**Spectron 12,
large sheaves, and
a clew block, plus
a fairlead block
eliminate friction
in this 8:1 rig**

drLaser's Outhaul

by
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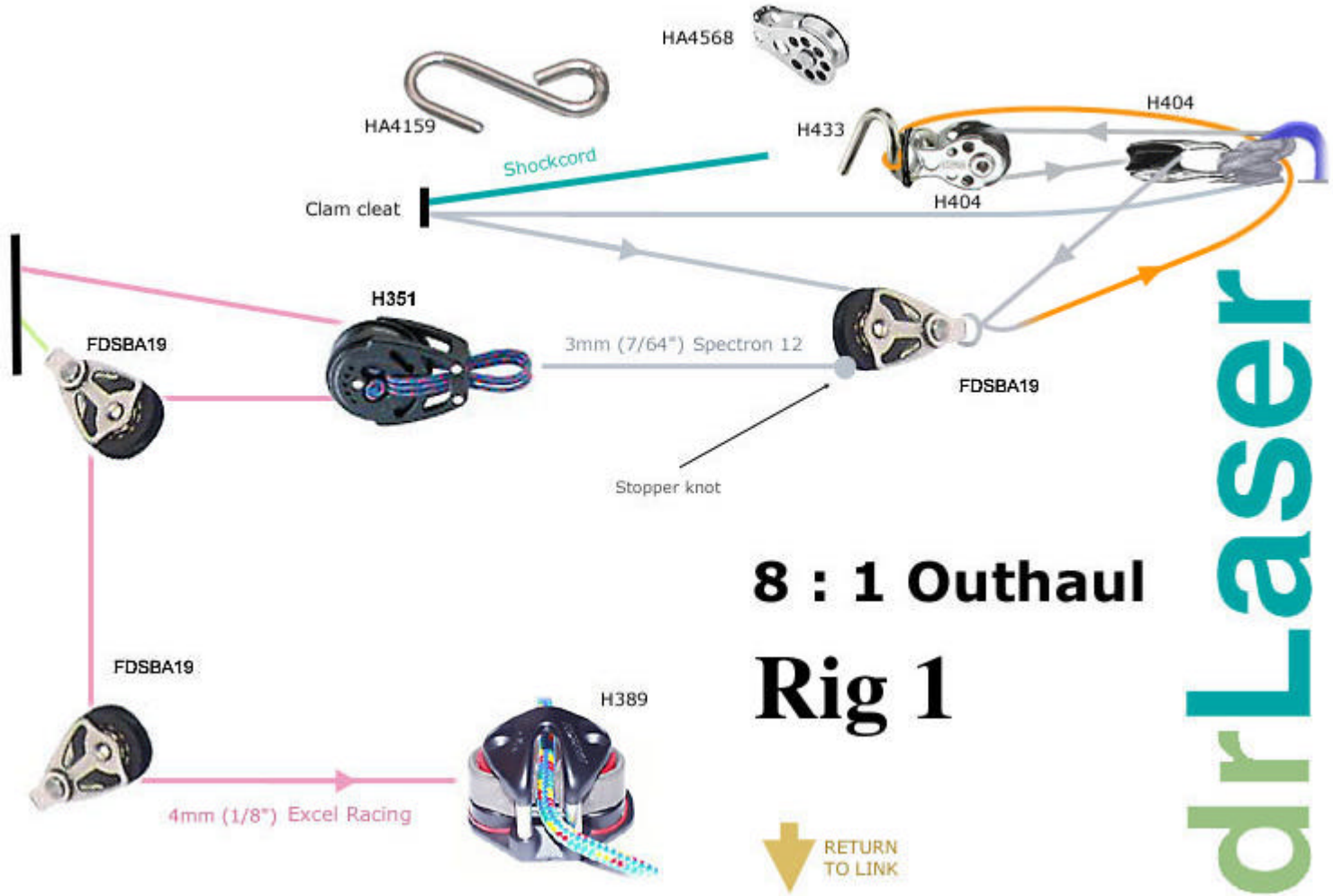
Most recent changes are marked with a 

 **Attaching a "block" to the control line, and then positioning this block right at the fairlead was legal under the 2001 Rules. An ILCA Rules Interpretation dated 1 December 2003 allowed attaching a block directly to the fairlead, but required a control line to be *moving* through the fairlead and made the original *drLaser* design illegal. As a result, off we all went back to the drawing board to beat these poorly worded Class Rules again! The orange part of the primary purchase line was added. This rig is now legal again.!**

The picture below shows the parts used in an outhaul system I designed to the new Class Rules. It is based on the design shown in Figure 21 in ***Designing Custom Control Systems*** in this web site. The system is tested and works fine. All improvement suggestions are welcome.



