HOT BuOYS S.V. Rigging Part 3

- Adapted to sailboat;
- Suits owner's need;
- Self-adjusts to winds;
- Chainplates share;
- Was affordable.

Summary Presentations 1 & 2

- A sailboats rig should match an owner's abilities and help achieve his goals.
- Traditional lifting sails work be directing air upward. It goes up along the face of the sail.
- Lifting sails are proven more efficient, however, many designs suffer bad tack.
- To eliminate the bad tack the mast can be located in the back.

Cautions

- In a brief presentation, it is not possible to show all the details regarding HOT BuOYS rigging. Those interested in duplicating my efforts may have to wait for the book.
- Changing my mast to the back was possible because my trimaran was built with two structural box walls.
- Areas for new chainplates were reinforced.

Sea trials #1: Aft-mast #1

Thai woodworkers epoxy glue strips of clear wood from Laos.

The first set of sea trials were conducted on a trip between Phuket and Singapore.

The tests looked at how the mast stood against the wind and sea with no sail.

Supporting the aft-mast #1

HOT BuOYS with 82ft epoxy/wooden mast at One 15 Marina Singapore

The prime concern when designing rigging to support the aft-mast #1 was resisting forward pull. I decided the best thing was to install a back spar. It would help pull a lot!

Using high-tech lines for rigging

All Dyneema rope rigging was selected for aft-mast #1. The chain plates were polished smooth.

Multiple wraps of a smaller line drew lines tight.

Despite manufacturer claims..

Ultra-low stretch is what they said. However, during Sea Trial #1 rigging lines had to be redone several times.

Hint: Do not splice the ends of high-tech lines until after they have been placed under a high load.

Despite new materials...

I purchased hardware from a big sail loft. This is what a thimble looked like after Sea Trial #1.

Thimbles sold side by side with high-tech lines are obviously not intended to go together.

Lessons from Sea Trial #1

- High-tech lines stretch more than expected.
- When tying the wrap lines, some knots worked better than others. See eventual book.
- Take thimbles to machine shop where they can reinforce them with brace.
- The spreader bars should be longer to reduce flexing.

However, upon return to Thailand

The rig shop that provided the spreader bars was in a bad mood. The rigging it supplied on another sailboat lasted only 1.5 hours. Suddenly it was not possible to use the same socket to mount longer spreaders.

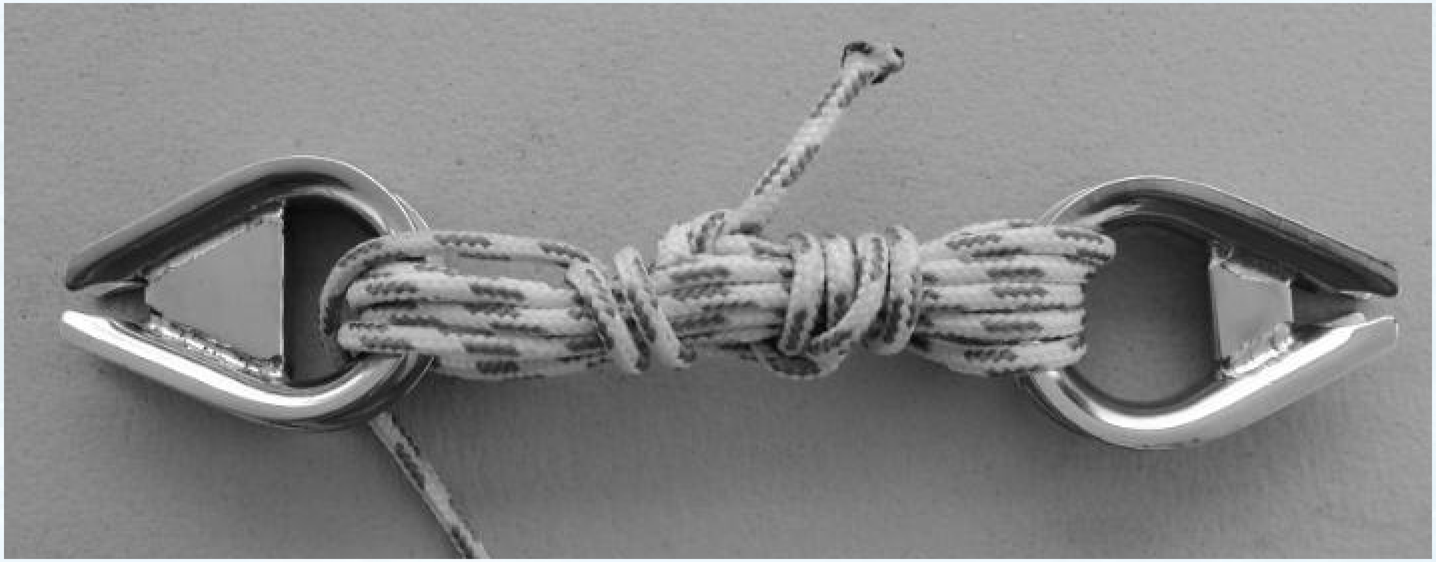
Other sailors recommended I reinforce the thimbles at a machine shop. However, this didn't solve the abrasion issue at the interface between rope and metal.

Results Sea Trials #2

Reinforced thimble.. However, metal to rope contact.

During Sea Trials #2 the lifting sail was flown for the first time. It sailed well. There were only light winds, however, it made windward progress.

Issues Sea Trials #2



Reinforced thimbles allowed more tension on the stays. However, in part since the spreader bars were not changed, the mast flexed too much. Additional lines were added.

Changes Sea Trial #2

During Sea Trial #2 mast support from the rear wasn't an issue. That was fine. However, the sail didn't pull the mast directly forward. Instead the sail pulls mainly at a 45 degree angle.

With no chainplate at 45 degrees to the mast, the mast was flexing too much. So to try and stop it...

Sea Trial #2. It worked...initially. The near horizontal lines pulled the backstay lines to make a better angle. Redundant backstay lines remained in place. All these lines under tension meant mast compression.

The big mistake: Sea Trial #3

The mistake made by owners of big sailboats that depend upon volunteer crew is to set sail to meet crew member schedules.   I had recruited crew to sail from Singapore. They expected to leave right away. I had more crew arriving that needed to be picked up in Borneo.

So despite knowing the issue of mast flex was still not solved, I set out directly across the South China Sea. Bad idea.

The first day out of Singapore, even more lines were added. Two lines were led to the very top of the mast 82 feet above deck. I went around and retied all the wrapping lines, and this time they were pulled with a winch to make them really tight.

In brief, I later learned, I was compressing the mast. The lines intended to stop the flexing were causing the problem. I was about to learn a very expensive lesson:

-->>Compression<<--

Lesson in compression

Owner Philip Maise plays fetch to get hardware and lines.

Wayne also sailed from One 15 Marina. He reported the squall that hit my sailboat packed 50 knot winds. The mast all nice and compressed from so many lines in tension snapped at 30 foot mark.

Maise against the elements

I've dragged my mess of expensive lines back aboard. The mast is seen off my left elbow. I am steps away from learning:

Slip + Winch= -Ribs

Sitting in a Malaysian ER...

With 4 broken ribs and a demasted sailboat in the bay, the painting above taunted me. Where did I go so wrong?

