About “forward lead”, and my happy return to the Hasler&McLeod style rig

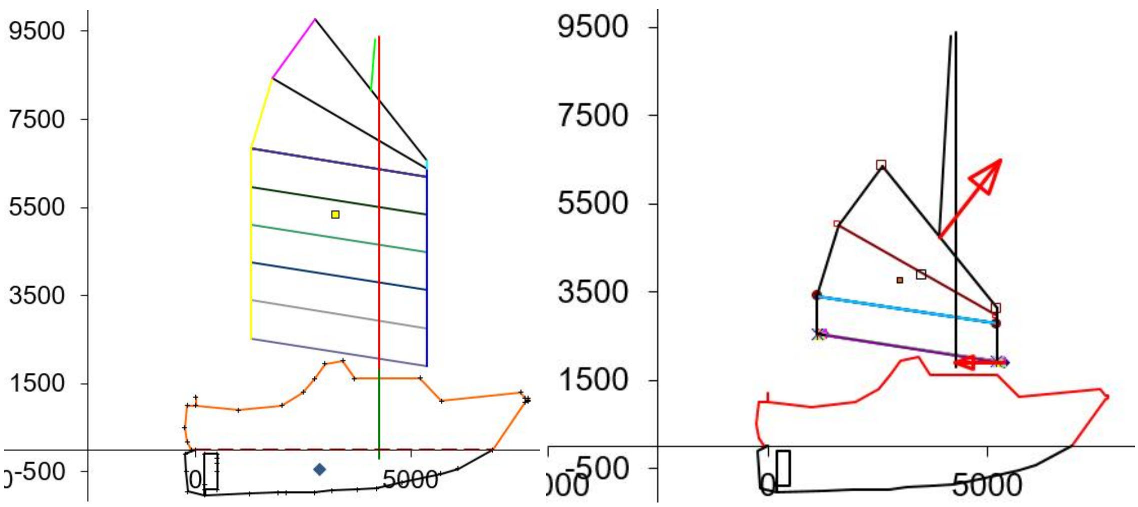
Last year I was really unhappy with my rig and wrote on this website’s Swap, Sell or Buy section that I asked if anyone was interested in buying my rig. Now, though, I can say that I am glad that I did not get rid of my rig, and I am enjoying the fjord sailing in my boat again. The short story is that I over the last 15 years,

> - started out with a Hasler&McLeod style sail,
>
> - then wanted more sail area, moved the mast forward and changed to wingsails of different shapes, but got fore-aft balance problems under some weather conditions. I still like wingsails, but for the hull of my boat I could not find a combination of mast position and sail geometry that worked for the wingsail.
>
> - and now I have a H&M style Junk Rig again which in fact has saved me from giving up sailing with my boat.

Below is the longer history of my rigs illustrated by diagrams from a self-made spreadsheet I have used to analyse the rig geometries. Over the years I have made four rig geometries for the same boat (or five if I count a moving the mast as a separate geometry). Now I am happy with the present rig geometry, and have no intention to make more great changes. This write-up is made for my own record, but I also like to share it with members who might be interested.

For each rig geometry there is one diagram showing full sail, and one or more diagrams showing reefed sail. In the spreadsheet, the number of reefed panels can be chosen and one of the diagrams in the worksheet will show the reefed sail’s geometry. Of course these diagrams do not tell the full story. For example, the sail can be shifted fore and aft and can also be tilted a chosen angle, and then the forward lead will change in value, and makes the rig more flexible than the numbers may indicate.

My first rig (from 2002, H&M style):