☐ ***Show component specifications***

IF CHECKBOX DOES NOT WORK, CLICK here.

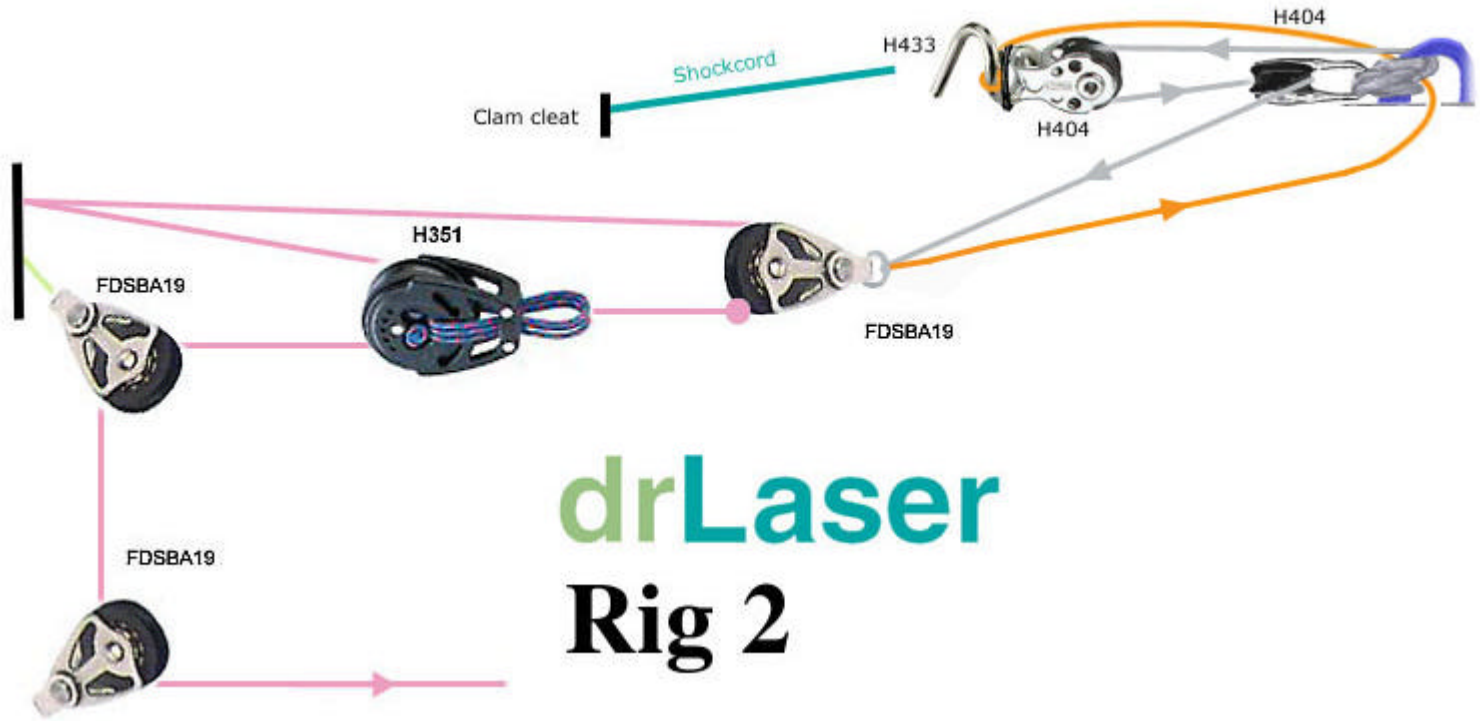
If you select any links below referring to the parts of the system above, the document will automatically scroll up to show the diagram. Moving your mouse over the fat "RETURN TO LINK" arrow will scroll the document back down to the paragraph you were reading.

The outhaul system is a *two* control line, 8:1 power ratio system using two 2:1 cascades inside a 2:1 primary purchase. There are two ways of rigging such a two-line outhaul system.

