160M Wire Loop Can Do What?

By Jim Wright, N2GXJ

We're lucky to have a remote HF station at the W2MMD Clubhouse, with a KPA1500 amplifier with a built in antenna tuner (ATU), and with a crank-up HF tower with antennas that include an amazing JK Mid-Tri-40 antenna for 10/15/20/40, and a dipole for 80 Meters. With that setup, you can talk the world when the conditions are right. But the DX isn't always on these bands. There are other ham bands too, and the radio we have at the Clubhouse is capable of operating on them, from 160M though 6 Meters. What might we miss-ing out on? It just seemed like there must be something we could try quickly and cheaply to find out. Wouldn't it be nice to have an antenna that could operate on these other bands we were missing out on?

Reading about an upcoming 160 Meter contest, and having no experience on that band, the time was right to take on a challenge. If we put our minds to it, surely we could come up with something to try to get on that band, and maybe fill in other missing bands while we were at it, even if just as an experiment. So there we were, out at a Tech Saturday Forum sitting around a table in out at the Clubhouse, when the challenge was thrown-down to see what we might be able to come up with together. It started with a question. How awesome would it be to come up with something to try as an experiment to get on 160 Meters with our remote radio in time for the contest, and maybe fill in some missing bands at the same time? A bunch of folks around the table and in the room lit up with the idea. It was on! Challenge accepted! That's when the brainstorming started.

A Plan For A Plan

If you were brainstorming something like this, what would you have done? Very few of us had any experience on 160 Meters. Fears, doubts, and uncertainties were quick to come out. We needed a plan, a "recipe" if you like, for a process we could follow to get where wanted to end up. So we started brainstorming it. Here's the process recipe we came up with :

- **Set the goal**
- **Identify likely risks and challenges**
- **Inventory what already have to work with and constraints**
- **Explore alternatives, with constraints in mind**
- **Decide which to explore further**
- **Simulate to refine details, get to a proposed solution**
- **Outline the proposed solution, bill of materials, costs, next steps and owners, then**
- **Go for it!**

We joked that even if the experiment completely flopped, it would be fun to try. That's one of the things I like about this group and Tech Saturdays out at the Clubhouse - collectively there will be years of ham radio experience in the room to leverage, with a bunch of folks willing to learn and try new things, even if they don't all work out. Things moved pretty quick from there.

The Goal

The goal was simple, try to get on 160 quickly, and cheaply, while filling in more bands we were missing if we could with the same antenna.

Risks And Challenges We Might Be Likely To Face

We were looking at this as an experiment - we knew there would be some trial and error here, and we knew we might not be able to achieve success in the end. There were lots of doubts, and fears, and uncertainties in the room. For this project, we asked ourselves to say out loud what were some of the risks we might face that could keep us from success? Here's what we came up with after a few minutes of discussion. Similar to what would have been on your list?

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- **Antenna size for the wavelengths associated with these low frequencies**
- **Low mounting height performance**
- **High noise floor impacting receive (e.g. electrical noise from Clubhouse)**
- **Tuner's reduced SWR tuning range on 160M (compared to other bands)**

We knew this would not be an easy project. But still, when looking over this list, we felt with the collective knowledge in the room, we had a chance at success. With that optimistic feeling, even without knowing yet what we were going to come up with, we agreed to move forward to the next step, to see what else we might have to work through before getting to commit.

Inventory What We Had

The inventory of what we had included the previously mentioned multi-band HF radio and amplifier with tuner, coax out to and up the existing HF tower, a multi-port remote antenna switch on the tower, the Mid-Tri antenna connected to one of those ports, and an 80 Meter wire dipole connected to another port. There was also another half-height tower about 120 feet away, and some poles at various locations in the fields around the Clubhouse to which wires might be able to be attached. Some in the room volunteered that they may have surplus wire and some other things to work with, if we needed any of that. Part of the agreed to goal was to try and do this quickly and cheaply. This was a good start.

We talked about it a little bit, and concluded we could re-purpose that 80 Meter dipole and its antenna switch connection for our experiment, while keeping the Mid-Tri antenna connection as-is and separate. Ok, that settled. So next we could focus on that 80 Meter dipole. There was already a 1:1 balun there, and a bunch of wire. Generally, we didn't like the idea of giving up 80 Meters just to see what might be on 160. So some preference might be given to an antenna that would let us play with 160, while still supporting 80, with a bonus if it would also let us try to get on 17 Meters - a band we did not have access to at the time, but a band where lots of DX was getting spotted recently. So it would be really nice if could fill in 17 Meters while we were at it. What kind of antenna might get us to our goals?

