# Calculating the Benefits of Dynamic Soaring

By Taras Kiceniuk

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The average climb or sink rate of a dynamiic soaring glider is calculated at different speeds. This average vertical speed is a useful measure of a glider's energy exchange with the atmosphere; although in dynamic soaring, a glider often gets much energy in a kinetic form, as extra forward speed. Figures are presented here showing graphs of equivalent average vertical speed calculated at increasing g forces in a dynamic soaring cycle. The calculations are done with a spreadsheet under various simplified atmospheric conditions. The air conditions used here can be viewed as a single dynamic cycle or as a repeating cycle of air motion made up of uniform air blocks. As used here a cycle has two air block types, which have two types of vertical motion; for example--we can assume the glider encounters a 100 foot long block of air rising at 5 foot per second followed by a 100 foot long block of air sinking at 2 Vs., then the two blocks repeat with another 5 Vs rising section again, and so on.

Each figure is for a given set of air conditions. All the graphs shown here are for the same glider performance, a 40:1 L:D ratio, with a one g best L:D speed of 100 feet/second. Eight cases of dynamic soaring technique are presented in columns across each graph. The different cases employ different degrees of varying g force. The first column case is steady one g flight; the other columns use increasing g fluctuation. All the techniques used here have one g of net upward lift. For added clarity, lines of equal speed connect the different column cases. In these calculations, we assume that the glider's speed does not change significantly during a dynamic soaring cycle. The benefits of dynamic soaring can be seen in the graphs by faster forward speeds and larger climb rates.

**Structure of the figures**

The top of each figure shows the glider characteristics used in that sheet of calculations. Below this glider specification box are the assumed air conditions. Then comes a graph showing the glider's calculated performance (presented as average vertical speed) with different dynamic soaring techniques. Average vertical speed is used to represent the glider's net power situation while the glider employs different g force profiles. Lines connect data points of various approximately uniform forward speeds. Directly under the graph are shown the cyclic g forces employed in the different cases. At the bottom of the figure are the cyclic changes in vertical glider speed and the cyclic changes in the angle of the glider's path. (Path angle is similar to pitch angle when one deducts the glider's angle of attack.) The forward speed of the glider is taken to be approximately constant throughout each dynamic soaring cycle.

**Description of the figures**

The first figure is for continuous 5 foot per second updraft. The best performance at all speeds is found in the first column case, which is constant I g flight. This tells us that in uniform air, smooth flight is best and there is no benefit to tying dynamic soaring. The fastest level running speed with no net climb or descent is 150 Vs, it is found in Case I by interpolation between the speed lines marked with triangles and with squares.

Figure 2 is mixed updrafts and stationary air. The horizontal sizes of the air mass blocks are both taken to be 200 feet. 200 feet of 5 Vs updraft is followed by 200 feet of still air. Here the best average climb rate is found in Case 3 at a speed oflOOfeet/second. This climb rate is about 1.5 f/s, which compares favorably to zero in Case 1, smooth I g flight. Case 3 uses a pull up of 2 gs in the updraft and 0 g in the still air. Fastest level running speed is 135 Vs with a Case 3 g force profile.

Figure 3 is turbulence with no net vertical flow, equal size up and downdrafts of 5 Vs strength. With no net up flow, this figure shows pure dynamic soaring. Here the best climb rate is found in Case 6 at a forward speed of 140 Vs. The fastest level running speed of about 173 Vs is found in Case 7. The g forces in Case 7 are +4 g and -2 g. This speed is faster than the level speed in Figure 1, which flies a constant 5 Vs updraft. The comparison with Figure I shows how with dynamic soaring a mixture of updraft and downdrafts can be a stronger source of energy than pure updraft alone.

In Figure 4 the downdraft is twice as strong as the updraft, 10 Vs versus 5 Vs. Despite the net down flow of 2.5 f/s, the increased wind shear gives dynamic soaring a big jump in speeds and energy- note the changes in graph scale. The best climb of 6 Vs is attained at a speed of 180 Vs 'in Case 5. The fastest level running speed is 250 Us 'in Case 8, with g forces of +8 g and -6 g.

Figure 5 is for mixed sink and still air-- 20 Vs downdrafts alternating with blocks of air at rest. Here there are some more graph scale changes. The best climb of about 9 Vs is produced at a speed of 270 Vs in Case 6, which uses plus 8.5 g and minus 6.5 g The fastest level running speed shown is about 320 Vs in Case 8. It is remarkable that a glider can fly so fast using only the energy from sinking air.

Figure 6 is for turbulence of mixed 20 Vs updraft and 20 Vs downdraft. The best rate of climb is 135 f1s at a speed of 390 Vs (Case 4). The fastest horizontal running speed is off the graph- more than 650 feet/second. The associated g forces are over +36 g and -34 g. With such high g maneuvering the effects of the one g force of gravity are relatively small and the glider's flight path can be quite inclined for short periods of time. These energy calculations are considered to be valid when the wind shear is approximately cross- wise to the glider's flight path, this includes vertical wind variation as well as side to side. Fore-aft wind variation is difficult for a glider to utilize to any large extent.

