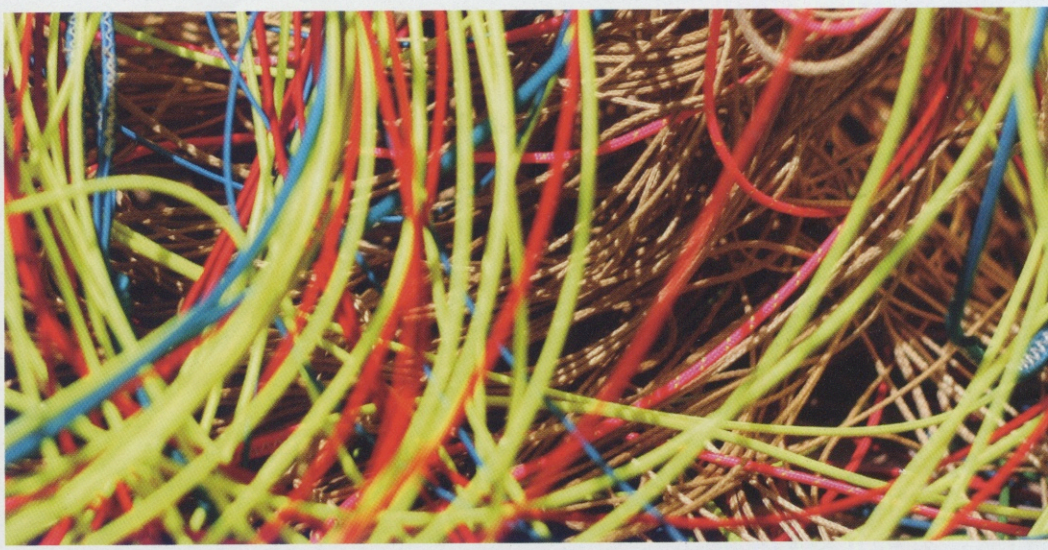
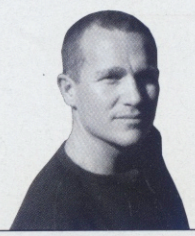

Knots, and their line strength reductions, are carefully calculated. Photo: Bruce Goldsmith



ICARISTICS

KNOTTING LINES: DON'T TRY THIS AT HOME

Bruce Goldsmith reveals how test pilots trim prototypes, and the dangers inherent in tying knots to shorten lines



by Bruce Goldsmith

Bruce is one of free flying's most accomplished pilots. Current vice European Paragliding Champion and multiple British Hang Gliding and Paragliding Champion, Bruce designs for Airwave and has written for Cross Country for over ten years

In June of this year I was very saddened to hear of the fatal accident of my friend and associate, Norman Lausch. Norman was a professional test pilot and died in a testing accident having made modifications to the main lines of a prototype paraglider.

Testing paragliders sounds like a very dangerous occupation, yet accidents are thankfully very few and far between. Professional test pilots are generally some of the most skilled and experienced pilots in the world. Their experience makes them acutely aware of the consequences of their work and, as improving the safety of paragliders is their main priority, their total concentration is not only on their own safety but that of the product itself.

However, as Norman's tragedy has shown us, accidents can still happen, so I decided to use this issue's Icaristics to explain how test pilots work and the processes and methods we use.

GLIDER TRIMMING

A test pilot flies a prototype paraglider and tests its flying and safety characteristics both in respect of the design brief as well as the certification requirements. They can alter the handling and behaviour of the glider in several ways to improve its characteristics. The most common way is to modify the line lengths to 'trim' wing. They can also modify the risers, the speed system or even the positions of the line attachments on the wing; however a surprising amount can be achieved by simply changing line lengths.

For instance, if a glider turns too fast following an asymmetric collapse the pilot might slow down the tips by shortening the outer C and D lines by 10mm to 20 mm. Equally if they glider had a high spin tendency they might lengthen certain brake lines to reduce the amount of braking at the tip. Even if the glider has a deep stall problem reducing the lengths of the A lines to decrease the angle of attack can often resolve the problem.

All these line modifications are done by tying knots in the lines and different knots change the lengths by different amounts. Test pilots know how much each knot changes the length of each line and, more importantly, how much each knot reduces the strength of the line.

The most common knot is the overhand knot, which o a normal 1mm sheathed line reduces the length by 10mn and the strength by 60% to 70%. A figure-of-eight knot reduces the length by 15mm and is slightly stronger than an overhand knot. Using a combination of figure of eights and overhand knots it is possible to reduce the line length in 5mm steps from 10mm upwards.

Generally speaking knots in lines are acceptable on the mid and upper lines at the tip, but not on the lower main lines, especially not in the centre of the wing as these line have the highest loading of all.

It is possible to adjust the length of main riser lines with less reduction in the strength of the line by looping the lines around the maillons. Using different types of loops we can reduce the main line by up to 40mm with only a 30% loss in strength. If we need to reduce the length by even more than 40mm we can add knots to the doubled part of the line that form the stitched loop but with a reduction of around 50%.

