# Fin Fixture

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Tripoli San Diego

April 16, 2009

Like a lot of you, I returned to model rockets after a long hiatus from a brief spell of boyhood Estes rocket kits. I am intrigued by the advances that have been made over the years and decided that the current high-power model rocket hobby was just the place to incorporate many of the areas of interest that I had developed during that time. Either because of business or hobby, I had been involved in computers, electronics, wood-working, machining, various model-making arenas, ham radio and model railroading. Model rocketry at the higher levels seemed to incorporate all of those aspects to one degree or another. And, who can resist the roar of a high-power motor!

I got excited and began a lot of research on the internet and massive reading of everything I could get my hands on. At some point, I realized I wanted to attain a Level 3 certification as my first major goal in the hobby. As I began my quest and started to assemble the knowledge to reach that goal, one thing continued to worry me – having to accurately attach the fins to my rocket. It seemed to be one of those "artsy/craftsy" processes that have tended to cause me trouble.

I guess I am more of a black-and-white sort, and the thought of having to eyesight my fin alignment and then tape it in place until it set really bothered me. I had these ugly visions of an embarrassing cork-screwing trail of smoke following my otherwise perfectly constructed rocket into space. Being such a common thing to do, yet seemingly one of the most difficult aspects of building a true-flying rocket, I assumed there must be an easier, better way.

I decided to dig deeper to see if I could find some sort of fixture that would make the process a bit more direct. Surely with all the builders out there someone must have solved this issue. My initial searching around only revealed a very professional looking device that cost hundreds of dollars. I am sure there are many other approaches to this problem that I have not yet uncovered, but this article is an attempt to chart my journey so far and describe the solution I eventually came up with that seems to address most of the fin alignment concerns.

Level 1 My first attempt to build a rocket in this new incarnation and Level 3 quest was an Aerotech G-Force. I liked when I read it was a good flyer and looked great at liftoff using relatively smaller, slow-burn motors. I had read enough by then to be familiar with most of the major rocket kit manufacturers. In my initial exuberance, I had gone to my local hobby store and bought a few of the familiar Estes kits, but before I ever got to putting one together I realized I wanted to bypass that step and do something right away that would allow me to go for my Level 1 certification. I gave the Estes kits to a buddy's kids.

Before I started on the G-Force, after more research/learning, I realized that with a modification in regards to the motor-mount-tube (MMT), I could also use this kit as the basis for my Level 2 certification. So, I bought a few more parts online in anticipation of installing a 38mm MMT in place of the stock 29mm supplied in the kit. This is probably when my worries about fin alignment really took hold. I sat down and read through the instructions (like I always do - of course) and pretty much realized that probably the most difficult or critical aspect was indeed the fin attachment process. It struck home particularly after having seen instructions for several other similarly constructed kits, but realizing that Aerotech had incorporated something unique in their kits

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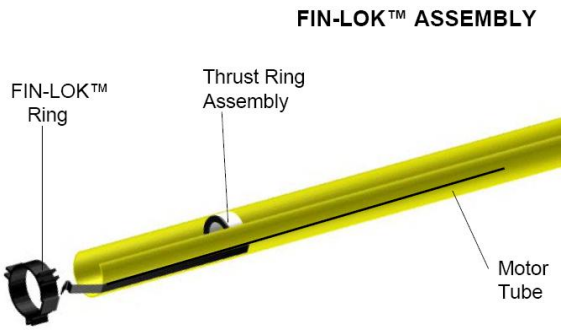
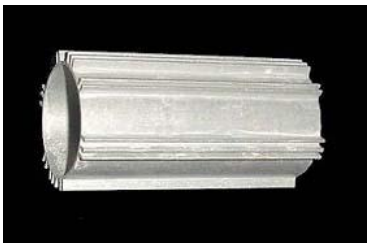
In that kit (and in many of their others), Aerotech supplies a set of their FIN-LOK™ rings which are designed to help the builder properly align through-the-wall fins and secure them to the MMT. Hmmm…I liked that! - once you get one fin properly set, the rest sort of fall in place! Nice touch for a novice builder like me. Further looking reassured me that Aerotech made such a setup for a 38mm MMT.