Figure 7 makes a comparison with Figure 2; in Figure 7 the updraft blocks are twice as strong, but twice as far apart. The case I performance is the same in figures 2 and 7, but the stronger gusts in 7 can give better dynamic soaring results.

Figure 8 shows the problem that occurs when the air blocks are too big. The graph looks the same as 'in Figure 3, but looking at the chart below the graph we can see that *in many of the higher g cases the +- change in path angel exceeds 30 degrees and the assumptions used in the calculations are no longer accurate. The two simplif~dng assumptions used here are that the glider's speed does not change much throughout a dynamic soaring cycle and that the wind shear is approximately perpendicular to the glider's flight path.

**Conclusions**

The benefits of dynamic soaring can be very great if turbulence or wind shear is present in the atmosphere. A mixture of updraft and downdraft can be a much stronger source of glider energy than just updraft alone. This is particularly true as the updrafts become stronger. Large g forces can be beneficial in even moderate strength dynamic soaring conditions. To get all the energy from an updraft rising at twice a glider's normal sinking speed, the glider can pull four gs while flying at twice its normal best L:D speed. High g loads and turbulence scale may both limit dynamic soaring possibilities. Atmospheric flow variations are best for dynamic soaring when within a certain size range. If the air blocks are too large the required changes in aircraft path angle become too large and the speed changes also. The high frequency limit may come from the wing's size and from the rate of lift force change possible on the wing. In dynamic soaring the high gs and aerodynamic forces can extract much more energy from the atmosphere than can a gravity-limited glider flying at one g. If we can find consistent airways containing enough wMid shear and can tolerate the high g forces used, then dynamic soaring technique can enable very long and fast flights.

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 5 5

**Glider Specifications:**

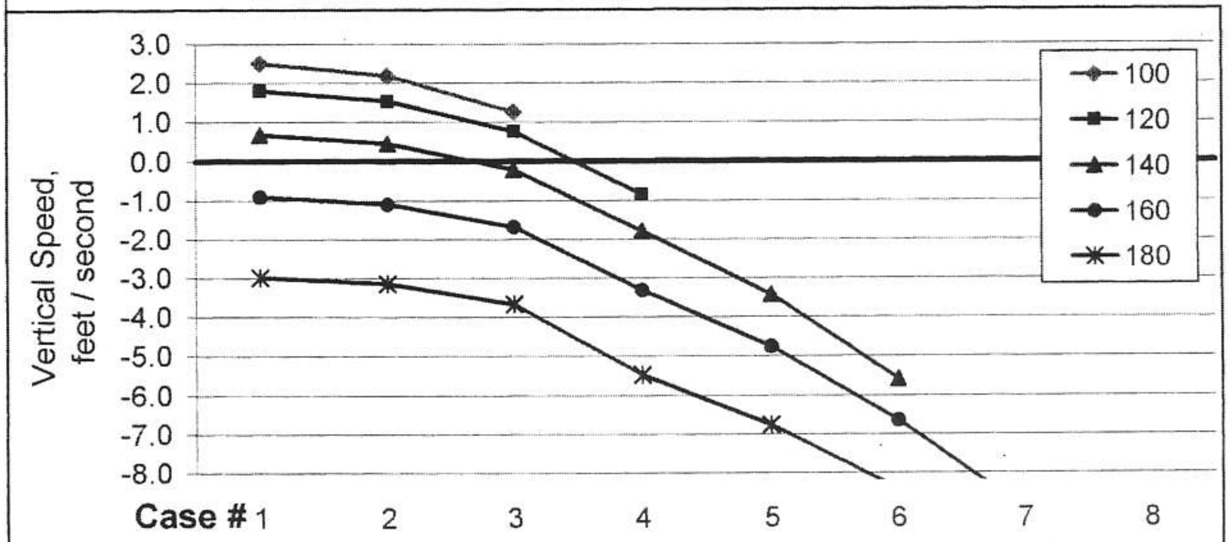
| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | | 10 | lbs |
| All Up Weight = | 800 | lbs | Friction Drag = | | 10 | lbs. |
| Fastest Glider Speed = | 180 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 20 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Smooth Lift

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **5** | feet/second | Upward Air Motion = | **5** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 0.5 x 32 f/s/s

**Glider Average Vertical Speed in Different Dynamic Gee Force Cases**




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 |
| Gee, Block 2 | 1.00 | 0.50 | 0.00 | -0.50 | -1.00 | -1.50 | -2.00 | -2.50 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 32 | 64 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **120** | 0 | 27 | 53 | 80 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 13 | 18 | -- | -- | -- | -- | deg. |
| **140** | 0 | 23 | 46 | 69 | 91 | 114 | -- | -- | f/s |
| | 0 | 5 | 9 | 14 | 18 | 22 | -- | -- | deg. |
| **160** | 0 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | f/s |
| | 0 | 4 | 7 | 11 | 14 | 17 | 21 | 24 | deg. |
| **180** | 0 | 18 | 36 | 53 | 71 | 89 | 107 | 124 | f/s |
| | 0 | 3 | 6 | 8 | 11 | 14 | 17 | 19 | deg. |

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**Figure 1.** Loss of performance produced by varying gee force when soaring uniform lift. At lower speeds the glider wing can stall and not make a high gee data point.

