How to design a cone-shaped mast coat

by
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(.. now with an appendix on p.7 showing the finished mast coat fitted to my 26' *Ingeborg* - plus another one on p.7 about fitting a better tape...)

The fabric mast coat, as shown here, on Johanna is developed as the side of a cut-off cone. The good thing with it is that there are no double compound curves involved, while the not-so-good thing is that it takes a bit maths to design it. I'll try my best to break it down into simple steps. It is actually my interpretation of how Hasler and McLeod describes it in PJR.

Photo 1: Johanna's mast coat, wrapped 1½ times around the mast...

Have a look at Fig 1, overleaf. The mast's diameter is D and the mast partner's diameter is T (the partners in this case is a welded aluminium collar with a rod welded around the top edge). Our exercise is to find the shape of the fabric that eventually will produce this cone-shaped mast coat. Don't worry about hems and such niceties now - our result will at first be a paper pattern, and any hems and the like will be added later.

So far we have two dimensions; T, D. Then we choose the height, H of the coat to get a nice-looking cone, tall enough to make room for the wedges between the mast and partners, but low enough not to interfere with the boom.

As can be seen, I have also drawn in two dashed helping lines, which extends the cut-off cone of the mast coat into a full cone. This point, *Top*, will be essential in letting us draw up the paper pattern.