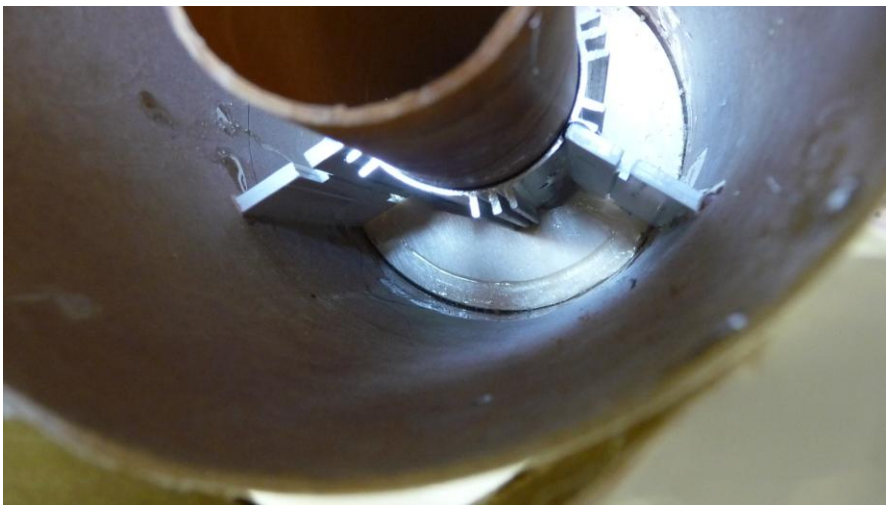



However, since my intent was to re-use the modified booster later on for my higher-power Level 2 certification flight, I was not so sure about the ultimate strength of the plastic-based, two-piece FIN-LOK system for that application. I seemed to remember a similar looking device out on another web site that did not really register to me at the time I first saw it. After hunting around a bit, I came across the GROOVE-LOK again.

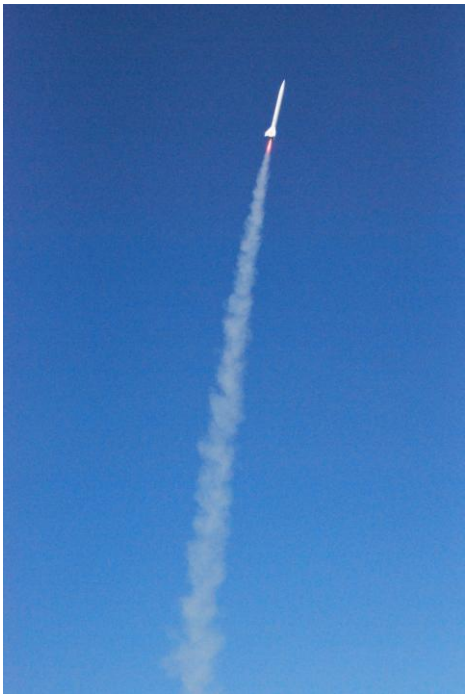


The GROOVE-LOK is supplied by Giant Leap Rocketry (www.GiantLeapRocketry.com). It is similar to the FIN-LOK, but better in my opinion for my application since it is aluminum and one piece. Once you affix it to the MMT and rotate the MMT to get one groove properly set in relation to the airframe (the grooves allow you to align both radially and linearly to the airframe centerline), the fins just slip into their respective grooves and achieve proper alignment with the airframe and each other. Sweet! Additionally, application of the normal internal strengthening fillets is made much easier. Nice device and it came in a size I could use on my 38mm MMT modification to the G-Force. I figured I could use this arrangement and have a pretty good chance of attaining a straight flyer!

I did have to modify the plastic fins included in the kit by removing some of the lower root to accommodate the larger MMT. Also, the width of the plastic fins furnished with the kit was wider than the two groove sizes provided for on the GROOVE-LOK. Rather than try to shave the sides of the fins down to fit in the grooves and probably lose the squareness needed to align them properly, I offset the GROOVE-LOK radially an appropriate amount and simply glued the fins directly adjacent to their respective grooves. I then put a fillet on the other side of each of the fins.



In this fashion, I was able to fairly easily align and install the three fins. The modified G-Force flew straight, so I assume the fin alignment was at least reasonable. I got my Level 1 certification using an Aerotech H128W with a 38mm-29mm adapter after a test flight with a G79W.




Level 2 For my Level 2 effort, Hermes 2, I scratch built everything forward of the booster section as a dual-deployment version of the basic G-Force. Since I used the above booster section from my Level 1 rocket, I obviously had no worry about how to align the fins - they worked! Having sort of overbuilt that first effort in anticipation of the Level 2 project, I felt the internal strength of the modified MMT/GROOVE-LOK assembly, along with having replaced the cardboard centering rings supplied in the kit with plywood ones, I had a booster section that could handle the larger motor needed to certify at Level 2. For that launch I used a CTI J180 and once again was successful in gaining my certification with the booster section holding up fine.