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads    5    0

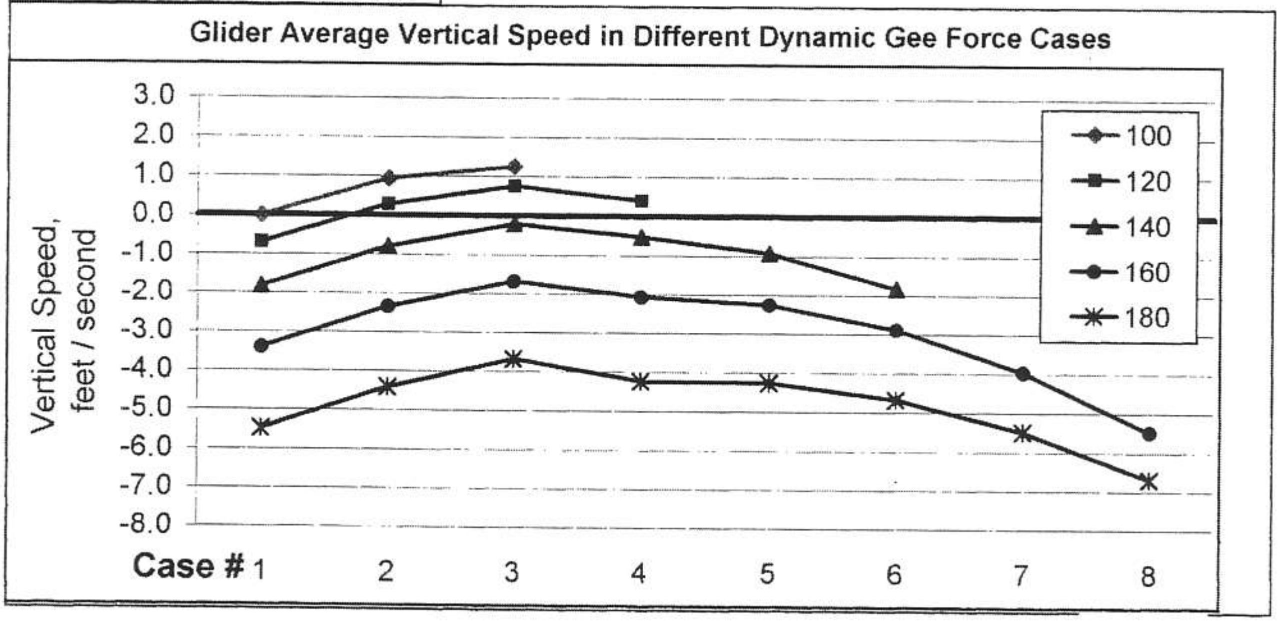
**Glider Specifications:**

| | | | | | |
|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | |
| @ Speed of | 100 | feet/second | Induced Drag = | 10 | lbs |
| All Up Weight = | 800 | lbs | Friction Drag = | 10 | lbs. |
| Fastest Glider Speed = | 180 | feet/second | Stall Speed +&- G= 70 | 100 | feet/sec |
| Speed Increment= | 20 | feet/second | Neg G drag factor= 1.25 | ratio | |

**Air Conditions:** Patchy Lift

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **5** | feet/second | Upward Air Motion = | **0** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 0.5 x 32 f/s/s




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 |
| Gee, Block 2 | 1.00 | 0.50 | 0.00 | -0.50 | -1.00 | -1.50 | -2.00 | -2.50 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 32 | 64 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **120** | 0 | 27 | 53 | 80 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 13 | 18 | -- | -- | -- | -- | deg. |
| **140** | 0 | 23 | 46 | 69 | 91 | 114 | -- | -- | f/s |
| | 0 | 5 | 9 | 14 | 18 | 22 | -- | -- | deg. |
| **160** | 0 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | f/s |
| | 0 | 4 | 7 | 11 | 14 | 17 | 21 | 24 | deg. |
| **180** | 0 | 18 | 36 | 53 | 71 | 89 | 107 | 124 | f/s |
| | 0 | 3 | 6 | 8 | 11 | 14 | 17 | 19 | deg. |

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**Figure 2.** Dynamic Soaring of Patchy Lift    Net Up Flow 2.5 f/s    Wind Shear 5 f/s