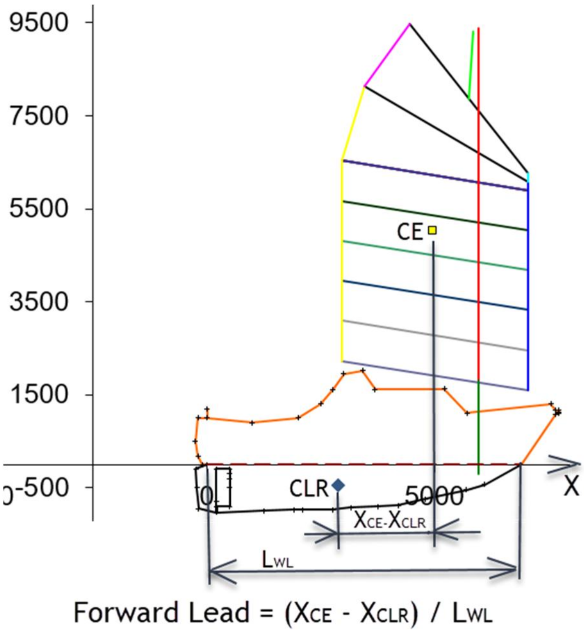


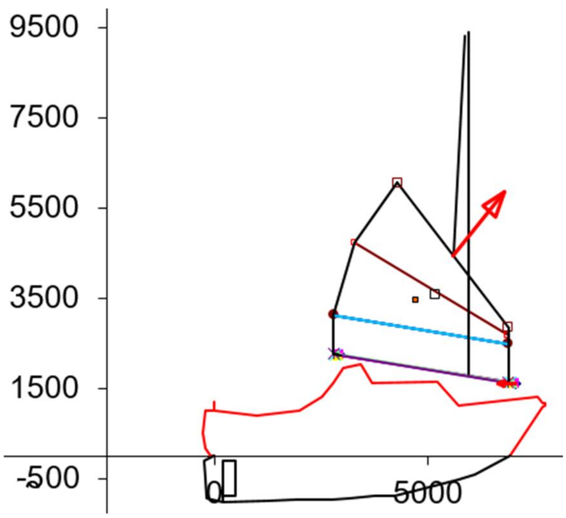
Foot length B (sail length along boom)			4140
Head length H			4140
For full sail:			
Sail area [m^2]	25,01		
% forward lead	5,79		
"SA/D" ratio	10,47		
For sail reefed as specified:			
Sail area [m^2]	10,92		
% forward lead	2,42		
"SA/D" ratio	4,57		

Fig 1   Geometry and some key data for first rig.

This first rig was designed mostly in accordance with the recommendations in Practical Junk Rig (PJR), so it can be called an H&M style rig. The rig made the boat balance well under sail. To avoid overstressing the cabin's window frames, I made a frame structure spanning over and outside the cabin as can be vaguely seen on Fig 1. The frame took the mast partners forces down into the lower hull in a proper way, but it was not so good looking, so I thought of ways to do without it. Also, I wanted more sail area. Therefore, I wanted to move the mast forward to the foredeck and at the same time was pondering about making a wingsail with pre-bent flipping battens aft of the wishbones.

The first sail moved forward (the intermediate geometry, 2009):





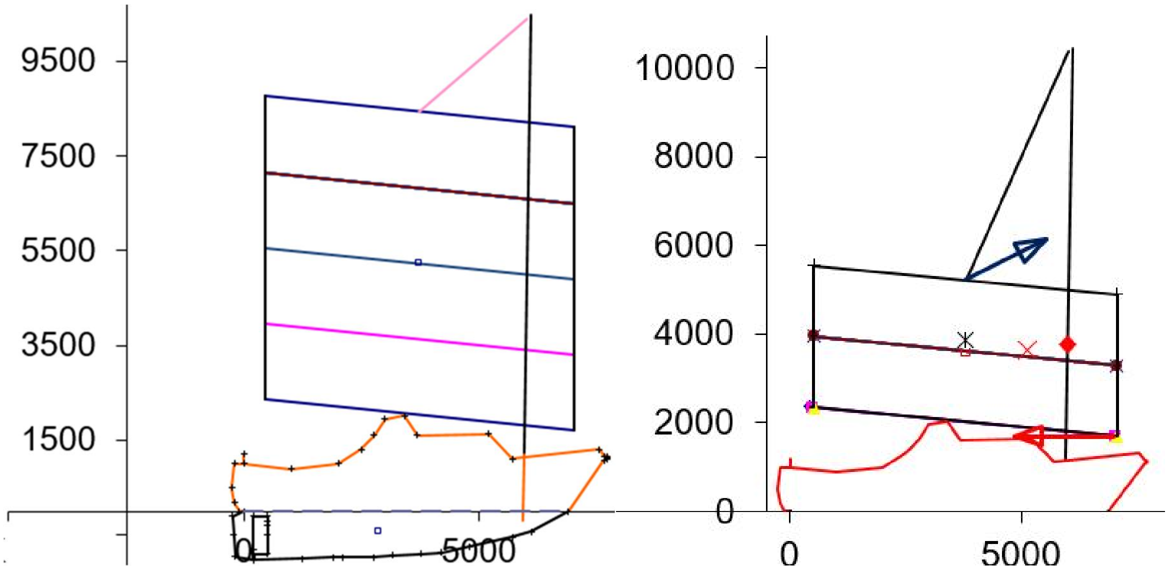
Foot length B (sail length along boom)		4140
Head length H		4140
For full sail:		
Sail area [m^2]	25,01	
% forward lead	30,14	
"SA/D" ratio	10,47	
For sail reefed as specified:		
Sail area [m^2]	10,92	
% forward lead	26,77	
"SA/D" ratio	4,57	

Fig 2 Geometry and some key data for "intermediate" rig. Forward lead is extreme!

