

- **CLR** is the Centre of Lateral Resistance, the point (in the case of a skiff) in the centreboard where the forces are resolved.
- **Lead** is when the CoE is in front of the CLR (causes lee helm).
- **Trail** is when the CoE is behind the CLR (causes weather helm).

The Laser Rigs

So, when we started to get bogged down with the new C5 rig, Takao suggested that we forget about "Flame rigs" and go right back to first principals. We did an analysis on the Standard Laser Rig, the Radial Rig and the 4.7 Rig. We knew the 4.7 was great in a breeze which is why it has been so successful in Europe, but it's poor in light air and with that in mind, we looked at hundreds of photos of Laser rigs and also of people sailing them. We also had lots of data from Olympic Gold Medalist [Tom Burton](#) from a program called SailEQ which is an analytical program under development.

We used the Standard Rig as a base line, and we determined that a well-sailed Laser was sailed at 6°heel, mostly to keep the skipper's butt out of the water. We also determined that the Lead was about 130mm. In a boat sailed flat, this would lead to lee-helm but because a Laser is sailed at 6° this results in the well known weather-helm.

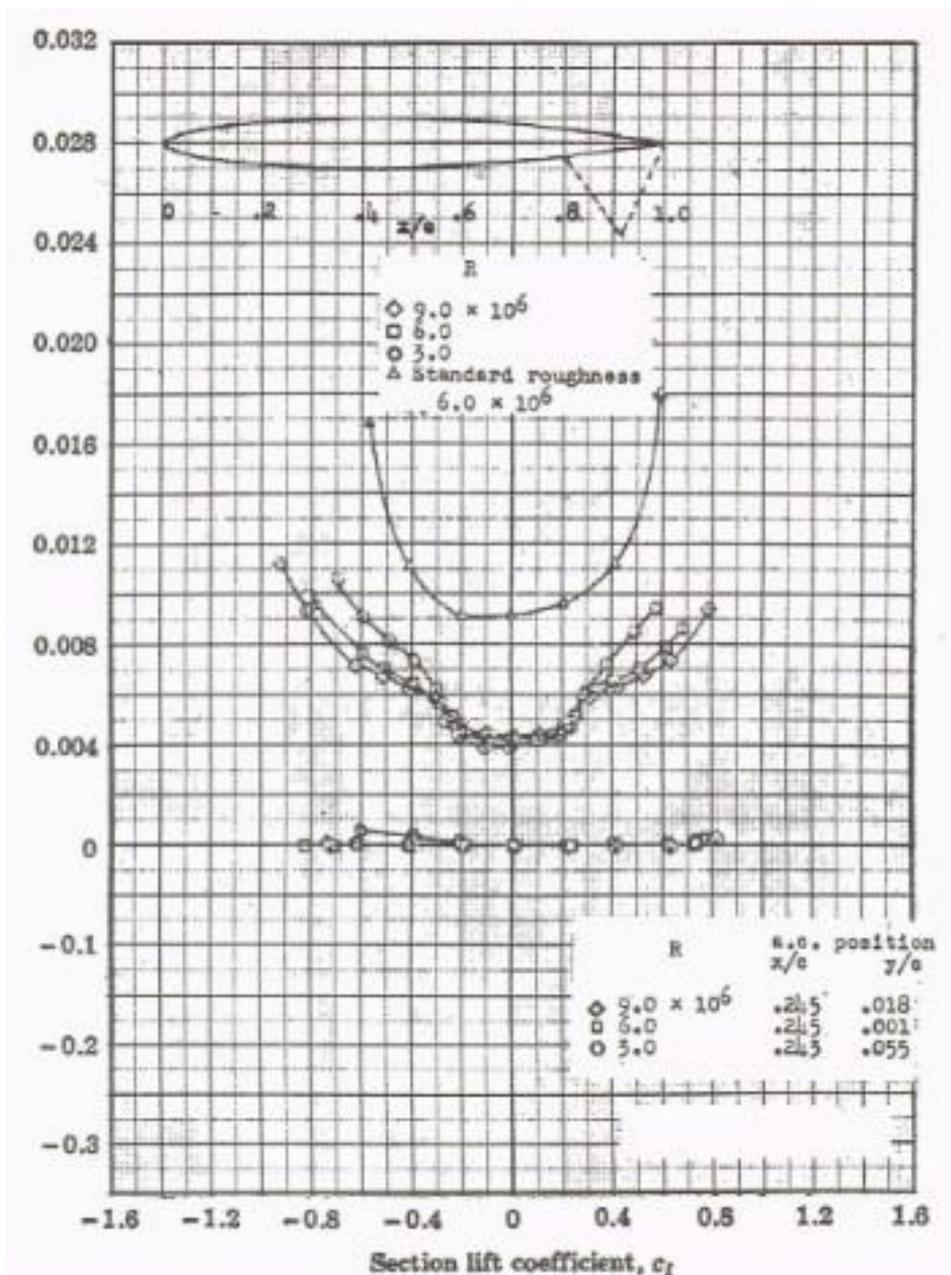
What we found with the 4.7 Rig was this Lead was upwards of 300mm so in lower winds with the skipper sitting upright and the boat is less than 6° heel, and without mainsheet tension pulling the CoE aft, you do get lee-helm and that has always felt awkward.

