Measurements of Sailplane Sink Rates between Thermals

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How strong are the average downdrafts encountered by a sailplane as it cruises from one thermal to the next? That was a question that I, among others, had speculated upon for years. Also, how close to still smooth-air glide performance could a modern low-drag laminar sailplane achieve in the moderately turbulent air between thermals? These appeared to be good questions worthy of a flight test investigation.

A total of five separate long soaring flights were performed where interthermal sink rate measurements were made between thermal climbs. During these flights the author flew almost entirely without the company of other sailplanes; therefore the finding of thermals between these glides was not enhanced by other sailplane «locators». Roughly half of the tests were flown during days when small cumulus clouds aided in thermal finding, and the other half were flown during dry clear days devoid of any cumulus markers.

Two separate high performance sailplanes that had previously been calibrated during smooth air performance testing were used for the interthermal testing. A 20.3 meter span Nimbus II sailplane was utilized during four of the soaring data flights and a 20.5 meter Jantar 2A was used during the fifth flight. These test sailplanes were equipped with calibrated altimeters and airspeed systems, and a stopwatch was used to determine average descent rates and air distances travelled while cruising between thermals. A total of 81 separate interthermal cruising runs were recorded where the sailplane flew at a constant indicated airspeed near that of the still air maximum L/D airspeed. A total cruising air distance of about 800 km was flown during the 81 data runs between thermals for an average of 10 km per run. The data runs were terminated when the next thermal suitable for climbing was encountered or landing pattern altitude was reached.

The test flights were performed two each during the spring and fall of 1977, and the last flight during a late winter (1978) day. All the flights were performed over flat farm land plains of eastern Texas, near Caddo Mills, and the convective conditions ranged from weak to moderate. Airborne insects were very few during the test days; so their wing leading edge roughening degrading effects upon the test sailplane's glide performance was minimized. Also, the test flights were performed only during days when discrete isolated thermals existed and no cloud and/or thermal streeting was apparent. Flying along thermal streets or valleys would obviously bias the sought after test data.

Figure 1 shows a sketch of an idealized convective atmosphere cross section where discrete, well formed thermals exist at regular intervals separated by large areas of mildly sinking air. Obviously, the real atmosphere is not this simple for the soaring pilot. Sometimes, when cruising between the well formed thermals, small or weak lift is encountered that is unsuitable for circling within. There the optimum procedure is to slow the sailplane's airspeed to near that for minimum sink when in the lift, but not to circle unless stronger lift is believed nearby. At other times, abnormally strong down currents are encountered between thermals, and the pilot can only grit his or her teeth and speed up to minimize altitude loss. As expected, these atmospheric vagaries cause considerable scatter in the test data's average sink rate measured values. For this reason a relatively large amount of sink rate test data was required to provide reasonable confidence in the sought after interthermal sink rate average values. Each of the 81 test data points shown in this paper was derived by means of simply noting the altitude when leaving the top of a thermal, starting a stopwatch, and gliding at constant indicated airspeed to the next thermal. When the thermal was encountered, both the sailplane's altitude and lapsed time were recorded.

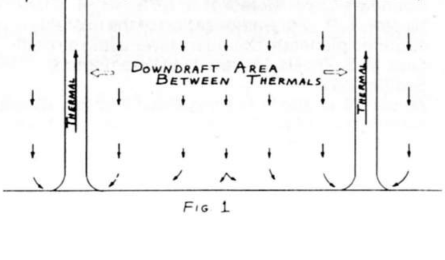


Fig 1

The sailplane's averaged sink rate during the cruise run was obtained by dividing the interthermal altitude loss by the lapsed time. The sailplane's previously measured smooth-air sink rate at the interthermal cruise airspeed was then subtracted from the cruise-run-averaged sink rate to derive the apparent averaged interthermal air sink rate. Air density corrections were made to reduce the observed sailplane interthermal sink rates to sea level values. Figure 2 presents these measured air sink rate data points plotted as a function of the gross thermal strength. The gross thermal strength used was equal to the sailplane's achieved climb rate plus an amount equal to the sailplane's still-air sink rate while circling. The measured air sink rate data were plotted against gross thermal strength because it is logical to expect interthermal downdraft velocities to be proportional to thermal strength. Though there is considerable scatter in the Figure 2 data, they do indicate that this is the case.

This data plot also shows that the average apparent interthermal downdraft strength is equal to roughly one tenth of the gross thermal strength. These downdrafts magnitudes can vary considerably, ranging from near zero to more than three tenths of the gross thermal strength. Just how much of the measured apparent interthermal air sink rate is attributable to the sailplane's possibly degraded performance in the moderately turbulent air is not known. However, only the apparent value is of importance to the soaring pilot because that tells him roughly

