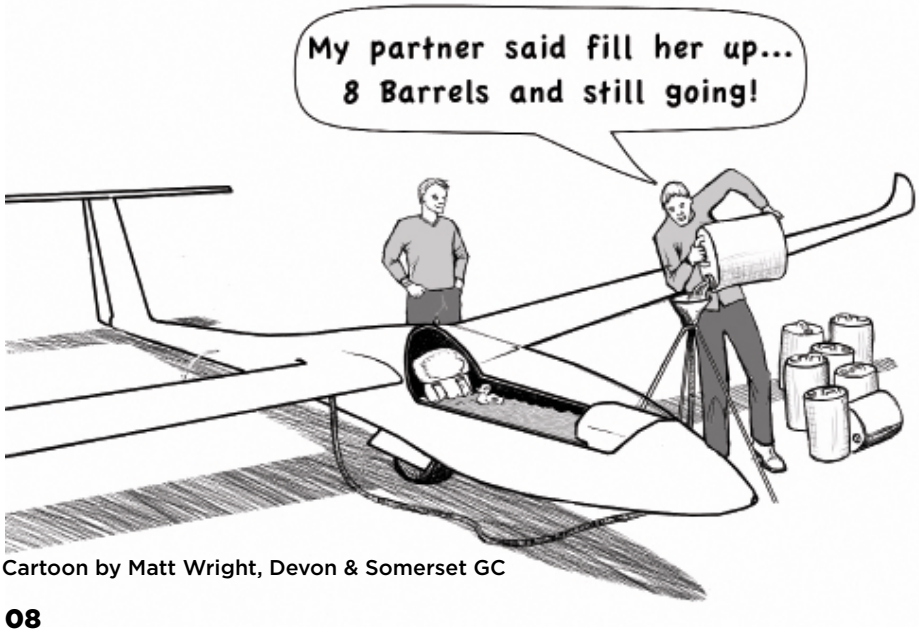
Photograph: Ron Smith

TO WATER OR NOT TO WATER?

Does water ballast make your glider go faster? Tim Macfadyen looks at the pros and cons of water in a variety of gliders

WATER ballast is probably the most talked about way of making your glider go faster. With most gliders in the UK, in anything other than top competitions, it is probably the least important. This article discusses the pros and cons of water in a variety of gliders, and also some other factors that govern your cross-country speed. As no days last for ever, cross-country speed equates to distance flown.

Most 15-metre span gliders fly at around 800 pounds (360kg); the ASW 20 discussed here is typical – this is a good weight for an average UK day with 2½ -3kt thermals. It is perhaps worth putting in a couple of barrels of water on a good day, especially for a short task. This also applies to the older gliders like the Standard Cirrus that is lighter, but has a lower technology wing. The more modern gliders with higher technology wings can be flown heavier. It is noticeable that the 15-metre span "turbos" fly along with everyone else in reasonable conditions, but lose out badly when it gets weak. They are at least 100 pounds heavier than pure gliders so this ties up with the theory.



Cartoon by Matt Wright, Devon & Somerset GC

Please look at figure 1 (above right). I know it looks complex, but if you spend a little time you will see it is not that bad and contains an awful lot of information. This is the manufacturer's data for an ASW 20 at sea level, with no wind and no streeting, but the same principles generally apply. The graph shows that what really improves your average speed is climb rate. For example, the optimum cruise speed (without water) between 3kt thermals is 85kts; this gives you an average cross-country speed of 79km/h. If you cruise at 70 or 100kts, this only reduces your average cross-country speed by 2km/h, but climbing at 2kts instead of 3kts will slow you by 15km/h. If you are full of water, with 4kt climbs you should average 99km/h instead of 91km/h when dry, but if the water reduces your climb rate to 3½kts you have gained nothing by adding water. On a weaker

day, if the water reduces your climb rate from 3kts to 2½kts you are definitely better off without it. The ASW 20 handbook says you only need full water (100kg, four barrels) if the thermals are 4kts or more.

A major difficulty is knowing how much the water is reducing your climb rate. The ASW 20 sink rate is reduced 0.3kt with full water, but the thermal radius with 45° bank is increased from 55 to 75 metres. If the thermals are big, or even better if you are spending most of your time running along streets, larger circles don't matter much and you should be heavy, but on a windy day, with tight broken thermals, weight can make a dramatic difference to your climb rate, or even whether you climb at all, and you need to be light.

