The Spider

A lightweight full-size tribander (20-15-10m) for portable operation

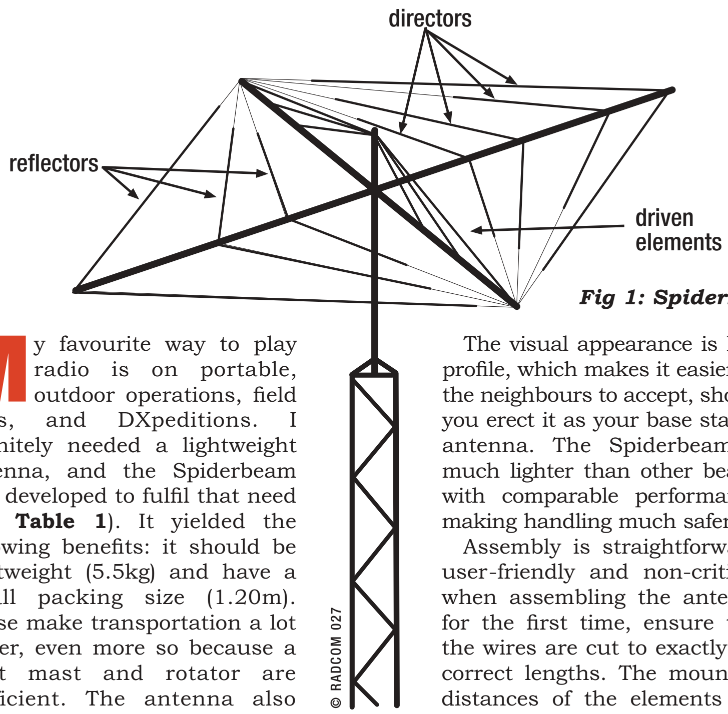

Fig 1: Spiderbeam schematic diagram.

My favourite way to play radio is on portable, outdoor operations, field days, and DXpeditions. I definitely needed a lightweight antenna, and the Spiderbeam was developed to fulfil that need (see **Table 1**). It yielded the following benefits: it should be lightweight (5.5kg) and have a small packing size (1.20m). These make transportation a lot easier, even more so because a light mast and rotator are sufficient. The antenna also presents low wind resistance.

Contrary to most boom-to-mast plates, which position the antenna on one side of the mast, the Spiderbeam is mounted exactly at its centre of mass. Antenna weight and vertical torque moment are optimally applied to the mast and rotator which means the load on these parts is reduced and makes it easier to raise the mast.

Setting up the antenna on site is greatly simplified because it can be carried and put up by a single person; it goes where you would never drag along a heavy conventional design of tribander. This makes it easy to select the most favourable location with the best radiation conditions.

Operating frequencies	14.0 – 14.35 MHz
	21.0 – 21.45 MHz
	28.0 – 28.8 MHz
Feeding	Single coaxial cable
Continuous HF power	Maximum legal
Weight	5.5kg
Dimensions (length x width)	7.0m x 7.0m
Turning radius	5.0m
Transportation length	1.2m
Rotator requirement	TV rotator

Table 1: Spiderbeam general data.

The visual appearance is low-profile, which makes it easier for the neighbours to accept, should you erect it as your base station antenna. The Spiderbeam is much lighter than other beams with comparable performance, making handling much safer.

Assembly is straightforward, user-friendly and non-critical; when assembling the antenna for the first time, ensure that the wires are cut to exactly the correct lengths. The mounting distances of the elements are not critical. No complicated or fragile parts are involved. The tuning procedure requires only a VSWR bridge and can be done in 10 minutes.

HISTORY

Five years ago, the Spiderbeam was just a dream. I was not convinced by the exaggerated claims by the mini-beam manufacturers of gain, front-to-back ratio and bandwidth. One day I stumbled on an antenna design called a 'bow-and-arrow-beam' (or 'Bird-Yagi' after its inventor Dick Bird, G4ZU). It is a three-element Yagi using director and reflector elements bent into a V-shape. Nowhere in the literature could I find a multi-band version to meet my requirements, so I decided to start development myself.

After countless simulation runs, the Spiderbeam eventually evolved. The remaining problems were mostly mechanical. The antenna had to be lightweight but sturdy; it had to be waterproof, have repeatable electrical parameters no matter how often it was put up and taken down, and should be easy to assemble with as few tools as possible. In the end it was a great pleasure to see the last prototype survive the heavy storms during my activity from CT3EE (*CQ WW CW 2002*).