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 5 -5

**Glider Specifications:**

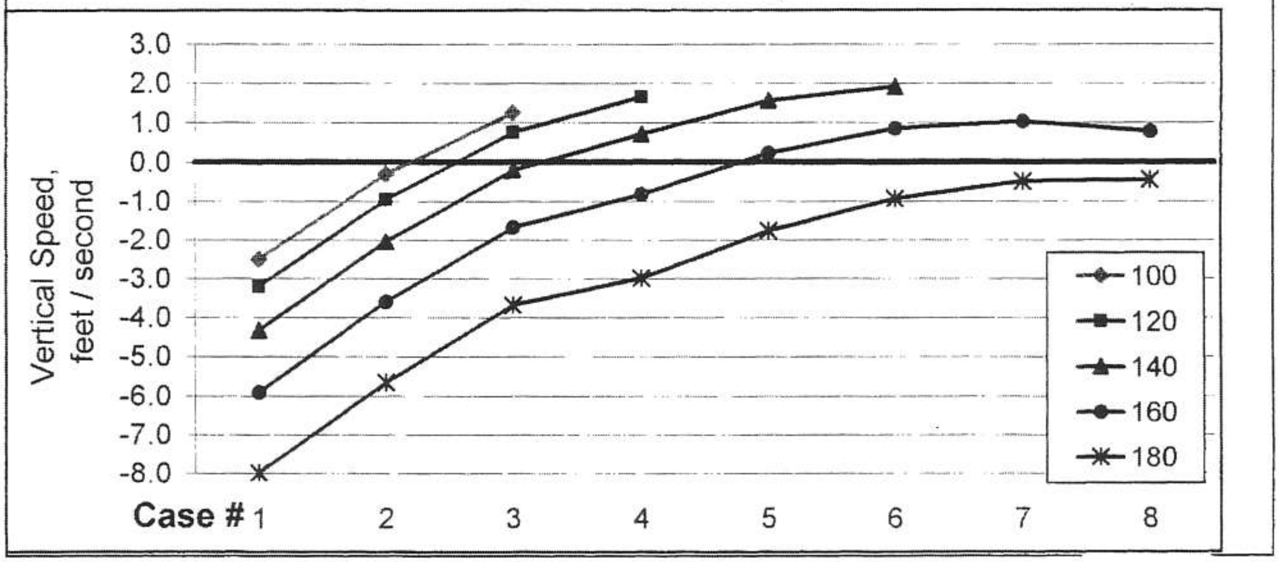
| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | | Induced Drag = | 10 | lbs |
| All Up Weight = | 800 | lbs | | Friction Drag = | 10 | lbs. |
| Fastest Glider Speed = | 180 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 20 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Turbulence-- Equal Up and Downdrafts

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **5** | feet/second | Upward Air Motion = | **-5** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 0.5 x 32 f/s/s

**Glider Average Vertical Speed in Different Dynamic Gee Force Cases**




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 |
| Gee, Block 2 | 1.00 | 0.50 | 0.00 | -0.50 | -1.00 | -1.50 | -2.00 | -2.50 |

| **Speed** | **Change in Vertical Velocity, f/s and + - Path Angle Change, deg.** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 32 | 64 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **120** | 0 | 27 | 53 | 80 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 13 | 18 | -- | -- | -- | -- | deg. |
| **140** | 0 | 23 | 46 | 69 | 91 | 114 | -- | -- | f/s |
| | 0 | 5 | 9 | 14 | 18 | 22 | -- | -- | deg. |
| **160** | 0 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | f/s |
| | 0 | 4 | 7 | 11 | 14 | 17 | 21 | 24 | deg. |
| **180** | 0 | 18 | 36 | 53 | 71 | 89 | 107 | 124 | f/s |
| | 0 | 3 | 6 | 8 | 11 | 14 | 17 | 19 | deg. |

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**Figure 3.** Equal Strength Mixed Updrafts and Downdrafts Wind shear 10 f/s