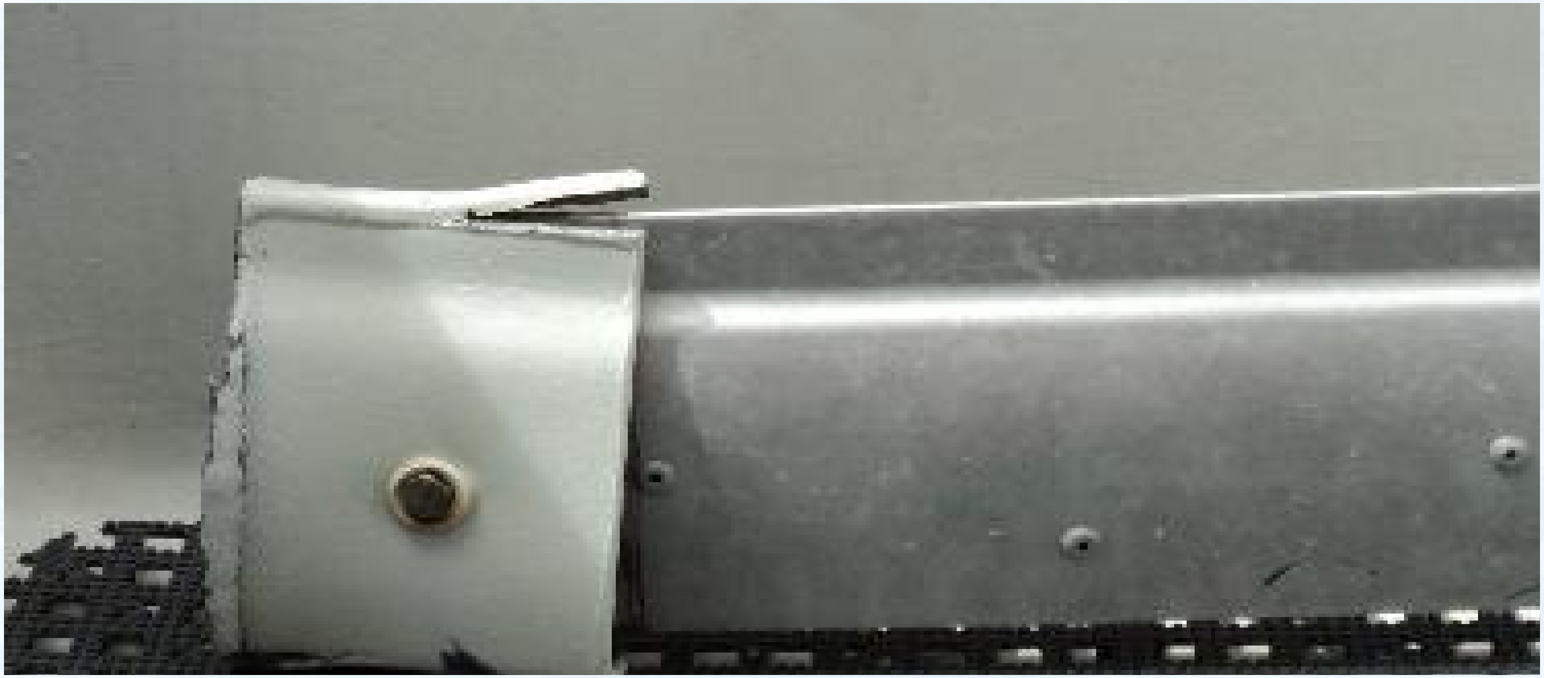
Well for starters...

I didn't go slowly and test and retest. I set sail knowing there was a design issue. I was sailing to meet crew schedules. Most cruisers do not head directly across the South China Sea from Singapore to Borneo.

I saw the heavy black clouds in the distance, however, incorrectly thought they were not going to be a problem.

I over compressed the mast before it hit.

Rigging held: So what broke?



No rigging lines failed. So was it the back spar, spreader, or mast? All three were broken. But which came first? The spreader is above.

Multi-hulls and demastings

HOT BuOYS in Miri Malaysia looking like somethings missing.

Big multi-hulls are prone to demasting because rigs are sized to fly the maximum sail under light winds.

Owners are sold on the idea of reducing sail size based upon wind speed.

However, with sudden wind shifts, there is no time to reef, and they don't spill the wind like mono-hulls do.

The upsides of being demasted

Almost immediately after the mast broke I felt kind of relieved. I knew something was wrong.

The demasting was a chance to start again.

To rethink and learn from the experience.

Lessons learned the hardway

Compression is bad. Trying to get a mast to stop flexing by compressing it more is a recipe for trouble.

A problem with a 99% fix remains unsolved.

Go slower and think things out.

I was pretty good at going slower

- I spent over 2 years in Borneo going slower.
- I researched tropical woods to build a new mast and came up with ideas on how to mix woods to build a compound mast.
- Several large used masts came on the market, however, none were big enough.
- Manufacturers of new masts wouldn't provide a quote without an engineering report. I paid for one. However, the engineer's program only designed Bermuda rigs.

The S.E. Asia problem...

Sailing in S.E. Asia is frustrating. Winds tend to either be too low to work with, or too high to safely fly any sail. Most cruisers sit at marinas for months waiting for the right winds so they can make a relatively short passage to the next secure port.

For this reason, most Bermuda rigs here spend most of their time motoring. Or, sometimes they simply take off the mast and give up on sailing...

The new mast in the Philippines

Crew member Bastian balances on the dagger board on the way to get the new mast.

A big catamaran owner gave up on sailing his Bermuda rig. He took off his big rotating wing mast.

Now this was a mast I could work with.

Before heading to the Philippines

I had worked out a solution to one big issue.

The metal to rope interface.

I needed to attach my Dyneema lines to metal chainplates and be 100% sure there was no chaffing.

I had some good ideas.

Here is the problem. Stainless steel thimbles act like razor blades cutting into high-tech lines.

Glass smooth interface

The ANSI 54-3 has a glass smooth surface, a wide turning radius, and 20,000 lb rating. A good match for Donaghy's Superbraid (16,852 lbs.) I found these locally for $3 USD.

In my distant past I recalled a term called glass smooth.

This led me to smooth ceramic glazing.

Meet the ANSI 54-3 strain insulator.

The humble strain insulator

Compare the picture of a thimble cutting into a line with the picture of the line around the strain insulator.