The development is now completed and I have written a detailed step-by-step *Construction Guide* (details are given later) which is available free from me by e-mail (PDF file, 23 pages, 600KB). Thus, while the following text will not provide every constructional detail, it will give a general insight into the antenna design and constructional methods.

BASIC ANTENNA PRINCIPLE

The Spiderbeam is a triband Yagi for 20, 15 and10m. It consists of three interlaced wire Yagi antennas strung on a common fibreglass spider. These are – three-element Yagis for 20m, and 15m, and a four-element Yagi for 10m. In contrast to a regular Yagi, the director and reflector elements are V-shaped.

The driven element is a multi-band fan dipole for 20, 15 and10m, ie three individual dipoles connected at their centre feedpoint. The feedpoint impedance is 50Ω, fed through a W2DU-type current choke balun, making a very simple and robust feeding system. No phasing lines or matching devices are needed (see **Fig 1**).

Band (m)	Reflector (cm)	Director 1 (cm)	Director 2 (cm)
20	1054	984	- - -
15	700	648	- - -
10	526	488	488

Table 2: Parasitic element lengths.

The wire lengths and mounting dimensions of the parasitic elements can be found in **Table 2** and **Fig 2**.

Please note that the

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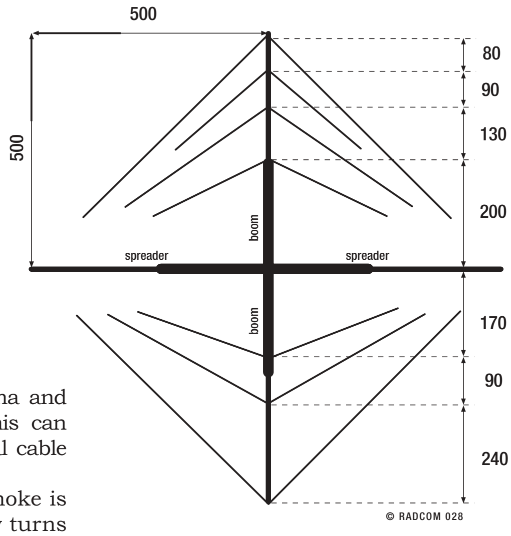

Fig 2: Mounting the parasitic elements.

specified wire lengths are only valid for bare wire of 1mm diameter! Other wire types (especially insulated wire) will result in different element lengths because of the change of velocity factor caused by the insulation. The same is true when mounting insulators at the wire ends, as they will also cause a change of the effective electrical wire length.

It is very important to cut the wires precisely to the specified lengths. Even an error of one centimetre will make a difference. Therefore it is also essential to use a wire type which does not stretch. I am using copper-clad steel wire (Copperweld®, DX-wire®). The first versions of the Spiderbeam were built using normal (soft) enamelled copper wire. Each time when assembling and dismantling the antenna, some elements had stretched up to 10cm. In turn, the resonant frequencies of the wire elements change, resulting in a deterioration of the radiation pattern, especially the front-to-back ratio. See the *Construction Guide* for further details.

The wire lengths and mounting dimensions of the driven elements can be found in **Table 3** and **Fig 3**.

The single dipoles of the driven multi-band dipole must be vertically spaced correctly, see Fig 3. The further apart they are spaced, the less is the mutual interaction, as with any multi-band-dipole. The distance between the highest dipole (20m) and the lowest dipole (10m) should be around 50cm. It is also important to keep the 10m dipole a few centimetres away from the fibreglass spreaders, otherwise the VSWR will change a lot when the spreaders get wet from rain.

Because the feedpoint impedance of the antenna is already very close to 50Ω, no impedance transformation is necessary, but a balun between the antenna and the coaxial cable is needed. This can take the form of a simple coaxial cable choke.

The simplest coaxial cable choke is constructed by coiling up a few turns

Photo 1: Ural Contest Group setting up their own local WRTC-style competition. Each of these single-operator stations used a Spiderbeam and 100W.

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Fig 3

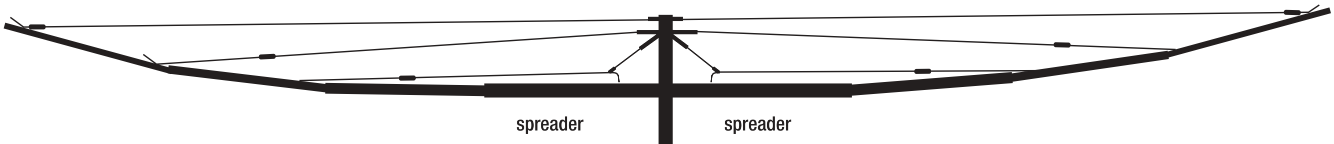


Fig 3: Mounting the driven element.

