Experiences in the Construction of a Portable Microwave EME System

or

Building a Really Big Lawn Ornament

Matt Reilly KB1VC

The moon is a harsh mistress.
Robert A. Heinlein, 1966

Figure 1: The Portable EME station aimed at the moon, August 27, 2002, in the driveway at QTH de KB1VC.

This is by no means an article about how to get on EME. It isn't even about how to mount a dish on a trailer. It may be a cautionary tale, or a source of inspiration, or even amusement. The purpose of this short story is to describe an experiment whose outcome is not yet known. As I tell the story, I'll identify the major lessons I learned along the way with ***<<brackets>>***.

The article won't present a timeline or talk much about how long all this took. As we all know, things take longer than we anticipate. At the same time, it doesn't really matter – most of the shop time I've spent on this project has been in "the zone" where we all lose track of time and notice that we've missed dinner when the mosquitoes start buzzing around the garage.

<< Lesson 0: You can be "about two weeks" away from completing a project for several years. >>

Why Bother?

EME seemed like it would be a whole lot of fun. But more than that, building a system that was portable, efficient, and effective looked like a real challenge. I began building microwave radios because it was a good way to learn about hard core RF design. Building a portable EME system looked like a good way to learn about mechanical design, construction, and even first-aid.

The project started like most, sketches on a napkin and a few parts in the shack. And then it started to grow.

The Trajectory

Six years ago (or maybe more) I started building a trailer portable microwave EME system. I'd heard that a well known ham near Philadelphia had a 10 foot Prodelin fiberglass dish that he wanted to sell. So, on a trip down to Baltimore, I stopped off and picked up the dish. When I arrived it was bolted together in two halves – each half comprised four petals. The two of us unbolted the petals in the dark and loaded them into the back of my Ford Explorer. We put the bolts in bags. That was a good idea – the bolts were stainless steel, and replacing them would have been quite expensive.

Driving with eight petals of fiberglass behind me for a few hours began to wear. At first, I was annoyed by the squeaking of the ribs rubbing together. After six hours or so, I was really irritated. I mean really irritated. The petals rubbing together generated a fair amount of fiberglass dust that literally got under my skin. Imagine spending the day insulating an attic – that's what driving from Maryland to Massachusetts felt like.

<< Lesson 1: Big hunks of fiberglass can emit irritating "fiberglass rays" – don't spend too much time next to stuff like that. >>

I stored the dish for a while at *chez* W1GHZ. When I'd finally acquired a garage to work in, I bought a trailer (see Lesson 1) and retrieved the dish from Paul's and Beth's gracious hospitality. The trailer was a two-wheeled utility trailer, about six feet wide and eight feet long. At the time, I thought the 1000lb capacity was going to be more than adequate. As it turns out, I was generally right, but there's a lot less margin than I originally anticipated.

<< Lesson 2: Building in margin is good. But we should expect that it will be eaten up along the way. >>

There was the issue of how to move the dish. I'd seen polar mounts with leadscrew positioners and pylon systems like the one at the very first big dish at Jodrell Bank.
(The Lovell Telescope at Jodrell bank is a true marvel. Completed in 1957, it still stands as one of the largest steerable dish antennas in the world at 76 meters. Sir Bernard Lovell chronicles his adventure in "The Story of Jodrell Bank," one of the classiest and most entertaining memoirs that I've read in a long time.)