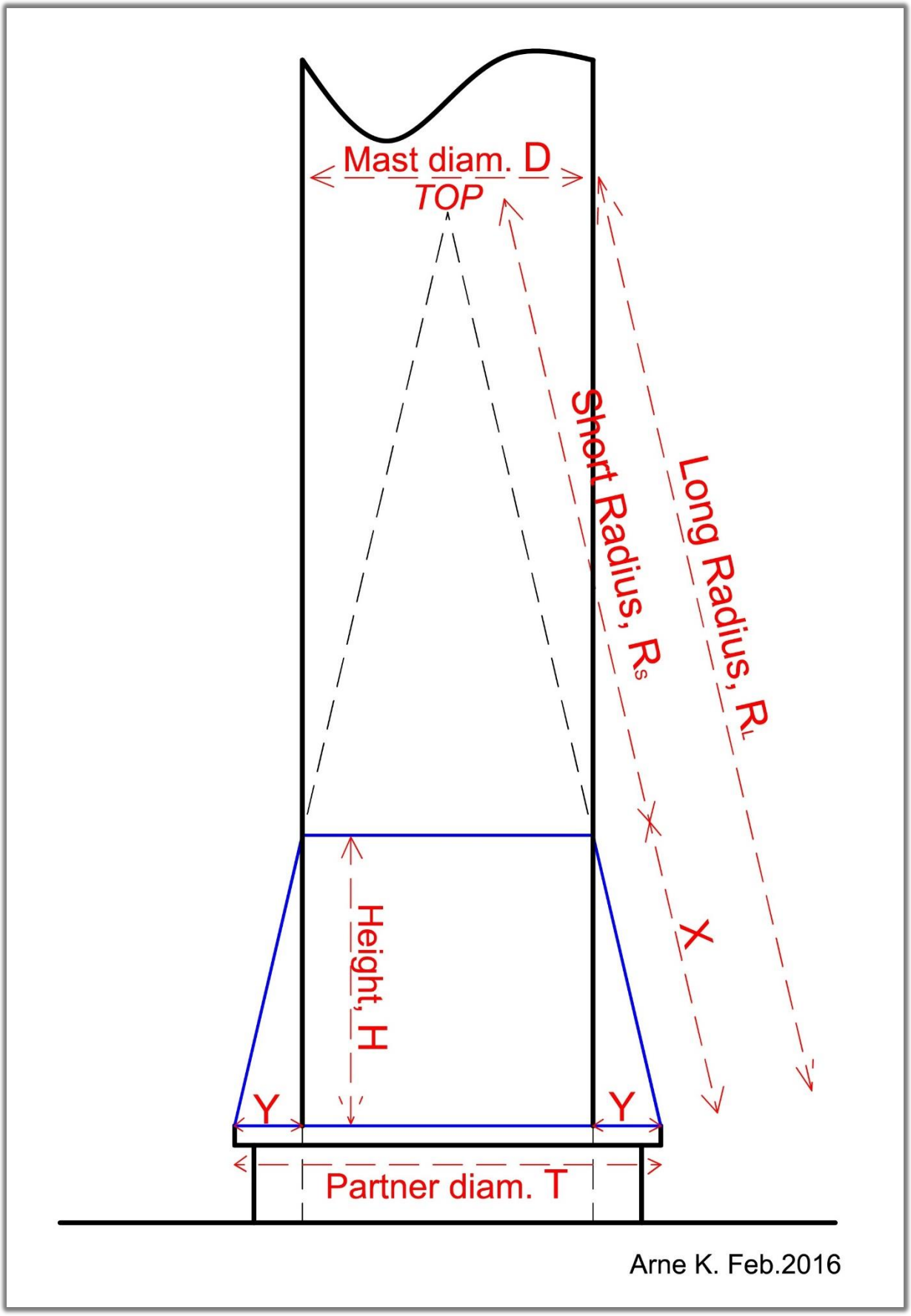


Fig. 1 The cone part of the mast coat (blue), and partners plus mast (black).

The first big job is to calculate the length of the "Long Radius" and the "Short Radius", R_L and R_S. These are needed for drawing the paper pattern of the cone. To help us getting there, we first must find the length of Y and X (keep Fig. 1 at hand)

We find *Y* from Fig 1 as:

(1) $Y = \frac{T-D}{2}$

and X is found, using good old Pythagoras:

(2) $X = \sqrt{Y^2 + H^2}$

Now comes the hard part, finding the long radius, R_L and the short R_S. We make use of the rules about like-shaped triangles, sharing *TOP* as the common corner:

Then...

(3) $\frac{R_L}{T} = \frac{R_S}{D} = \frac{R_L - X}{D}$

.. and to make a long story short, it results in...

(4) $\boldsymbol{Long\ radius,\ R_L = \frac{T \times X}{T-D}}$ and...

(5) $\boldsymbol{Short\ Radius,\ R_S = R_L - X}$

Actually, one needs not understand the maths! As long as we are able to punch in the numbers in formulas 1, 2 4 and 5, into our calculators, we should be OK.

Example: I happen to be in the process of preparing to make a mast coat for my Marieholm IF, *Ingeborg*, so that will be our practical example. The key numbers are:

- The diameter of the partners is *T=22.0cm*,
- The diameter of the mast is *D=15.0cm*
- I decide the height of the cut-off cone to be *H=15.0cm*

> ***Note: One could well add a millimetre or two to the actual T and D to compensate for the thickness of the fabric. I haven't bothered as I am to make an "open version" coat, just wrapped 1 ½ times around the mast. That worked well on Johanna.***

Then Formula (1) gives $Y = \frac{T-D}{2} = \frac{22-15}{2} = 3.5cm$

Formula (2) gives $X = \sqrt{Y^2 + H^2} = \sqrt{3.5^2 + 15^2} = 15.4cm$

Formula (4) gives $\boldsymbol{Long\ radius,\ R_L} = \frac{\mathrm{T \times X}}{\mathrm{T-D}} = \frac{22 \times 15.4}{22-15}$**=48.4cm** and...

Formula (5) gives $\boldsymbol{Short\ Radius,\ R_S = R_L - X} = 48.4 - 15.4 = \boldsymbol{33.0cm}$

(From now on, I continue, using Ingeborg's numbers)

Now we have most of the numbers needed to start drawing up the paper pattern. The next step is to actually draw two concentric circles on a big piece of painter's paper (paper tablecloth is also good). The two radiuses are R_L= 48.4cm and R_S=33.0cm.

Look at Photo 2, below:
Here I have drawn up parts of the two concentric circles, with centre in TOP. We only need the arcs of the circles to be long enough to reach around the partners (and maybe another half round). This forces us to do another bit of maths. Luckily it should be fairly logic.

First, find the circumference of the partners, C_P:

(6) $$C_P = \pi \times T = \pi \times 22.0cm = 69.1cm,$$

If we draw a full circle with Long Radius R_L= 48.4cm, the resulting circumference, C_L would be:

(7) $$C_L = 2\pi \times R_L = 2\pi \times 48.4cm = 304.1cm$$

From (6) and (7), and by looking at Photo 2, we understand that we only need a fraction of a full 360° circle to reach around the partners. The maths goes like this:

(8) $$\boldsymbol{Sector\ angle, v1} = 360° \times \frac{C_P}{C_L} = 360° \times \frac{69.1cm}{304.1cm} = \mathbf{81.8°}$$

Since I, as said, use to wrap the mast coat 1.5 times around the mast, I need a ...