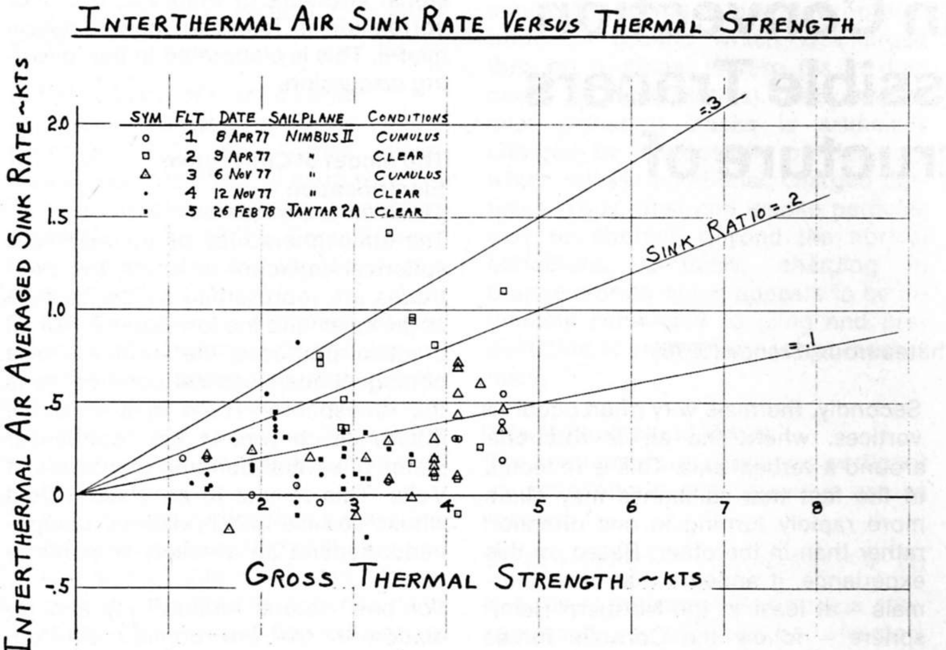
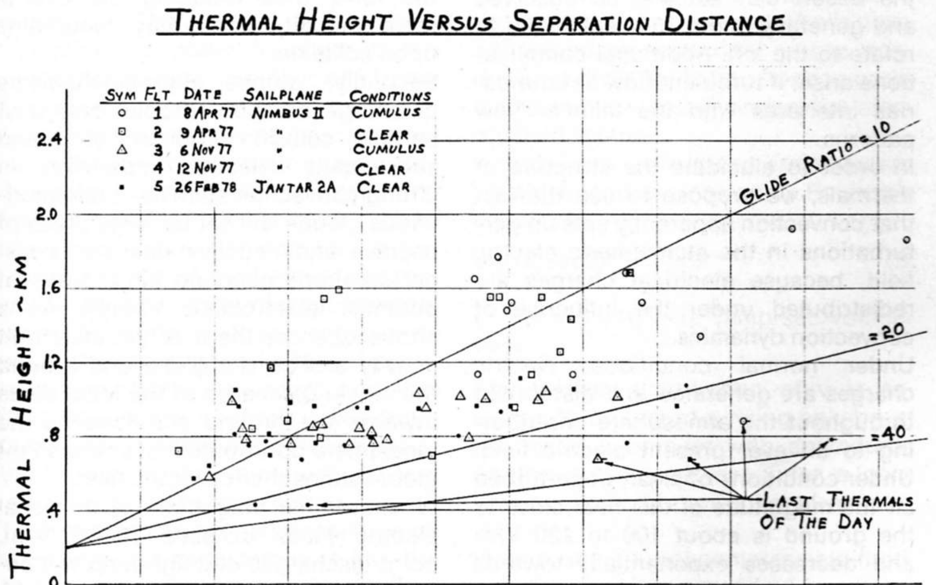


FIG. 2

FIG. 3



what sink rates he can expect to average between thermals.

Figure 3 is the final data plot that shows the measured correlation between the thermal height and the distance to the next useable thermal encountered. These were obtained from the same 81 interthermal cruise runs discussed earlier. It does generally show that the higher convective heights are characterized by wider thermal spacing, and that the average thermal height is roughly one tenth of the thermal spacing. It should be appreciated that the nearest thermals were undoubtedly closer than indicated by the Figure 3 data, but until sophisticated and not yet available remote thermal detection systems are developed, the pilot must guess and somewhat unscientifically find his next thermals.

The Figure 3 data does show that a sailplane achieving an effective interthermal glide ratio of 20 or better has a high probability of reaching the next thermal with sufficient altitude to climb again. Here a minimum thermaling altitude of 200 meters (660 ft.) was assumed. Also, Figure 3 indicates that an achieved glide ratio of 10 provides a probability of less than 0.5 that the next thermal will be reached. Most of the current hang gliders are in the 10 to 1 class, and therefore they generally are unsuccessful at extended cross-country soaring except where thermal streeting and/or ridge upcurrents are available. On the other hand, the modern sailplane's 40 to 1 capability provides their pilots little excuse for landing prematurely under normal convective conditions. The 5 lower data points shown in Figure 3 for «last thermals of the day» were widely spaced, and they did require a glide ratio of 30 to 1 and higher to reach. Effective or actual glide ratios average significantly less than those which can be achieved in still smooth air, principally because of the above discussed interthermal downdraft effects. For example, a Standard Cirrus sailplane measured about 35.9 maximum glide ratio at 52 kts airspeed during smooth air tests (Reference A). If 6 kt gross thermals exist, its climb rate will be about 4.5 kts in the thermals and it will encounter an average interthermal downdraft of approximately 6 $\times$0.10=0.6 kts. Adding this to the Std Cirrus's still air sink rates causes its maximum glide ratio to degrade to about 25.7 at 56 kts. The popular small American 1–26 sailplane measures about 21.6 L/D max in smooth air (Reference B), but degrades to about 16.8 when the same 0.6 kt average interthermal downdraft is added. The Figure 3 data indicate that the 1–26 flying alone should be able to get to its next thermal about 90% of the time, but more performance is needed for extended soaring under this paper's test thermal conditions.

Further interthermal sink rate testing needs to be done under stronger conditions to see if the above conclusions still hold true. West Texas and New Mexico would be excellent summer test locations because their thermals are more vigorous and the thermal insect populations are relatively low there. It is probably not practical to attempt to make air inter-thermal sink rate measurements with a laminar sailplane during summer conditions in east or central Texas because too many flying insects exist then and their roughening effect on the leading edges creates higher and uncertain sailplane sink rates.

References

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B. Johnson, R. H. «A Flight Test Evaluation ot the Schweizer 1–26E», Soaring, February, 1977.