Taking things stepwise, I started with just moving the mast and keeping the rig unchanged like in Fig 2, and tried it on the fjord before changing the sail. The lead is defined by the formula given below a diagram in Fig 2, and for a sloop the recommended lead in PJR is 6 % forward although PJR advises caution and says there is no fool proof way to determine the lead.

For this rig configuration the lead was far away from the recommended value (as you can see on the numbers), and I did not expect the boat would be sailing well at all. The boat was much lee helm, but to my surprise it could be handled, and the rig even seemed to make the boat sail better windward. If this was a right observation, it was perhaps because the sail now stood in a "cleaner" air flow. I therefore kept on sailing my boat with the rig like that through the 2009 season, and did not come into any critical situation. I therefore became a bit relaxed to the recommendation in PJR, simply because I had not tested the rig in strong enough winds.

The wingsail rig from around 2010:



Foot length B (sail length along boom)	6600
Head length H	6600

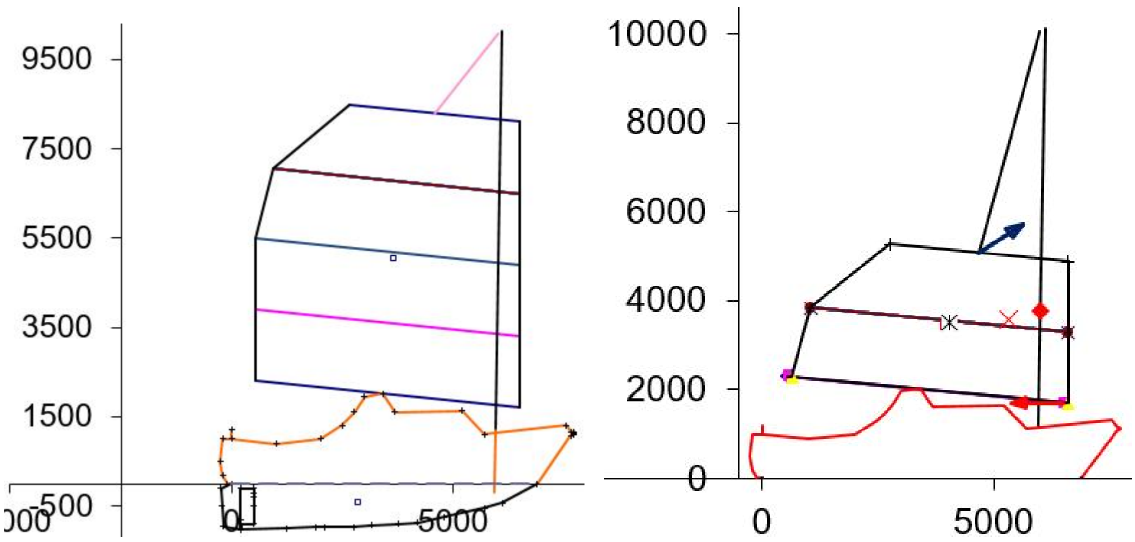
For full sail:	
Sail area [m^2]	42,03
% forward lead	12,45
"SA/D" ratio	17,60
For sail reefed as specified:	
Sail area [m^2]	21,02
% forward lead	13,45
"SA/D" ratio	8,80

Fig 3 Geometry and some key data for first wingsail rig.

This first wingsail was a great “renewable-energy motor” which I used for fjord sailing two or three summers[1] without any difficulties to speak of. But as you can see, such a sail does not look pretty when it is deep reefed, where the aspect ratio gets ridiculously low. I therefore planned to cut the top aft corner off and also to shorten the wishbones with a half metre to have a better aspect ratio both at full sail and when reefed.

[1] A departure from the technical intent of this article: The birth of triplets in 2013 made my number of grandchildren double in a day! Then it became more meaningful to be a “home deck hand” in my spare time than fiddling with the boat, so the boat was almost not used in 2013 and 2014.