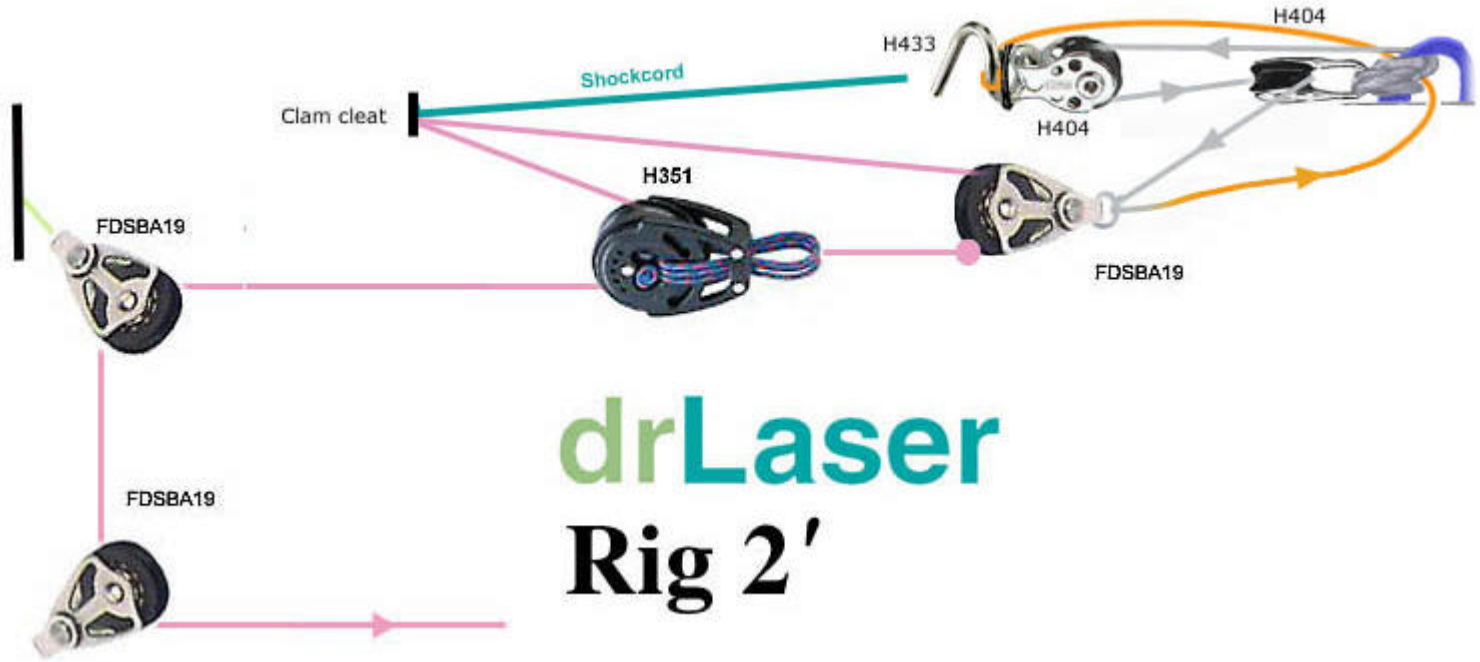
- **Rig 1:** Using a single line for the primary purchase and the first cascade (as shown above), *versus*
- **Rig 2:** Using a single line for the first and second cascades (as shown below).

The remainder of the aricle explains "Rig 1". Only limited comments (shown in purple text) are offered on "Rig 2", which is the design I am currently using.

An example of "Rig 2" is shown below. This particular design dead-ends the middle of the cordage acting as the primary and secondary cascade lines on the mast, right over the gooseneck. I don't particularly like this system because it increases the time I need to get my outhaul set up for a sail. (And time is of prime importance for me.) My preferred alternative is shown as Rig 2' below.



Rig 2' is the outhaul I raced with during the 2002 & 2003 seasons (except for the new "December 2003 Interpretations requirement" orange part of the primary line). This alternative is slightly inferior to the one shown above, since more weight is located further aft along the boom. However, this is my preferred rig since, for me, "rigging" and "unrigging" this outhaul requires *only* unshackling one block from the boom. (I leave my boom with the hull, and the outhaul pre-rigged on the boom.)



I prefer an 8:1 outhaul because the 8:1 provides the power lacking from the 4:1 systems (like the standard *Vanguard Performance Upgrade Kit* and the Eupropean *XD Power Pack*), much needed while sailing double blocked upwind. Until an ingenious design is developed to eliminate the friction of the clew tie-down, I believe an 8:1 (or at least 6:1) outhaul system is really desirable.

Samson's 3mm Spectron 12 cordage (an extremely soft and slipperly line) is used for the primary purchase. For the free (control) end that goes through the deck cleat, either *Samson*'s 4mm Spectron 12 cordage or *Marlow*'s 4mm Excel Racing line may be used. Large diameter lightweight sheaves are used as much as possible to improve the performance of the outhaul when it's released. Note that a shockcord between the boom clam cleat and the clew tie-down acts as an inhaul when the control line is released, also helping to reduce any outhaul sag as the line is released.

I personally prefer Spectron 12 even for the control end (pink) because it does not absorb any water, is lighter even when dry, and cleats fine with no slip in the cleats shown even when brand new out of the spool. Plus, the control end is loaded by at most 10kg, and hence there is no need for a hefty line with a soft and comfortable feel. Even if I wanted a hefty handle, I can get that by either braiding a handle or passing the handle loop through a rubber tube.

