Rigging Documentation and Sea Trials of Philip Maise's Aft-Mast Mounted Semi-Double Crab Claw Rig

Date: November 12th - 13th , 2010

Location: Rawi Island Thailand to Langkawi Malaysia

Winds: 0 Knots to 11 Knots

Seas: Calm to light depending upon day and time

Boat: Philip Maise's 65ft Trimaran

Loading:
5 Crew including master/owner
7 Tenders
150 HP engine
Dingy Engine
3000 Liters of fuel and water
80 Liters of Oil
4 Month supply of food
3 Large Anchors 1 Small
2 Sea Anchors
4 Sails
1 Piano, Full Size Oven, Tools, and Misc.

Sails and Placement: Small Crab Claw Sail No. 1 with attachment at the 67ft mark.

Comment About Loading....The trimaran was fully loaded for long term cruising. Test results were not skewed by emptying the boat.

Test Objectives:
Raise a sail.
Adapt deck hardware to control spar in sail.
Make rigging adjustments.
First test sailings.
Upwind angle test.

Disclaimer:
This documentation is not intended to be used by anyone to modify or build their own sail boat.

Test Results and Comments;

Rawi Island provided the perfect cover to test raise the crab claw sail number 1. We didn't have to contend with any wind or significant sea. My crew and I hoisted the sail according to my original plan.

We first removed the forestay and took it to the back of the boat where we attached it to the head of the sail. Now the boat had no forestay and the mast was held by the forward leading sidestays. Okay, I can hear loud groans across the Internet so I guess at this time I better explain the standing rigging I designed. This is rather dry stuff, so you may want to skip a few paragraphs. I just want to document the rigging in detail for future reference.

Beginning at the bow of the boat:

A machine shop in Thailand rounded and polished the of the bow chain plate so it would accept rope without cutting it. The hole used to connect a pin that led to the fork of a turnbuckle. The shop also welded a ring onto the plate to increase the bending radius of the rope. This reduced the the weakening of the rope. Side Note: *I needed assistance from shop welders to remove the plate from the boat. Some of the original bolt heads broke off with only nominal torque on the ratchet.. Clearly, anyone with a boat in the tropics, should be removing their chain plate bolts and replacing them on a regular basis. I installed all new bolts upon installation and carefully filled an voids around the bolt heads with 3M 5200.*

I passed redundant Dyneema lines about 8 feet long through the bow's chain plate and tied them off on a 1-1/4" 316 stainless steel shackle. I then connected the shackle to the sail's tack using a 15 foot line. This allowed me to loop the line back to the shackle. For details of knots used see separate section on knots.

When I am not using the sail, there is very little tension on the combination forestay/halyard. I can safely remove it completely. It is very neat to look out from the boat when I do this. There isn't a single line in front of the pilot house coming down from the mast. It is just all wide open view. It is kind of like being in a neighborhood were all the utility lines were put underground. The feeling of spaciousness is incredible. I also get more then a few stares from other sailors that are used to having their ocean views marred with rigging lines and foresails on furlers.

Behind the bow, at the point the original stay sail was attached, I have a Dyneema line that runs up the 50 foot mark. I found this line useful to attach when I'm in high seas. The ultimate intention is to fly one crab claw sail of the bow chain plate and the other off the stay sail attachment point. One issue I need to work on is the attachment point of that point is a piece of Vectran line that has been out in the sun for several years. I want to dig up the deck area and reattach a new line before depending on this particular point.

I removed the two original side chain plates and took them to the machine shop. I refer to these as my primary chain plates since as part of this project installed another two side chain plates. The machine shop rounded and polished the pin holes. The builder installed the plates angled forward. This provided back support and side port to the old mast. I reinstalled them angled backwards to provide forward and side support to the new aft-mast mounted rig. I was able to reuse one of the bolt holes, filled the other boat holes with epoxy, and drilled new bolt holes in epoxy plugs.

I installed 3 lines to each primary side plate. These led to the masts 67ft, 50ft, and 30 ft mark. To attach three lines to one connection point. I first installed a short piece of line about 6 feet long through the chain plate. At the end of this line I put two custom reinforced thimbles. I had the machine shop make me a bunch of these reinforced thimbles. I discovered in prior testing that off the shelf thimbles did not stand up to the loads. The shop did a great job welding on stainless steel struts and then polishing them to perfection. I'm thinking of offering these reinforced thimbles for sale as other sailors must also be running into this problem when using high-tech lines and large loads.