(5–10) of coaxial cable right at the feed point. The performance of such a choke is highly dependent on the operating frequency, the coaxial cable used, and the diameter and height of the coil.

A much better solution is the coaxial choke developed by W2DU [*QST*, March, 1983]. Take a piece of thin coaxial cable and slip a number of ferrite beads over the outer plastic jacket, which effectively stops current from flowing on the braid (outer conductor), resulting in a good match of the balanced antenna to the unbalanced coaxial cable. Using a piece of Teflon cable makes such a coaxial cable choke easily capable of handling 2kW continuous HF power.

After preparing the coaxial cable choke as described above, it is mounted into a suitable piece of weatherproof plastic 'U'-section. One end of the cable is connected to a SO-239 coaxial socket, the other end to two stainless steel M6 bolts. These connections are then made watertight with epoxy. A piece of flat plastic panel is glued on top and serves as the lid of the box. The choke is shown in the photograph.

The balun housing has a second function – it will be strapped to the antenna mast, thus serving as a stable mount for the feedpoint. The driven elements are then connected to the M6 bolts.

A few words are needed regarding the mechanical design of the antenna. The heart of the construction is the centre joint made from aluminum sheet metal and tube: **Fig 4**.

Band (m)	Driven element (cm)
20	2 x 502
15	2 x 347
10	2 x 262

Table 3: Driven element lengths.

Band	Forward gain in free space	F/S ratio (dB)	F/B ratio (dB)
20m	6.5 dBi (4.3 dBd)	12	15–20 across band
15m	6.6 dBi (4.4 dBd)	15	18–25 across band
10m	7.2 dBi (5.0 dBd)	18	20–30 across band

Table 4: Performance data.

The long slots make it possible to slide the aluminum tubes in and out and thus accommodate diameters of vertical masts from 30 to 60mm. Many push-up masts have top sections smaller than 60mm. With the long slots, the tubes can always be positioned in a way that the mast is perfectly pinched between them. Hence most of the load that normally stresses the U-bolts is transferred to the tubes. U-bolts are necessary only to prevent the antenna from rotating on the mast.

With this construction, it is possible to use a wide range of vertical mast diameters without compromising stability. This means more flexibility when putting up the antenna.

As already mentioned, most boom-to-mast plates put the antenna on one side of the mast. With the centre joint described here, the mast goes right through the centre of mass. Antenna weight and vertical torque momentum are optimally applied to the mast and rotator, which means the load on these parts is reduced.

The fibreglass tubes are the bottom 5m elements of 9m fishing rods. All bolts are stainless steel M6 bolts (M6 = 6mm diameter).

The spider itself gets its extra stability by guying it completely within itself, a concept well known from sailboat masts (see **Fig 5**). The guys are Kevlar lines (1.5mm diameter, 150kg breaking strength). Kevlar has the big advantage of not stretching at all, so the guy-lines always stay as tight as you pulled them during assembly.

It is a good idea to use sailors' hitches for fastening the guy-lines, so they are easy to untie when dismantling the antenna (see **Fig 6**).

Attaching the wire elements to the spider is quick and easy, using cable-ties. Short pieces of polyamide hose are used for stress relief at the bending points and also to cover the joints between the wire ends and the fishing line insulators.

All the tools necessary for assembly are two spanners for M6 nuts, some cable-ties, and some sticky tape.

For transportation, all the wires and guy-lines are wound onto a big spool (in the most appropriate order for assembly). Such a spool could be found in kite stores.

Many further details can be found in the step-by-step *Construction Guide* mentioned above.