Laser's have Leads because when the boat is heeled at 6° it wants to round up. A 49er has Trail because it's sailed flat there is no round up.

The Rudder and Centerboard

The centreboard is designed to resist sideways movement while the rudder is designed to steer the boat. These are very different functions, so it's not smart to load the rudder up completely, but you are dragging it through the water and less than 5% of the time its steering, so you may as well make it do something.

Therefore we load it about half of the side pressure that you would on the centreboard. In a perfect world, you set up the boat to carry about 23-24kgs on the centreboard and about 2.5kgs on the rudder. So a gust hits, it automatically wants to "feather" to head up without putting an excessive load on the rudder (too much steering is like throwing a bucket over the transom, hence a "bucket curve").



This is close to a Laser's rudder. Above 2.2° the drag jumps, so the trick is to keep the rudder "in the bucket."

In a breeze, the kids in Europe are good, they strap their sails down to the deck pulling the CoE aft, and they sail often at heels far greater than 6° that reduces the weather helm.

The next thing we found when we actually measured the area, a 4.7 is not 4.7m^2 it's actually a little under 5.1m^2 . In fact, we found all 3 Laser rigs are understated. It all depends on how you measure the area, and to be honest the area is just a number, what's important is that you use the same system across the whole design spectrum.

Lessons from Other Rigs

Next bit gets interesting because we already knew that if you reduced weight aloft, as in going to a mast like a carbon rig, you have to increase sail area or you will skew the rig to lighter weights. With the 49er we tacked on 170mm of mast height and about 1.5m^2 onto the total mainsail area of 19m^2 . But with the 49er we also wanted to increase crew weight from about 148-152kgs to 165kgs and to date, that's exactly what's happened.

We also had the Flame rig data and to a lesser extent information from the 29erC rig.



We knew we had to up the sail area, approx. 10%, so say 0.5m² was about the target, but we decided to hold that down to 0.4m² because the target market was smaller Asians and it also allowed us to reduce the mast height. So even though there was more area, the Arm (distance between CoE & CLR vertically) actually reduced.

To be honest, I don't know where we ended up, because empirical testing always trumps theoretical but my guess is we are at 5.4 – 5.5m².

Fine Tuning

By this stage, we were committed to a square head at the top of the sail, but the big issue with a square head is how big should the length of the top batten be. If it's too big/long then you have to use excessive downhaul tension to make it reactive. Too short, and it may as well be a pin-head rig and you lose all the advantages.