Explore Antenna Alternatives With Constraints In Mind

All kinds of antenna ideas were tossed out : vertical, low mount dipole, inverted L with elevated radials, with various pros and cons discussed. To get on 160 Meters, we knew the sizes of potential antennas would be large and that would be a challenge. A low mount dipole/inverted-V would be over 250 feet long. An inverted L probably would be the best performer, but then there were the complications of radials. In the end, we opted for a big multi-wavelength sky wire loop, an antenna type we'd had some success with on 20 Meters with during a recent field day. Because the ham bands are generally harmonically related, we figured a big loop like this might also be able to be tuned to work on our missing bands. A wire loop could be built and tried fairly quickly and inexpensively using readily available THHN insulated stranded wire and a balun. There was already a balun on the tower feeding the 80 Meter dipole, connected to a port on the antenna switch which was already on the Mid-Tri's tower. We'd just add more wire and connect this to the ends of the dipole we already had to make a giant multi-wavelength horizontal loop.

It's counter-intuitive to many, but a multi-wavelength horizontal loop actually is not a cloud warmer, instead sending energy out horizontally in high gain lobes and spikes towards the horizon, rather than straight up. You can read about this and see pictures of these patterns in the ARRL's antenna handbook. This can also be readily seen with antenna modeling. Given that ham bands are harmonically related, we theorized that if the loop was big enough it "should" be possible to operate this loop on 160 Meters, as well as on 80 Meters where the dipole had been, plus potentially pick up 17 Meters, and maybe 12 Meters too, if the right length of wire was selected.

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So how much wire could we put up? And what length should we put up? For that, we'd need to know generally what loop lengths we might be talking about here, and then we'd need a site survey to see what we could use for corner anchors points for our big sky wire.

How Big A Loop Can We Fit?

For a general idea of what loop lengths we might be talking about, we used the "rule of thumb" loop formula : wire length = ~1,005 feet / freq in MHz. Since 160 M is quite a wide band, we picked 1.8MHz, at the low end of the band, for the initial approximation to give us a longer wire length. Knowing we just needed a gross approximation at this point, and could refine it for best tuning and harmonics on other bands using modeling later, this gave us an approximation of 558 ft (rounded up to 560 feet) to start with to represent a 1 wavelength loop for 160 Meters. Thus a two wavelength loop for 160 Meters would be about 1,120 feet, and a triple wavelength loop for 160 Meters would be about 1,680 feet. Are lengths like this even feasible at our site? We had a good laugh when it was pointed out that a quarter mile is about 1,320 feet. That would be a lot of wire to put up if we could pull that off!

For a site survey, we knew we had approximately 2 acres of space around the Clubhouse with various towers and poles and trees on site. But we didn't have a map laying out the distances between all of them, and measuring on foot could be time consuming with the scale of what we were working with here. After a couple minutes of discussing, someone had the good idea of using Google or Bing maps to get the measurements we needed from satellite pictures. So that's what we did!

For a loop, it's all about enclosing an area in the same of some kind of polygon. You can use 3, 4, 5, or more support points, based on whatever is available. So horizontal triangles, squares, rectangles, or generally any polygonal shape is OK with pattern details for various frequencies we can model.

With the satellite pictures, we got creative, playing around with all the possible support points we could find, and the distances between them, but unfortunately could only come up with a max perimeter of between 900 and 1,000 feet, short of the 1,120 feet we were targeting for a two wavelength loop. So, for the experiment, we'd be settling with a 560 foot loop, which though only a single wavelength on 160 Meters, is still a big loop, and is favorably multi-wavelength on 80 Meters and above. So how might this perform, not only on 160, but on the other bands that would be nice to fill in as well?

Antenna Modeling For Balun Selection

There was discussion about the balun that would be needed. Some suggested the 1:1 from the existing 80 Meter dipole would work. Some were advocating for a 2:1, or 4:1 balun. How would we choose? We needed data to be able to make a better data-driven decision.