The wingsail rig 2015-2016:



Foot length B (sail length along boom)			**6000**
Head length H			**3868**

For full sail:	
Sail area [m^2]	**35,84**
% forward lead	**11,59**
"SA/D" ratio	**15,01**
For sail reefed as specified:	
Sail area [m^2]	**16,74**
% forward lead	**15,70**
"SA/D" ratio	**7,01**

Fig 4 Geometry and some key data for second wingsail rig.

The new wingsail also behaved well as long as I didn't have to reef it more than two panels. But one day I was out, the weather was nasty. When the wind got stronger and I had to reef really deep, the boat did not turn into the wind but fell off. The boat was so unruly that I had to take the sail fully down. So without the engine to help me out, who knows what could happen. Then, with all the sail down, the boat rolled unpleasantly in the waves, so it was no good day out on the fjord.

What made things so wrong? It was quite obvious that the deep reefed sail's wind force attacked too far forward on the boat, and that this had to do with the wingsail's shape. The wingsail's leech is angled forward in the two top panels. That means that the sail's Centre of Effort (CE) moves considerably forward and the sail's forward lead increases with the reefing as you can see on the lead numbers in Fig 4.

For the wingsail, the sail's forward lead was on the high side already as un-reefed, so I should have understood what I went into if I had analysed the rig. Another effect may have added to the problems, the windage of the hull with "house". This is not part of the equation in the forward lead formula, but as it is mentioned in PJR, the effect of windage of the hull is a factor, and for this boat probably more than for a standard sailboat hull with a fin keel. To illustrate this, as a plain motor boat and with the motor turned off when fishing, my boat always turned its bow away from the wind, and stabilized at an angle pointing about 45° away from the wind direction. Therefore, the hull windage made the excessive forward lead effect worse.

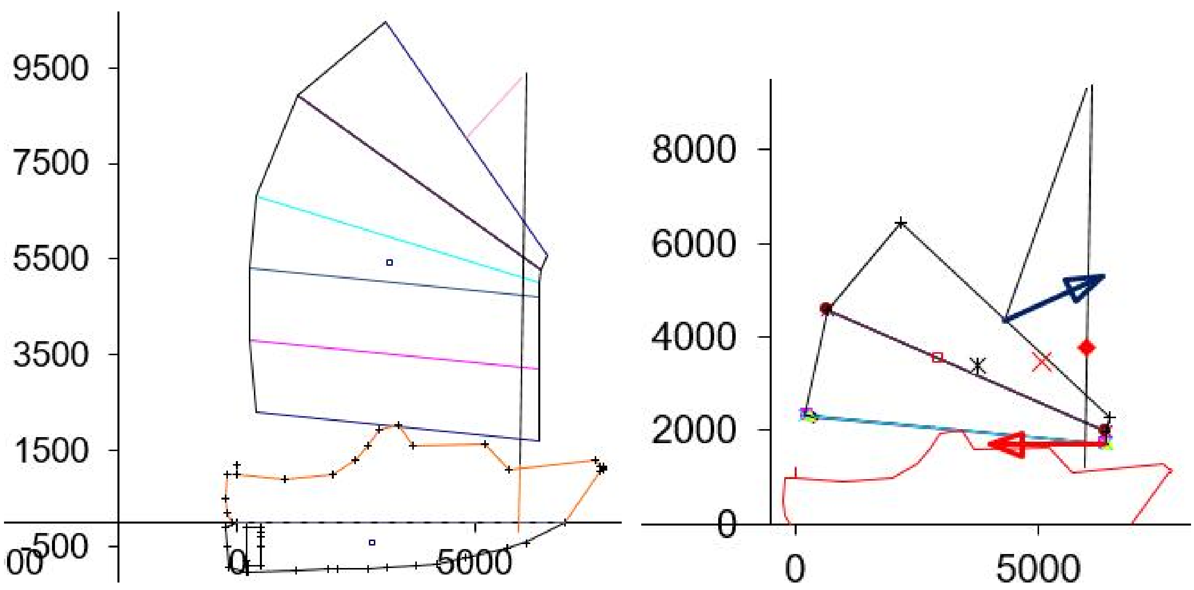
Unlike for the first rig, I made the wingsails based on rough paper sketches. The calculation with diagram and the analysis of forward lead for different degrees of reefing for the wingsail are done now in hindsight after the bad experience out at sea. *The calculations should have been done upfront!*

I found that the way to go was to go was to drastically reduce the forward lead, and I tried to see what could be done with the actual mast position. Nothing was wrong with the wingsail as such, but with this boat and the mast which had to remain on the foredeck, its forward lead would be too large, especially when deep reefed.

