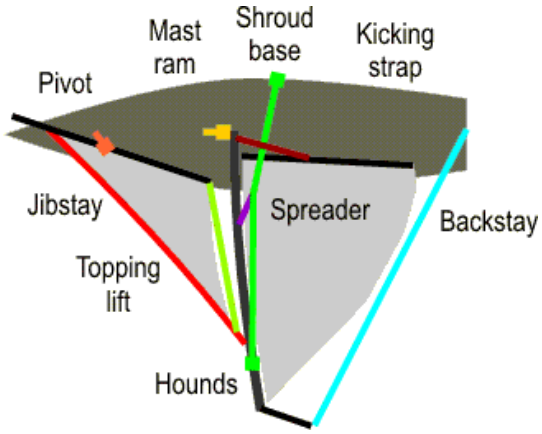
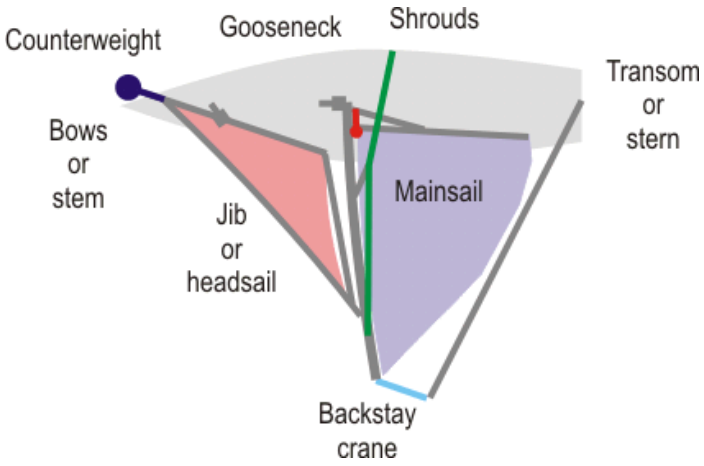
Rig basics

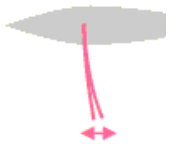




Marty Jones asked me about an IOM rig. I thought it might be useful to explain some of the basics.

In the following discussion, focus is given to each element of the rig in turn, and its relationship to the other rig elements explained. This does lead to fair amount of (intentional) repetition.

Mast



Besides holding the sails up, the mast does three important things. The first is that it handles the rig tensions, in particular taking the backstay and shroud tensions and transferring them to the jibstay. The other two things it does is bend: fore and aft, and sideways.

Fore and aft mast bend changes the shape of the mainsail in two ways. One is that the mast either pushes fullness into the body of the mainsail when it straightens, or pulls fullness out of the mainsail when it bends more. Two is that the head of the mainsail either twists off as the mast bends more, or twists off less as the mast is straightened.

Sideways mast bend also brings two main changes. One is that it changes the slot, the gap between the jib and the mainsail. If the mid-mast bends to leeward, the slot closes, and if it bends to windward, the slot opens. Two is that sideways mast bend changes the effective twist of the mid-main. If the mast bends to leeward, the twist in the middle of the mainsail reduces, and vice versa if the mast bends to windward.

Mast pre-bend

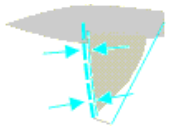
Some pre-bend is usual if the mast is a minimum-section mast. If you have a stiff mast, then pre-bend may not be needed. Remember that mast pre-bend is "forward"; when you tighten the backstay you straighten the mast and pull the pre-bend out. When you tighten the backstay further you then set the mast into its "normal" bend.

If you don't pre-bend your mast, you'll not be able to crank in much backstay tension, and that'll generally leave you with too little jibstay tension. I say generally. There are

two exceptions. One is, if you are sailing in very light winds, you probably don't want very much jibstay tension, because you will want some jibstay sag to match your jib luff curve. Two is, if you have your shroud base well aft, then shroud tension will feed into your jibstay, possibly enough so you don't need very much backstay tension at all. If you have your shroud base well aft of the mast step, then you may not need a pre-bent mast.

An 11.1 mm "A" rig mast with 0.60 mm wall thickness, without pre-bend, will allow no more than about 0.75 kg of backstay tension before it bends excessively. With 40 mm pre-bend, you can run up to about 3 kg of backstay tension.

Backstay



The backstay is tensioned so that, broadly, the mast bend matches the mainsail luff curve. Fine adjustment of backstay tension (along with spreader "V" and the mast ram) pushes a little body into the mainsail, or takes some draft out.

Having set the broadly correct amount of backstay tension to match the mast bend to the mainsail luff curve, and having set the mast ram and the spreaders to be consistent with this mast bend, further backstay adjustment mainly affects bend in the upper part of the mast, around and above the hounds.