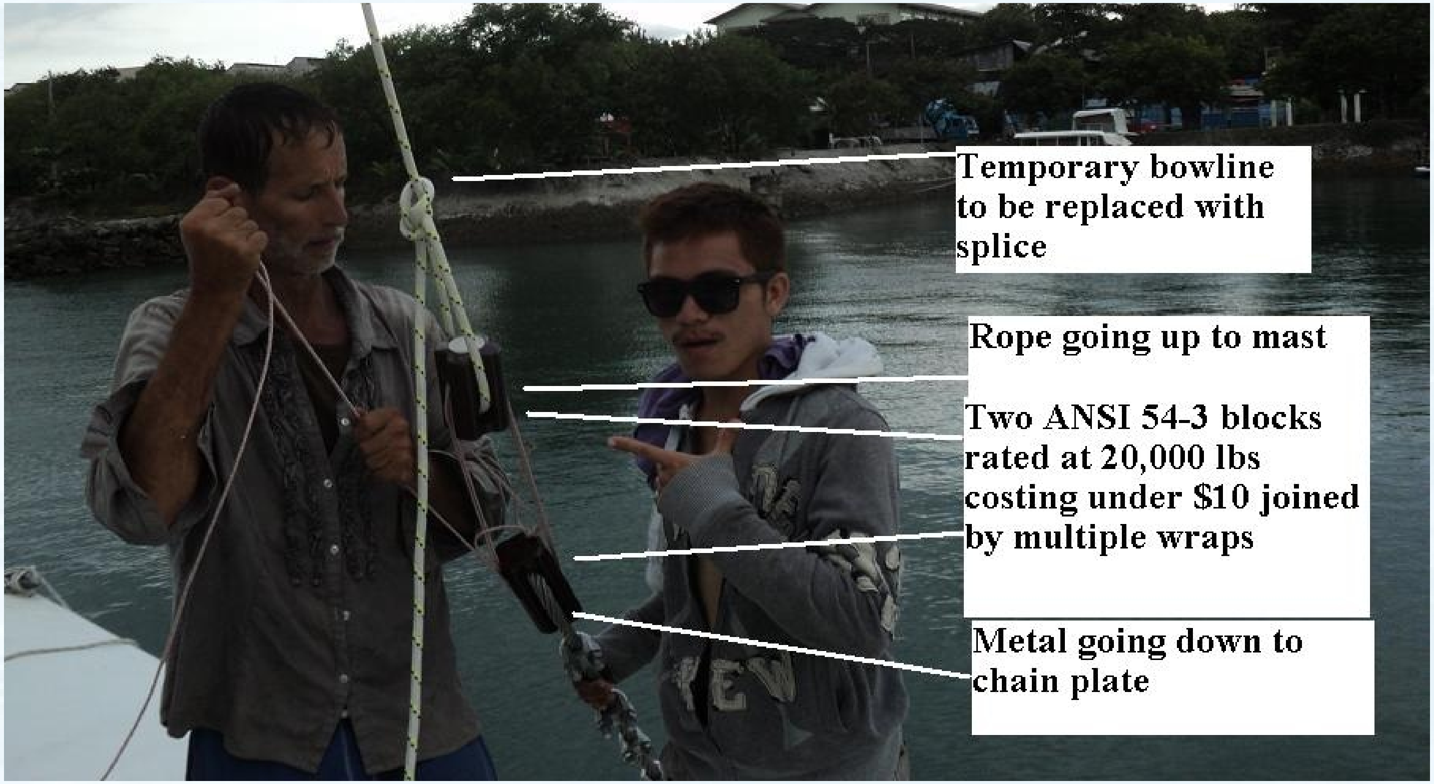
The wide turning radius and glass smooth surface of the strain insulator will greatly reduce wear.

See E-Book for more details of the strain insulator and how to use it to tension lines.

I like to capture funny mistakes made in the English language. A costumer is a person who makes or changes an actors costume.

Like a costume, many things sold at a rigging shop should be for show only.

Strain insulators are used to help support millions of telephone poles. Start looking at lines going to telephone poles and you will see them. Two of them together with wrap lines between tighten a line.



Turnbuckle versus 2 strain insulators

Turnbuckle	Strain insulators
Material: Stainless steel	Material: Ceramic
Cost: Over $500 (large sizes)	Cost: Under $10
Rating: Manufacturer rated	Rating: ANSI
100% Corrosion proof?: No	100% Corrosion proof?: Yes
Direct to high-tech line?: No	Direct to high-tech line?: Yes
Direct to wire rope?: No	Direct to wire rope?: Yes
Zero maintenance?: No	Zero maintenance?: Yes

Metal to metal

I used galvanized wire rope with galvanized wire clips for two reasons. Wire rope can turn around strain insulators. Cable cannot. Local shops with stainless steel wire clips only stocked a few small ones.

Using galvanized steel

Initially, I had trouble with the idea of galvanized steel. However, it has been pointed out to me that it is stronger than stainless. Further, galvanized steel is far less expensive and can be more easily replaced. Corrosion on galvanized steel is low to begin with, and can be further mitigated by coating wire with linseed oil.

Galvanized wire sections are very short and easily inspected, maintained and replaced.

Tips on using galvanized wire

Most vendors offer cheap welded shackles. Use only forged shackles that are stamped with a rating. Get real thimbles, not the junk sold at the sail lofts. There are three grades of wire clips. The mid-grade is suitable.

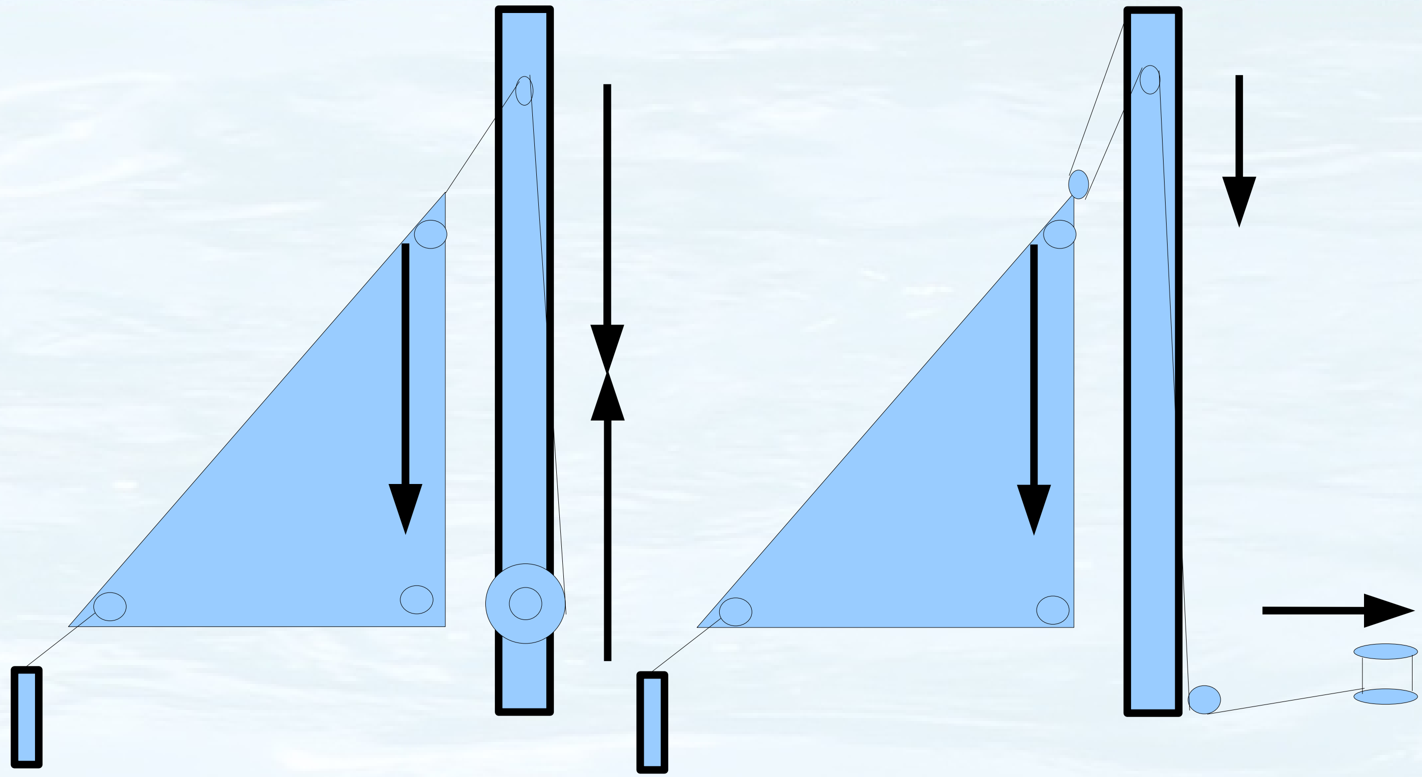
Initially tighten nuts on wire clips, raise mast, and recheck right away. Check again after mast is loaded. Then check regularly. See E-Book for pictures and treatments to extend life of lines.