My present rig (from 2017):

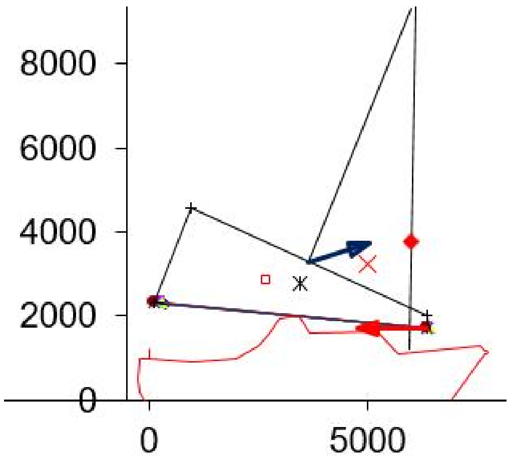
The solution to reduce the forward lead considerably with the mast position unchanged, was to go back to an H&M style sail with a fanned upper part, and I extended my old yard from 4.1 metres to 6.2 metres, then followed on with longer battens and boom, and to do the most of it, I went for forcing the sail back by means of the luff hauling parrels to have a minimum balance about the mast. Fig 5 shows the geometry with the sail forced quite far aft.

It has been questioned what the point is of having a triangular top like on the H&M style sail, and I have also been in doubt about that when I went for the wingsail. So is there any benefit of a sail where its aft end of the yard is pointing high into the sky? Well, I now see one benefit that was just what I needed: panels that are fanning out aft, contribute to moving the CE aft, in other words that the forward lead is reduced.



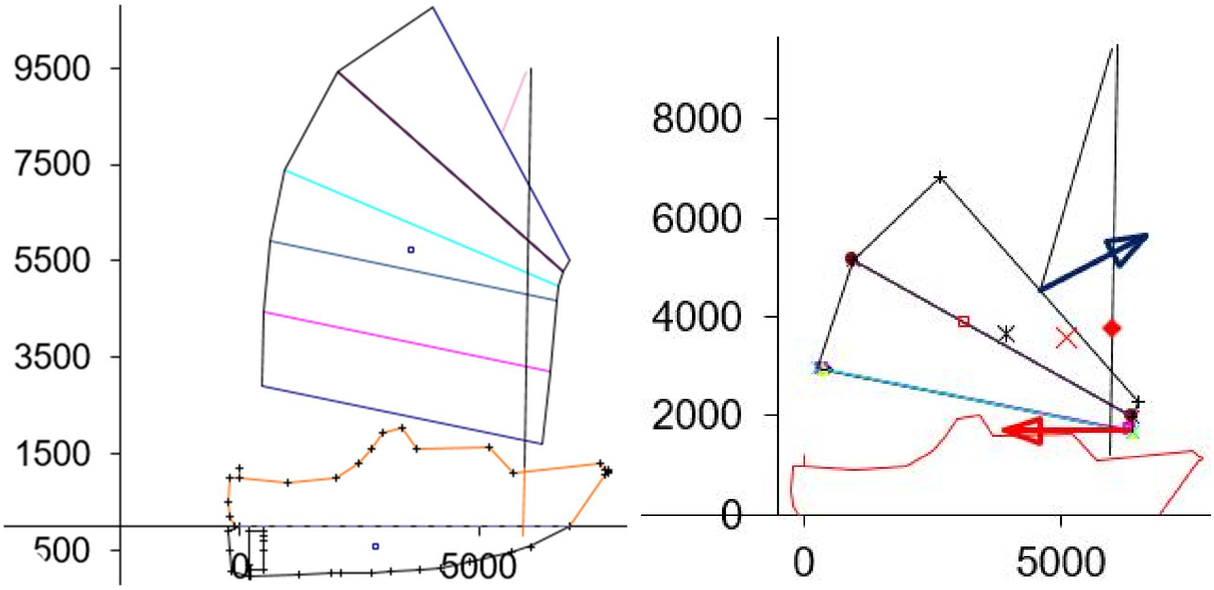
Foot length B (sail length along boom)	6000
Head length H	5973

For full sail:	
Sail area [m^2]	39,76
% forward lead	5,20
"SA/D" ratio	16,65
For sail reefed as specified:	
Sail area [m^2]	16,05
% forward lead	1,18
"SA/D" ratio	6,72



For sail reefed as specified:	
Sail area [m^2]	8,07
% forward lead	-2,71
"SA/D" ratio	3,38

Fig 5 Geometry and some key data for my present Junk Rig, sail forced far aft for low forward lead.