The components used are a 16mm ***Harken*** **H404** single hooked to the clew with a ***Harken*** **H433** clew hook (or a ***Holt*** **HA4159** S-hook), another ***Harken*** **H404** right at the boom-end fairlead, a 19 mm ***Frederiksen*** **Ultra SBA-19** single at end of the primary purchase, a large but very light 29 mm ***Harken*** **H351** CarboAir Ti-Lite single at the end of the first cascade, a 19 mm ***Frederiksen*** **Ultra SBA-19** single as the mast/gooseneck junction turning block, and another a 19 mm ***Frederiksen*** **Ultra SBA-19** single as a deck turning block to lead the control line to the cleat. The cleat kit is the ***Harken***

H389 with aluminum Micro Cam-Matic 338 cleat with a 329 fairlead. Total hardware weight is 112g (123g with the *Holt* S-hook), with 53g of this on the boom (64g with the *Holt* hook).

The system should ideally be designed for clew loads loads of maximum 125 kg and outhaul loads of maximum 80 kg, as rationalized in ***Designing Custom Control Systems***. Upon mixing and matching blocks, the effective Safe Working Load of this outhaul is 113 kg, and the Breaking Load is 544 kg.

If your clew tie down breaks and the total clew load is transferred to the clew block, the *Harken* H404 at the clew may get damaged in strong winds. As a precaution, you may want to use the stronger ***Holt* HA4568** as a clew block. However, the *Holt* HA4568 is 17mm longer, and it will allow you to haul in the clew less, just when you need more outhaul in heavy air! In heavy air, I simply prefer securly tying my clew tie down rather than using risky quick release rigs like the one shown in the "Rigging" subsection of the *drLaser* FAQ.

Also, among the clew hooks, I prefer the H433 since it is considerably shorter, lighter, and much easier to unhook. Its disadvantage is that it orients the clew block vertically rather than horizontally as the HA4159 S-hook does, but this is not a major problem given the way I tie the blocks and the clearance between the clew cringle and the boom.

To mount the clew block on a hook, you may need to pry open the hook a bit. The H404 slides effortlessly through the H433 hook. Just insert the head onto the upen end of the clew hook, and slide it over. I also slide a little rubber O-ring (like those used for the bailer) onto the clew hook and push it against the head of the block to keep the block aligned and in place. Such a runner O-ring actually comes with the H404 as an "Anti-Capsize" device, typically used to prevent this tiny block from flipping over, with the sheave becoming the head and the head becoming the sheave.

Rigging the primary purchase

In "Rig 1", a single piece 3 mm diameter **5.25m (17')** long Spectron 12 cordage (grey line) is used for both the primary purchase and the first cascade to satisfy the (silly) Class Rule which permits just two control lines for the whole outhaul system.

For primary and first cascade, a 5.25m length will be ample, leaving you some extra line at both ends to allow you to adjust the positions of your blocks as you wish, or the positions of your knots over the years to increase the lifespan of the cordage. Basically, this line is tied in its middle to the (standard original) outhaul clam cleat on the boom, and one tail is used as the primary purchase line (including the "orange" extension in the diagram), and the other tail is used as a cascade line.

To rig this line, mark the line approximately
2.5m (8')
from one end. This is where the fairlead block will be tied to the fairlead.

Before the December 2003 Interpretations, we had to attach the block to the line first, and then pass the line through the fairlead and somehow securely position the block as close as possible to the front of the fairlead. With the December 2003 Interpretations, we are now allowed to tie a block directly to the fairlead, and life becomes much simpler: we attach the block to the fairlead just using a **clove hitch**, finished with couple of half hitches.

Simply hold the *Harken* H404 block with its sheave in a horizontal orientation, and butt its head firmly against the forward post of the boom-end

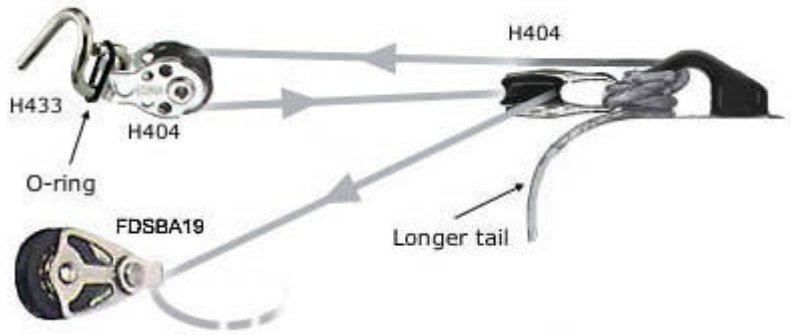
fairlead. (To keep the block's head there as you work, you can just tape the sheave part to the boom, leaving the head accessible to work on.) Lead the line through the fairlead from the port side. Pull the line through the fairlead so that the short tail is leading forward and the the long tail is leading aft, and so that the mark on the line remains right at the head of the H404 block. (Just lead through the other tail if you ended up with the shorter tail leading aftward.)