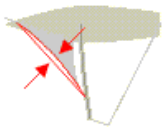
At the top of the wind range for the rig, the backstay can be tensioned further to increase twist at the head of the mainsail and to flatten the head of the mainsail. The head will flatten only if the spreaders and mast ram continue to control their own parts of the mast, the mid- and lower mast. Otherwise increasing backstay tension will change the whole of the mast bend in probably undesirable ways.

If in "A" rig with light winds, the backstay can be eased a little to push more body into the middle of the mainsail for more drive, and remember to ease the kicking strap a little to compensate for the reduction in twist at the head.

The second purpose of backstay tension is to obtain adequate jibstay tension. The more tension in your backstay, other things being equal, the more tension in your jibstay. The major way to change jibstay tension at the pondside and thus control jibstay sag is to adjust the backstay tension.

Typical values of backstay tension are around 2 kg for a pre-bent mast.

Jibstay



Jibstay tension results from backstay tension and shroud tension (if the shroud base is aft of the mast step). The higher the backstay tension, the higher the jibstay tension. In fact, because of the characteristics of the fractional rig, every gram of backstay tension yields around 1.6 grams of jibstay tension.

Jibstay tension regulates jibstay sag. The tension of the jibstay is set to match the jib luff allowance, the curve cut in to the jib luff, to the expected jibstay sag. If there is very little jib luff allowance cut into your jib, you need a higher jibstay tension to keep the jibstay from sagging as the wind builds up. If you have considerable jib luff allowance, you need less jibstay tension. The downside of having much jib luff allowance is that the jibstay needs to be quite slack in very light airs, otherwise the jib does not develop sufficient draft.

Jibstay sag does two things. First, it pushes fullness into the jib. Second, it reduces the twist of the jib. Jibstay sag is probably the hardest thing to control on an IOM rig.

Jibstay tension also feeds in to the topping lift tension, according to the position of the jib pivot. If the jib pivot offset is closer to the jib luff, less tension feeds in to the topping lift, and vice versa as the pivot offset increases.

Typical values of jibstay tension are around 4 kg, for a jib with very little luff allowance.

As an aside, the length of your jibstay plus the jib boom pivot length determines your mast rake, if your mast is stepped so that its heel cannot move and the boat is balanced by raking the mast forward or aft as needed.

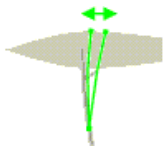
Shrouds

The shrouds support the top of the mast. It is my opinion that the shrouds do not do much to regulate sideways mast bend. I think that the top of the mast will sag or bend to leeward when the wind gets up, more or less regardless of the shroud attachment point at the hounds. Much more significant is the location and length of the spreaders in managing sideways mast bend.

Shroud tension does three things. The most obvious is that the shrouds keep the mast upright, and the shrouds need to be tightened as the wind picks up in order to hold the mast as upright as possible. Less obvious, but more important, is that shroud tension does two other things. One, it feeds in to the jibstay tension. Two, shroud tension is what allows the spreaders to be effective.

Shroud tension can vary from about 3 kg to over 15 kg in extreme cases. It is likely that, when well-heeled, a leeward shroud tensioned to only 3 kg on the pond-side will become quite slack on the water.

Shroud base



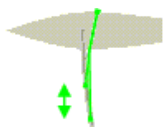
Shroud tension feeds in to the jibstay in proportion to the shroud base. The further aft the offset of the deck attachment of the shrouds from the mast step, the more tension is put into the jibstay. Conversely, if the shroud base is abeam the mast step, no shroud tension finds its way into the jibstay.

It is possible that, if you have your shroud base well aft of the mast step, you do not need to pre-bend your mast. An aft shroud base means that backstay tension is less significant in affecting jibstay tension than shroud tension, and you can use your backstay purely to manage fore-and-aft mast bend. In this case, your control of jibstay tension and jibstay sag depends much more upon adjustments to your shroud tension.

The amount of spreader "V" you need simply depends upon your shroud base offset. The further aft your shroud base, the greater the spreader "V" angle required.

Between 0% and 30% of the shroud tension is transferred into the jibstay depending as the shroud base varies from 0 to 50 mm aft of the mast step in "A" rig.

Hounds



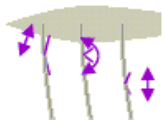
Broadly, it is my opinion that the shrouds will keep the mast relatively upright pretty much regardless of where they are attached at the hounds. I say "relatively", because it is also my opinion that the mast head will sag to leeward when the wind gets up, pretty much regardless of shroud tension, shroud attachment, or spreader geometry.

Nevertheless, hounds position will have subtle effects upon sideways mast bend. Hounds which are lower down the mast will allow the mast head to bend to leeward more when the wind picks up, and vice versa for hounds located higher up the mast. Perhaps more important is that hounds position controls top mast bend, while the spreaders control mid-mast bend. Lower hounds allow more of the top part of the mast to bend to leeward, while higher hounds allow less of the top part of the mast to bend.