The halyard: The up and down

Most designers don't seem to think about mast compression. If they did, halyard winches would all deck mounted and no rope locks mounted on mast.

For a typical rig, each 1 pound of force to raise and hold up a sail adds 3 pounds of mast compression.

The alternative is to run the halyard down to a deck mounted block and then over to a winch. This eliminates the upward compression force. A further refinement is to add a block on the sail's head. With this arrangement, each 1 pound force by the sail adds 1 ½ lbs compression not 3 lbs.



Each 1 lb of force required using a mast mounted winch, or lock, increases mast compression 3 lbs.

The right figure depicts a halyard turned around a block at the sail's head. Mast compression is cut in half! Each 1 lb of force here increases mast compression 1.5 pounds.

Waiting for the winds to change

Pondering the question of compression led me to ask a whole bunch of questions.

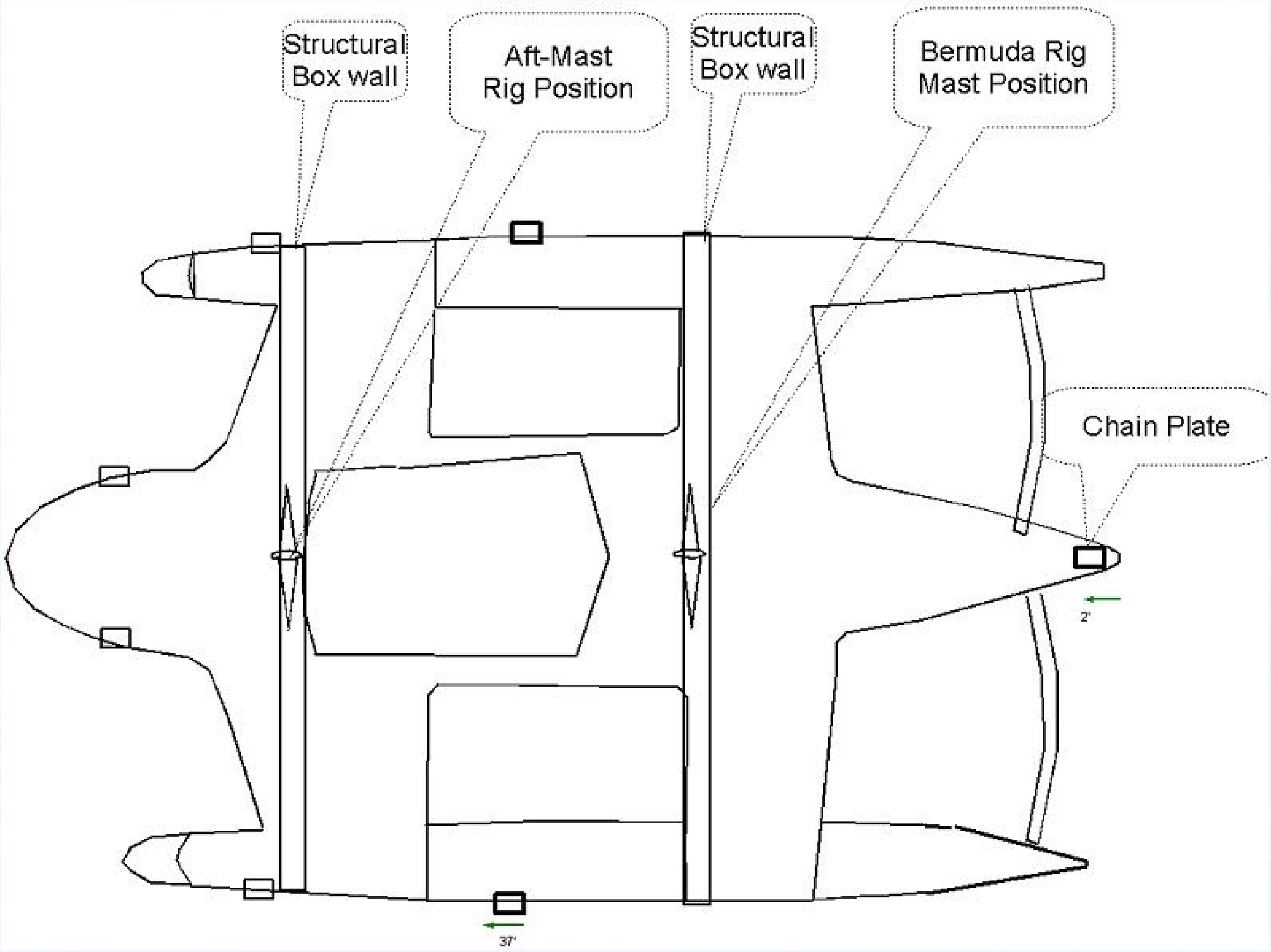
The topic of tensegrity interested me greatly.

Tensegrity uses multiple lines in tension to support an object.

Sailboats certainly have many lines in tension. Too much tension. All that tension causes compression.

Looking at examples of structures built using tensegrity reminded me of the rigging mess I had made during the first set of sea trials. It also focused me on my primary problem.

Overcoming the structural issue



Pacing the deck searching...

The first set of sea trials demonstrated mast support from the rear wasn't the issue. It was support at 45 degrees behind the mast.

In the previous slide you can see the locations of the 4 new chain plates. Two are 90 degrees to the mast and near the structural box wall. Two are on the main hull and provide mostly aft support.

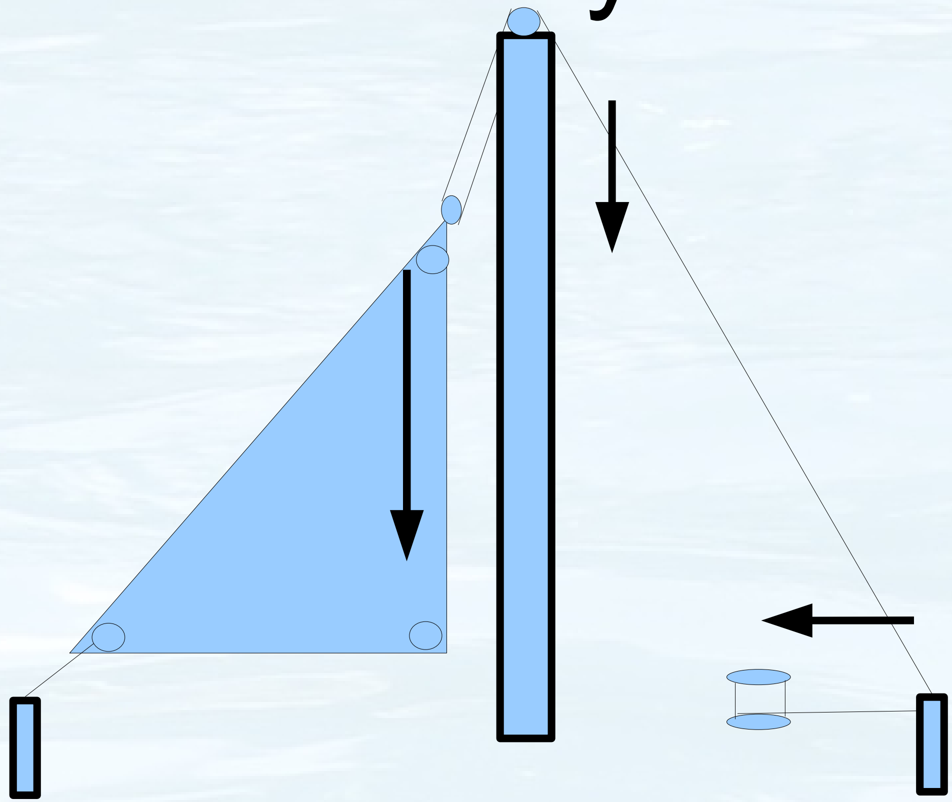
Looking at all mast compression

If mast compression could be greatly reduced just by changing the location of the winch to raise the sail, what other opportunities were there?