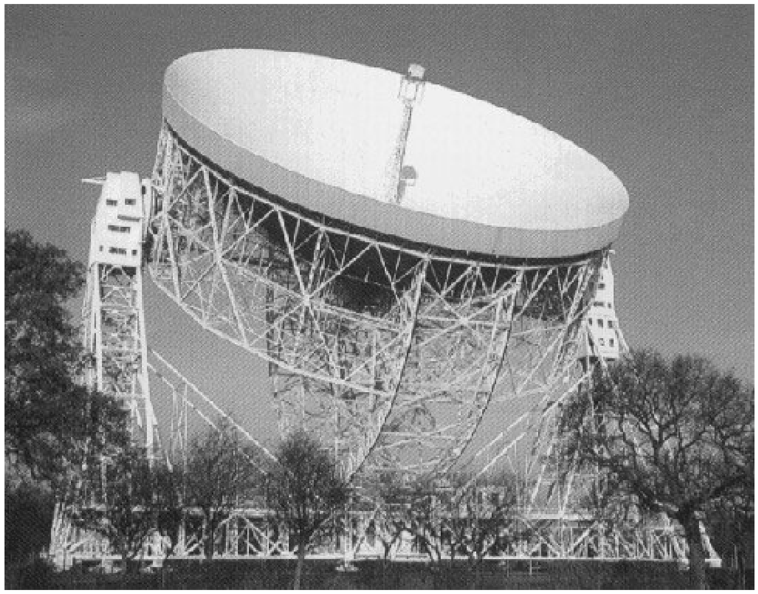

Figure 2: The Lovell Telescope at Jodrell Bank[1]

The Lovell Telescope rides on a circular track that allows 360° rotation. The crescent shaped bow that runs from the bottom to the top of the dish carries a rack that is used for the elevation drive.

I chose to build a single (central) pedestal with an AZ-EL mount to steer the dish. A polar mount scheme was attractive, but I wanted to be able to use the dish for terrestrial work too, so the AZ-EL plan seemed like a natural. Certainly the central pedestal idea was tried and true. I even found, in the course of the years I spent on this project, that a few such mounts hit the local market. Each time I'd look at the price tag and say "gee, that sure is nice, but I can do it cheaper."

<< Lesson 3: When you roll it all up, the homebrew solution for really big mechanical stuff is rarely "cheaper" than a surplus industrial solution that is being sold at near scrap value. It may, however, be rather fun to build. >>

The AZ-EL Mount

Over the years I'd amassed a prop-pitch motor or two. (Amassed is correct – once in place, those widgets don't move much. There are probably more of these units occupying permanent floor space than there are in actual use.) I even had some lead screws and about a dozen 12V light-duty rotator systems. I spent many happy winter evenings (and many otherwise tedious meetings at work) sketching various schemes for moving a dish up and down and side to side with "stuff I had around the house." Being an optimist, I was pretty convinced that something in the shop could be made to work.

Then I saw the ad on the reflector. "Industrial AZ-EL mount," it said. "Removed from service," it said. "Just $300," it said. So I sent off my check and eventually the unit arrived at the doorstep via motor freight. It was about two feet wide, a foot in diameter, and weighed fifty pounds or so.

---

[1] The image of the Lovell Telescope is from a wonderfully constructed web site on the Jodrell Bank Observatory -- http://www.jb.man.ac.uk/tech/lovell/anatomy.html.

Inside it was chock full of wires and diodes and nasty old looking caps (0.1uF electrolytics – a hint as to its age). The controller for this widget had, apparently, not been "removed from service" or if it had, controller and mount weren't kept together.

Now it is time for a confession. I took "Electrical Machines" in school. That doesn't mean that I actually learned anything about "Electrical Machines" in school. After reverse-engineering the schematic for the rotator and reading a chapter here and there about DC motors and field windings and all that stuff, it looked like things would go a whole lot smoother if the wiring in the box got simplified. A whole lot.

So, I ripped out all the diodes and capacitors (except a suppressor cap or two that were part of the rotor contacts) and re-wired the mount. The basic organization is shown in Figure 3. The switches in the diagram are limit switches that stop the elevation unit from pointing below the horizon or much above vertical. (The azimuth switches keep the rotator from spinning all the way around.)

I replaced the obsolete mateless connector on the side of the unit with a new plastic weatherproof 9 pin connector from AMP. I'd intended to make the connector mounted on the unit a MALE connector so the "high" voltage (100VDC) signals on the AZ-EL control cable wouldn't terminate in things that stuck out of a connector body. Alas, a brain fade occurred and the connector was wired as FEMALE. I'd spent a half hour or five getting the thing put together, and sloth got the better of ambition. So, don't touch the end of the rotator cable.

<< Lesson 4: Little mistakes, left uncorrected for years, will eventually not bother you a whole lot. >>

One can imagine that the simplified hook-up shown in Figure 3 made for a very simple controller box. It did. Just two momentary DPDT switches (to apply + to A and – to B or vice versa) and a SPST switch (to apply power to the field windings) and I was done with the controller.

Perhaps a brief word about DC motors is in order. DC motors that don't have permanent magnets to establish the magnetic field for the rotor to work against have, instead, a field winding. This winding can be energized separately from the rotor winding, or placed in series with the rotor, or in parallel. I decided on separate field excitation. Just because.