ANTENNA PERFORMANCE & TECHNICAL DATA

The antenna was developed using the *NECWires* software by K6STI and the free software, *4NEC2*. During the test phase, the antenna was put up at 10m height in an open field and was measured extensively. It was found that the wire (DX-wire 1.0mm, black enamelled) had a unity velocity factor, ie the lengths derived from the computer model could be used directly in the real world. It also

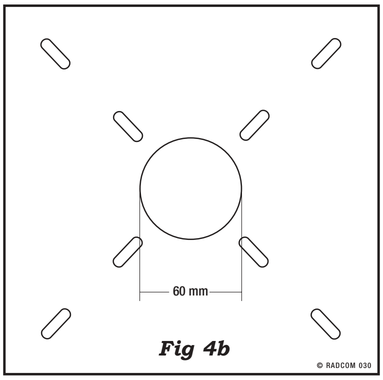
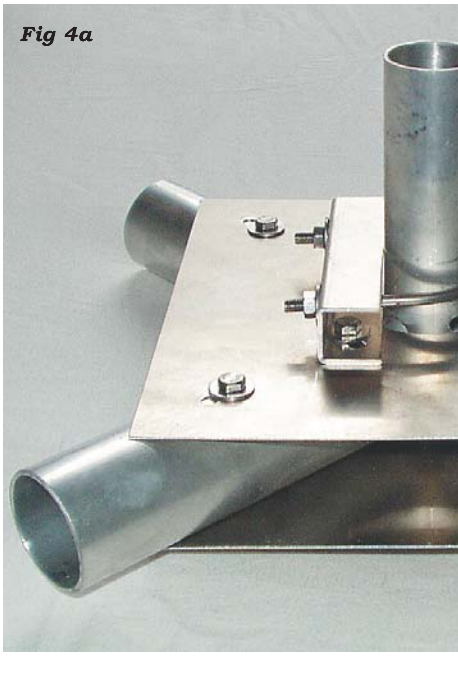


Fig 4: (a) The centre joint; (b) the aluminum plate.