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 5 -10

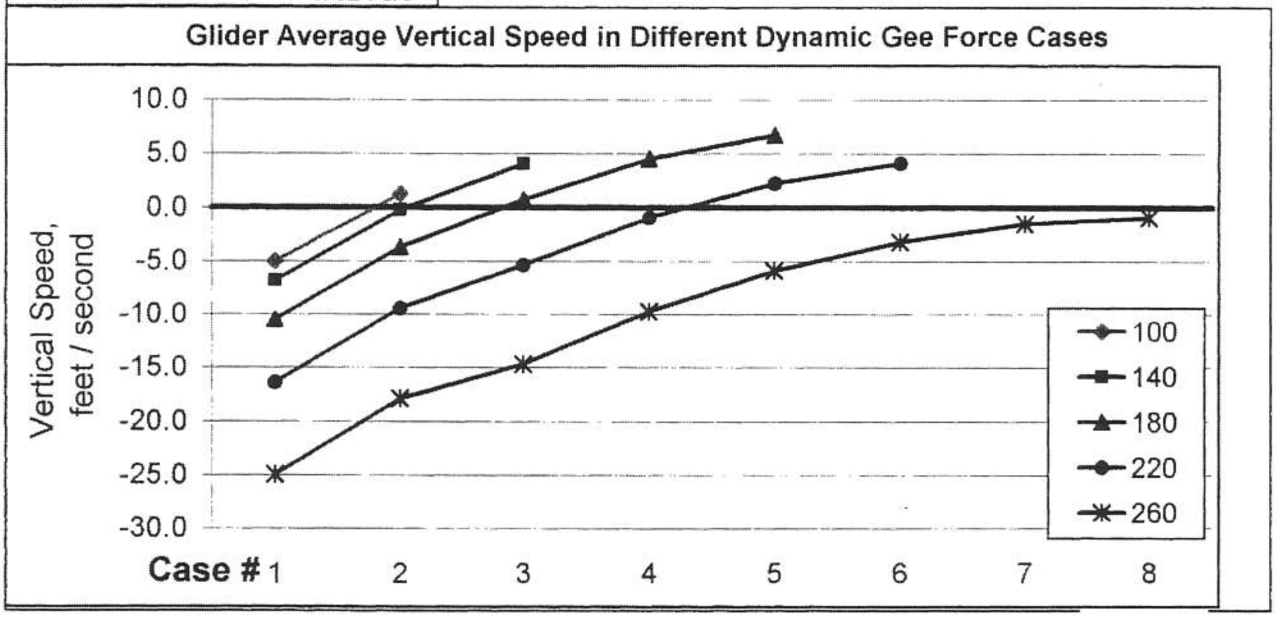
**Glider Specifications:**

| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | | 10 | lbs |
| All Up Weight = | 800 | lbs | Friction Drag = | | 10 | lbs. |
| Fastest Glider Speed = | 260 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 40 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Net Downflow-- Downdrafts Stronger than Ups

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **5** | feet/second | Upward Air Motion = | **-10** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

| G increment = | 1 | x 32 f/s/s |
|---|---|---|




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 |
| Gee, Block 2 | 1.00 | 0.00 | -1.00 | -2.00 | -3.00 | -4.00 | -5.00 | -6.00 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 64 | -- | -- | -- | -- | -- | -- | f/s |
| | 0 | 18 | -- | -- | -- | -- | -- | -- | deg. |
| **140** | 0 | 46 | 91 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **180** | 0 | 36 | 71 | 107 | 142 | -- | -- | -- | f/s |
| | 0 | 6 | 11 | 17 | 22 | -- | -- | -- | deg. |
| **220** | 0 | 29 | 58 | 87 | 116 | 145 | -- | -- | f/s |
| | 0 | 4 | 8 | 11 | 15 | 18 | -- | -- | deg. |
| **260** | 0 | 25 | 49 | 74 | 98 | 123 | 148 | 172 | f/s |
| | 0 | 3 | 5 | 8 | 11 | 13 | 16 | 18 | deg. |

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**Figure 4.** Dynamic Soaring in Net Down Flow. The updrafts are the same as the previous figure, the downdrafts twice as strong. Net Down Flow 2.5 f/s.

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 0 -20

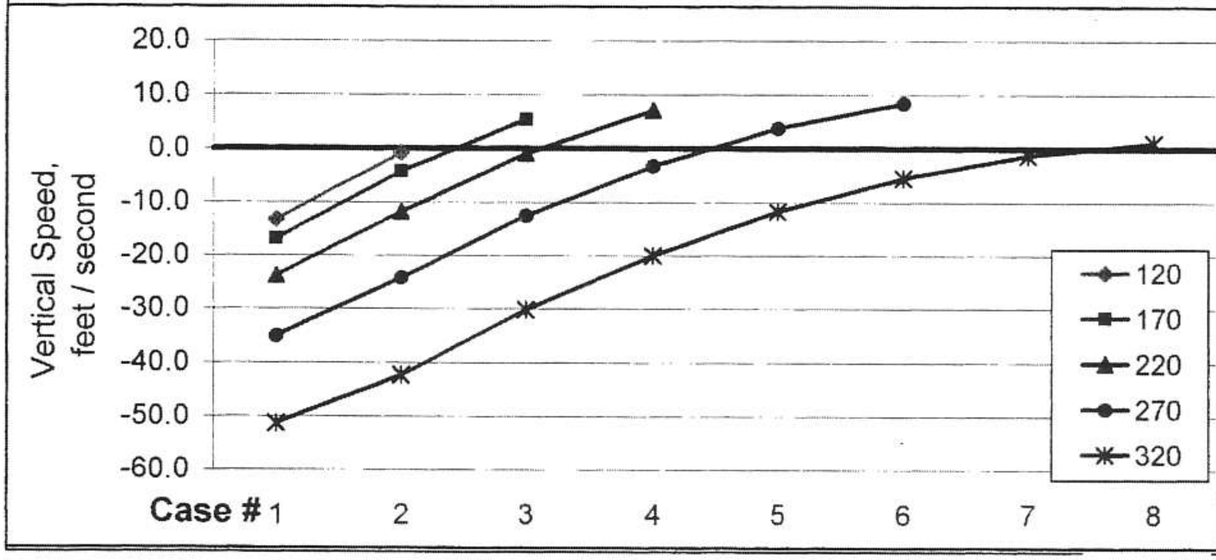
**Glider Specifications:**

| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | 10 | | lbs |
| All Up Weight = | 800 | lbs | Friction Drag = | 10 | | lbs. |
| Fastest Glider Speed = | 320 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 50 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Downdrafts Mixed with Still Air