Level 3 The Level 3 certification rocket, Hermes 3, was to be completely new, so my concern renewed on how to approach fin alignment. Most of the articles I had seen to this point called for alignment by sight, and then taping the fin in place while it set - then repeating that for each fin. That seemed troublesome, time consuming and susceptible to various errors. For one, I just did not trust my eyesight – I have drilled too many holes that I thought were square and then had to deal with the actual result! I wanted something more precise than a good guess. Multiply the potential error by two or three more guesses as I attached the other fins, and I knew I would have a mess on my hands. So, I continued to scout around on the in search of a better solution.

The issue I started by asking myself what it was I was actually looking for in an alignment tool. What did it mean for a fin to be in alignment? It seemed to me there are three primary aspects – you need to be aligned longitudinally to the centerline of the airframe, you need to be aligned to the perpendicular of the tangent created by the airframe radial, and you need the fins to be equally spaced around that radial when they are attached to the airframe – then maintain all that while the epoxy sets! Hmmm…that is a lot to ask – no wonder it is troublesome. The GROOVE-LOK solved the first and last, but left the second once again to the eye. Plus, it is not available for the larger diameter MMTs. Someone must have a relatively simple, inexpensive solution to deal with these issues, right?

Tim Van Milligan In my research I came across a nice fixture that helps explain the concepts involved with the problem, and offers a solution. The fixture is detailed in a video-article by Tim Van Milligan - *Building Skill Level Two Model Rockets* (the DVD is available on the Apogee Rockets web site www.apogeerockets.com) Apogee Rockets is a great site full of useful education, tips and resources for both the beginner and skilled modeler.

In that video, Tim explains how to form a fixture from balsa wood. It incorporates the concept of using a slotted 90-degree wooden angle fixture to clamp the fin on the perpendicular of the tangent to the circumference of an airframe tube. It also aligns it along the centerline. It is a clever design.

Hmmm...maybe I just needed to scale that approach up to fit my 98mm Level 3 airframe. Then again, I would have to do this for each of the fins individually. The rocket I was building for the Level 3 project had a pre-slotted through-the-wall fin mounting scheme, so the equal spacing issue was not really a problem, but it could be with this particular fixture if you were doing a direct to the airframe fin mount. Tim does include a series of printable templates and such that alleviate a lot of the work involved in setting up the fixture and the spacing.

I thought more about creating a fixture based upon Tim's design, but scaled up. That is an interesting notion – creating a "vee" that sits on the airframe. If you placed a wooden vee, either fabricated like Tim did or using something like a piece of large carpenter's right-angle molding, on a table or miter saw and were very careful, you could create a slot of the proper width for your particular fin material right at the apex of the vee.

If such a wood piece (or even aluminum angle) was thick enough (relative to the tangent), i.e., had enough side-wall, the slot you create could also hold the fin perpendicular. Then you simply apply some

epoxy to the bottom of the fin root, insert it into the slot in the airframe (or directly if you are not using through-the-wall fins) until it hits the MMT, then slip the slotted angle over the fin. If the slot is thick enough as described above, then the fin will be perpendicular – if not, you just align by sight and tape it - at least you have an "assisted" fin alignment tool.

I found some right-angle wood molding at the local lumber store that was relatively wide on each side and thick enough that I thought I might be able to make a vee fixture with enough "meat" in the slot to actually hold the fin in the fixture properly. Now, at least at this point, I felt reasonably good that I might be able to align and affix my fins reasonably well with a scaled up version of Tim's fixture. However, I still had the issue of radial spacing and multiple applications. Things seemed better and still inexpensive, but not yet precise.

Vern Knowles  About this time I came across another great web site that got me even closer. Vern Knowles has a wonderfully rich site (www.vernk.com) that is chock full of helpful articles that chronicle his many, many rocket projects – so far, I have found nothing that compares to the detail he provides coupled with such excellent design and workmanship. In looking at what he had done for fin alignment, I found a neat fixture he created that solved more of my issues – in particular not having to do each fin process one at a time, as well as assuring that each of the fins was set properly relative to each other, i.e., they were at 90 (for a four fin rocket) or 120 (for a three fin rocket) degrees apart from each other. At least this way, once you set one fin correctly to the perpendicular to the tangent, all of the fins would be correctly aligned. Excellent!