While talking about this around the table, it was suggested that we could simulate using antenna modeling software ahead of building it, to see how whatever antenna we would come up with might perform. Seemed like a good suggestion, so that's what we did next. Having some experience already with the capable 4nec2 software, we did some quick "what if?" analysis. For the dimensions, we used the site survey to lay out a triangular loop that would fit, fixing the feed point at the location of the Mid-Tri tower, then stretching the wire out in one direction towards the UHF/VHF tower, then assuming some sort of rope attachment there that would allow us to continue to loop wire down towards a telephone pole out in the field, again with another rope attachment that would allow the loop to come back up to the other side of the balun on the Mid-Tri tower again. On the maps, it looked like it would all fit.

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With a 3D perimeter of ~560 feet of wire for this simulated triangle, we used a little geometry to come up with the [x,y,z] points for each of the rope tie off locations in free space to put into the model, and then ran it. We then ran the model for a target frequency in the low end of the 160 Meter band assuming average ground, and then swept it across the band to see what the SWR bandwidth on this band might be. Next we swept the frequency through the other ham bands to see if any parts of those bands might also be in range of the amplifier's tuner. Good news for us was it looked like this antenna might be a good choice to help us get to our goals.

For 160 Meters, what we saw was that the predicted SWR to 50 ohms was going to be over 10:1 at the low end, and over 40:1 at the high end, with a lowest match of around 2:1 around 1.88 MHz. That's not a very good match, but the results were not surprising. The range of frequencies in the 160 M band are large, and we already knew that the theoretical feed point impedance for a full wave loop would be in the vicinity of 120 ohms. To better match to 50 ohms, such an impedance would requires either a 2:1 impedance transformer for single band loops, or a 4:1 balun to match on multiple bands. **See Figure 1.**

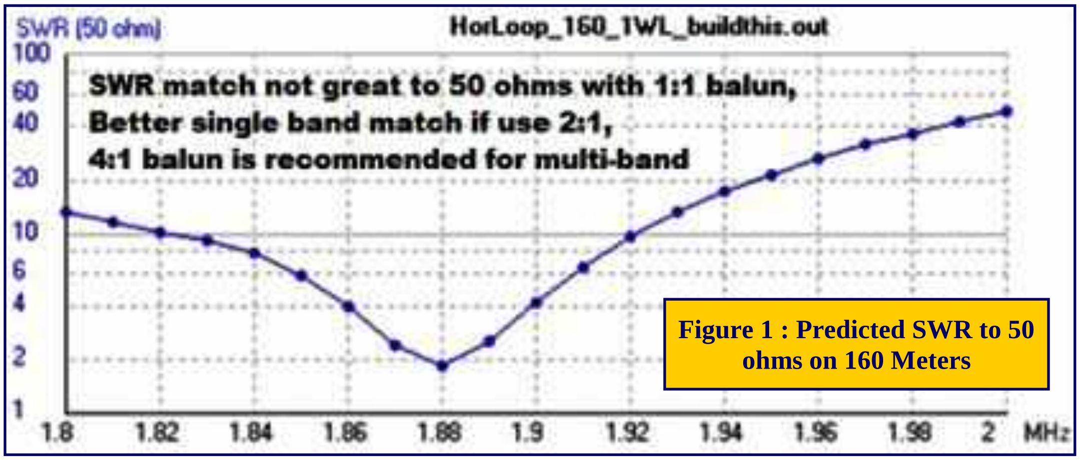

Figure 1 : Predicted SWR to 50 ohms on 160 Meters

Next, we looked at the constraints in the tech specs of the tuner in the amplifier we already had. The specs pointed out a problem for us to solve. The SWR range the tuner could match on 160 Meter band was less than what it could match on other bands. And the SWR range would be further reduced if the amplifier was to be used at above 800 watts. On most bands, the specs showed the ATU would be able to match up to a 10:1 SWR at up to 800 watts, while on 160 Meters, it would only be able to match up to a 5:1 SWR. Above 800 watts, the ATU would only be able to match up to a 3:1 SWR.

Clearly with these constraints, the idea of using the existing 1:1 balun from the 80 Meter dipole for this loop antenna was now out the window. We were going to need to get ourselves a new high power balun, to allow us greater operating bandwidth on 160, and to allow us to operate within the ATU's tuning range on other bands too. We talked about our choices, and in short order, based on positive feedback from some in the group with this manufacturer, selected a model 4115 dual core 4:1 5kW 1-54 MHz Current Balun from Balun Designs for the job.

Refining The Details - Really Multi-Band With Just This One Loop?