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **0** | feet/second | Upward Air Motion = | **-20** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 1.5 x 32 f/s/s




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 2.50 | 4.00 | 5.50 | 7.00 | 8.50 | 10.00 | 11.50 |
| Gee, Block 2 | 1.00 | -0.50 | -2.00 | -3.50 | -5.00 | -6.50 | -8.00 | -9.50 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **120** | 0 | 80 | -- | -- | -- | -- | -- | -- | f/s |
| | 0 | 18 | -- | -- | -- | -- | -- | -- | deg. |
| **170** | 0 | 56 | 113 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **220** | 0 | 44 | 87 | 131 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 11 | 17 | -- | -- | -- | -- | deg. |
| **270** | 0 | 36 | 71 | 107 | 142 | 178 | -- | -- | f/s |
| | 0 | 4 | 8 | 11 | 15 | 18 | -- | -- | deg. |
| **320** | 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | f/s |
| | 0 | 3 | 5 | 8 | 11 | 13 | 16 | 18 | deg. |

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**Figure 5.** Downdrafts and Still Air-- Wind Shear 20 f/s Net Down Flow 10 f/s

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 20 -20

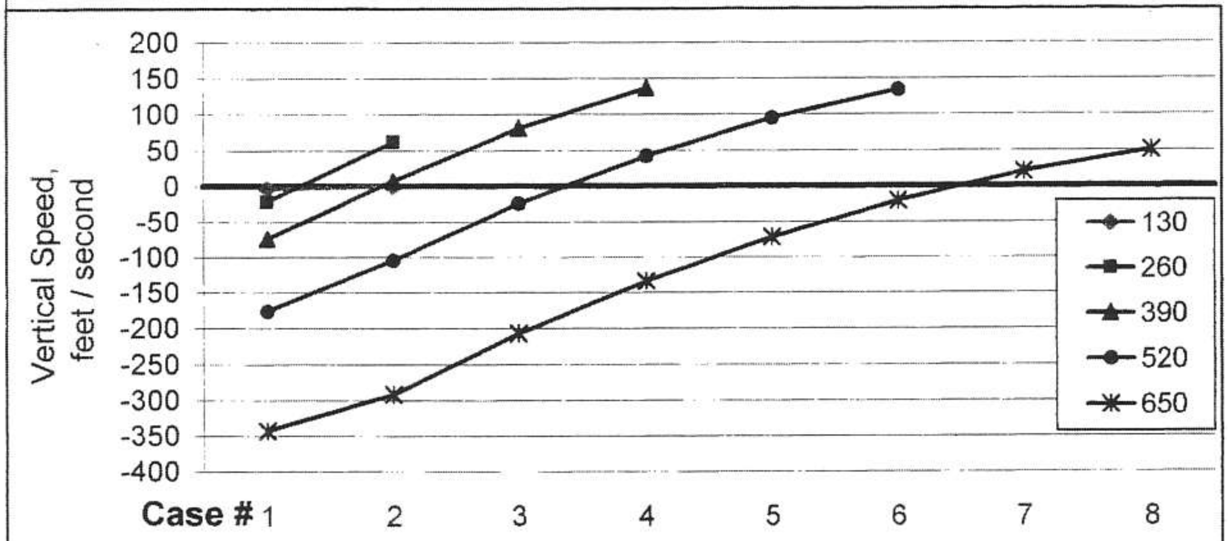
| Glider Specifications: | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | | 10 | lbs |
| All Up Weight = | 800 | lbs | Friction Drag = | | 10 | lbs. |
| Fastest Glider Speed = | 650 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 130 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Strong Turbulence

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **20** | feet/second | Upward Air Motion = | **-20** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 200 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 5 x 32 f/s/s

**Glider Average Vertical Speed in Different Dynamic Gee Force Cases**




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 6.00 | 11.00 | 16.00 | 21.00 | 26.00 | 31.00 | 36.00 |
| Gee, Block 2 | 1.00 | -4.00 | -9.00 | -14.00 | -19.00 | -24.00 | -29.00 | -34.00 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 130 | 0 | -- | -- | -- | -- | -- | -- | -- | f/s |
| | 0 | -- | -- | -- | -- | -- | -- | -- | deg. |
| 260 | 0 | 123 | -- | -- | -- | -- | -- | -- | f/s |
| | 0 | 13 | -- | -- | -- | -- | -- | -- | deg. |
| 390 | 0 | 82 | 164 | 246 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 12 | 18 | -- | -- | -- | -- | deg. |
| 520 | 0 | 62 | 123 | 185 | 246 | 308 | -- | -- | f/s |
| | 0 | 3 | 7 | 10 | 13 | 16 | -- | -- | deg. |
| 650 | 0 | 49 | 98 | 148 | 197 | 246 | 295 | 345 | f/s |
| | 0 | 2 | 4 | 6 | 9 | 11 | 13 | 15 | deg. |