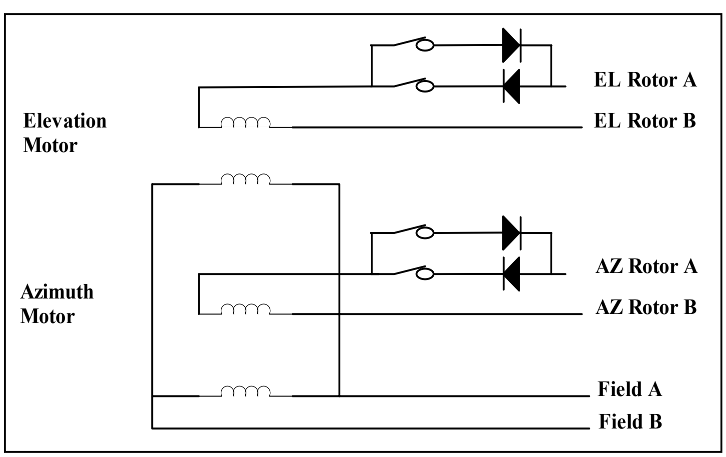

Figure 3: Simplified wiring for AZ-EL rotator

But just how powerful was this rotator? Would it be able to elevate the two hundred pounds (or so) of dish and cruft? How would I know without building it? Well, of course, I couldn't just wait until I'd finished the construction to find out if it would work.

One way to figure out what a motor will do is to hook it up to progressively larger loads and see what it takes to stall the motor. There's a better way to do this – called a "blocked rotor test" – but I didn't have the scales and other junk around the shop that was necessary for such a test. I did, however, have a bunch of cinder blocks, a few buckets full of scrap metal, and a bathroom scale. Figure 4 shows the setup I used. The horizontal bar was a two foot long piece of angle iron clamped to the AZ-EL mounting plate. (Angle iron is pretty useful stuff.) I kept adding weight to the block hanging from the end of the beam until the motor stalled. Goosing the motor voltage a little over the continuous rated value (100V DC) moved the weight. I called that the maximal load. Multiply "length" by "weight" to get the maximum torque.

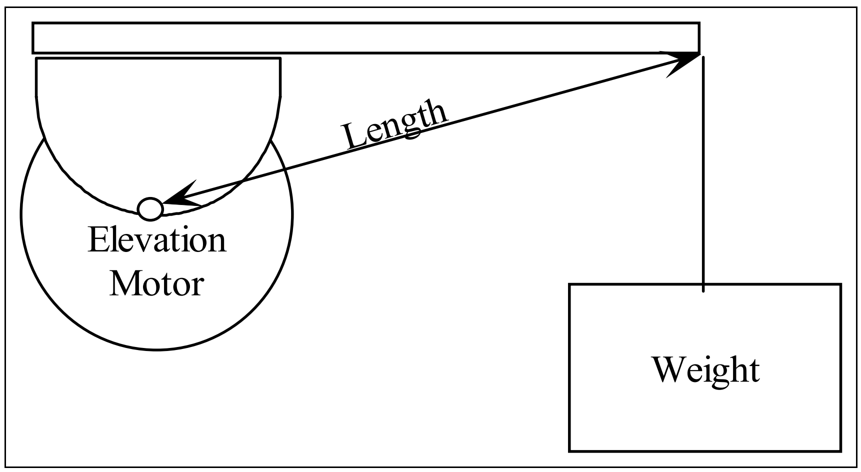

Figure 4: Measuring the capacity of an elevation rotor

I ended up with about 40 ft-lbs. That isn't real strong. In fact, it is pretty anemic, but the project was fairly far along, so the design would have to accommodate the parts at hand.

The problem, of course, is that the dish weighs about 300 lbs. It is about 2 feet deep and, even without the frame holding it together or the feed hardware, that would probably result in a moment about the elevation pivot of 150 lbs-ft or so. Adding the frame and some offsets to allow the dish to move without fouling the elevation motor, the total moment from the dish was going to be something way beyond 250 lbs-ft.