*One of Vern Knowle's fixtures.*

Pondering (as I always seem to do) the creation of a fixture like Vern's, I realized there is yet another parameter or aspect that bears consideration. It is not so apparent if you are looking at this problem with the rocket horizontal like I had been, but with it vertical as in Verne's device, I realized the squareness of the airframe relative to the fixture's base platform was another potential source of error. A simple enhancement would obviate this concern. I decided that in addition to fin-clamping blocks, I would mount a couple of  squares to also align the airframe to the platform – then all the pieces of the puzzle would be square, aligned and properly spaced and therefore no source of worry. I was home!

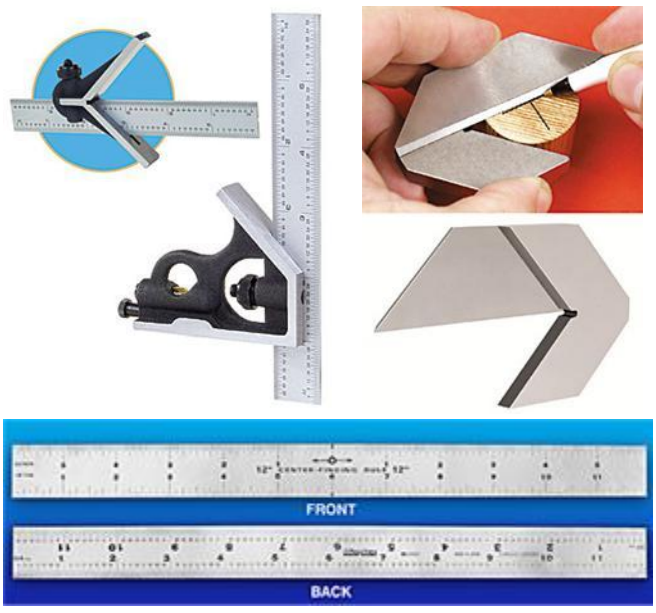
Fixture Construction  The fixture is actually pretty straight-forward, quick and relatively inexpensive to fabricate. The fixture can be made for one particular project, or, with a bit more work can be made to handle virtually any size airframe/MMT/fin combination with only minor adjustments. In Verne's fixture he was working with a three-fin design, whereas I was working on a four-fin project, which is what I will

describe as I go along. The initial key to the fixture is defining the intersecting centerlines to which the fins and the airframe will be aligned. There are several sources for fin alignment templates to use for defining those lines, including some printable templates in Apogee's (see above) popular RockSim™ software program.

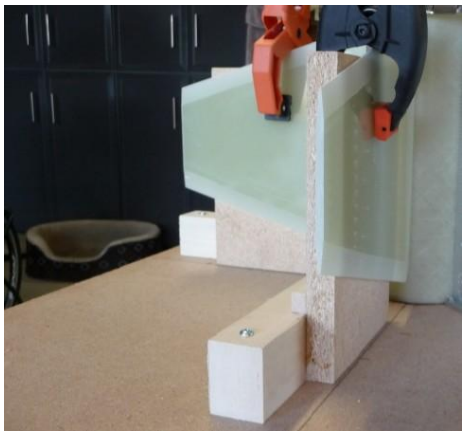
For the platform, I used a piece of 3/4" composition board I had in the scrap pile – its linear dimensions are not critical as long as it is big enough to hold all the components. Comp board is pressed together from zillions of wood particles and therefore very uniform and, if kept dry, very insusceptible to warping or changing shape or dimensions – it is usually a good choice for fixtures. Using a carpenters square, I simply drew two right-angle intersecting lines since my project had four fins. A three fin fixture like Vern's requires a bit more setup.

The intersection point of the lines will be the mounting center point for whatever sized centering ring or bulkhead plate you use for your particular project. I was focused on this particular project application and glued a spare 94mm-75mm MMT centering ring in place. It would be better to keep the fixture more multi-purpose. I suggest inserting a 10-32 or similar threaded-insert into the intersection point so you can screw a properly sized bulkhead plate to the fixture. That plate can then be replaced with another different sized plate for differing airframe diameter project.