Even thou I had the primary chain plate holes polished to accept rope directly, I listened to the advise of another sailor. He recommended that I use thimbles whenever possible to avoid chaffing. So I used my winch to open up a thimble a little and passed it through the hole. I guess I can now describe the

hole as being polished to accept a thimble. Placing two thimbles on the ends of the rope provided me with two connection points. To gain a third point I repeated the procedure with a second 6 foot section of rope . This rope was passed though one of the reinforced thimbles and terminated with two more reinforced thimbles. Again, to reduce chaffing, the second rope used another thimble that was opened up so it could pass through a reinforced thimble. When I write a book about this I will have fancy figures and pictures.

In review, from the primary chain plate I used 4 reinforced thimbles and 2 thimbles that were opened up to provide 3 attachment points all connected to the same chain plate hole.

I used 3 more reinforced thimbles to terminate the lines coming down from the 67ft, 50ft, and 30ft marks. To join the downward pointing thimbles to the upper pointing thimbles I used smaller 3 to 5 mm lines wrapped multiple times. The gap between the thimbles joined by these smaller lines are essentially my adjustable turnbuckles. They allow me to tighten the big lines by drawing the gaps closer using the smaller line. I used both new Dyneema line and some Vectran line I already had aboard. I gained purchase like a multi-block when pulling lines tighter. Further, I was able to see which lines were loose when the mast was being pounded by the sea and only tighten the lines that needed it.

Special Chaffing and Redundancy Notes: I found even high-tech lines when under heavy loads were subject to chaffing and being cut by metal connection points. Therefore, I have attempted to use thimbles wherever possible and redundant tensioning lines in critical areas. Further, I recognized that on the primary chain plate, I installed just one line that ultimately joined up to three. For this reason I selected a new length of 14,000 kg breaking strength Dyneema line. When doubled around the chain plate, this line will hold around 20,000 kg. The loss of 4,000 kg (14,000kg*2-20,000kg) is due loss of strength owing to the knots at the rope ends and bend around the plate. By keeping the connection lines relatively short, I was able to eliminate the possible situation where failure of 1 of the 3 down coming lines would lead to the failure of the other 2. In this setup, the other two lines will still hold and simply loose some of their tension. Regular inspections of the lines and connection points will be necessary to detect any chaffing before it becomes and issue. Also, crew need to be taught to tighten lines that work themselves loose since chaffing is quick when lines have significant movement

In general I think the most dangerous period for any boat equipped with high-tech lines is during the initial tightening process. I found it necessary to take the rig to sea and allow the waves to pound it to work the stretch out of the lines Even the “ultra-low” stretch lines had to be shortened so I could have a significant gap to install tensioning lines. For this reason I was glad I didn't pay to have the line ends spliced around the thimbles and used knots instead. Now that the lines have the initial stretch worked out of them, I'm thinking of doing the splices to make everything look neat. So if anyone knows how to do splicing and can do it without taking the lines down and running back and forth to a shop, Welcome Aboard!

The lines at the 67 and 50 foot marks are attached to custom metal collars that fit around 2/3rds of the mast section. These are beefy pieces of metal through bolted into the mast. The attachment tangs were installed into slots in the collar, and then welded on the inside, and out. The tangs are the same thickness as the chain plates. The polished metal holes in the tang plate were designed for direct rope attachment, however, again, I used thimbles that were opened up. I used tensioning lines to connect the opened up thimbles to thimbles at the ends of the 67 and 50 foot mark lines. These lines themselves were the new Dyneema line. (All told I spent about $5,000 on Dyneema lines for the boat.) I do not

use the tensioning lines aloft to adjust tension, and only inspect them prior to passage to make sure they are secure. Since these locations receive fewer inspections, I have redundant tensioning lines that join the two thimbles together.

At the 30 foot mark I have a single spreader bar. It is in the same position and same length as my original mast. This allowed me to wrap a single line around the mast and lead it from one chain plate to another. It is wrapped completely around the mast to help prevent the line from sawing my combination wood/epoxy/fiberglass mast in two. The point where this rope wraps around the mast is also an inspection point prior to passages.

Side comment about mast and rigging.
The experienced rigger and mast builder I initially worked with spoke of supplying me with a large heavy wall mast with no taper. He wanted me to go with 3 spreader bars and something like 12 turnbuckles to keep it in tension. All told the bill was going to be more then a little higher then my budget. I began to wonder whether he was trying to sell me a whole bunch of parts. I found one book that described the benefit of having all this weight aloft is an increase in roll stability. They had a cute word for this hardware, scantings or scantlings. If they only cost and weighed a scant amount I would consider buying them, however, on a boat my scale everything is expensive and heavy. Masts like the one he wanted me to buy cost a fortune to buy and maintain. Further life cycle on aluminum masts seems to be shorter the taller the mast. I found several big used masts around the world complete with rigging all around 8 years old. I admit to being tempted by their low asking price. However, based upon the previous owners experience of having his boat demasted at the 8 year mark, I've concluded they are not worth the trouble. All told they still have over 100 single failure points that can't be inspected for certain. Send them to the recycle yard.