The answer is as obvious as the problem. A counterweight of about the same moment (give or take 40 lbs-ft or so) would pretty much put the load within the range of the elevation motor. The counterweight was the absolute least expensive component for the entire project. (See Figure 5.) Concrete blocks cost less than a dollar each and are easily maneuvered into place. The frame supporting the dish is welded to two four foot long angle iron beams that carry the counterweight blocks. A few experiments showed that three blocks were insufficient, so two more short beams were added to allow an extra block or two to be stacked on top. C-clamps hold a retaining bar in place to keep the blocks from moving after they've been positioned. (The elevation rotator has lots of play in it. The blocks are placed so as to move the center of gravity just a little forward of the pivot so as to keep downward pressure on the elevation gear.)

This scheme works out fairly well, except at high angles of elevation. The problem comes from the fact that eventually the top of the dish crosses over the elevation pivot, moving the center of gravity from just in front of the pivot to just behind. This can cause the dish to suddenly tip up and settle on the upper limit of play with a bit of a clank. I'm working on a solution, but haven't found a sufficiently simple and foolproof one yet.

Figure 5: The Counterweight

The Pedestal

I had the goal of mounting a10 foot dish on a pedestal with an AZ-EL mount on a trailer. The mount was to allow the dish to be pointed at the horizon. That meant that the center of the dish had to be five feet above the fenders of the trailer.

The first attempt at a pedestal was a bolted-together affair that proved too skimpy to support anything but a very light load. (As an experiment, it was used to support the AZ-EL mount and a small 1 meter dish. It was not nearly rigid enough.) That gave me an excuse to do something that I'd meant to do for a long time – learn to weld.

<< Lesson 5: Be ready to throw out a solution or two. >>

There's not much to say here, other than one should work out all the dimensions of the cross braces to make sure that the diagonal structural members don't foul the back of the dish as it turns. The finished pedestal is shown in Figure 6. It is welded to the trailer frame. Notice the diagonal cross bracing for every "box" shape in the pedestal. The frame is extremely rigid. (The welder is in the background.)

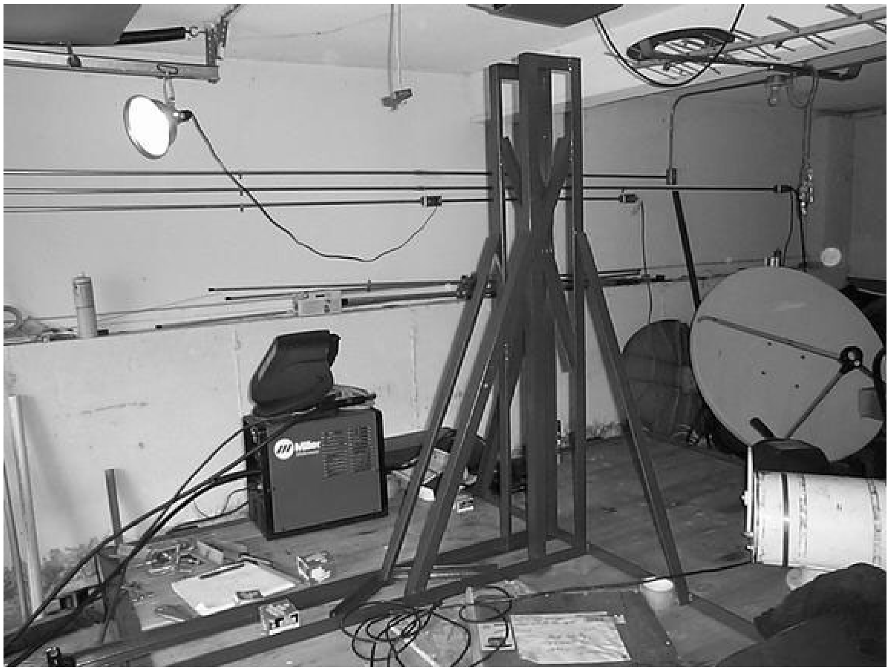

Figure 6: Pedestal frame on the trailer.

The Dish Frame

The fiberglass eight-petal dish requires a frame behind it to hold it rigid and to fasten it to the elevation mount. Early experiments showed that when the dish was pointed at the horizon, the elevation mount needed to be inclined to horizontal by 45° so as to allow elevation from horizon to almost straight up. This meant building a bracket to match the angle. The bracket also needed to include the counterweight rails. (See Figure 7.)