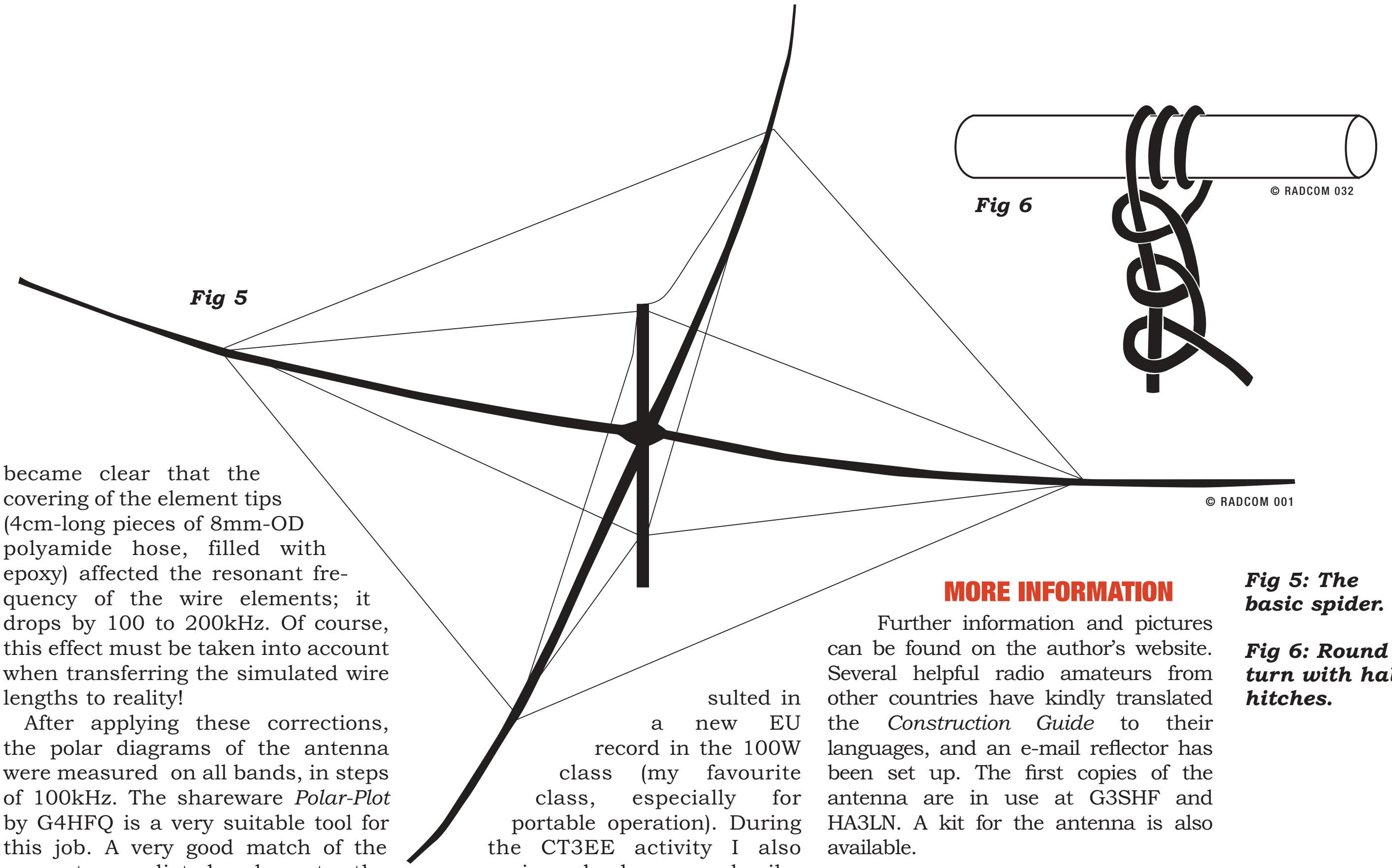


Fig 5: The basic spider.

Fig 6: Round turn with half-hitches.

became clear that the covering of the element tips (4cm-long pieces of 8mm-OD polyamide hose, filled with epoxy) affected the resonant frequency of the wire elements; it drops by 100 to 200kHz. Of course, this effect must be taken into account when transferring the simulated wire lengths to reality!

After applying these corrections, the polar diagrams of the antenna were measured on all bands, in steps of 100kHz. The shareware *Polar-Plot* by G4HFQ is a very suitable tool for this job. A very good match of the computer-predicted values to the measurements was found. The values are summarised in Table 4.

These are roughly the same data as for a typical modern tribander with a 6 or 7m-long boom.

Diagrams showing the calculated patterns at 10m height and the changes of gain and F/B ratio across each band are available from the author's website (see below).

OPERATION

The Spiderbeam has fulfilled all my expectations in practical use. Since the year 2000 I was lucky enough to go on tour with it for all three *CQ* WW CW Contests (9H3MM, CS7T, CT3EE). The CS7T activity even resulted in a new EU record in the 100W class (my favourite class, especially for portable operation). During the CT3EE activity I also experienced phenomenal pile-ups, but unfortunately the heavy storm resulted in a power failure before the contest was over. Therefore I was very pleased (and the pain was eased a bit) by the fact that the Spiderbeam had survived the storm.

All in all, having a lightweight antenna that can be put up at the best suitable location has proved to be a very good concept.

The specified wire lengths are a good compromise for CW and SSB operation. For single-mode operation it is, of course, very easy to use one set of wire elements optimised for CW and another one optimised for SSB, thus squeezing the last decibel out of the design.

THE FUTURE

Of course there are always more ideas and plans for the future, for example a lightweight stack of two Spiderbeams (where a normal tower should be sufficient), and a WARC version.

One advantage of this style of construction is that it is not limited to the tribander described here. Once the supporting structure has been built, other wire antenna designs can be tried easily and cheaply. Apart from the wire elements, everything remains the same.

There are also different ideas regarding the bending of the elements. For example, on the same supporting cross, a Moxon beam, an X-beam or a bent HB9CV could be constructed.

All you need is antenna simulation software and a few ideas! For some inspiration, W4RNL's web site can be recommended to anyone interested in antennas and simulation.

MORE INFORMATION

Further information and pictures can be found on the author's website. Several helpful radio amateurs from other countries have kindly translated the *Construction Guide* to their languages, and an e-mail reflector has been set up. The first copies of the antenna are in use at G3SHF and HA3LN. A kit for the antenna is also available.

CONSTRUCTION GUIDE

A detailed 24-page *Construction Guide*, including many pictures, and describing every single step is available directly from the author. If you are interested, please e-mail df4sa@contesting.com to receive this *Construction Guide* as a free PDF. If you do not have Internet access, ask a friend who has, to download it and print it out for you.

THE KIT

A complete kit of parts is available from the author. It costs 300 Euros plus shipment, which is 25 Euros to the UK.

The box is 115 x 20 x 20cm, weighs around 8kg, and is shipped by regular mail.

Please remember that the author is not a big manufacturer. In fact, this is a secondary project which creates a lot of work for him.

Contact him by post or e-mail regarding payment details. ◆

Photo 2: The coaxial cable choke.

WEBSEARCH

DX-Wire	www.dx-wire.de
4NEC2	www.qsl.net/wb6tpu/swindex.html
Plotting software	www.g4hfq.co.uk
DF4SA website	www.qsl.net/df4sa
E-mail reflector	http://groups.yahoo.com/group/Spiderbeam
W4RNL	www.cebik.com