The Soaring Engine volume four

"Airframes and avionics"

The fourth volume of the Soaring Engine series will be available in May 2021.

Volumes one and two investigates the nature of soaring conditions and how to exploit them, and volume three outlines how a pilot may achieve excellence in the sport of cross country soaring.

Volume four is about the equipment. Gliding is an unusual blend of technology and artistry, and today's sailplanes are aerodynamically refined and optimised. Current avionics suites are equally sophisticated, with powerful processors, moving maps, complex user interfaces, electronic conspicuity systems and internet connectivity. This high performance comes at the cost of significantly increased complexity.

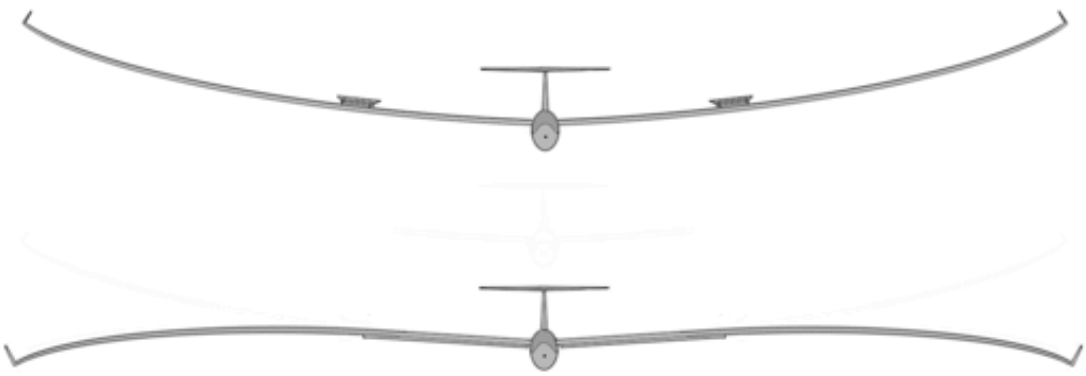
The aim of this book is to review some of the important features of modern composite airframes, explain and clarify the latest developments in avionics, and show pilots how to operate their glider and instrument suite to maximum effect. Intended for pilots at all experience levels the content is easy to follow with many colour illustrations and a comprehensive appendix.

See the example pages below:

Flaps and brakes

A wing with camber changing flaps will generate a different stall line for the flight envelope at each flap setting. This is far too complicated fo us to keep track of, so it is assumed for the purpose of generating speed and *g* limits that the flaps are set to a fixed position, slightly negative. Deploying the airbrakes will change the lift distribution and reduce the wing's *g* limits, so again it is assumed when discussing the flight envelope that airbrakes are closed.

The ASH 25 really does bend this much



What happens when we move the flaps or open the airbrakes? Opening the airbrakes reduces the lift where the brakes are located. The load shifts towards the wing tips, increasing the bending moment and reducing the *g* limit. With the brakes open the glider is limited to only +3.5*g* and -1.5*g* at any speed. A good firm pull out of a loop or a hurried recovery from a spin can easily exceed this, so we never use the brakes during these manoeuvers. On the other hand there are no airspeed limits for use of the airbrakes, only *g* limits. You may open them at Vne, although they are likely to snatch a bit and could be impossible to close again without slowing down.

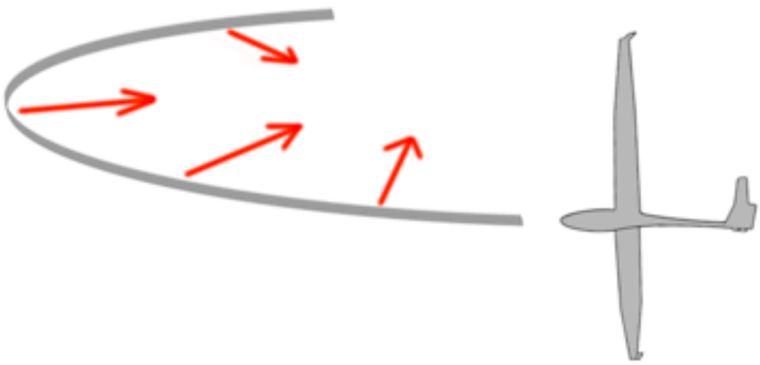
Camber changing flaps change the amount of *g* that the wing can generate. Air loads at high speed stress the drives, hinges and the flaps themselves. If a control surface is already deflected through a large angle then bending the wing too much could rip the hinges out of their sockets. To visualise this, fold a sheet of paper in half and then try to bend it across the fold line...the fold stiffens the paper and it won't bend smoothly. To protect the wing, the hinges and the flaps themselves, each flap setting has a maximum speed limit, Vf. You'll find these limits specified in the flight manual and shown on the airspeed indicator. It is easy to exceed these limits by mistake if you spin the glider by accident: see the page on spin recovery in big gliders.