Sometimes a test pilot needs to lengthen the lines. The safest way to lengthen a main line is to add an extra maillon. If we want to lengthen one of the upper lines we either add a small piece line, or unstitch the actual loop and re-tie the line to the attachment tab. However, the lin is then only as strong as the weakest knot used, so you can expect at least a 50% reduction in strength.

Some manufacturers even make their prototypes with

no loops on the top of the lines. Instead they tie each line to its attachment tab with a knot so that they can easily adjust the length. However these knots can, and do, come undone easily!

BIG ISSUES

There are several other issues the test pilot would consider when adjusting line lengths:

- Heavy pilots load lines more than lighter pilots.
- Because of load test rules all sizes use the same line diameters. So a heavy pilot flying an XL wing high in the weight range will put considerably more strain on the lines compared to a pilot flying high in the weight range on a small.
- Lower lines have more loading than upper lines.
- Central lines have more loading than tip lines.
- Brand new lines are stronger than used lines.
- Certain manoeuvres create much higher loadings on the lines. Spiral dive with big ears is the worst, closely followed by a normal spiral dive.
- Shock re-inflations break lines, but these line breakages tend to be only single upper lines and not catastrophic line failures.
- The test pilot should strongly consider the safety implications of what they can do if there is catastrophic failure of all their lines.

In the case of Norman's accident he chose to shorten the main line lengths by tying knots in the main lines above the doubled, stitched section. In doing so he severely reduced the line strengths. He then tested the glider for spiral stability which involves very high G forces and an immense strain on the glider. The result was a total and catastrophic line failure close to the ground that separated Norman from his glider and threw him in to free fall without sufficient altitude to deploy his reserve. As to why a very experienced test pilot like Norman chose to ignore the advice of the designer and other test pilots and shorten the main lines in this way, we will never know. However, we as an industry have been shocked by Norman's death, and its circumstances, and must learn from his tragic mistake.

SAFETY WARNING

Making knots in lines is a very dangerous activity and invalidates the certification and load testing of your wing and is expressly forbidden by all manufacturers. This article has been written to explain the process used by test pilots during the trimming of a glider, not to encourage non professional test pilots to experiment with the trim of their wings. Remember that when you see a test pilot with hundreds of knots in the lines those knots, and the reduction in line strength they create, have been carefully calculated, as has the loading likely to occur in the manoeuvre being tested. There have been several fatal accidents recently that have involved gliders that have either been altered by the pilot, usually for acro, or poorly maintained lines. Once you start altering lines you can cause stress on the lines that are way beyond their strength and lines with 100 hours on them could be 30 % weaker than when new. Microlines are more likely to be more than 50 % weaker, provided they have never been damaged. This means they could break during high G manoeuvres.

All the information provided here is indicative only and based on Kevlar lines sheathed with polyester. Strength reductions with unsheathed microlines are all even greater. XC

A QUICK GUIDE TO TRIMMER'S KNOTS

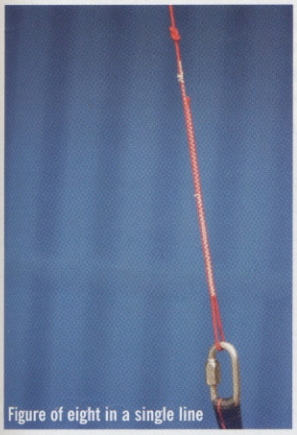
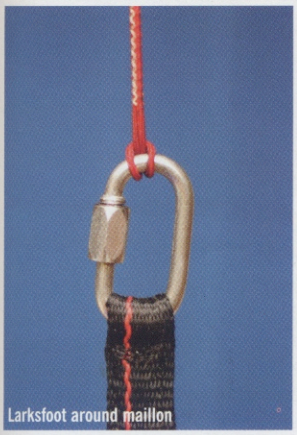
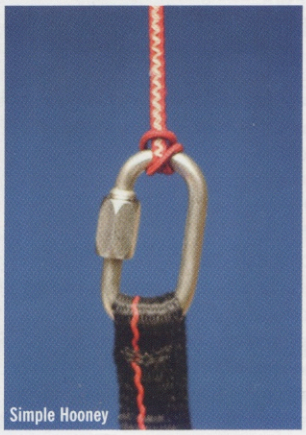


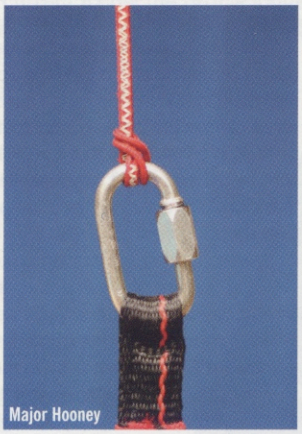
Figure of eight in a single line


Figure of eight in the sewn double line


Extra loop on maillon


Larksfoot around maillon


Simple Hooney


Major Hooney