Just standing around

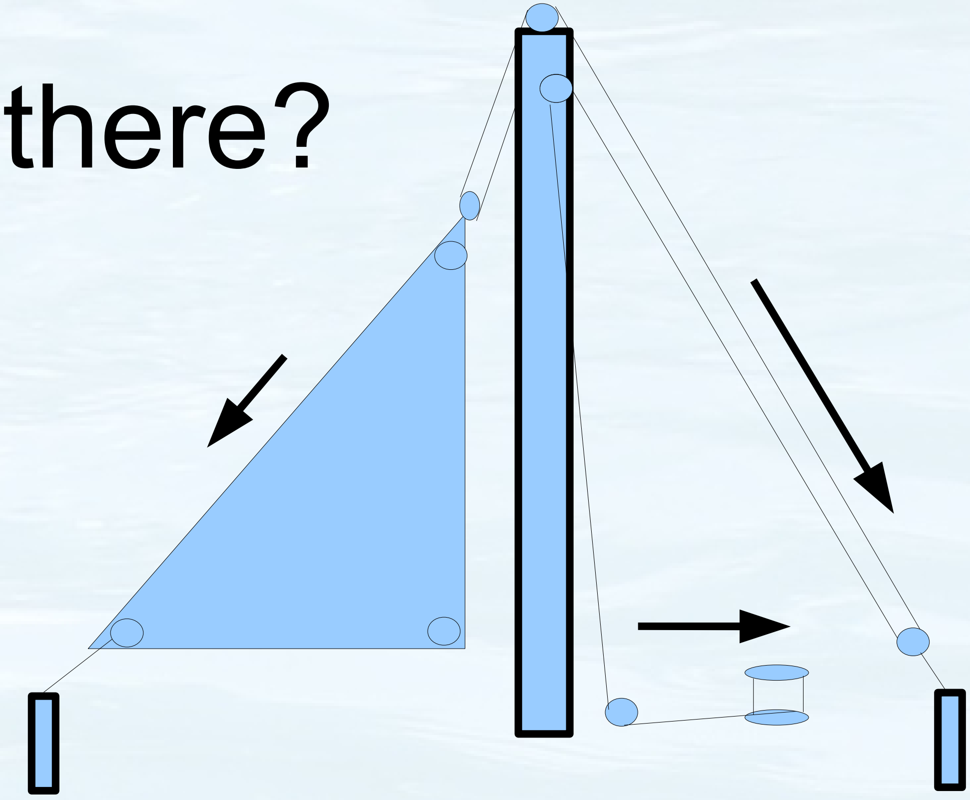
"*Standing*" isn't a good adjective for the *standing rigging* of a Bermuda rig. It isn't standing around and it doesn't help the mast stand. Instead it is under high tension, actively compressing the mast, and trying to pull it down. Bermuda rigging must be pretensioned enough to withstand the highest winds that will be encountered. A better name is "*withstanding rigging*".

A combination halyard/backstay?



Running a single line is possible if there is a bolt rope within the sail. Forward leading sidestays support the mast when the sail is taken down.

But why stop there?



In this configuration there is a block on the aft chainplate and the line is turned back up to the mast. This rigging is dynamic.

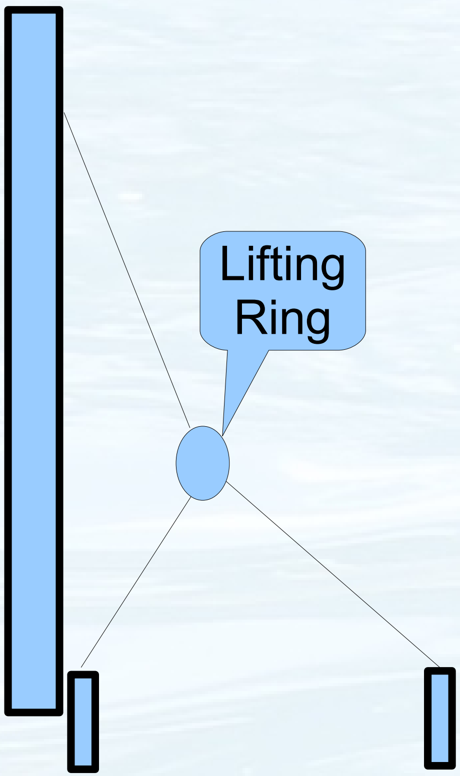
I liked the idea of reducing lines

If I can combine a backstay with a halyard, the backstay automatically tension to meet sail load.

It is an idea I have set aside for the moment.

I came up with an even better idea.

What if I combined 2 stays?



Previously, I used a block and separate line to pull the backstay to the side. This was messy. What if I joined two stays mid-air before reaching the mast?

What if I combined four stays?

That is exactly what I have done. I have run a single rope down and up to the mast joining 4 different stays and creating 2 pseudo midair chainplates at 45 degree to the mast.

Two chainplates are termination points for the line and two chainplates have blocks that send the line back up to the mast.

I thought yes!

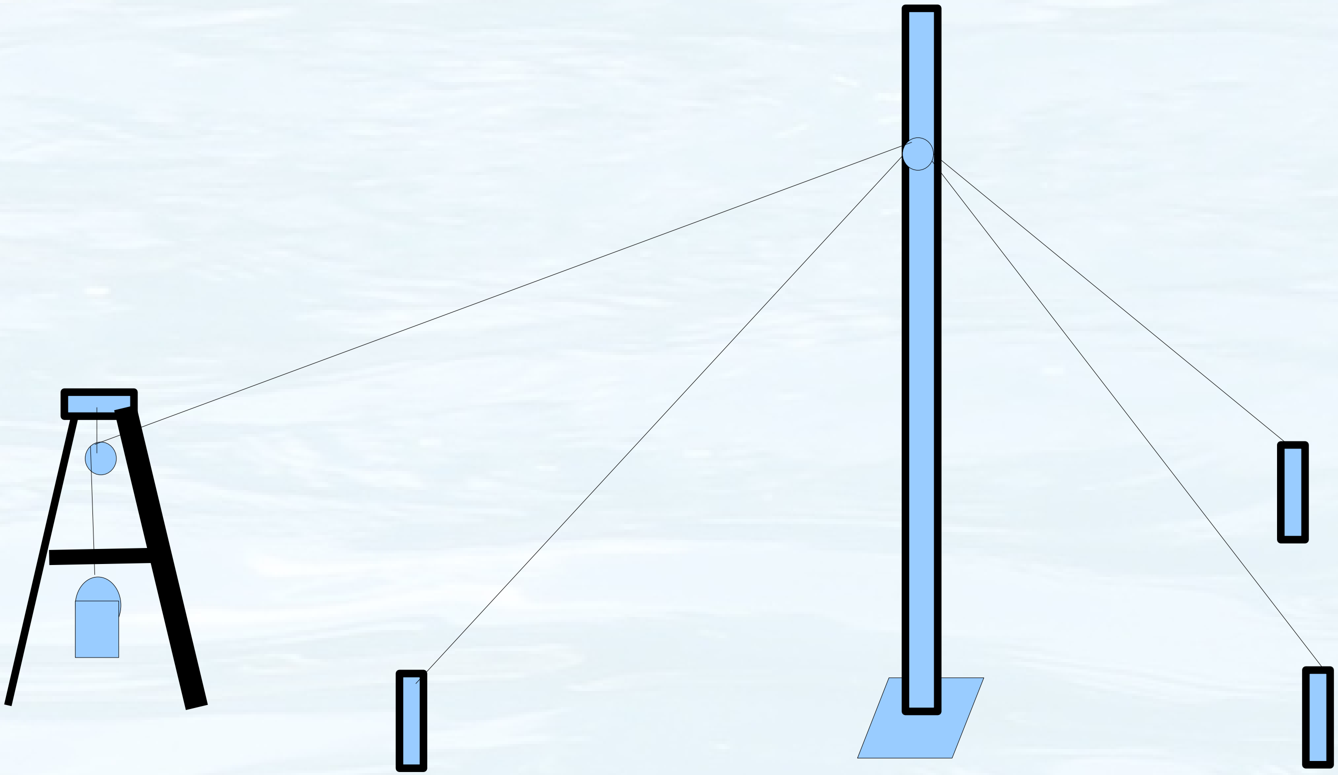
Using blocks on chainplates sounded like such a good idea, I built a scale model and tested it.