We swept the simulation on other bands, to see if we'd do better to tune to the lower, mid, or higher end of the 160 Meter band. The simulation confirmed our hypothesis that a properly sized single wavelength loop for 160M could be tuned to be used as a multi-wavelength antenna on other bands as well. **See Figure 2**.

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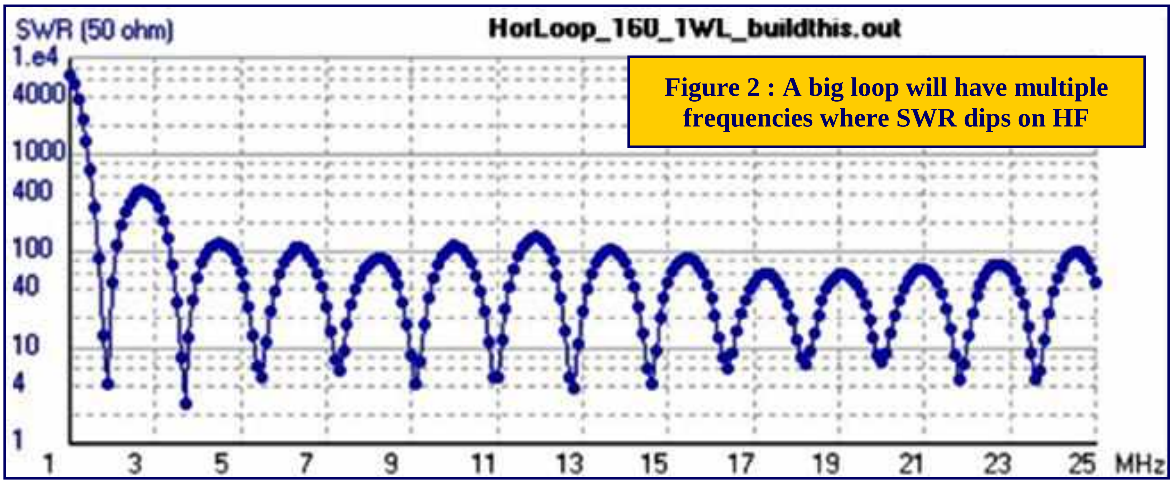

Figure 2 : A big loop will have multiple frequencies where SWR dips on HF

Focusing in on the 17M band, which is a very narrow band, we saw in **Figure 3** that we could get a predicted SWR dip to occur in band if we set the 160M point of resonance to be low in the 160M band. The software showed us we might expect better than 8:1 SWR match with a 1:1 balun, which meant that with the 4:1 balun we'd already picked, we'd also be benefiting on 17 Meters with an SWR that might be closer to 2:1 across the whole of the 17 Meter band. Even if our tuning prediction were off by a bit, we would be well within the 10:1 tunable range of the ATU at 800 watts on this band.

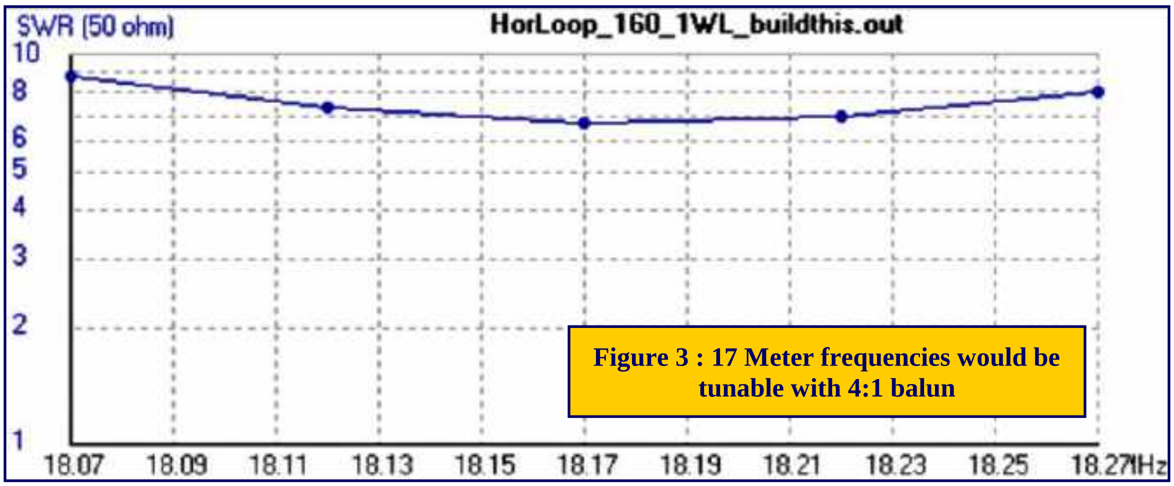

Figure 3 : 17 Meter frequencies would be tunable with 4:1 balun

This was great news! The goal of filling in missing bands with this same antenna now appeared achievable!