(9) $$\boldsymbol{Sector\ angle, v2} = 1.5 \times v1 = 1.5 \times 81.8° = \mathbf{122.7°}$$

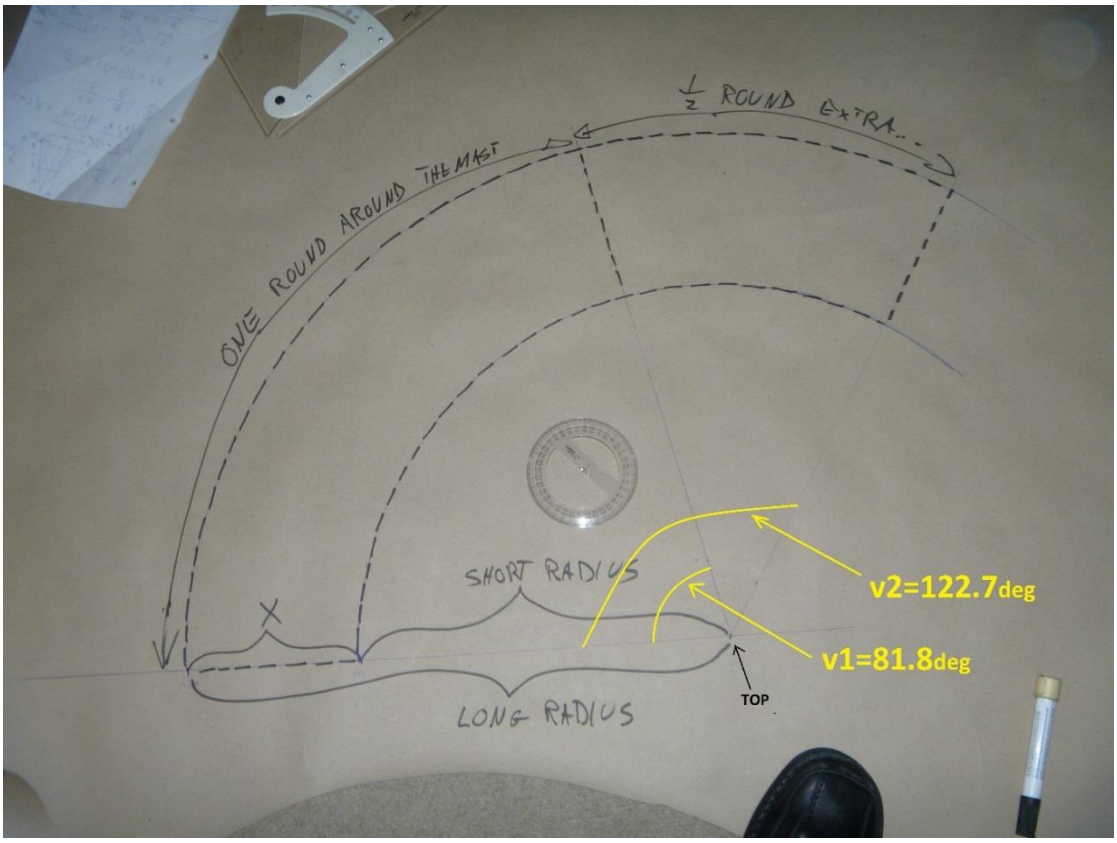


Photo 2: Drawing up a pattern for the cone of Ingeborg's mast coat.

The pattern for the cone-shaped mast collar.

..and here it is erected to see if it makes sense...

So far...

So far I haven't started to cut in canvas. One may choose to fit a 50mm straight strip of fabric to the upper and lower edge of the cone. On my coat, as on the one for Johanna (photo1), I haven't bothered, as the cone has so steep sides. Instead I have just added some extra fabric to

the edges; about 2cm to the upper edge and around 5-6cm to the lower one. I am less concerned about wrinkles than about leaks, so I prefer to make the coat in one piece if I can.

I will finish this write-up later, when the coat has been finished and fitted to the mast.

Cheers, Arne

PS: It is interesting to find the practical connection between a flat circular surface and a cone. I made this sun-hat in 2004, just by cutting a circle-round piece of cardboard, 60cm wide. Then, after making a cut to the centre, I could make the cone-shaped hat in seconds. Saved my neck from the burning sun...

Appendix 1, 20160702:
The mast collar, as fitted to Ingeborg's 150mm aluminium mast.

before..

..after...