For full sail:	
Sail area [m^2]	**39,76**
% forward lead	**10,82**
"SA/D" ratio	**16,65**
For sail reefed as specified:	
Sail area [m^2]	**16,05**
% forward lead	**4,03**
"SA/D" ratio	**6,72**

Fig 6 Geometry and some key data for my present Junk Rig, sail tilted 6 degrees forward.

When reefing deeper for stronger wind, we can see that the reefed sail's forward lead is reduced, and the more the sail is reefed, the more the forward lead is reduced. One could say that this helps the boat to weathercock. Or, the deep reefed sail gives a "mizzen effect". This gives the boat the safe behaviour which is very important as I see it. From the numbers connected to the diagrams you can see for the H&M rigs shown here that the forward lead is reduced at the reefed sail, while for the wingsail, especially that on Fig 4, it is the opposite. That could perhaps indicate that the recommended forward lead for the full wingsail should be lower than the Junk Rig's 6% to have good balance also for the deepest reefing.

When the new rig was tested, I found that the changes had helped a lot! Now the boat tends to turn into the wind (becomes more weather helm) as the wind picks up. I also enjoy the new rig when I am out fishing: Then I set the sail deep reefed to have almost no forward speed, and the "weathercock-like" sail makes the boat keep its bow close to the wind.

I would have liked to combine the fanned rig with wishbones and wingsail features, but found that this would be difficult. For a slow hull a wingsail profile probably does not make much sense to gain speed anyway. The sail can be tilted by means of the control parrels, and on Fig 6 is a geometry which is more in line with the photo on Fig 7. This geometry is also fully functional in practice perhaps except for the deepest reefing. Therefore, the sail does not always need to be forced as far back as in the example above, but I find it is good to have the possibility for an extra low forward lead for this particular boat.

Then what about the rolling problem I mentioned for the wingsail when no sail was up? I did some changes which would help: Cutting 1 metre off the mast top which was a spruce pole and also reducing some weight by removing the wishbones and replacing these with single batten lengths. These changes have moved the centre of gravity down. However, I haven't had chance to test it yet, so it is possible that I still will have a rolling problem with no sail up, but that is no worry as long as I have some cloth to hoist and the boat balances safely when the top panel is hoisted to act as a roll damper.

Some features (or should we say peculiarities) of the present rig:

Luff hauling parrels:

The sail position in Fig 5 means a low degree of balance (mast position relative to battens), and I found that it was necessary to force the upper part of the sail aft by means of the luff hauling parrel (LHP) to achieve this. At the same time the lower part of the sail had to be given a lower force from the LHP to avoid tilting the whole sail forward. To be able to control the forces on the luff better I therefore now use two luff hauling parrels; one upper and one lower. One more running line to handle, but well worth it, I find.

Fig 7 The present tarpaulin sail, its appearance with a great improvement potential…!

Fixing battens and yard to the sail:

The battens are "point fixed" to the sail. Each fixing point is a small double-plate "clamp" as shown in Fig 8. A short, thin "lace" runs twice through the clamp and the sailcloth and then around the batten before its ends are tied together. The clamp is simply two 40 x 40 x 4 mm plates held together by a Ø5 mm screw. The holes for the lace are Ø8 mm. The sail is also fixed to the yard in a similar way. Thus the whole sail is what I like to call "sailmaker free"! No use of needle and thread here.