Landing flaps bend the wing even more, by shifting the span loading inboard, and they are subject to much lower speed limits. The sketch shows just how flexible the wings can be on some big gliders, especially if the outboard ailerons go up at the same time as the landing flap goes down. The limiting speed for landing flap on the ASH 25 is only 76kt, and when I look out at the bent wings I can see why. It's scary.

Elevator power and turning

The elevator is the most sensitive of the controls and we don't need to move it much to change the attitude and speed. Despite this we still have to bring the stick a long way back in a thermal turn. This is partly because a tight turn demands a high angle of attack. But unlike straight balanced flight, the turn isn't a static situation. The flight path is curved and the glider is pulling extra *g*.

Bank and yank



In a tight circle the glider is constantly both pitching up and yawing into the turn: in a right turn the stick is back and the rudder well to the right: in a left turn the stick is back and the rudder to the left. The rudder keeps the glider yawing, and the stick back keeps the nose coming up. The geometry of the turn prevents the nose from rising above the horizon: in a spiral dive, at nearly 90° of bank, the stick can be on the aft stop without returning the glider to level flight. Pitching up at this angle of bank merely generates more *g* force, tightening the turn.

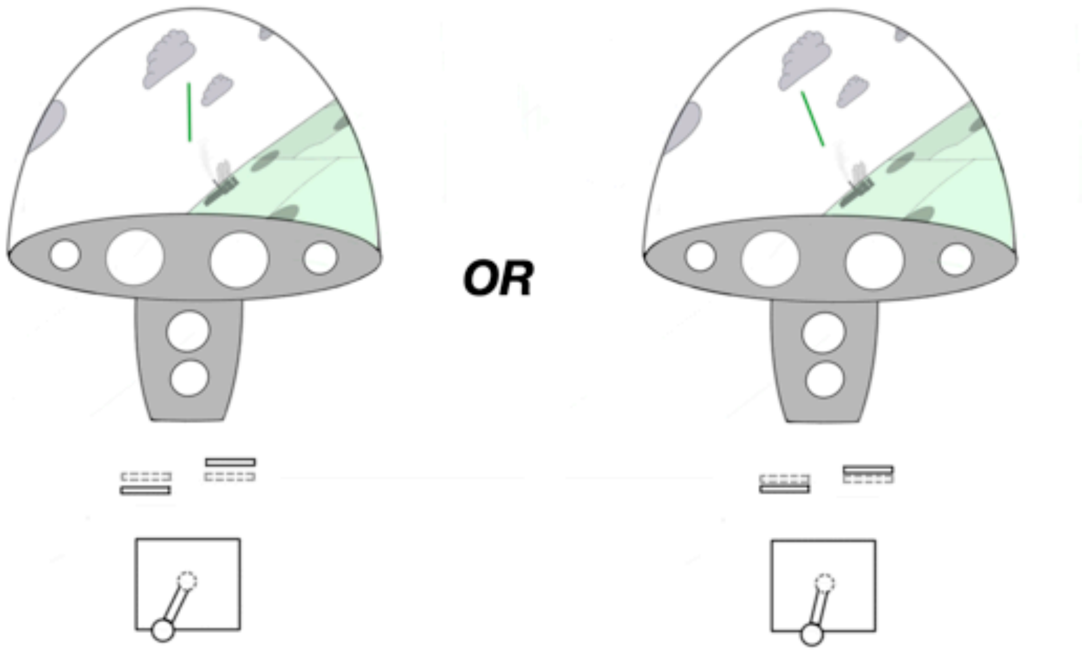
This effect is not as extreme in an ordinary thermal turn, but we still need a lot of back stick to keep the nose up. If the glider is too nose heavy then we can "run out of elevator," a state where the tailplane cannot make enough downforce to keep the glider pitching up at required rate, even though the centre of pressure is ahead of the centre of gravity. This seems odd but bear in mind that the low speed and the constant rate of pitch ensures that the fixed part of the tailplane sits at a positive angle of attack. Running out of elevator control then ruins the rate of climb.