Figure 7: Mounting bracket between dish and elevation mounting plate. (The elevation mounting plate is the white plate in the center of the photograph. The counterweight rails were later welded on as extensions of the vertical bars.)

The right-angle bracket was then welded to the four braces that provided the attachment points to the back of the dish. (One of the attachment points and three of the braces can be seen in Figure 5.) The right angle bracket and braces fastened to the AZ-EL unit as shown in Figure 8.

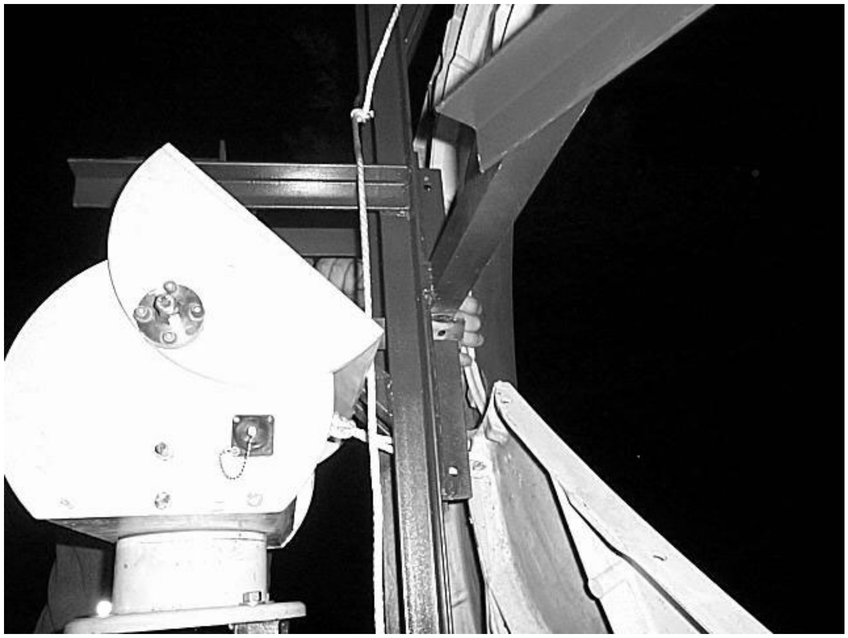

Figure 8: View of the partially assembled dish and the right angle bracket and elevation unit

The Focal Mount

There are a few places in the world where one can find all the atmosphere needed for true inspiration. Ansel Adams had the wide open spaces of the American landscape. Toulouse-Latrec had the bordellos of Paris. Garage shop hackers have the Home Depot.

Modern dishes have elaborate schemes for holding the electronic gear and feed antennas at the focus of the dish. The object is, of course, to eliminate feedline loss between the signal collector and the receive pre-amplifier. My portable system had some additional requirements:

1. The dish would be used on multiple bands, so any mounting strategy should either share most hardware between bands, or be so simple as to allow inexpensive replication.
2. The feedpoint would likely need to be disassembled for transport and assembled on site, in the dark, by one tired operator.
3. Location of the focal point should be simple and quick. It should not require sun-noise measurements or complicated alignment in the field.

I had toyed with the idea of PVC tubing for feed struts, or a central pillar approach using large diameter PVC tubing. Unfortunately for the latter scheme, PVC doesn't shed water very well and there are some indications that it might be lossy or even reflective at some microwave frequencies. (These conjectures are, of course, presented without evidence. My source is the Internet, so it must be true. Or it might be baloney. Such is the information that we use to make our decisions in these home-brew projects.) One afternoon, I was thinking about cleaning the workshop when I noticed a length or two of steel EMT tubing that I'd used when wiring the shop for the milling machine. That stuff is easy to work with, cheap (so you can afford to have a few mishaps), and has all kinds of fittings that can be used to fasten it to other stuff. EMT won the contest for strut/mount material.

Then came the problem of how to connect the EMT struts to the actual radio gear. I knew enough about trying to fasten two, three, or even four spindly things wandering around in three dimensional space to know that I didn't want to be standing on a ladder with a radio in one hand and a wrench in the other while trying (with the third hand?) to wrestle a strut into place. What I needed was a way to connect all the struts to a feed mounting point and then slide the radio into the mount.