We had some concerns about what to expect for performance with this antenna. What about the gain and directivity for this antenna on 160, and 17 Meters? While we had the simulation available, it was easy enough to check to find out.

On 160M, we found the pattern to be mostly omni-directional, with high angle of take-off probably most suitable for NVIS type communications up and down the East Coast. As one might see with a low mount dipole, as seen in **Figure 4**, this is not that exciting of a pattern to look at. Though it may be possible to make some DX contacts with this antenna, with that pattern, this was clearly not going to be a DX antenna. Still, it looked like it could end up working well for NVIS distance contacts, and with it being simple to build, we should be able to get it up in time to experience what it is like to make contacts during the upcoming 160M contest.

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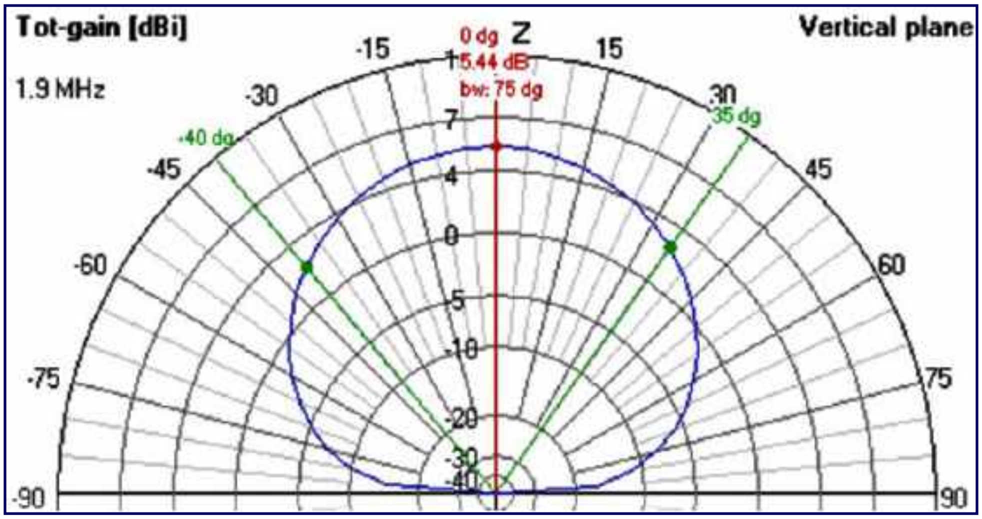

Figure 4 : Predicted gain pattern for 160M loop operated at 1.9 MHz

On 17M, the predicted pattern was pretty wild, with high gain spikes at low angles in many directions. We'd be looking at spikes of up to 12dBi at low 15 degree take off angles with this antenna. Yes, this might be fun. **See Figure 5.**