Care must be taken to assure that the mounting hole is in the exact middle of the bulkhead plate. Most bulkhead plates come with an eyebolt hole already drilled. I have seen rather haphazard placement of the eyebolt hole in a few of the bulkhead plates I have received (centering accuracy of the eyebolt hole is not usually an issue for the manufacturer), so I would either make my own ring, or buy one that is blank so you can assure a correct centering is achieved. Micro-Mark sells a few nifty center-finding tools.

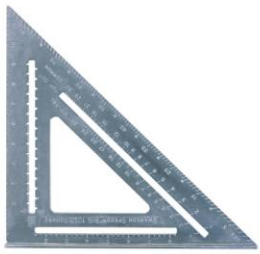


Next, fabricate the fin clamping blocks. Sizing of the pieces again depends upon the size of the airframe and fins you are using. For the vertical piece, I again used comp board due to its uniform size.



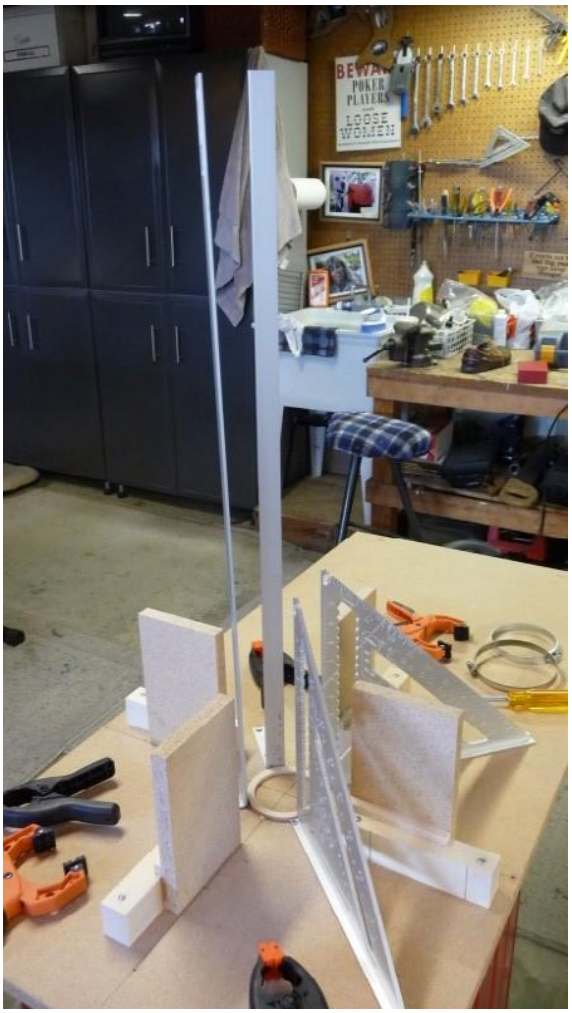
The lower part of the block can be made from any square material such a kiln-dried pine. Any square stock in the wood pile will do. As an extra step if you buy stock from the hardware/lumber store, have them plane the stock to assure it is square. Glue/screw the vertical pieces to the base blocks. Then, drill through-holes into the base blocks, align the blocks and screw them in place on the platform.

*Important*: Offset the block laterally - one-half the width/thickness of the fin stock you are using - from the alignment center line you drew on the platform for each fin's placement. This will assure that the actual centerline of the fin will be accurately aligned with the appropriate intersecting fin centerline on the platform. The offset from the platform's centering ring should be verified by clamping and dry-fitting a fin against a section of airframe. Check to be sure the center of the fin aligns with the centerline on the platform.



Next, place a section of airframe over the centering ring. Between two of the fins, slide a Swanson's Speed Square (can be purchased at any hardware store for a few dollars) snuggly up against the airframe section and drill a couple of holes and secure it in place. 90 degrees around the airframe, secure another speed square in the same manner. These speed squares will assure that the airframe is square relative to the platform.

You will need to clamp the airframe to the squares with a plumber's band clamp when you use the fixture. If your fins are too tall for the speed squares (the squares come in various sizes) and get in the way of the band clamp, you may need to increase their height by placing some squared support blocks underneath them such that they clear with enough space to clamp the airframe in place.