In genuinely strong conditions (normally overseas), say 6kts or more, so little of the flight time is spent climbing that losing a bit of climb rate through being very heavy has little effect on the overall average speed. In these conditions it pays to fly as heavy as possible.

If you have taken a day off work, it is by definition a "good day". You therefore fill with water and ignore all the 2kt thermals, take the 4kt ones and go fast. You tell your mates that it was the water that made you go fast. In a way it did, but psychologically not physically. You probably would have gone just as fast without the water and would have gone further if you had launched earlier instead of faffing around with water.

On blue, gaggling competition days it can pay to fly somewhat heavier than would be ideal for the thermals. The lighter gliders get to the top first and then often hang around at the inversion like sheep waiting for somebody to leave. Meanwhile the heavier gliders, which have been climbing more slowly, catch them up at the inversion and so achieve the same average climb rate despite actually climbing at a slower rate. As an added bonus they might also block lower and faster climbing gliders (although the really skilled pilots often seem to find a way past). On the subsequent glide the heavier gliders pull away (or fly at the same speed and gain vertically); if the next blue thermal should happen to be strong they can sometimes achieve a clean break from the gaggle.

Sums for the seriously sad… Say you are flying in a competition in an ASW 20 and doing 250km in the middle of a 750km day. If you climb at 4kts when dry, 3.7kts with half water (two barrels) or 3.4kts with full water (four barrels), you average 91km/h in all cases. However, 16 per cent of the task will be final glide, on which it is a big advantage to be as heavy as possible.

Figure 1: manufacturer's data for an ASW 20 at sea level (Enhanced by Steve Longland)

The speed at which you achieve any particular glide angle increases with the square root of the weight increase. A 30 per cent increase in weight gives a 15 per cent increase in the speed at which you get a 30:1 glide angle. Say there is a 4,500ft cloudbase: A 30:1 final glide is possible at 98kts (wet) instead of 85kts (dry) – this is worth two minutes, 1km/h, up to 20 contest points. So it is worth being heavier than theory says on short tasks.

If you are flying 750km you will probably have to struggle in weak thermals for the first and last hours (or more), so the last thing you want is water. If full water reduces

MOST PEOPLE FLY TOO HEAVY MOST OF THE TIME BECAUSE THEY ARE FRIGHTENED OF DUMPING WATER AND BEING UNABLE TO GET IT BACK (THAT WOULD BE A USEFUL DEVICE!)

Day scrubbed at 2011 Club Class Nationals (Ron Smith)

IF YOU START WITH THE CofG IN MID-RANGE AND ADD TWO BARRELS TO MOST GLIDERS THEY WILL BE UNCOMFORTABLY NOSE-HEAVY

If in doubt, fill it up and dump some water later when the nature of the day becomes clearer (Susan Newby)

your climb rate from 2kts to 1½kts, you go 10km/h slower with water.

Bigger gliders

Climbing ability goes roughly with span loading (kg per metre), so an 18-metre glider with 20 per cent more span than a similar 15-metre one will climb as well with 20 per cent more wing loading, about five 25kg barrels of water, or an engine and a lot of fuel. Even on a pretty weak day, it is worth putting a lot of water in an 18-metre ship (fat pilots with engines excluded). Do the sums on your own glider, extract the data from the polar and plot out a graph like Figure 1. If you can't do sums, then phone a friend – every club has its tame nerd.

Even bigger gliders

The Nimbus 3/4DT and ASH 25, with two prosperous looking pilots, fly at around 750kg when dry, which is a good weight for UK. The single-seat versions without engines are 200kg lighter so need eight barrels of water just to get to a sensible UK weight and, even at 850kg, have less wing loading than the modern ships. That is why the older Open Class lose out to the modern 18-metre, which fly at 600kg on good days.