That is what happened to the original 26 foot boom and the bottom 15 feet of my original mast from my boat. Since they weighed it in order to pay me, I finally learned how heavy the monster was. The boom was 261 lbs. The 15 foot section was 308 lbs. That mast section at 308 lbs extrapolated up to the original non-tapered mast works out to 1600 lbs. In comparison the combination wood/epoxy/fiberglass mast and spar I have weighs approximately 1300 lbs. It is both lighter and more flexible. I'll concede that I too am awe struck by a big heavy wall aluminum mast held in perfect column with just a handful of stainless steel cables and fittings under great tension. We are led to believe that things that move and bend are less secure. However, anyone that has watched just how much the wings flap up and down on a big airplane, or watched a tree recover after being bent over by the wind, has to concede that rigid isn't always better.

But I digress. Lets continue our tour of the boat's rigging.

I added two new chain plates to the boat mounted on the two ama and in line with the mast. The word “ama” by the way is a word like sheep. You got one sheep or two sheep but never three sheeps. These two chain plates help maintain my mast in column. They were installed with backing plates and new bolts. I had the machine shop make two holes in each chain plate so I could put redundant shackles. I selected galvanized shackles and they both hold onto a single thimble. Another engineer informed me that galvanized shackles were stronger then stainless steel shackles. I used anti-seize in the threads to help prevent corrosion. Corrosion is however, expected, but these shackles are cheap to replace.

Two lines from the mast connect to each chain plate. I again used a short section of Dyneema line terminated in two thimbles to double the number of attachment points from one to two. One Dyneema line leads up to the mast and is connected at the 50 foot mark. I was a little more creative with the

second line. The second line branches into two lines. One of the branched lines leads up to the tip of the spreader bar located at the 30 foot mark. The other branch of the line leads to a tang located at the 6 foot mark. With this design I have effectively provided some lateral support to the mast at the spreader bar which in turn holds the mast with diamond lines in 4 different locations. At the 6 foot mark a line now leads up to the spreader bar and across to the Y in the line leading down to the chain plate. Using this approach I have provided lateral support in two ways to the mast at the 6ftt mark without creating a line you can trip over. The only turnbuckle used in the rigging is located at the 6 foot mark to adjust tension between the 6ft mark and line coming down from the spreader bar. Note: I speak of the lines as if they are different lines after going through the Y. In reality it is a single Dyneema line running down from the spreader bar to the chain plate. The Y in the line is created using a bit of customized rigging hardware. On one side the rigging hardware has a small wheel that allows the Y point to move up and down the line without wearing. The other side of the rigging hardware is connected via a knot. I found this arrangement necessary after a prior sea trial. On that sea trial I had a line running directly to the spreader bar. It created too much lateral load on the bar.

To off set the forward loads of the mast, I installed two new chain plates as far back as feasible. I knew these two plates would take very high loads and added a large amount of reinforcement to the inside wall. Bolts were drilled into epoxy core and filled with 3M 4200. The machine shop again provided rounded holes. In this case there was not enough clearance to work a thimble into the hole. For this reason, I have redundant Dyneema lines connecting the down coming lines. There 3 lines attached to each plate for a total of six. Two very high strength Dyneema lines run up to the tip of the backspar. Two lines run to the 50ft mark, and 2 lines run to the 67ft mark. For these two lines I reused a jib sheet from the old running rigging and an old halyard. Ideally I would like to change to match Dyneema, however, I think I have supported Honeywell Corporation enough for the moment. After all in my previous occupation they were a competitor.

From the tip of the back spar there are 3 other lines. One leads up to the 67ft mark and the same line turns around a thimble in the spar and goes back up to the 50ft mark. You might notice a common theme in my rigging philosophy. I like to think of the mast as a total column and not individual points. By this I mean it is possible to use rigging to distribute loading along the length of the column. In this particular example a sudden strong pull forward by a sail hung at the 67ft mark will transfer some of the load down to the 50ft mark where additional lines absorb the shock One concern I initially had was that the line would travel around the thimble and wear. However, what I have been finding in practice is that the thimble itself rotates slightly in the polished chain plate hole. This is again different then holding everything rigid. I feel that the overall reduced compression loading upon the mast more than off sets checking for wear and reducing relatively in expensive items. Sailing will never be a completely free sport and getting the gift of power from the wind still requires some continued maintenance.