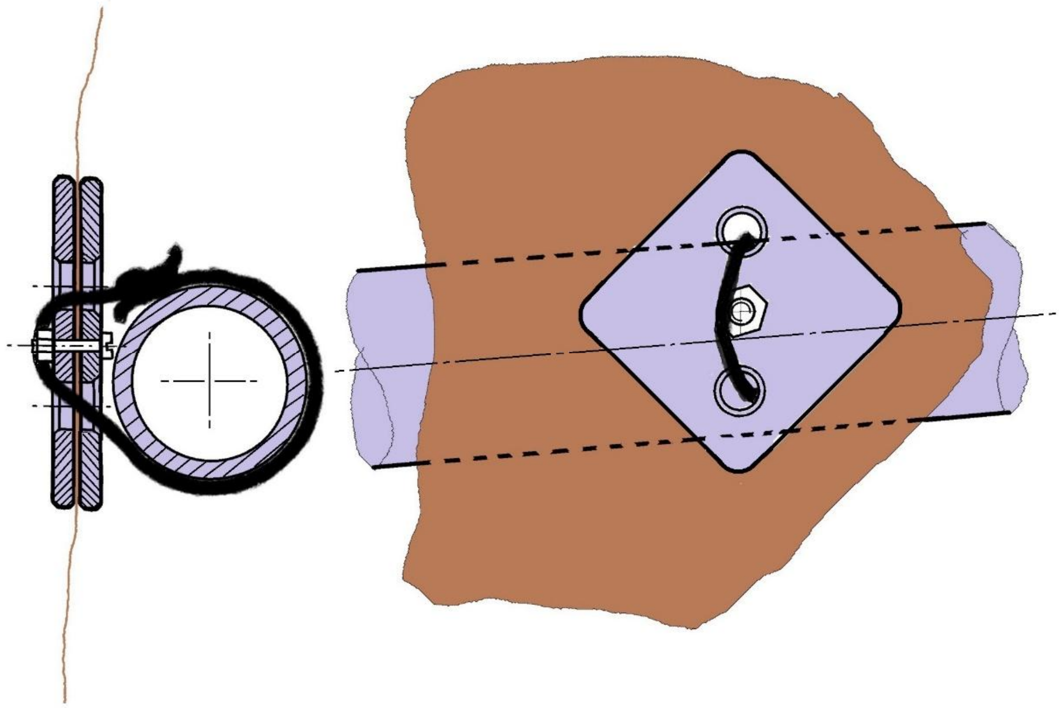


Fig 8 A clamp and lace making a fixing point for the batten to the sailcloth (vertical section view to the left)

Pre-bent flipping battens for camber:

The battens are permanently bent to give camber. In addition to the pre-bending, the battens will bend somewhat more under the wind load on the sail. The battens are aluminium tubes with outer diameter Ø32 mm and wall thickness 3.5 mm, about 4.1 m long from the old rig. When I now extended the batten lengths to around 6 metres, I joined tubes Ø25 mm x 2mm previously used in the wishbones, to each end of the old battens. As the bending moments on battens decrease towards the ends, the smaller tube batten extensions have shown strong enough except at the two uppermost battens' aft ends. The upper of the two (the one with the sheetlet lifter – see Fig 7 and below) was increased to Ø32 after the Ø25 tube broke at a spot weakened by drilled holes, while the Ø25 batten end below looks weak and will also be changed to Ø32.

In practice it has shown that the pre-bent battens now flip around by themselves after a tack. In my earlier rigs I have experimented with dedicated lifting parrels to help the flipping, but those don't seem necessary now, and that makes it all simpler.

The "sheetlet lifter":

On my first H&M rig the uppermost batten which was between the two triangular panels, was not attached to the sheet. In strong winds I found that was a disadvantage, as zones in the top panel would start fluttering. This I think could have been avoided if the top batten had been subjected to a side force from a sheetlet, thus making the top panel take up more wind force and get an increased pressure difference between the two sides of the sailcloth. However, with the given shape of the sail, the uppermost batten would need to stick very far out to avoid that its sheetlet doesn't snag on the sail at tacking. I therefore have introduced a "sheetlet lifter" that sticks far out at tacking only, as can be seen on Fig 7. When I tack, I pull a special parrel and the sheetlet lifter swings out and keeps the sheetlet away from the leech. When the tacking is done, the lifter parrel is made slack, and the lifter becomes just an extension of the sheetlet. After the photo was taken the sheetlet length was adjusted so that it went better clear off the leech below.

Fig 9 The hinged mast laid down and ready to act as a hanger for the winter tarp tent.

The hinged mast:

The hinged mast, where a two metres long sleeve over the hinge provides the stiffness when upright, was made to make me independent of bridges opening for boats to get out on the fjord and in again in Trondheim. The hinge makes access to the mast top easy, and when it is laid down the mast also serves as the top tube in the tarpaulin tent I use some winters (see Fig 9). Winters are a gamble here: Some winters a metre or more snow can fall in a short time, and then the winter tent is great to have, while other winters happen be almost snow-free here at sea level.