Now we tie the block to the fairlead post: Using the long tail (only), loosely attach the block head to the fairlead's forward post using a **clove hitch**. Tie the clove hitch so that its second hitch is made **above** its first hitch. (This will leave the short tail *under* the long tail.)

Then, to finish the knot:
- With the long tail, take a turn around the fairlead post, and lead the long tail forward from *under* the block;
- With the short tail, add a locking **half hitch** above, only around the fairlead post, and lead the tail forward from *over* the block.

Then, just grab on both tails and pull them forward along the boom to tighten the knot.

Take the long tail (which leads from under the fairlead block) to the mid-boom clam cleat and temporarily cleat it there.



Lead the short tail of the line (which leads from *above* the fairlead block) forward and through the clew block from **above** its sheave, then back to boom end through the fairlead block (depending on which side of the boom you prefer your outhaul to be rigged). Then lead it forward and tie it from its "middle" to a *Frederiksen* SBA-19 with a **buntline** (shown to right) or bowline. The point on the line where you tie the SBA-19 on should be about 110 - 113cm (43" - 44") from the end of the boom, when the line is hauled to double-block the clew and fairlead blocks. At this *maximum-outhaul* setting, the head of the SBA-19 should not reach reach any closer than 4cm (2") to the aft end of the clam cleat. With the primary purchase slacked so that the distance between the clew and fairlead blocks reaches 26cm (10"), the head of the SBA-19 will be about 64cm (25") from the end of the boom.

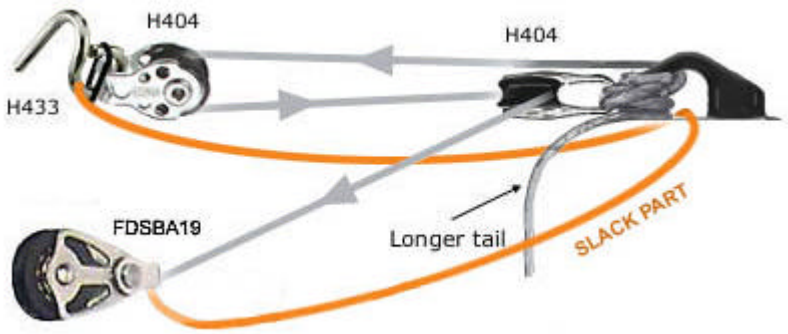
[*In the case where a single line is used for the first and second cascades, the fairlead block is tied against the fairlead with two clove hitches using the primary purchase line. The long (and only) tail of the clove hitch is then led to the clew block, and back through the fairlead block to lead forward to the SBA-19.*]

Dealing with Interpretation 6

Interpretation 6 passed on 1 December 2003 requires an outhaul control line to "pass through the fairlead and be a moving line". The Interpretation also notes that the "fairlead is one of the maximum of six turning points allowed" in the outhaul rules. This clarifies that (probably only when a line moves through the fairlead) it must be counted towards the "maximum of 6 turning points" allowed in the Rules. However, this badly worded interpretation falls short of *requiring* the fairlead as a "turning point": it does *not* state that the outhaul system must be rigged with the boom-end fairlead as a required turning point (i.e., *under load*), plus up to five other turning points. As long as a line moves through the fairlead, it's a legal rig. This line is not required to be under load.

In addition, the requirement verbalized as "moving through the fairlead" does not impose any conditions on the "nature" or "duration" of the required movement. In particular, there is no "continuity" requirement on this "movement"! Even if "continuity of movement" were required, such a restriction

could be by-passed. (See "Playing the Devil's Advocate" below.)



Therefore, to create a frictionless outhaul system that satisfies Interpretation 6, the only thing that one has to do is to add to the above primary purchase design a control line that (from time to time) moves through the fairlead *without creating any friction*. And one way we can do that is to simply lead aft the tail remaining on the (buntline or bowline) knot at the SBA19 *loosely* through the fairlead and then dead-end it at the clew hook (see orange part shown in inset diagram)!

To ensure smooth passage of this (orange) line through the boom-end fairlead, before leading the tail through the fairlead, you can just wrap the knot tieing the fairlead block to the fairlead post with couple of turns of electricians or rigging tape.

This part of the primary control line is left **slack** so that it is loaded neither as the outhaul is pulled in, nor as it is eased and the inhaul shockord pulls the clew forward along the boom.