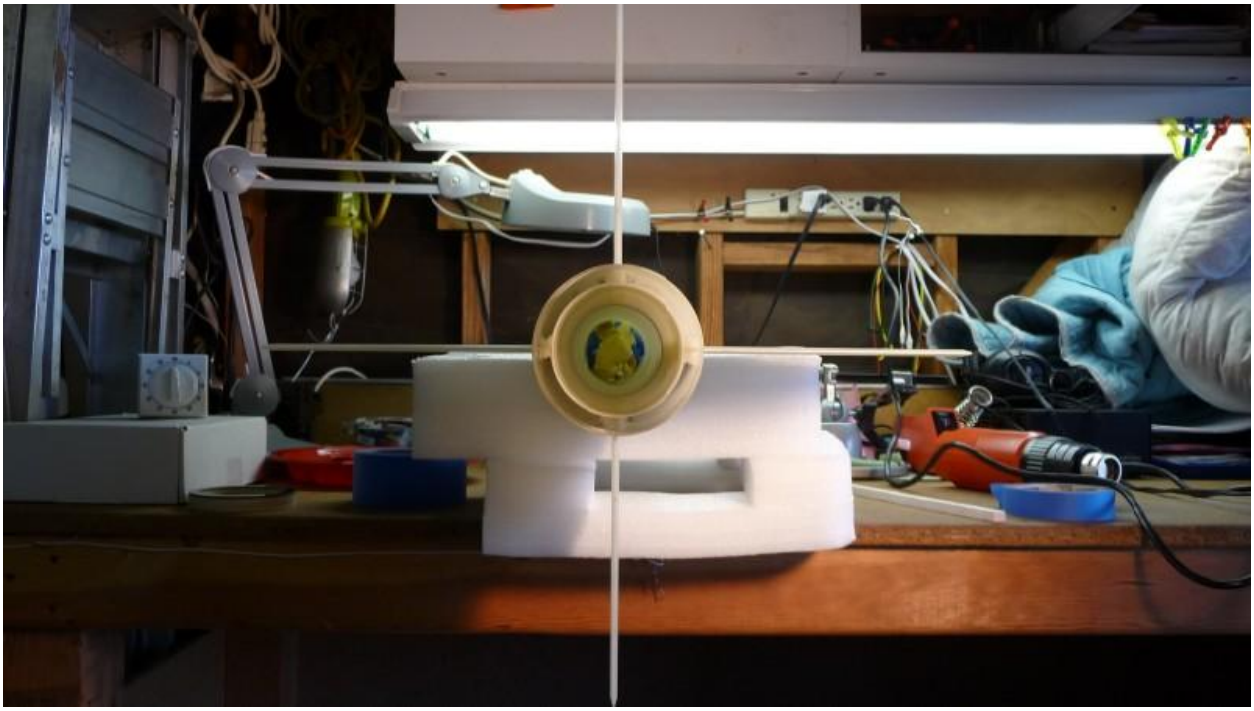

Now fabricate one or two L-brackets from some 1” x 1/8” or 3/16” aluminum bar stock. Make the leg part of the L about 3” long and the length sized to fit the airframes you will be working with. Push the L up against the opposing side of one of the Swanson Squares and secure the leg portion with a couple of screws into the platform. The L will help keep a longer section of airframe more stable in the fixture while you work. Use plumber’s pipe band clamps to secure the L(s) to the airframe.

Use  This completes the fabrication of the fixture. Place the booster over the centering ring and rotate it such that one of the fin slots or your mark on the airframe is in roughly the proper position. Tighten the band clamps such that the airframe is securely mounted and square to the platform, but so you can still rotate the airframe within the clamps for final adjustment.

Place a fin against one of the fin clamping blocks, slide it into place so it nominally rests against the MMT (or against the airframe if mounting is to be direct) and clamp in place. Clamp the other fins into position. Assure that each fin is sitting longitudinally height-wise (usually up against a MMT centering ring and fully square against the MMT or airframe. If using through-the-wall mounting, average out any disparity of how the fins align in the fin slots in the airframe (you may find that your fixture is more accurate than the one used to form the slots!. At this time, double check that each fin is still centered on the platform centerlines. Slowly tighten/adjust the band clamps to assure that everything is properly seated, stable and ready for final attachment. Check it all over one more time.

Now, unclamp each fin in turn, apply epoxy to the base of the fin root and portion of the fin that will contact centering rings. Then, re-seat the fin and clamp it back into the fixture - make sure that the fin is once again firmly seated against the MMT or airframe along the entire root, then move on to the next fin.

Congratulations! You have created a relatively inexpensive fixture that should prove very accurate and precise in projects of all sizes and shapes with little or no modification required. Setups are easy to change and repeatable.



The end result of this project was a perfectly aligned set of fins that I feel could be duplicated time and again with minimal additional effort. This would make a good club project to be shared with others.