The 5th and last line attached the the tip of the back spar angles down about 45 degrees and attaches to the mast. I saved the old boom vang attachment and it helps hold the backspar down.

Of the 9 lines counteracting the forward pull of the mast, 4 of them are not necessary. They are just a very cheap insurance policy. I already owned the lines. I will admit I feel a bit self-conscious about not having all pretty new lines for everyone to see. Recently, however, a 120 year old boat came in for some work near mine. It had lines everywhere. So for now I will accept them.

There are 4 more lines leading down from the 81 ft mark. These really are two lines on blocks. One is used only to hoist me up and down the mast, and one is for the spilling line. The spilling line on a crab

claw sail draws the boom upward in order to reduce the amount of sail area exposed to the wind. This reduced sail area works like reefing a sail.

My crew and I raised the sail for the first time on November 12th, 2010. This was obviously a major milestone in my project and coincidentally exactly one year to the day after I signed paperwork to buy the boat. Our objectives that first day were rather modest. We just wanted to raise the sail and attach a control line. This line ran from the deck up to the boom and back down again at 4 attachment points the first day of testing. On the second day of testing I also attached the line to the sails tack making it 5 attachment points. I used multiblocks for purchasing power to control the boom close to the mast where the sail has the most area. Yes it is yet another Dyneema line. Dang Honeywell.

Overall, I am working with over 100 feet of line running up and down between the deck and boom. To control this amount of line I was lucky to have aboard a Three Speed 55 Lewmar Winch. Speaking of winches, I used the deck mounted winch that used to control the jib sheet to hoist the sail. I was ablel to do this even though it meant running the halyard through an air block that made a 90 degree turn because the sail had no friction created by mast cars and batons. I didn't need to have a winch mounted on the mast with a perfect pulling angle. I didn't reinstall 3 winches on the mast and they are sitting an an ama. I'm sure Lewmar won't be happy to learn my rig only needs 3 winches instead of the 7 the former owner installed. (I can use one winch to lift both sails). However, I did find a need for brass inserts in deadeyes. In just one day of use my all plastic deadeye was melted by the friction of pulling so much line through it.

The sail was raised using the combination forestay/halyard that was run through a block located at the 67 ft mark of the mast. This block was selected since the block for the 50ft mark intended for the crab claw sail No. 1 had not been installed yet. The sail raising steps we followed were:

One. Remove combination forestay/halyard from the bow and attach to the head of the sail.
Two. Attach the front foot of the sail to the bow chain plate via the big shackle. (Its a nice shackle.)
Three. Attach back end of the foot via the control rope to the mast and down to the winch.
Four. Raise combination forestay/halyard.

The mast and rigging supported the sail when raised with no appreciable deflection. This was not surprising since they had already been used to lift and set the main dagger board. It weighed far more then the sail.

We were short on day light hours that first day as we finally got to this point around noon and had 8 hours to go before we reached Langkawi Malaysia. The plan was to put in for the night in Langkawi to avoid fishing boat traffic. It provided to be far more dangerous then just continuing to sail. When a storm kicked up we were suddenly in the path of dozens of fishing boats heading for cover. were surrounded by fishing boats rushing for cover.

Anyway, back to the sails owing to the light winds and time slot we decided to first conduct a test motor sail. An accidental gybe was not on the menu, however, my crew decided to add it. I looked up from what I was doing the sail we raised on the port side of the boat was now flying on the starboard. I didn't even hear it cross over the mid-point. Mind you, winds were very light. I had the crew turn the boat around and we did a 360. Ada, the girlfriend of one of the crew members, looked up nervously from her book when I shouted Tacking! She asked if she should do something. My reply was no nothing we are just supposed to say that. As we crossed into the wind the sail came down from the starboard side and swept across to the port side. We didn't need to adjust or change one line and the

boat was now tacked with only the turn of the wheel.