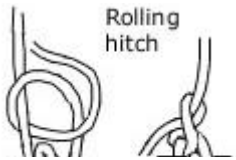
How slack should this (orange) part be? At the maximum outhaul setting (double-blocked at boom end), it should be almost tight between its two ends at the clew hook and the SBA-19. As the outhaul is eased, the line will continuously move through the fairlead, but since the SBA-19 will move aft at twice the speed as the rate of separation between the two H404 blocks, some slack will develop in the part between the fairlead and the SBA-19. On the other hand, as the outhaul is tightened, first the slack between the fairlead and the SBA-19 will be taken out; simultaneously some slack will form between the two H404 blocks, and only then the line will start moving through the fairlead.

This is surely just one way of getting a control line to pass through the boom-end fairlead. Since the announcement of Interpretation 6, sailors around the world have devised other ways of satisfying this rule, too. The above is just the option preferred by *drLaser* compared to all other options. One option is to mount the fairlead block right *next to* the fairlead, leading the line both through block and the fairlead. This option (theoretically) reduces friction on the fairlead only by about 60%. (See photo to left.)

Another alternative is to use *two* fairlead blocks, one on each side of the fairlead, with the control line going through first one block, then the fairlead, and then the second block. This option can (theoretically) eliminates 100% of the friction on the fairlead. (See photo to right.)

These reductions in friction are "theoretical" because it is quite impossible to position and keep the fairlead blocks in place just by using knots. (Both these rigs and their photos are courtesy of Ted Wong.)

Rigging the first cascade



First, we secure the (ptreviously cleated) longer tail of the primary control line to the clam cleat permanently. With the long tail, take two turns tightly around the bridge of the cleat. While holding the line taut with one hand, finish up with a clove hitch over the standing part

leading to the fairlead. (That is, you just tied a "Round Turn & Two Half Hitches" or "Rolling Hitch" around the cleat bridge.) The line between the fairlead and cleat should be drum tight.

Now, to rig the first cascade line, lead the line again over the bridge of the clam cleat and then through the cleat backwords. Pass the line through the SBA-19 block at the end of the primary. At this point, I also put a figure-eight **stopper knot** (see diagram to right) on the cascade line exactly where it exits the SBA-19 with the primary cordage at the maximum slack position. (This stopper knot will keep your clew back and allow all rigging to stay on the boom if any attachments or componets fail anywhere forward of the first cascade.) Finally, attach the *Harken* CarboAir H351 Ti-Lite to the end of the line using a single or double bowline knot - the block head approximately 110cm (43") from where the line exits the clam cleat bridge. For rigging the Ti-Lite with its rope straps, follow the instructions provided by the manufacturer.

When you haul in on the CarboAir to double-block the clew and fairlead blocks, the CarboAir sheave should reach within 3 cm (1") of the vang strap on the boom, but no closer. With the outhaul slack with 26cm (10") between the boom-end blocks, the head of the CarboAir should be at about 137cm (54") from the end of the boom.

[*In Rig 2 where a single line is used for the first and second cascades, the control line is folded into two, and with the folded end, a tight bowline is made around the mast and finished with a half hitch. In Rig 2', the line is folded into two, the tip of the bight is passed under the bridge of the clamcleat, and the two tails are just led through the loop to attach the line to the clamcleat just the way you would attach a double sided jib sheet to a jib clew grommet. In both Rig 2 and Rig 2', one tail serves as the first cascade line, the other tail serves as the secondary cascade line leading all the way to the deck.*]

Once the stopper knot is put on to limit how slack the first cascade can ever get, you can also tie on the shockcord to be used as an inhaul.

The North American builder *Vanguard* suggest that the clew end of the shockcord should be attached to the clew tie down, not to the clew hook. Attaching the shockcord to the hook is claimed to cause the hook to come off the clew cringle when the outhaul is slacked. However, even in the lightest winds, I have not observed this problem, and my shockcord is attached to my clew hook. In fact, tying the shockcord to one side of the clew tie-down twists the tie-down rig and increases the friction between the boom and the tie-down.

Lead the other end of the shockcord to the boom clam cleat, pass it through the cam cleat by leading it first *above* the bridge and then through and under the rolling hitch, and out the aft end of the cleat. Pull on the shockcord from its clamcleat end so that it is stetched 80-100% and then release back 50% of the distance you pulled and fix with a knot right where the bungy exits the mouth of the clamcleat. Push the stopper knot into the cleat mouth, and cut any excess shockcord. At least 3cm (1") of shockcord sould extend out of the clam cleat, beyond the stopper knot.