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**Figure 6.** Stronger Atmospheric Turbulence No Net Vertical Flow 40 f/s Wind Shear

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 10 0

**Glider Specifications:**

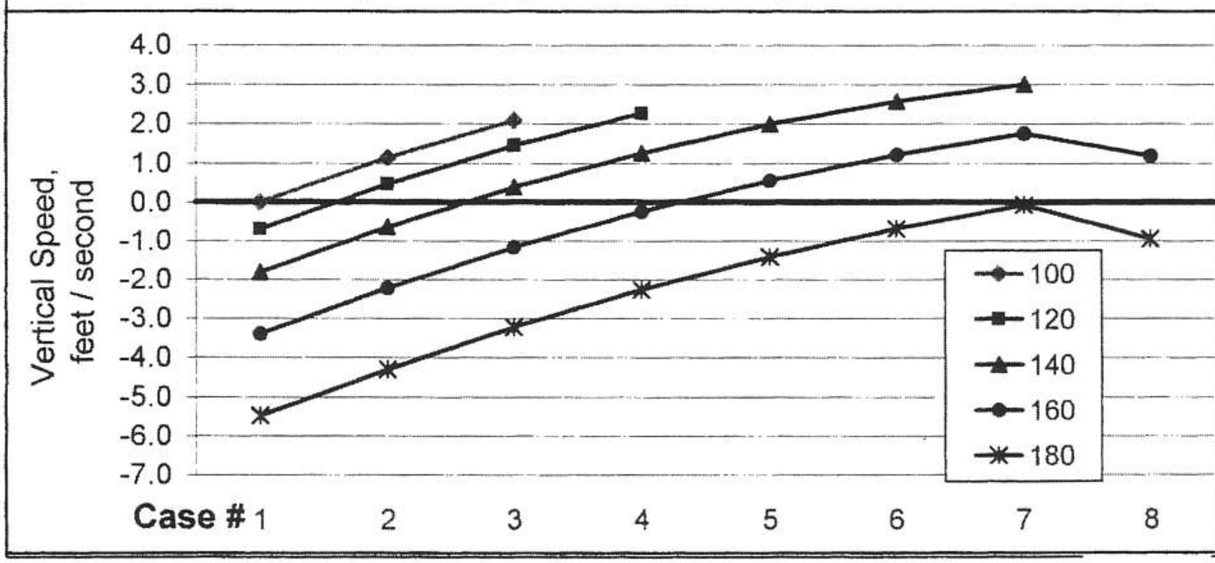
| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | 10 | lbs | |
| All Up Weight = | 800 | lbs | Friction Drag = | 10 | lbs. | |
| Fastest Glider Speed = | 180 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 20 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Patchy Lift-- Stronger Patches, Farther Apart

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **10** | feet/second | Upward Air Motion = | **0** | feet/second |
| Hrz, Size = | 200 | feet | Horizontal Block Size = | 600 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 0.5 x 32 f/s/s

**Glider Average Vertical Speed in Different Dynamic Gee Force Cases**




**Gee Forces in the Different Cases**

| **Case #** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 |
| Gee, Block 2 | 1.00 | 0.83 | 0.67 | 0.50 | 0.33 | 0.17 | 0.00 | -0.17 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| **Speed** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 32 | 64 | -- | -- | -- | -- | -- | f/s |
| | 0 | 9 | 18 | -- | -- | -- | -- | -- | deg. |
| **120** | 0 | 27 | 53 | 80 | -- | -- | -- | -- | f/s |
| | 0 | 6 | 13 | 18 | -- | -- | -- | -- | deg. |
| **140** | 0 | 23 | 46 | 69 | 91 | 114 | 137 | -- | f/s |
| | 0 | 5 | 9 | 14 | 18 | 22 | 26 | -- | deg. |
| **160** | 0 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | f/s |
| | 0 | 4 | 7 | 11 | 14 | 17 | 21 | 24 | deg. |
| **180** | 0 | 18 | 36 | 53 | 71 | 89 | 107 | 124 | f/s |
| | 0 | 3 | 6 | 8 | 11 | 14 | 17 | 19 | deg. |

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**Figure 7.** Patchy Lift with Stronger More Separated Updrafts
Net Up Flow 2.5 f/s Wind Shear 10 f/s