Then one day I wandered into the local Home Depot. There it was, a big orange bucket. It screamed out at me. So I bought two of them. The first would become the feed bucket. I mounted it just beyond the focus of the dish by fastening it to the four feedpoint struts which were then inserted into EMT sockets mounted at the top, bottom, left, and right edges of the dish. The result is shown in Figure 9.

<< Lesson 6: Inspiration may be as close as your local hardware store. >>

Figure 9: The Feed Bucket (Note the name of the manufacturer/equipment-vendor on the side). The bucket contains a 3.456GHz transverter in this picture.

The second bucket was used as a mock-up to test packaging ideas for the transverters.

To hold the transverter in the feedbucket (which may be nearly vertical at times) I cut two holes in the back of the bucket. The transverter frame has two U-channel aluminum pieces that stick out of the back of the transverter. These protuberances slide through the holes in the end of the feed bucket and are held in place by a "keeper" or retainer bracket screwed to the frame on the *outside* of the bucket. (See Figure 10.)

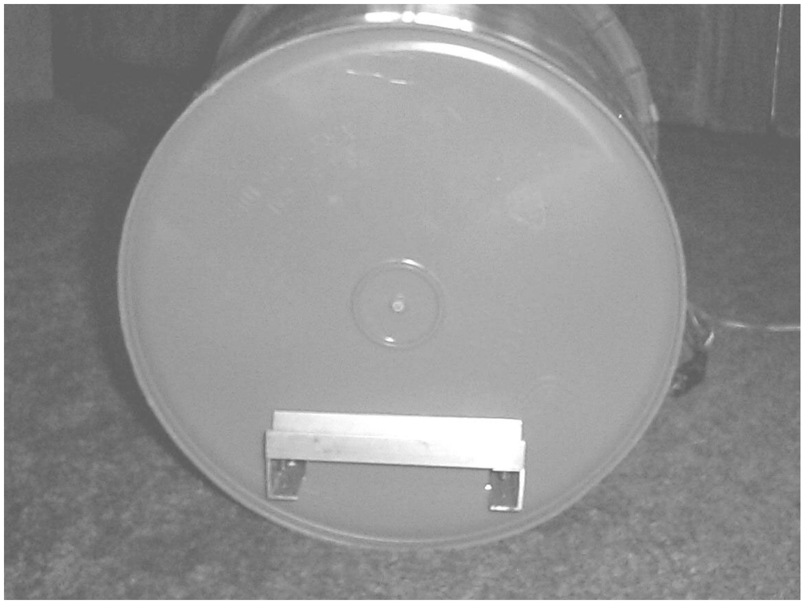

Figure 10: Retainer bracket at rear of feed bucket

So now I had a place to put the feed, struts to hold the feed bucket in place, and a dish bolted to a mount. But still, something was missing.

The Radio

It seems obvious to me now, but the construction of the "radio" part of this portable system was actually a pretty small part of the whole project.

The original goal was to build a 10GHz system with "things I had around the house". Several years ago I began to amass TWTAs and have several ranging from 5W to 100W. The 100 watt tube is, sadly, missing a power supply.

For reasons that I've forgotten, I decided to start with a 3456 system instead. Perhaps I was concerned about QRM and knew that I wouldn't be plagued with unwanted confusing echoes on 3456. In any case, I built the DEMI 3456 transverter and married it to a Pyro Joe 40W solid state amplifier and an LNA salvaged from a crate (!) of dual band LNB units that I'd bought a few years ago. (See Figure 11.) The package is fairly compact, and even with heat sink, fan, and a Chaparral feed (Figure 12), it fits easily in the feed bucket as you can see in Figure 13.