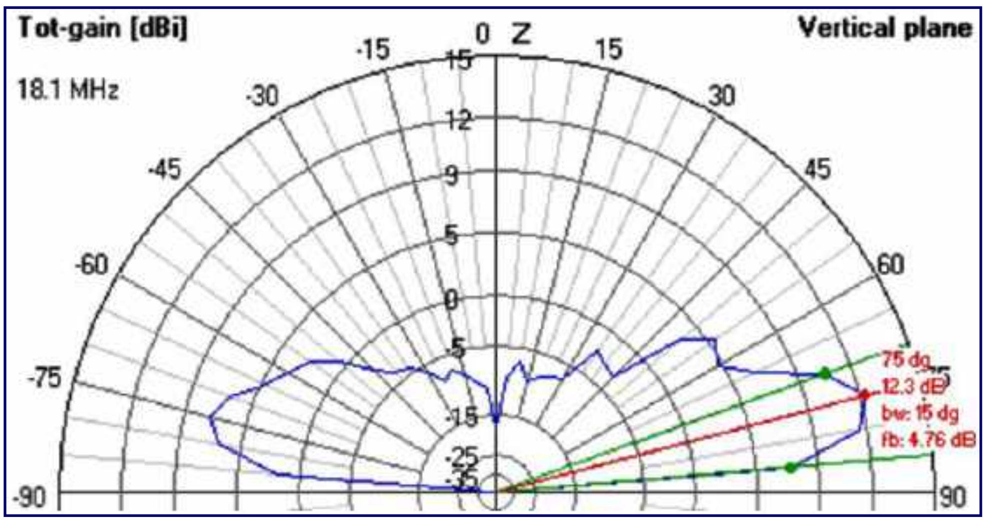

Figure 5 : Predicted gain pattern for 160M loop operated at 18.1 MHz

In the big picture, we really did not know if having an omnidirectional high angle pattern like this would be any good for 160 Meters. But we theorized that if there is anyone out there to make a contact with, out to several hundred miles, we probably would be able to. It looked like it could work. And in addition to being able to operate on 160M, it appeared that this antenna would have the ability to fill in some of the missing bands we had for operating on too, with some level of exciting performance.

Good enough we declared. We had our plan. Time to move forward with implementing it.

Strain Relief At Support Corners

As a tip for others maybe considering putting up a similar loop, we knew we wanted to use some kind of tubing for the rope to tie off to, with the insulated wire allowed to slide freely through it for strain relief **(Figure 6)**. This proved very useful when lifting the loop, as we could raise the feed point triangle corners and another corner to their intended positions and then just leave them there, using the third point as the single point we would then adjust for lifting and tensioning the whole of the triangle to its final operating height and position.

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How Well Did It Work?

On the weekend of February 24, 2023 I got to try out the loop during a 160M SSB contest. Operating the Clubhouse station remotely on sideband, over an 8 hour period, I was able to selectively hunt-and-pounce to make over 130 confirmed contacts. Collectively, the contacts spanned 36 different states and 3 DX countries. As the Clubhouse station is located in New Jersey, it was not surprising that most of the contacts made were here on the East Coast, from Florida up to Maine, and then out through PA to Ohio and down to Tennessee, with a few further out contacts made to Arizona, Kansas, and Colorado. For the DX, surprisingly to me were that none of the DX contacts made were to Canada. Instead, two of the three were to the Caribbean, with the third contact being made with a station in Italy. That was a very difficult contact, certainly at the limit of what might be possible. But post-contest, I can see it was confirmed as a valid contact. So there it is, in the log and confirmed. Kind of exciting!

Figure 6 : Allowing the insulated wire loop to slide naturally through tubing for strain relief at tied off corners

Overall, operating on this band had similarities to my previous experience operating on the 80 Meter band. There really was nobody to make contacts with until after the sun went down. And then most that I could hear were not very strong, despite the massive amount of wire up in the air in the loop antenna. When it came to DX, this configuration was clearly not a good DX antenna, with most contacts being from within a footprint spanning just a few hundreds of miles from New Jersey. But then then there was the interfering noise. Thankfully, the band is quite wide, and this problem did not ruin the whole band. So it was possible to tune around it. But there were these two swatches of frequency ranges on the band that were virtually unusable to me due to a constant S9+ man made noise in those ranges. I suspect that this is noise originating from within the Clubhouse itself, though it would take some effort to isolate to confirm this. And now that it is summer, I'm finding it more fun to chase DX on the higher bands.

Speaking of the higher bands, it is very nice to have the ability to get on 17M now. In the past few months I've had fun making contacts all throughout Europe on this antenna, with an occasional contact further out, including at least one contact with Japan in the West, and Israel in the East.

Lessons Learned, And A Chance To Learn More

As always with any project, there are things that if had to do it again, you might do a little differently. There are always lessons to be learned with 20/20 hindsight. As learning more about antennas is generally something of interest to many hams at one time or another, we've scheduling time in some upcoming forums to share these learnings, and discuss this further.

For those of you interested in learning more, the first opportunity will be at the **GCARC Hamfest** on **September 10th**. At 8am, we'll be sharing an educational program further highlighting some of the challenges and lessons learned during this project. Then, on **Wednesday, October 4, 2023**, as part of the program that follows the business portion of the **General Membership Meeting**, we'll be taking a deeper dive look into some of the antenna modeling used to help us in getting to this solution to try. Computer modeling of antennas is a very broad topic, and this will just scrape the surface of what is possible, but may be of great interest to anyone else who may be interested in duplicating a similar antenna, just maybe at a smaller scale, for use at their own QTH.

Hope you enjoyed this article, and look forward to seeing you at one of these upcoming presentations!