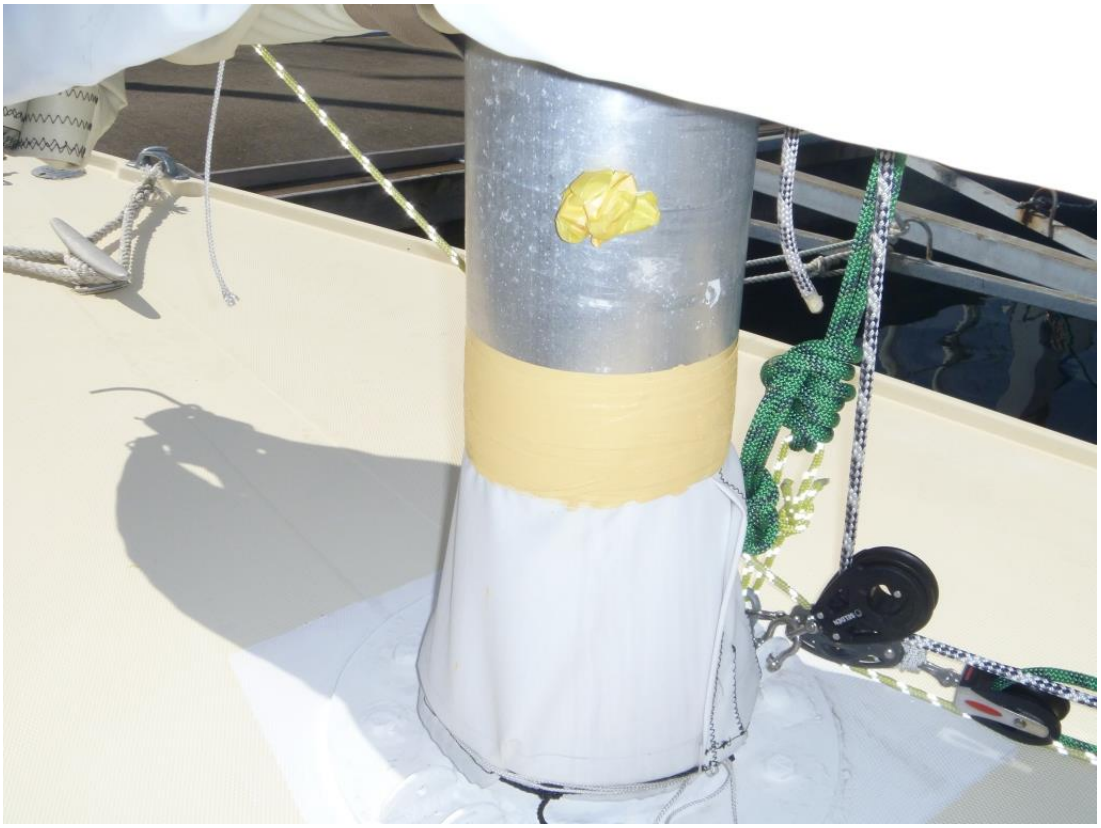
on 5. June 2016, as soon as the wedges had been trimmed to size, and the mast was properly aligned and secured, the mast coat came on. It is a straight copy of that paper template on p.5, but with a 50mm double hem added along the lower edge (with a 5mm string in it) and a 10mm (single) extra edge along the top. The collar was just taped along the top, and then firmly lashed along the lower edge. This is when that 10mm rod around the partners, combined with the 5mm line in the hem comes in handy: It lets one make a tight lashing without having it slip off the edge.

You may wonder what those three short vertical zigzag seams at the lower edge are. They secure bits of 5mm string (you can just spot the ends protruding). The idea is that they provide drain holes. Remember, the coat is just wrapped 1.5 times around the mast with no vertical seam to close it. This is not so good in theory, but in practice it has kept my boats dry - that is, until the tape needs being renewed. Good enough for me.

Appendix 2, 20171106: Fitting a better tape on the mast coat.

The spring 2017, the red duct tape holding the mast tape had turned yellow, and I feared the glue would soon turn into useless dust, as always seems to happen to duct tape when used outdoors. Still, since it had not come apart yet, I decided to just beef it up by running 2-3 rounds of 50mm sports tape over it. This is a sort of cotton fabric tape so is not watertight. I therefore painted over it with yellow oil paint. This sucked so well into the tape that I gave it another coat a few hours later. It will be interesting to see if this tape holds 'forever'. See photos overleaf.

20170502 Second coat of paint on...



20170503 The masking tape coming off the day after...

So far - at 20171106 - this looks very good.