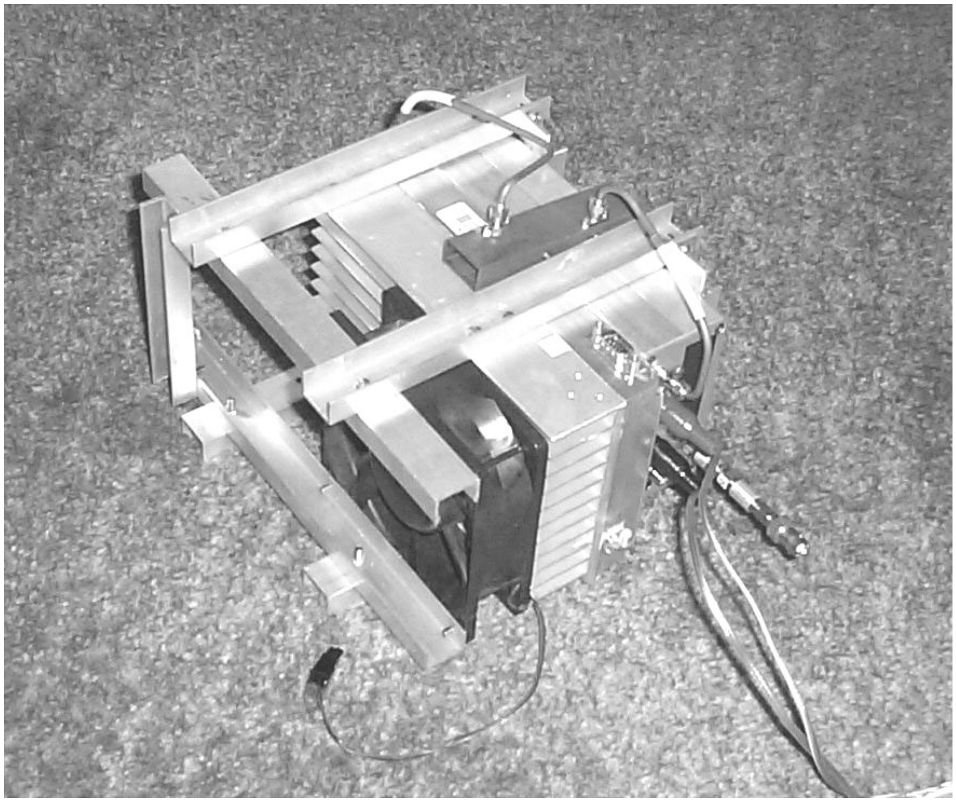

Figure 11: 3.456 GHz transverter, power amplifier, heat sink, filter, and fan mounted in the transverter frame

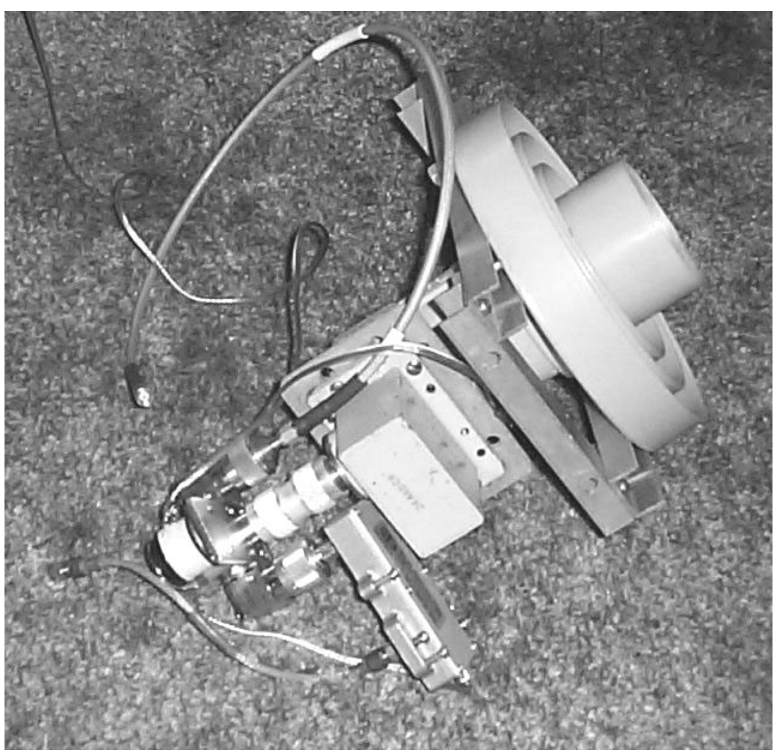

Figure 12: Chaparral feed, waveguide transition, relay, and RF pre-amplifier in mounting frame