Mast compression

Backstay and shroud tensions result mainly in mast compression forces. You can pretty much add up the backstay tension, and the two shrouds tensions taken separately, to obtain the mast compression. If you use a lot of tension, you could find 35 kg of mast compression at your mast step. Make sure you have a good mast box!

Spreaders



Spreaders have three major characteristics. One is their position on the mast -- located towards the top of the mast, or towards the deck. Two is their length. And three is their angle or "V".

Angled-back spreaders are needed simply to allow a shroud base to be quite aft of the mast. If the shroud base is more or less abeam of the mast step, then you won't have angled back spreaders, you'll have "in line" ones.

The spreaders do two things. One is they provide subtle control over fore-and-aft mast bend, and two, subtle control over sideways mast bend.

As you change the angle (the "V") of the spreaders, you are using shroud tension to pull the middle of the mast aft and thus straighten it, or you are allowing the middle of the mast to move forward and thus bend more. You are fine-tuning the mast bend, having set it grossly with the backstay. Keep in mind that the mast ram will also affect mast bend lower down, and your spreader "V" will have to be consistent with your mast ram setting.

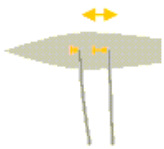
As you change the length of the spreaders, you are using shroud tension to pull or push the middle of the mast to windward or leeward when beating and heeled, subtly opening or closing the slot. Shorter spreaders, under 50% of beam, have the effect of pulling the mast to windward and opening the slot, while longer spreaders have the reverse effect, pushing the mast to leeward and closing the slot. To see how this works, remember that the windward shroud tightens as the boat heels under wind pressure, and the leeward shroud slackens. The windward spreader then gets to work, pushing or pulling, while the leeward spreader loses its effectiveness and is much more of a passenger.

Keep in mind that, as the boat heels when the wind gets up, the top of the mast will sag to leeward regardless, and so it makes little sense to use very short spreaders in the hope of keeping the mast relatively straight. In my view the mid-mast must be allowed to sag to leeward a little, so that the whole of the mast maintains a consistent bend, and the ideal spreader length is therefore around 55% or 60% of beam.

The effect of the spreaders depends on shroud tension. Their control of the middle of the mast works off shroud tension, and if you don't have much shroud tension then your spreader effects will either be less, or you will have to exaggerate your spreaders (length, "V") in order to get the effects you need.

The position of the spreaders, higher or lower on the mast, is not critical in my opinion. Nevertheless, if your boat has a high mast ram and effective mast partners, the spreaders can be about 60% up the mast. If your boat does not have much of a mast ram, then your spreaders would do their best work about 45% to 50% (halfway) up the mast.

Mast ram

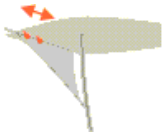


The effect of the mast ram is to control fore-and-aft mast bend in the lower part of the mast, complementing the spreaders in their control of mast bend in the middle part of the mast. To be effective, a mast ram needs a secure mast step, and needs to be as high above the mast step as possible to ensure sufficient leverage and control.

Some hull designs also have mast partners at or near the mast ram position. These partners give sideways support to the mast, and are very useful, but their effect is quite independent of and different from the mast ram.

Mast bend in the lower part of the mast transfers to the gooseneck axis, and as the mast ram is wound in or out, changes will have to be made to the kicking strap accordingly.

Pivot

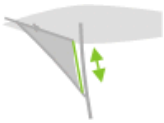


The position of the jib pivot, the amount of the jib pivot offset, has two major effects. One is it regulates the amount of tension in the topping lift, and two is it exposes more or less of the jib to the wind when on the run. There is some discussion that it has a third, minor effect, in that it displaces the jib luff from the boat centreline and thereby reduces the drive of the jib when close-hauled. It is my opinion that in fact the displacement of the jib luff to weather is very slightly beneficial, not detrimental, but that this is not an important consideration in any case.

A rule of thumb is that the pivot offset should be about 20% to 25% of the jib foot. If you have a shroud base set well aft of the mast step and have higher shroud tension, the offset could reduce to about 15% since otherwise excessive tension may remain in the topping lift when the wind gets up.

The length of the pivot, if adjustable, affects mast rake and hence boat balance.

Topping lift



The topping lift has one purpose, to regulate the amount of twist in the jib. The more tension the topping lift has, the longer it will keep its setting. At some point, when the wind reaches the top of the rig's range, there is insufficient tension in the topping lift, and the jib leech opens, increasing relative jib twist.

It is interesting to recall that, as the wind rises, jibstay sag increases, decreasing relative jib twist. It is my opinion that there is therefore little need to have excessive topping lift tension, since you do want the jib leech to open (ie the topping lift to release) in order to counteract the effects of jibstay sag.

Typically, a topping lift will have about 0.75 kg static tension.

Kicking strap

The kicking strap regulates the amount of twist in the mainsail. When attached to a mast fitting that includes the gooseneck, it is affected by mast bend, and will need adjusting as mast bend is adjusted.

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