If you want to achieve the best possible glide angle at low speeds then the glider should be nose heavy, but to get the best climb in circling flight the glider should be tail heavy to reduce the tailplane force and associated drag required for tight circles. In normal cross country thermal soaring we spend almost all of our time either thermalling or cruising fast. We rarely cruise at the best glide speed or slower, so it isn't worth trying to optimise for slow straight flight. This means that the optimum centre of gravity position for cross country soaring is somewhere in the rear half of the range. How far back is sensible?

Circle with a little slip

Visualise starting a turn. "Look around, now look forward. Roll into the turn with stick and rudder. At the desired bank angle put the stick in the middle and reduce the rudder. Stop the nose falling with a small backward *and outward* movement of the stick." Why "outward" movement? Because the combination of into-turn rudder to keep the string in the middle with back stick alone would lead to a spiral dive. To stop the bank increasing we need out-of-turn aileron as well.

The view looking forward and the control positions



The first drawing shows the string in the middle and the positions of stick and rudder required to achieve this: a considerable amount of right rudder with a lot of back stick and out-of-turn aileron. The controls are crossed, but this is safe and normal in a glider as long as the yaw string isn't pointing into the turn.

The second drawing shows the glider slipping just a little: the yaw string points about 20° out. To achieve this the pilot has slightly reduced the into-turn rudder and brought the aileron closer to the centre. There is still a lot of back stick, which is to be expected. Just don't overdo it and pull the stick all the way back!

Some gliders may be more stable in the turn and climb just a fraction better if you fly with a little slip: it is worth experimenting to see what works for you. I always circle with a little slip when close to the ground: this is an old mountain pilot's trick that reduces the risk of an unexpected departure when scraping the glider off a ridge in gusty air.

The Cruise page

Many pilots prefer to cruise with "track up" so that the map aligns with the terrain ahead. Note the north arrow. The default scale is much larger, and because I want to look down track you'll see that the glider icon has moved to near the bottom of the page. The basic navigation information is in the same place as before: the same nav boxes, the same colours, the same fonts and the same icons on the screen. I've added a turn indicator: this is the same colour as the track line it refers to.

Configured for cruising

The climb information has gone, replaced by data pertaining to the task. Notice the colour coding: waypoint bearing and distance in grey, altitudes in yellow, active track line and "turn to" in pink and task data in blue. The two boxes on the left are common to both racing tasks and AATs. The middle row shows task delta and time remaining, parameters that are used for AAT decision making. The other two boxes show the bearing and distance to the centre of the current AAT area.

I need this information for competition flying. You may make different choices. For instance, a flapped glider benefits from combining the flap position indicator with a speed indicator tape, or you could use an altitude tape to show your start and finish limits, airspace ceiling and working height band. The possibilities are endless.

The basic principles remain: set up the moving map with the information you need and keep it clean and clear.

Solid state variometers

Manufacturers tried to build a better variometer. Will Schumann's "Sage" taut-band variometers were probably the peak of the art, but even the best mechanical instruments are delicate and suffer from time lag, overshooting in gusty thermals, or both. Nobody would bother to design a new mechanical variometer now: solid state pressure transducers can reliably measure absolute pressure and minuscule pressure changes with pinpoint accuracy.

A pressure transducer variometer

The modern flight computer with integrated variometer is a solid state instrument with no moving parts. The heart of the variometer (now often called the "air data computer" utilises a pressure transducer, not a flow meter. The transducer can sense even a tiny pressure change instantly, so the air doesn't have to move in the pneumatic line. The variometer indications are given by an audio tone: no inertia issues there either, and you can keep your eyes outside the cockpit. And if you do need a needle, then a screen can supply a digital pointer which has no mass, no momentum, and therefore no tendency to overshoot or lag.

It's a brilliant solution. There are still compromises: the character of the vario response depends on the designer's choice of software, the filtering algorithms, audio tones and the look of the display screens: many of these choices are arbitrary and often infinitely configurable. This is great if you know what you want, but sometimes something simpler is easier to figure out. Most gliders have a mechanical variometer in the panel "as a backup." And the pressure transducer variometer *still* suffers from lag: remember the glider itself has inertia and momentum. However fast the variometer, the indications of lift always arrive just a moment after the pilot feels the glider start to go up. Despite this a solid state variometer is much faster and more useful than a mechanical one.

Copies of all the Soaring Engine volumes can be obtained from:

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