The big advantage of a square-head over a pin-head is the mast bend is only half! Long term, this leads to a near indefinite mast life. It also reduces problems with hoisting the main and having overly hooked leaches in light airs.

Ian MacDiarmid and I worked on this along with mast stiffness and position of the bend so that we could end up with reasonable downhaul tensions which allows us a wide range of crew weights and without excessive vang loads. We reduced foot lengths, but the big breakthrough was being able to “splice” (grind) the mast at deck level. This allowed us to drop the whole mast further aft, it allowed us to use a stiffer topmast, and it got the Lead down into the 120-130mm in all wind ranges. All this made the helm feel good.

Later, Takao made some unilateral decisions to reduce the “splice” to reduce the helm when sailed at 6° and Clive Watts (CST owner) was able to deliver us a “kinked” mast at deck level and that reduced weight and cost.

Late last year, Takao and I played with vang lengths which allows us control over lower mast camber. Sure, we threw away some booms that had become Swiss cheese and the lower mast of the now C8, it's quite hard to believe it's still standing but we had something really special.



The original C8 mast now has about 40 holes in it from various fitting configurations, what you are seeing here is three versions ago. Quite amazing the mast is still standing.

In February, I happened to be in Longchi, China, working on the 29erC rigs and I watched two smallish Chinese girls struggling with a 4.7 rig. Everything Takao had talked about was there in front of my eyes. The precise Standard Laser Rig Lead is 136.83mm but would obviously be less than that with the main sheeted hard down. The precise 4.7 Rig Lead is 295.84, more than double. By splicing the mast and going to a square head, we got that back to about the same spot so the boat feels so much better.

We have the splice at 7.5° in this, we ended up less after Takao opted for less weather helm, we also ended up a bit bigger than this shows, with longer cord lengths. I need to re-do those measurements.

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The New Laser Rigs Explained



2016 drawing and turning point for understanding the 4.7 problem

By Julian Bethwaite

It's been about 4 months since Eric Faust (ILCA Executive Secretary) showed the C5 [video](#) at Sarasota, which was then shown on Sailing Anarchy, Scuttlebutt and other social media platforms. Some suggested that I should not add facts to spoil a good conspiracy theory.

It's time to just set the record straight so the conversation can be re-centred. C-Rigs, as they have become known, spun out of a far more comprehensive rig development project that Up Marine started in 2012. In chronological order:

- Up Marine is a disruptive Hong Kong company that decided to use the Laser because of its vast success and its simplicity.
- In 2014, Chris Caldecott (GM, PSA) learned about the project and asked if we could 'screw' the development to generate a new carbon rig for the Laser. MoU's were generated

and we altered focus a little. At the November ILCA conference, Chris showed photos and reported on the development.

- In 2015, an International Patent was filed by Up Marine and has been subsequently granted as a unique and novel invention. The ILCA conference in October reviewed the larger C8 rig, liked it, and the focus changed from the C8 to the smaller C5 and the issues of the lighter Asians. At the time, 4.7 rig was hugely successful in Europe but not elsewhere. Hugh Leicester (VP ILCA), Chris Caldecott and I met in Sydney and the C5 progress was called exciting. The development process to date included 28 masts, and 4 sails, with testing by sailors that included Tom Burton, Gerard West, Brett Perry and many others. At this point, the project was nicknamed Flame Rig.



- In 2016, Tracy Usher (ILCA President) flew to Sydney for one day to sail the C8. Subsequent meeting Tracy, Hugh, Chris and myself started to map out a process but at this stage, the Asian issue and the lack of traction of the 4.7 started to come to the fore. Mid-year, lead builder started to move from PSA to PSJ, mostly due to the physical stature of the principals. Chris is 95kgs, whereas Takao Otani San (PSJ owner) is significantly lighter.

Takao and I had met in Montreal in 1978 under the watchful eye of the late and great Ian Bruce and we had become lifelong friends. Takao was pivotal in the 49er and 29er programs being a founding partner. The 29er just would not have happened without Takao, so there was considerable history between the two of us.