I carry a 30 foot mast aboard. I used it as a scale model and put stakes in the ground around it at the yacht club to simulate the locations of my chainplates. Under the mast I placed a digital scale. I then tested various configurations of rigging at different angles.

Scale model testing of rigs

Complete details, photos, and graphs of the results are in the E-Book. You can replicate testing if you don't believe the results.

I first simulated the original Bermuda rig. After tensioning, I applied load to simulate the load created by a sail.



Understanding Bermuda rig

After applying load to the Bermuda rig, the weight as read on the scale below the mast didn't go up. In fact, it frequently dropped. Sail load on the Bermuda rig was decompressing the mast. This is the opposite I expected. What is going on?

The odd data obtained

I had to add several weights before the scale started to show any increase in Bermuda rig mast compression. I'm sure to some sailors this isn't news to them. However, it was surprising to me.

The number of weights before readings changed depended on angle. I simulated a sails pull at 0, 45 90, 135. and 180 degrees.

Bermuda rig demasting

I must have “demasted” my test stand at least 50 times. I'm sure the yard's workmen found it funny. I didn't. I wanted to know why.

Even in technical books on sailing, some of the most basic things are not explained.

I think I now know the real reason to pretension a Bermuda rig?

Why pretension a Bermuda rig?

My own ignorance about why a Bermuda rig must be pretensioned reminds me of people that are given the keys to a car and not told to change the oil. If no one explains it fully they won't.

Isn't going around and tightening everything more and more a bad thing?

Based on the testing, the answer is pretensioning is essential to hold up a Bermuda rig.

Explaining the observations

Observation: Initial load created by a sail doesn't translate into more mast compression.

Theory: Pretension of the rig acts like a stored energy. It is a force created by the stays before the winds act on the mast. The wind load initially takes off a net amount of stay load. Yes, we are all familiar with the lee stay going slack, and weather stay going tight, however, the net of all stay forces is lower. No new compression is added until the pretension force is overcome.

Explaining the observations

Observation: Sometimes the Bermuda rig fell over after weight was added. (Nothing broke.)

Theory: Depending on the angle and amount of a sail's pull, two of the three main stays holding up a typical multi-hull's Bermuda rig will go slack. There are three angles the Bermuda rig is most vulnerable.

Bermuda rig's vulnerable angles

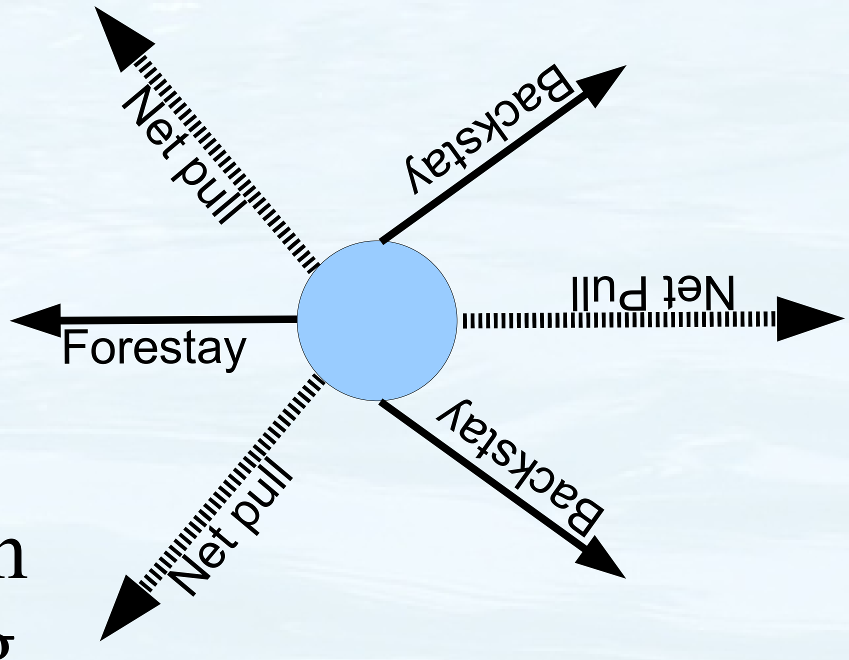
I don't recall anyone telling me about the 3 angles that a sail's load is most likely to demast a Bermuda rig. Two are near 45 degrees to the front, and one is directly behind.

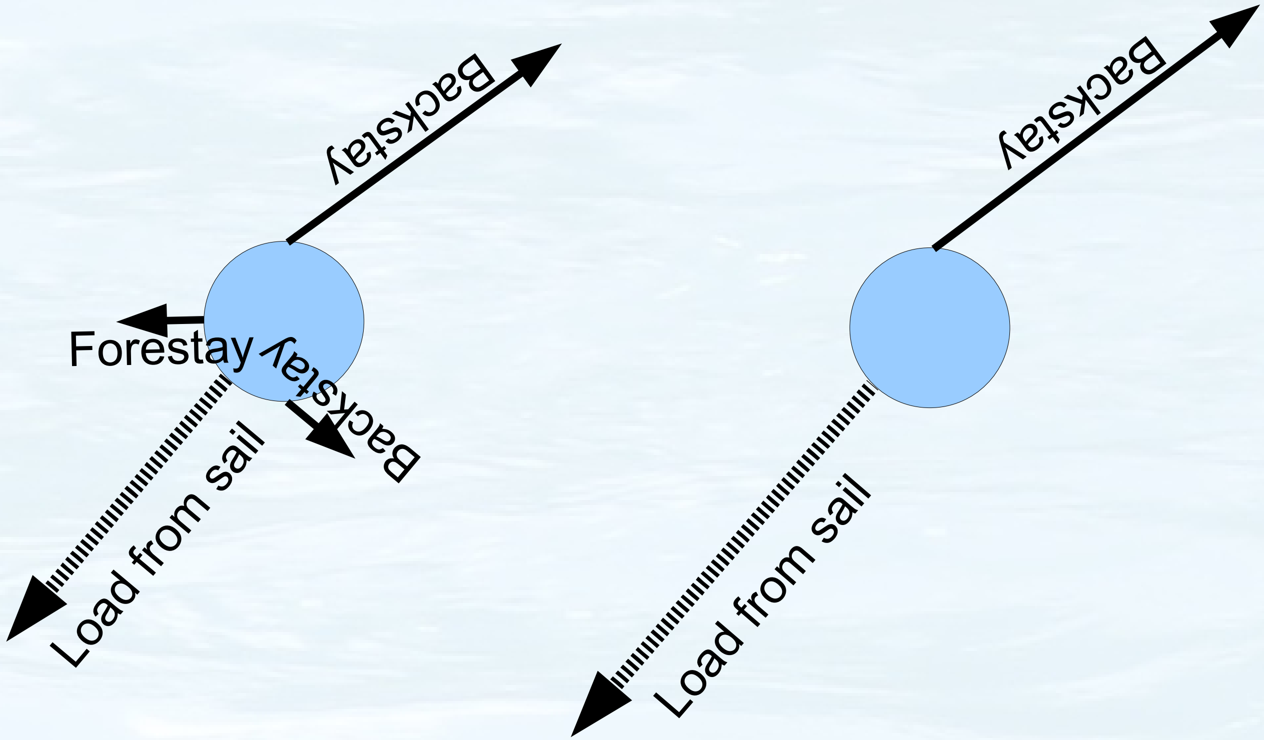
Note: My testing was on a scale model of my initial Bermuda rig for a multi-hull. Only three primary lines supported the mast.   I encourage you to repeat tests if you don't believe this summary. (Complete data will have to wait for the book.)