The wedge retainer arrangement:

On the first rig my partners wood wedges had the annoying habit to work themselves upwards and become loose. My solution was to add two retainer rings made of aluminium plate - of which the lower can be seen on Fig 10. The upper retainer ring is above the partners and covers the top of the wedges and holds the wedges down. The upper retainer ring is held down by four "Pull-Down" bolts (rods) fixed to the lower retainer ring by nuts. The lower retainer ring is held down by four "Push-Down" that are adjusted vertically to contact the underside of the "partners plate". Thereby the upper ring is prevented from moving upward, and thus holding the wedges in place. With this arrangement my partners have become totally trouble-free. By the way, three of each type bolt (rod) would be enough.

Fig 10 *The wooden wedges at the partners look messy as they are not cut to same length below, but their upper ends are made level and are held down by an upper retainer ring above the partners. Fig 11 below explains it better.*

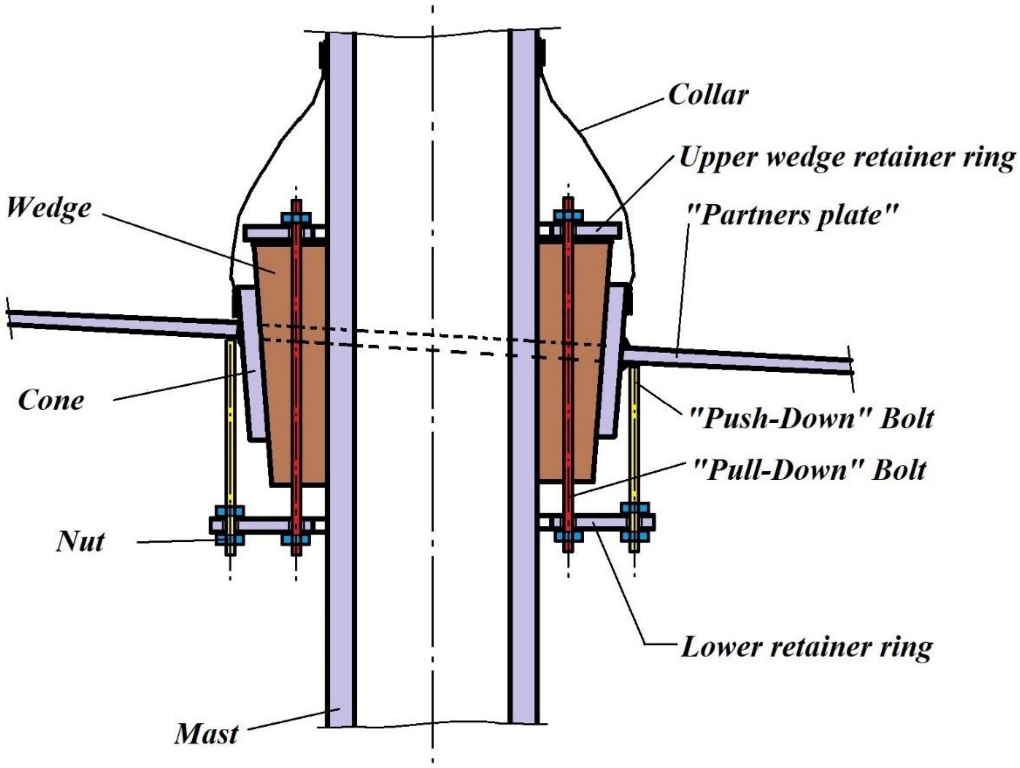


Fig 11   Sketch of the wedge retainer arrangement at the partners

More things to be done:

The look of the tarp sail is almost embarrassing, where I have patched together used pieces from the wingsail. But now as the behaviour of the sail is satisfactory, the sailcloth can well be changed to something better-looking and more durable. Maybe I will do that, but I like to do rough experiments rather than making things with a nice finish, so time will show. At least I will be correcting the leech contour as indicated on the photo, and trim batten lengths and make "no-snag" connections between all sheetlets and battens.

Trondheim, November 25, 2017

Nils Myklebust

P.S.

If anyone would want use my spreadsheet to calculate a rig geometry, just ask and I will send it to you on e-mail. I can also do it for you or help you using the spreadsheet, as I am now mostly retired and have time for such things. A version of the spreadsheet has been uploaded on the Yahoo Junkrig site for years, but as far as I know only one guy in Canada has used it for designing his own rig.