To prove the sail actually could drive the boat I had the crew place the engine in neutral and we observed 1.5 knots of speed upwind. Repeat, the boat sailed upwind. This was a long time coming for me and there were many detractors, including one that predicted I would sail backwards. I was getting pretty sensitive from all the ill comments from other sailors and when I found what looked like dog doo on my boat in Thailand I was not amused. Who would have brought their dog onto my boat so it could take a dump? Anyone who cruises the Pacific has probably figured out by now it wasn't a dog and my paranoia was misplaced. I just hope that monkey is still not aboard

Testing continued the next day November 13th, 2010. Winds were fresher. When raising the sail for the second time, I learned the hard way it is best to have the wind coming from the correct side of the boat instead of having the sail drag across the pilot house. After raising the sail we soon learned we had a problem. The boat simply refused to point downwind. We had too much weather helm meaning the center of effort (CE) was too far back. Once we figured that out all we did was adjust one rope drawing the sail closer to the bow. The boat promptly turned downwind and we now again underway. Being able to adjust CE so easily was not expected. One reference book I read said most people predict CE based upon simple area calculations of the sail and don't take into account the real life performance of the sail. I'm rather pleased that the boat was refusing to go downwind, as it has been my intention overall to build these sails and rig to go upwind. My current desired destination is many hundred of nautical miles upwind.

During the downwind testing I noticed too much mast deflection between the 67ft and 50ft mark. The 50ft mark was steady as a rock, however, the 67ft mark was being effected by the pull of the sail. From a top down view, the sail was pulling at an angle of around 45 degrees and 315 degrees depending on which tack the boat was on. My obvious problem was counter supports were at approximately 35 degrees 90 degrees, and 180 degrees. This meant for the range 90-180 degrees there was no support. To solve this problem without adding a new line or new chain plate, I added what I call a running forward stay. The running forward stay doesn't pull directly on the mast. Instead the running forward stay pulls on one of the back stays and one of the forestays. To effectively make this pulling force I added a block that road up redundant back stays until it was nearly 20 feet in the air. The forward stay now pulls the pair of redundant back stays forward so I gain support at an angle near 70 degrees. The result was the mast held steady without adding a line and plate directly in line if the angle of pull from the sail.

Figuring out how to do the running forward stays took up most of the day. Near the end of the sailing day I finally had time to direct the most important test of all. Lets call it the upwind angle of approach test. I'm sure there are official ways to do this test, however, here is how I did mine and here are the results.

1. I had the crew member at the helm turn the boat into the wind.
2. I sailed fairly close to the wind and at that time was running 3.0 knots upwind.
3. I had the crew member look at the compass and add 90 degrees.
4. Then the crew member turned the wheel till the boat turned around the 90 degrees.
5. We monitored the boat speed and found the boat topped out at 3.2 knots after making the turn.

All this was done with the engine off. The boat now proved that it had at least a 45 degree approach to a light wind using the small crab claw sail and could tack without the engine. I hope further testing with the smaller sail in stronger winds, or the big crab claw sail will decrease the angles and still

provide effective to wind performance.

Results of these tests however, won't come for another month or so. I have to recruit new crew and prepare for the next passage where I am expecting higher winds in the South China Sea. Anybody want to go?

In the post sail meeting with my crew, one complained that my boat was so “boring”. She said on my boat you basically didn't have to do anything to sail it, adjusting the line after tacking was optional. So the only action was to push the button on the autopilot and the wheel turned for you and the sail moved across. She said she just came off another boat where there were 4 crew members that all had something to do while tacking. She said it was exciting and my boat was in again in her terms “boring”.

Oh well, if you are as old as me you might remember General Mills Cherrios used to have a dark brown one every now and then. As a kid I also said,,,Yick, Yuck, but always ate it anyways. It was burnt and full of flavor. I'm partly the blame for more control of the temperature of the machine that makes Cherrios, and now it is so boringly bland. Every Cherrio is perfectly the same.

I don't like knowing that I already helped make the world more bland. So please please, if you are reading this report on my attempts to make sailing safer and easier. Don't tell anyone.

Philip Maise
Owner-Captain-Master-Designer
Hot Bouys Trimaran
Registered Volcano Hawaii

p.s. My big trimaran is the perfect real life test bed to prove sail designs and mast positions. I can easily install load cells and recording equipment. I used to sell all that kind of gear.

I am also always looking for crew members to join me on my trips. I tend to go upwind and like to go places where the last sail boat the local Pacific island residents saw, was mine.

p.p.s. I still have to try out the big sail and then comes getting the big one to fly above the little one. Another small issue is how to roll the sail up around the bottom spar in the foot. We tried lowering it to the deck and had 4 people turning the boom. I've got to figure something out a little better.

p.p.p.s. Today a big monohull from London pulled in next to me here at One 15 Marina in Singapore. It is called Aspiration. It is a typical incredibly huge non tapered heavy mast in the center with almost a dozen big winches around it to control the sails. There is no protection at the helm, and I bet my trimaran beats it hands down in both speed and comfort. Why? I guess it isn't bland to be tossed about the sea and suffer the wind, rain, and sun all day long.