Bermuda rig's vulnerable angles

For a Bermuda rig, each pair of stays can be resolved into a net pull from one angle.

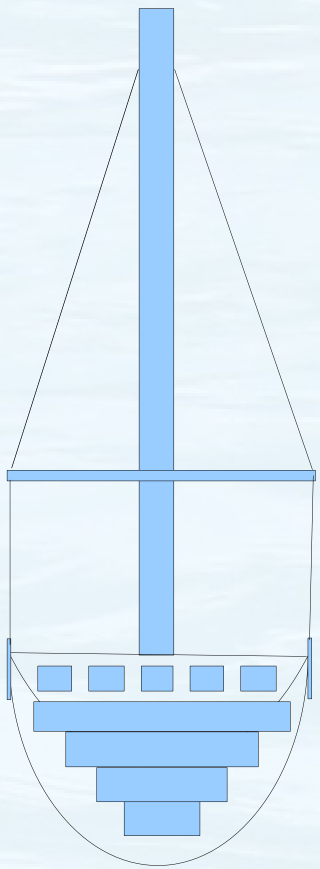
When the sail load is the same or higher from these angles, demasting is likely.





I found that enough sail pull at the net pull angle of two stays isn't good. The scale model mast would come down with the right weight and pulling angle. Is this the reason why a Bermuda rigs stays are highly tensioned?

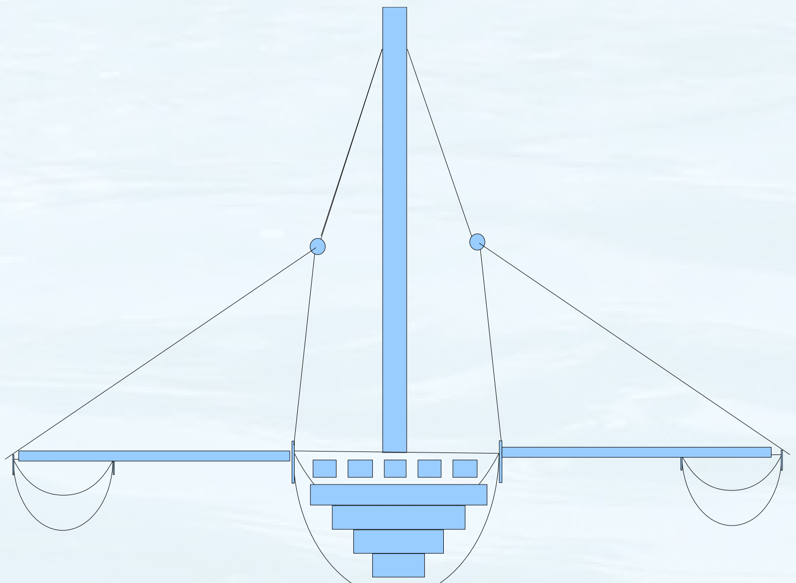
I tested a few designs. Overall I was trying to achieve rigging that would adapt to the load. In keeping with ideas of tensegrity I initially tested a compression spar. The purpose of the bar was to push apart the two backstays and improve pulling angle.



Note: The spar shown is not a spreader bar attached to the mast. It is a floating compression spar pushing apart two backstays.

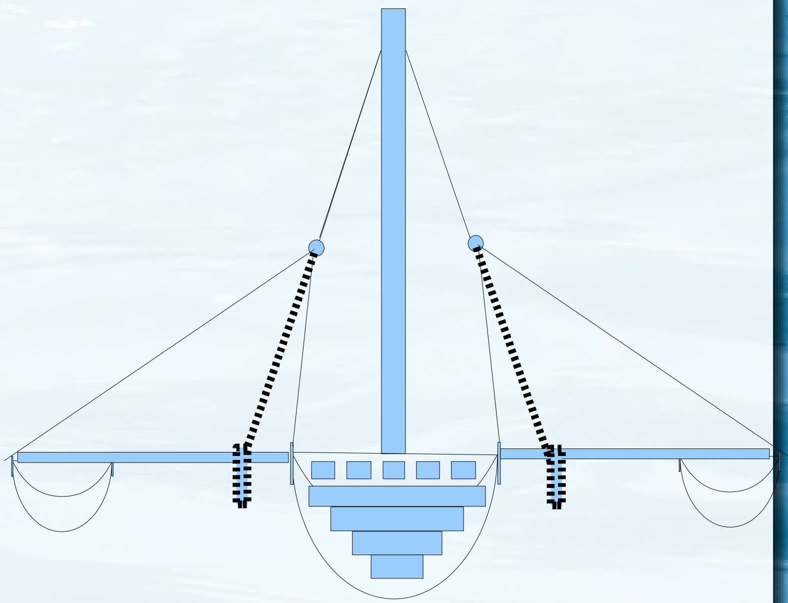
Doing the trimaran reach

Pushing apart the backstays for an improved angle isn't required with a beam of 40 feet. In later tests I pulled the lines apart using a line that reached out to the ama.



This solved the missing problem

The dashed lines are the net effect of combining two chainplates. They are meet at a lifting ring. Each backstay line's load is shared by two chainplates. See E-Book for detailed photos.



More innovations

Perhaps someone has also positioned chainplates exactly where they are best suited by combining two stays midair. But, did they compound the lines?

Further did they solve the worst defect of the Bermuda rig?

An unforgivable defect that has led to many demastings and loss of life?

Worst defect of a Bermuda rig

Demasting is the result of the defect, and pretensioning is the current solution. The defect itself is clear. Two of the three stays on a Bermuda rig go slack if the sail pulls at the right angle.

HOT BuOYS rig is unique by combining port and starboard chainplates. Lee and weather side loads on the stays and chainplates are always equal.