The new 18/21-metre ships also have stunningly good modern wings that help a lot – 40:1 at 100kts is staggering, but it costs at least seven times as much as 40:1 at 60kts. Is it seven times as much fun? Probably. I would definitely recommend trying it if you can. The old 20-metre Nimbus 2s and ASW 17s need as much water as you can get in them on any reasonable day, though their ancient tanks probably leak as badly as their ancient owners and I am told the handling of the early (all flying tailplane) Nimbus 2s is pretty intimidating full of water.

If you are in any danger of landing out, dump the water. Getting home slowly is far better than landing out. Being in danger of breaking your glider landing in a small, rough field when heavy is really stupid.

On his Nympsfield soaring courses, Andy Davis very often says: "If we leave this thermal now, are you reasonably confident you will reach a better climb ahead? If the answer is 'yes', leave now; if the answer is 'no', climb a bit higher and then ask yourself the same question again." How much time do you waste climbing slowly when you should have left? I am definitely guilty.

Average climb rate

One of many sad facts of life for glider pilots is that your average climb rate is not the 6kts that you occasionally see, but the real average from when you start turning to when you straighten up, including all the turns in sink! SeeYou will give you the real average for the day, which will be 2½kts in the UK if you are flying pretty well.

Centre of gravity (CofG)

Many people think that their gliders won't climb properly because they are too heavy when the problem is actually that the CofG is too far forward. If you start with the

Emily Francis checks the ballast situation at the 2011 Standard Class Nationals (Ron Smith)

CofG in mid-range and add two barrels to most gliders they will be uncomfortably nose-heavy. With four barrels, the tailplane is trying to produce a large down load to balance the water in the front of the wing and generating an awful lot of drag in the process.

Some gliders, like Astirs and Vegas, with large tailplanes don't seem to mind where the CofG is, but most really do mind.

You need to weigh your glider very carefully with you in the cockpit and put enough lead in the tail to make you fly it dry with the CofG fully aft (you on min placard weight). Get your inspector to do the sums very carefully, as to fly with the CofG too far aft is, at best, very nasty and unstable and, at worst, unrecoverable from a spin. Now when you put in two barrels, the CofG position is still acceptable and with four it isn't too bad.

Much better, of course, is to have a tail tank so different weight pilots can always have the CofG in the optimum position.

Streeting and energy lines

The analysis so far assumes that the flight consists of classic MacCready climb and glide segments. However, a skilled soaring pilot is often able to follow lines of energy that greatly improve the achieved L/D for the flight. You can use the statistics function of flight analysis software such as SeeYou to see how well you perform in this respect.

It is not unusual for a skilled pilot on a good day to return an average L/D for the entire task, some 20 points in excess of their glider's nominal best L/D, eg 40:1 glider flight analysis returns 60:1. This has the effect of significantly increasing the time spent gliding, where ballast is advantageous, and reducing the time spent climbing, where ballast is a disadvantage, thus the heavier glider will achieve a higher average speed.

When considering how much ballast to put in, ask yourself if there is likely to be significant streeting or cumulus patterns you can follow, or is the day likely to be mainly climb and glide. On tasks up and down wind you are more likely to be able to take advantage of streeting than on crosswind tasks.

If in doubt, fill it up and dump some water later when the nature of the day becomes clearer. Dumping ballast in increments until the glider feels right in the thermals before starting a task is a perfectly valid way of setting up the glider for a given day. Practise flying your glider at a wide variety of weights and learn from experience what would be a good initial weight for today's flight.

In conclusion, in competitions you probably need water, but when club flying 15-metre span gliders in the UK put in some water if you must to make you feel good, but the best way to go fast and far is to climb faster.

Tim Macfadyen started gliding just before there were any gliders in England with water ballast and has been involved with the sport ever since. He has never quite won a nationals and flew in the first Europeans in ASW 20 EEE that he bought new and still flies. Tim flew the first 750km in the UK in a 15m glider and then had to do it again because the camera failed! CFI of Nympsfield for 10 years, Tim still teaches cross-country and ridge running there whenever possible. He has flown over half of the types of glider in the UK, including a fair number with water ballast. Tim has been on the BGA Technical Committee for 20 years, edits the BGA Data sheets and has carried out many glider repairs and modifications.


Nigel Gough in his LAK 17 during the 2012 Bicester Regionals (Ron Smith)

■ The author would like to acknowledge the considerable contribution to this feature from Andy Davis and Afandi Darlington