wing drag probe functions well when its probe-height-towing-chord ratio is near its intended .025 value. Since the DG-600 wing plan form is tapered and we only had the 21.2 mm high probe available, the probe really became too tall to assess drag magnitudes out near the wing tip. The higher the probe height as compared to the wing test station chord, the lower its theoretical drag indications will be as is shown in the Figure 7 data.

After flight number 23, I discovered that the wing drag probe measurement instrumentation system was dynamically overly compensated because a pneumatic
restrictor in its pitot source line had inadvertently remained from prior testing. The over-compensation did not significantly change the conclusions reached from the preceding drag probe data. However, it did make the indicated drag magnitudes all appear a bit lower than they should up to 70 kts. Above 80 kts. the impact of the over-compensation was more significant because of the higher sailplane sink rates associated with the higher airspeeds. Dynamic pneumatic balancing compensates for rate of altitude change effects on the drag probe readings.

Prior to flight number 24, the overcompensation was corrected and the flight test was repeated to measure the differences. Those data are shown in Figure 8, where the new data from flight 24 show a near classical laminar airfoil bucket shape that was apparently suppressed by the earlier overcompensation. Since we could find no fault in the left wing panel airflow, we decided to check one station on the right wing also. Figure 9 shows the relative wing profile drag values measured there with and without turbulator strips installed. Again, the top surface turbulator appeared to function well, but addition of the bottom surface turbulator appeared to have little effect except in the 53 to 61 kt., 75 to 85 kt. and above 105 kt. regions where the measured differences were not very large.

For some reason, the Glaser-Dirks factory did not install any turbulators on the 1.25-M long 17-meter wing tip extensions. Since our preceding drag probe testing had indicated significant drag reductions could be achieved thereby, at least over the inner portions of the wing panels, we decided to extend the factory turbulators through the 17-meter wing panel extensions and remeasure the overall sailplane sink rates. Flights 29 through 32 were devoted to that testing, and those test data are shown in Figure 10.

Surprisingly, no improvement was shown anywhere in the DG’s 17-meter polar, and sink rates appeared to be slightly higher at both minimum sink and at airspeeds above 70 kts. The reason for that poorer than expected turbulator performance on the tip extensions is likely associated with the lower Reynolds Numbers at which the smaller chord wing tips operate, where the turbulators may be ineffective; or it could lie in the data scatter, as only four flights were used to evaluate that configuration.

It was decided to devote the final portion of our DG-600 testing to wing drag probe tests where the chordwise locations of both the upper and lower surface turbulators would be varied to determine if more optimum locations existed. Since the inboard .66 meter station data shown in Figure 7 indicated perhaps higher profile drag than it should have, that location was selected for our last day’s testing.

Flight 34 was a repeat of flight 21, with top and bottom surface turbulators at the factory .68c and .82c positions, respectively. Those test data are shown in Figure 11 and they indicate significantly lower drag than did the earlier flight 21 data. Possibly a speck of some roughness or dirt existed at a critical position on the DG’s airfoil that we had not observed.

During the following three flights the lower surface turbulator strip was moved forward in .04c increments to .78, .74 and .70 chord positions, respectively. The data taken with the turbulator at .78c showed almost equally low wing profile drag as those taken at the factory .82c location. Slightly higher drag was indicated in the 47 to 57 kt. region, but somewhat lower drag was indicated in the 63 to 95 kt. region.

A surprise came when the lower surface turbulator was moved forward to the .74 chord position. Only modest drag increases were indicated up to 67 kts. but suddenly at all higher airspeeds enormous drag increases were shown. Those data were remeasured during that flight with a repeated data run which checked with the first. Apparently, a large separation bubble is formed on the wing lower surface at airspeeds above 70 kts. when the bottom surface turbulator tape is located at .74c.
The next flight, 37, tested the bottom surface turbulator at .70c. As Figure 11 shows, the profile drag data with the turbulator at that location appears to follow the classical early laminar-to-turbulent flow theory, with moderately higher drag shown at all airspeeds. From these test data runs, one must conclude that the factory has the lower surface turbulator strip near optimally located at .82c. Farther aft would place the turbulator on the flaperon itself.

Figure 12 shows similar wing profile drag data where the top surface turbulator is moved forward to .04c increments, starting at the factory .6c location (Flight 34 data). Forward turbulator movements incurred higher drag levels at all airspeeds. One more test flight with the turbulator located aft of the factory recommended position would have been interesting, but unfortunately, our test funds were exhausted and the sailplane needed to be returned to its owner.

After the flight test data were collected, time was found to do some soaring and comparison flying with a Ventus B/iS. One result of the comparison flying was that the DG-600 appeared to thermal better at a flap position of plus 10 degrees, rather than the factory recommended plus 5 degrees. With the 15M winglets installed and wing flaps set to plus 10 degrees, the DG-600 appeared to climb equally well as the Ventus B/iS, at least in our unballasted comparison condition.

Overall, the DG-600 is a beautifully constructed modern sailplane with superb handling qualities. Its long fuselage tail arm along with well sized vertical and horizontal tail surfaces, provide excellent pitch and yaw stability. A parallelogram mount for the control stick eliminates “G” induced feedback into the elevator control system. All controls connect automatically on assembly, and are light in movement and easily reached by my 1.78M (70 in.) tall frame. The full span one-piece flaperons are spectacular in their lightness and responsiveness.

45 degree to 45-degree roll times at 50 kts. LAS with plus 5 degree thermaling flap average roughly 4.3 seconds with the plain 15M tips, and about 4.0 seconds with either the winglet or 17M tips. As with practically all-modern high performance sailplanes, the DG-600 gives essentially no buffet or other warning when stalled. There a wing rapidly drops during both level and turning stalls, but stops immediately if a moderate amount of forward stick is promptly applied.

The cockpit is generously sized and the low cockpit sides provide probably the best pilot visibility of any modern sailplane in production. Only the upper rail of the left side canopy window interfered with my vision. Large 1.46M (4.78 ft.) long double-paneled SchemppHirth type airbrakes are located on the wing top surfaces, and they function without fault. When closed, the air brakes appeared to seal well. The wing drag data measured during Figure 7’s flight 22 was with the probe located behind the airbrake and minimal drag values were indicated there.

The main landing wheel is a well-sized 5 X 5 Tost wheel with a drum brake that really works. The final portion of the airbrake handle travel actuates the wheel brake. The wing surface chordwise waviness measurements averaged about ± .08mm (.003 in.) with our 2 inch gauge. [hat magnitude is remarkably low, even for a modern sailplane. The wing planform area measured 10.95 M2 (117.8 ft2 in the 15M configuration and 11.59 M2 (124.7 ft2 in the 17M configuration.

The empty weight of our test DG-600 was 277 Kg. (611 lbs.) equipped with instruments, battery, radio and oxygen. Each wing panel weighed about 67.6 Kg (149 lbs.); so they were not difficult for two men to handle. We did not perform water ballast capacity measurements; however, the handbook indicates that 180 Kg (397 lbs.) can be carried in the wings and an additional 6 Kg (12 lbs.) can be loaded into a tail fin tank.

We are deeply indebted to Buzz Averill and his wife Deanna, who generously trailered their new DG-600 from Albuquerque, New Mexico to Caddo Mills and back for our testing. Also, special thanks are due to our tow pilots, especially to Dick Seaman, who happened by on a trip from Colorado and to local pilots Bob McNeill, Chris Bobka and Howard Hughes. The Dallas Gliding Association supported the testing financially, and its members assisted. Thanks, again.

REFERENCES