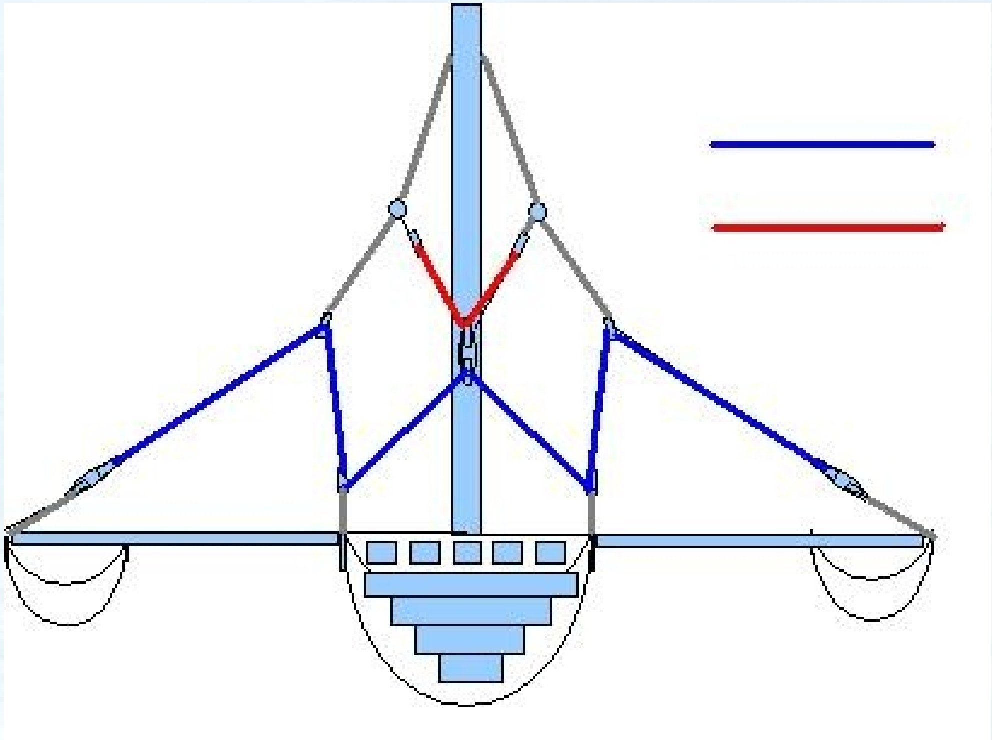
HOT BuOYS' combination stay

Four chainplates have been combined to form two 45 degree midair pseudo chainplates that balance the load.

Dynamic compounded rigging

ANSI 54-3 turning blocks are being employed to move two lines to make this stay. Pairs of blocks with multiple wraps of smaller lines serve as the tensioning device.

See E-Book for more detailed photos and the scale model testing that showed sail load immediately imparts mast compression. This means rig doesn't have to be pretensioned like Bermuda rig.



The line in blue begins at 90 degrees to the mast to hold side loads. It travels up to a turning block, down to the stern, up to a double turning block, down to the stern again, and up to another block where it terminates on the opposite ama. The line in red begins at the lifting ring on one side travels down to the double block and back up the lifting ring.

HOT BuOYS' Rigging

Mast shroud lines were Photo Shopped out. See E-Book for more pictures

Looking up from the stern most of the rope you see in this photo is all one line running from ama to ama. It makes 4 trips up. Load is shared by four chainplates. Lee and weather chainplate loads are always equal.

Results

Within one week of being up, a typhoon tested the mast with 50 knot winds. A month later super typhoon Yolanda came by. The sail wasn't up, however, the mast stood.

High pretensioning of this rig is not required. No stays ever go slack. The only purpose of initial hand-tight tension for my rig is to limit mast sway. It is a rotating mast so even mast sway is okay.

Results

A whole different issue about masts and rigging has not been mentioned yet. If you, yourself, standup in high winds, you must shift your weight between your feet or on and off your toes. You are adjusting your balance.

Once the initial compression forces of the Bermuda rig are overcome, the mast will do the same. It will begin to move at the base. If a mast is set on a flat mast step, any movement like this will concentrate the load in one small area of the mast section.

Rigging Summary

Bermuda rig stays go slack under load.

Bermuda rigs must be highly pretensioned.

Sea trials showed HOT BuOYS needed a chainplate at 45 degrees behind the mast.

HOT BuOYS' new rig obtains this angle using a midair lifting ring and 2 chainplates

The new rig is low tension and never goes slack since 1 line runs to/from 4 chainplates.

Conclusions

It is possible to convert a rig from a high compression Bermuda rig to a low compression aft-mast rig.

Terminating and turning high-tech lines under high tension is best accomplished using a glass smooth surface with a large radius.

It is possible to eliminate the problem of stays going loose under load.

When changing to low compression rigging, a rotating mast is best to prevent toe/heel load shifts.

Overall summary

A rig should suit owner, sailboat, and local conditions.

Bermuda rigs are not always best.

Traditional lifting sails are proven more efficient.

A mast in the back eliminates the bad tack issue. I proved it.

Rigging can be dynamic and compounded so stays never to slack. I proved it.

I can rest.

Patent versus render assistance

I, Philip B. Maise, hold and reserve all rights to all patentable ideas and innovations detailed in these presentations. However, as a captain of a sailing vessel I am required to render assistance whenever, and wherever it does not imperil my own vessel and crew. A firm rule on my vessel is that assistance is freely given and nothing is expected in return.

It is my firm stance that big Bermuda rigs are a danger to life, limb, and jeopardize the sailboat. My beliefs have been backed by testing. I proved my results.

I intend to place patents on my innovations.   However, if what you have read here can be adopted to an existing sailing vessel, it is my obligation to assist. You are free to incorporate my concepts and innovations.

New vessel builders and motor vessels can utilize the demonstrated innovations to reduce the number and size of winches, sails, lines, and masts. A little in return for demonstrating this is warranted. Contact me at pbmaise@yahoo.com or on my two Facebook pages, “Philip Maise” or “HOT BuOYS Trimaran”.

Where do I go from here?

The rig and sail for HOT BuOYS are done. Performance has been proven. I am finally satisfied it works and confident it will stand up to local winds. There are a few areas that can be cleaned up like splicing lines and an easier way to stow the sail.

However, the big issues have been solved. If I have to sell, and it looks like I may, I know that I would be turning over a seaworthy rig.

Like pioneers that innovate:

I now must either:

- Find sponsors interested in my continuing research into making sailing safer;
- Look to the sailing community to purchase my E-Book to help shoulder the costs;
- Find cruising mates that share actual costs; or
- Sell and move on to next project.

My crew and I prefer to sail,

HOT BuOY crew member Ryan poses next to another innovation. This suspended tempered glass table replaced a big wooden one.

Why would you help support someone cruising on his yacht called HOT BuOYS in S.E. Asia?

Perhaps because I am doing research that one day will help improve the safety of your sailboat too.

pbmaise@yahoo.com

Philip B. Maise in Cebu

If I can find crew members,

The plan is to sail among the 7000 Philippine islands till Spring 2014. At one stop we will climb Moyan volcano. Spring 2014 is a trip to Taiwan for 2 months. Summer 2014 SCUBA in Yap and Palau. Fall 2014 Philippines, Malaysia and Singapore. Early Winter 2014 Thailand.

What about a book?

At this point, I have enough material to base a book. Unlike most sailing books I cover new ground with new ideas.

Soon I will release a more complete description of HOT BuOYS' rigging along with more of the testing results. It will be an e-book. If you want me to contact you when the book is out send an e-mail to pbmaise@yahoo.com. Face Book Philip Maise or HOT BuOYS Trimaran