By late 2016 a complete re-thinking of the smaller rig had started and we tested various breakthroughs, the biggest one was the spliced mast which allowed us to get the Centre of Effort in the right place WRT the CLR (centre of lateral resistance) which in turn leads to weather helm (or in this case lack of it) without ridiculous mast bend, which leads to longevity and ease of pulling the mainsail up.

- In 2017, the C5 was being sailed at Sydney's RSYS by their junior program and a continuous development program led to fitting development evolved at a rapid pace. There's nothing quite like arm's length testing. There were various meetings between Tracy, Eric, the late Jeff Martin, Takao and myself, mostly at World Sailing conferences.
- In 2018, Takao tested the new C5 rig in Sydney in windy conditions. Takao had not seen the larger C8 so I sailed it. Videos were sent back to Tracy and the ILCA. In March, Up Marine and PSJ entered into a contractual arrangement for the C-Rigs. Midyear, Tracy and Eric travelled to Sydney to see the C5 and the "talking head clips" that you see in the video were done then.

A C5 rig was flown to Japan for Takao to test in the local market. That led to some subtle but significant modifications. There was also a meeting at the Sarasota World Sailing Conference between Takao, Tracy, Chris, Jeff, Eric and myself about introducing the C5. Late in the year, the ILCA/ALCA decided to test the C5 nationally in Australia. Ken Hurling (ALCA President, ILCA VP) fully supported the project.

The C5 rig then went to Tasmania so Sarah Kenny (Chair of WS Events) to be sailed by as many kids as possible, and then more testing and refinements with the C6 by Takao, Ian MacDiarmid.

The last four months has been chaotic. We knew that if you are going to have a family of rigs, then you need to have plans for all of them. For example:

- We decided that a rigs should be small enough to fly on commercial flights. The C5 and C6 are relatively easy but the larger C8 was more complicated because it involves three pieces.
- CST owner Clive Watts has developed a new technique to "kink" the mandrel in the winding process, so it comes off the machine finished.



- ILCA wanted the C5 rig with a full specification "suitable for the LCM" (Laser Construction Manual) so they engaged Clive Humphries (ILCS tech officer) to generate the whole spec. Clive travelled to China with Ian to oversee the whole sailmaking process, he also liaised with Clive Watts about the mast making process, and has a full set of drawings/3D files.
- Two days ago, Chris, Ian, Clive Watts and I put every rig in a Laser and checked the whole process and then sent the C5, C6 and C8 rigs to Valencia, Italy as an insurance policy.
- The plan is to produce 100 C5 rigs for Australia over the next 4 months and scatter them across the country with a few leaking into Asia and no doubt to other parts to test the whole process that we have gone through to ensure that these rigs are ready for the market. Specifics about how PSA will do this can be read at the [ALCA Annual General Meeting](#). Arms-length testing is critical, we have learnt that time and time again, nothing beats it. From my point of view, the C5 is near perfect as a final product. Takao and I have sail the C6 but I have not seen a young 60kg girl or boy sail it. The C6 has been sailed extensively with glowing reports, but we need more testing to be sure. The plan is to make five C6 rigs for testing this year.

I've sailed the larger C8 in everything from 5 – 30 knots, have tried to break it, and have tested it capsizing. We're not done with the "checked luggage" solution yet, but the rig looks good. Chris believes it's "fit for purpose!" The plan is again to make five C8 rigs for testing this year. The feedback from Ken, the analysis of the feedback coming from social media, particularly the interest coming from Asia in particular for the smaller C5 tell me that Tracy and the ILCA/ALCA have hit the nail right on the head. This has all been a clever, think outside the box, structured plan.

There will always be change, and change is always painful. But if done well, it will always leads to significant up-side. For example, the Radial rig and the Carbon rig on the 49er/FX both have led to significant growth in their respective classes. It will be a busy year.

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