Rigging the secondary cascade

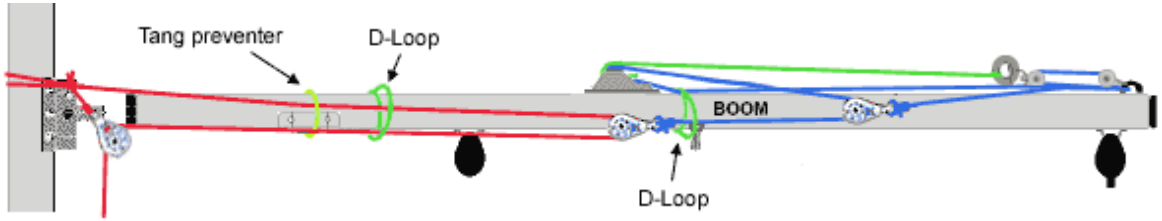
For the second cascade shown in the rig above (i.e, Rig 1, which uses a separate second cascade line), you will need at least 5m (16') of the 4mm cordage. (You may also need a small diameter line to permanently tie the mast/gooeseneck junction block, *if* that's your preference. The rig shown here does not tie the turning block to the mast/gooseneck junction permanently.) You can reduce this amount by up to 1m (39") if you increase the length of the first cascade line by up to 0.5m (19") in which case the CarboAir at the end of the first cascade would move up almost all the way to the gooseneck when the outhoul is double-blocked at the clew. (However, I did not take this path.)

You will need an even longer line if you are planning to use double handles on the tail end of the control line, and even longer if you are planning to *braid* any handles as shown in the ***drLaser FAQ***. However, **you are advised *not* to use any handles at all with such 8:1 outhaul rigs.** *They only get in*

the way and cause line management problems on the deck.

Using Rig 1, I dead-end the second cascade control line right around the the mast itself using a *double* bowline. When doubling the line to make your double bowline, leave the short tail long enough so that after the double bowline is tied around the mast, the short tail extends about 18 cm (7") past the knot. Then, the mast/gooseneck junction turning block is securely tied to this short tail. [Alternatively, you can just make a small bowline on the tail, and attach a mast/gooseneck junction turning block *with an internal (*  *or external) shackle* to this little bowline loop.]

Next, lead the long tail through the CarboAir, forward through the mast/gooseneck junction block, and down through the turning block and the cam cleat on the deck. Take the extra slack out of the line with the system in maximum slack position, and put a hefty stopper knot where the line exits the camcleat. The system should look as in the figure below.



The advantage of this bowline rig is that if you will keep your boom with the outhaul rigged next to your boat, unrigging involves only undoing this double bowline knot. Untie the double bowline from around the mast, tie it again without anything going through it just to preserve the shape and position of the bowline for your next sail, and you are set to go. You can just store the boom as is on the deck, or right next to the boat on the dock if you are storing your boat hull-side up. Anternatively, untie the bowline, tie it again to pereserve knot position, and unrig any handles you have at the tail end to take you boom and go home, with your outhaul almost fully rigged on your boom.

The figure also shows the optimal locations of any shockcord loops you may want to tie to prevent the outhaul system from drooping under the boom. A special "D-loop" is used, providing a D-shaped ring to only one side of the boom for the rigging the go through. To make a D-loop, tie a piece of shockcord tightly around the boom with a square knot under the boom, and then lead the tail on the rig side in a wider loop, around the rigging and to the top of the boom. Pass the tail under the tight shockcord loop around the boom, and tie it. Cut the excess cordage off. The D-loop can be rotated around the boom, and the top knot can be slid to port or starboard to align the D-loop with the outhaul blocks going through it.

Note that the aft D-loop is tied tightly around the line part between fairlead and the clam cleat to keep it close to the boom and out of the way. This aft D-loop should be positioned so that the H351 (block at the end of the primary) rests right on the shockcord when the system is at maximum slack. [*In Rig 2 where a single line is used for the primary and secondary cascade, there is no need for the shockcord D-loop between the boom end fairlead and the clam cleat. Rig 2' still benefits from this D-loop.*]

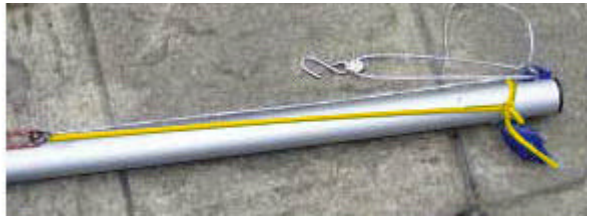
Note also the shockcord that's used as a "tang preventer" to captivate the tang in the boom cradle. This tight shockcord is tied around the boom and the part of the cascade line attached to the mast. At maximum outhaul, the H351 should reach within 2" of this shockcord.

Variations

This rig avoids all the friction associated with leading the primary purchase line through the clew cringle and the boom-end fairlead. If I wanted to save some money and weight at the aft end of the boom, I would first give up the clew block, lead the primary through the small *Harken* clew hook, and keep the fairlead block since the fairlead generates more friction than the clew cringle.