# Dynamic Soaring Calculations

Simplified Two Air Block System at Different Speeds and Gee Loads 5 -5

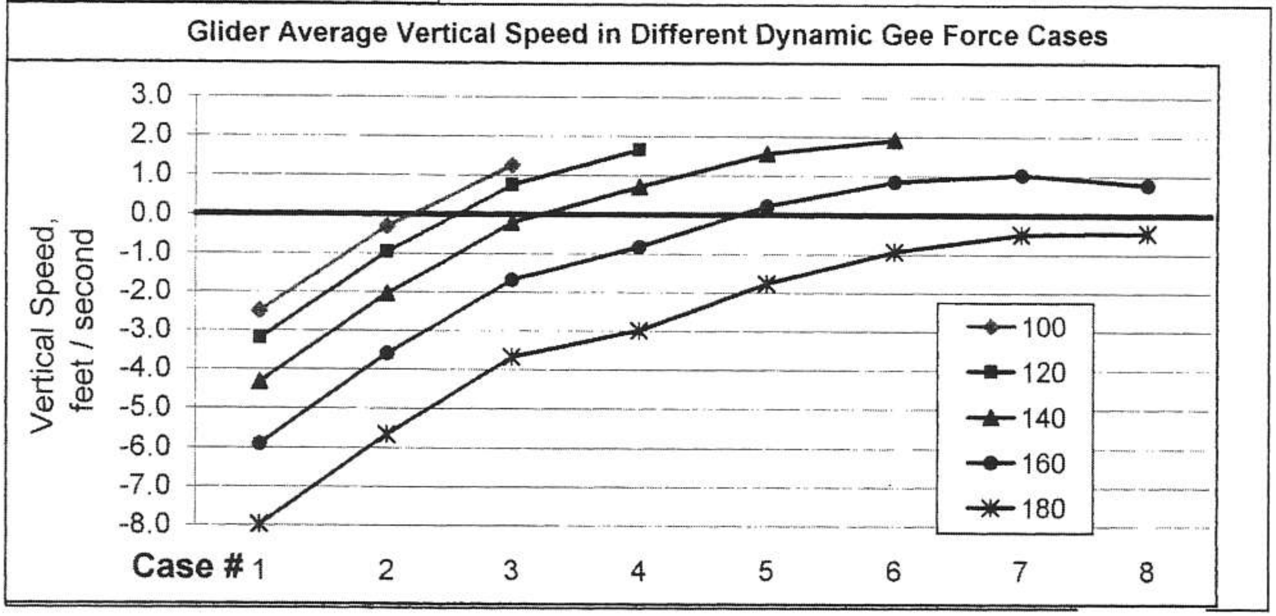
**Glider Specifications:**

| | | | | | | |
|---|---|---|---|---|---|---|
| Best L:D = | 40 | to one | Drag @ Best L:D speed & 1 gee | | | |
| @ Speed of | 100 | feet/second | Induced Drag = | 10 | lbs | |
| All Up Weight = | 800 | lbs | Friction Drag = | 10 | lbs. | |
| Fastest Glider Speed = | 180 | feet/second | Stall Speed +&- G= | 70 | 100 | feet/sec |
| Speed Increment= | 20 | feet/second | Neg G drag factor= | 1.25 | ratio | |

**Air Conditions:** Turbulence-- Lower Frequency

| | Air Block 1 | | | Air Block 2 | |
|---|---|---|---|---|---|
| Up Air Motion = | **5** | feet/second | Upward Air Motion = | **-5** | feet/second |
| Hrz, Size = | 600 | feet | Horizontal Block Size = | 600 | feet |
| G Load C1 = | 1 | x 32 f/s/s | Gee Load Case #1 = | 1 | x 32 f/s/s |

G increment = 0.5 x 32 f/s/s




**Gee Forces in the Different Cases**

| Case # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Gee, Block 1 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 | 3.50 | 4.00 | 4.50 |
| Gee, Block 2 | 1.00 | 0.50 | 0.00 | -0.50 | -1.00 | -1.50 | -2.00 | -2.50 |

**Change in Vertical Velocity, f/s and + - Path Angle Change, deg.**

| Speed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **100** | 0 | 96 | 192 | -- | -- | -- | -- | -- | f/s |
| | 0 | 26 | >30 deg. | -- | -- | -- | -- | -- | deg. |
| **120** | 0 | 80 | 160 | 240 | -- | -- | -- | -- | f/s |
| | 0 | 18 | >30 deg. | >30 deg. | -- | -- | -- | -- | deg. |
| **140** | 0 | 69 | 137 | 206 | 274 | 343 | -- | -- | f/s |
| | 0 | 14 | 26 | >30 deg. | >30 deg. | >30 deg. | -- | -- | deg. |
| **160** | 0 | 60 | 120 | 180 | 240 | 300 | 360 | 420 | f/s |
| | 0 | 11 | 21 | >30 deg. | >30 deg. | >30 deg. | >30 deg. | >30 deg. | deg. |
| **180** | 0 | 53 | 107 | 160 | 213 | 267 | 320 | 373 | f/s |
| | 0 | 8 | 17 | 24 | >30 deg. | >30 deg. | >30 deg. | >30 deg. | deg. |

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**Figure 8.** Problems can arise with path angles when air blocks become too large.