If you don't like the feel of the 3mm Spectron 12 or the alternative 4 mm Excel Racing, note that this system can *not* accommodate a control line thicker than 4mm as is. You will need to replace the mast/gooseneck junction block and the turning block at the deck to handle 5mm diameter lines. I would advise the 19mm *Frederiksen* Multi HB-19 loop head single for both if you can find one, since it is discontinued. If you can't find them. use the 29mm but extra light *Harken* CarboAir H351 for both. You can use any 5mm Spectra or Dyneema core and Polyester cover line. Even a lighter weight and non-absorbant Polypropylene cover will do since this is not a high friction application. Although very few manufacturers offer 4mm lines, you have **quite a selection** in 5mm diameter cordage, including Yale Pulse, British Braids Dyneemabraid, Samson Ultra Lite, and Yale Lite Competition.

The stopper knot shown above will work if your lines forward of the first cascade ever part or knots get undone, but the knot sucked into the blocks will damage the cordage. To prevent the knots from being sucked into the blocks, it is actually a very good idea to be able to protect them with plastic "**ball stoppers**" (such as the *Holt* HA22, or the *Ronstan* RF1318). Unfortunately, such balls are not allowed for in the current Class Rules (but they should be).



If we had a frictionless clew tie down, the shockcord between the cleat and the clew tie-down would be sufficient to both inhaul the clew and also take up any slack out of a relased control line. But the clew tie down friction can be significant even with parrel beads on the clew tie-down. A nice way of ensuring the outhaul will not droop under the boom when it is released is to add a second shockcord (yellow in the system diagram and in the photo to right) looped around the end of the boom and tied the head of the SBA-19 block at the end of the primary purchase. Unfortunately, this is not legal! (The exact wording of Rule 3(f)vii is "*Shockcord and/or rope loops (rope loops may be part of the control line) can be tied around the boom and/or the outhaul control lines to retain the outhaul lines close to the boom.*")

I intend to use the ball stoppers at least in our fleet races and campaign for their legality in sanctioned events.

Finally, if you are too fanatic about it, you can slice off another 3 to 7 grams from the system weight by going to a carbon cleat such as the *Ronstan* C-Cleat RF5000 or the *Harken* Micro Carbo Cam 423, respectively.

Note that the primary disadvantage of this system is that it's a pain in the neck to unrig it completely! We haven't had any theft in our high security marina for years, and just like all my old rig, I leave the boom with everything fully rigged right on the deck. Just untie the bowline dead-ending the secondary cascade to the mast. And when I'm cartopping, the boom travels with me in the car, fully rigged.

Playing the Devil's advocate:

What happens if ILCA changes the rules of the game again? One possibility is that ILCA will recognize and accept the poor wording used in the 2003 Interpretations, and will issue an "interpretation of the interpretation", unashamedly stating that "movement through the fairlead" has always implied "continuous, uninterrepted movement during any outhaul adjustment".

We have two ways of dealing with that eventuality:

- The first, the simple and the no-cost solution is to just lead the (orange) tail coming from the block at the end of the primary system first through a SS thimble, and then through the fairlead. The weight of the thimble and good old gravity will ensure that this part of the line will *always* move through the fairlead. (If a thimble is objected to, there are no rules against a "monkey's fist"!)
- The second solution (shown in diagram below) sacrifices from the power ratio, but still offers a *great* system that can be equally easily disconnected from the mast. This solution is to suffice with a 1:1 (mere re-direction) system instead of the 2:1 primary purchase above, and to follow that with a 3:1 primary and a 2:1 cascade, resulting in a 6:1 outhaul.

In this rig, the primary control line would be dead-ended at the block at the top of the cascade, would jump between the becket and head of the block at the top of the primary purchase system, and would be led from there to tie on the clew hook (without any attached blocks), and led back (with some minor slack) through the fairlead back to the top of the 3:1 primary pruchase. At boom end, the loaded (grey) part and the unloaded (orange) parts of the control line would always move at the same speed whenever any outhaul adjustment was made.

The second possibility is for ILCA to explicitly change the rules (with ILCA Membership approval as the ILCA Constitution requires it) to now require the boom-end fairlead as a **"required turning point"**. In this case, using a fairlead block would become sub-optimal since it would necessiate at least a 3:1 primary purchase system at the boom-end to minimize the friction through the fairlead.

We are all paying the penalty for some World Council members who can not communicate their thoughts in writing.

The original (December 2001) version of this article is available here.

Splicing instructions for Spectron 12 (12-strand HWMPE splice) ***(PDF)***
Lock-stitching and Whipping Instructions **(PDF)**
WARNING: Splicing only looks neat! It will prevent you from adjusting your lines to either fine tune your rig or to move any warn areas around to maximize cordage useful life.

Send your comments

The publication of the figures above in any form in other media outlets is subject to the approval of drLaser.