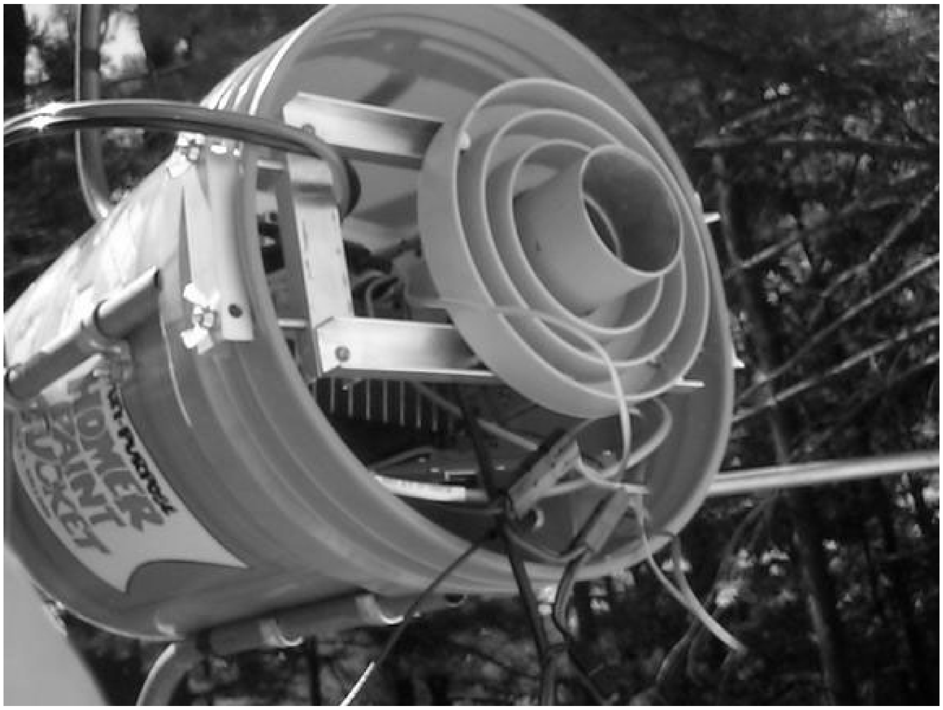

Figure 13: Transverter, feed, and amplifiers for 3.456GHz Mounted in the feed bucket

Assembling the Dish

Assembling the dish is much harder than I thought it would be. The first adventure is something of a cautionary tale.

The frame was complete, the pedestal and all the other metal work had been painted and was ready for the dish. So, I called Paul Wade, W1GHZ and the two of us set to work on adding petals. It seemed like a good idea at the time to position the frame as if we were pointing straight up. Then it was a mere matter of lifting the petals over the frame and bolting each one in place.

The first two petals went on with the grunting and cursing that you'd expect of any process involving something so awkwardly shaped. (We intended to assemble the dish in quarters.) We then lifted the second quadrant into place right next to the first. This completed the bottom half of the dish. It also put way too much strain on the shear pin that linked the elevation gear to the elevation axel. As a result, the frame pivoted rapidly, with its 150 lbs of fiberglass, and clobbered us both.

<< Lesson 7: A whole lot of fun stuff can become not so fun in a hurry. Make sure that nobody is standing underneath really big stuff that can fall down. In any case, if you're going to do something that could end in death, have a friend present. >>

We both recovered quickly: no permanent damage was done. (We were more frightened and chagrined than physically harmed.) A few days later, when I'd recovered my ambition, I turned a new shear pin out of stainless steel: such a pin isn't likely to shear under any anticipated load.[2]

[2] I suppose if an elephant sits on the lower lip, we'll probably pop the shear pin. We're just as likely to shred the elevation cog or the worm that drives it. That's one eventuality that I'll ignore for now.

The assumption is that I'd rather chip teeth off the elevation cog than have the whole assembly come crashing down.

Frankly, I still don't have a very good solution to the dish assembly problem. Ideally, the system would allow for quick disassembly into two halves that could ride on the deck. Unfortunately, the halves are quite heavy. Perhaps an engine jack or some similar mechanism is the answer here. This is an opportunity for experimentation.

Needless to say, Paul was not eager to pitch in on the second attempt. One Sunday afternoon I called some non-ham friends over and offered them dinner and a potential adventure. They were game. (They'd spent the previous week with three children suffering from colds, sniffles, and the attendant projectile behavior – assembling a dish in the cold night air was an opportunity to get out of the house.)

It helped that Gill and Kathie are both very tall. We pointed the dish mount at the horizon (not so far to fall!) and started bolting on petals. Figures 14 through 16 show part of the dish assembly process. The whole exercise took about two hours with four people lifting panels in place.

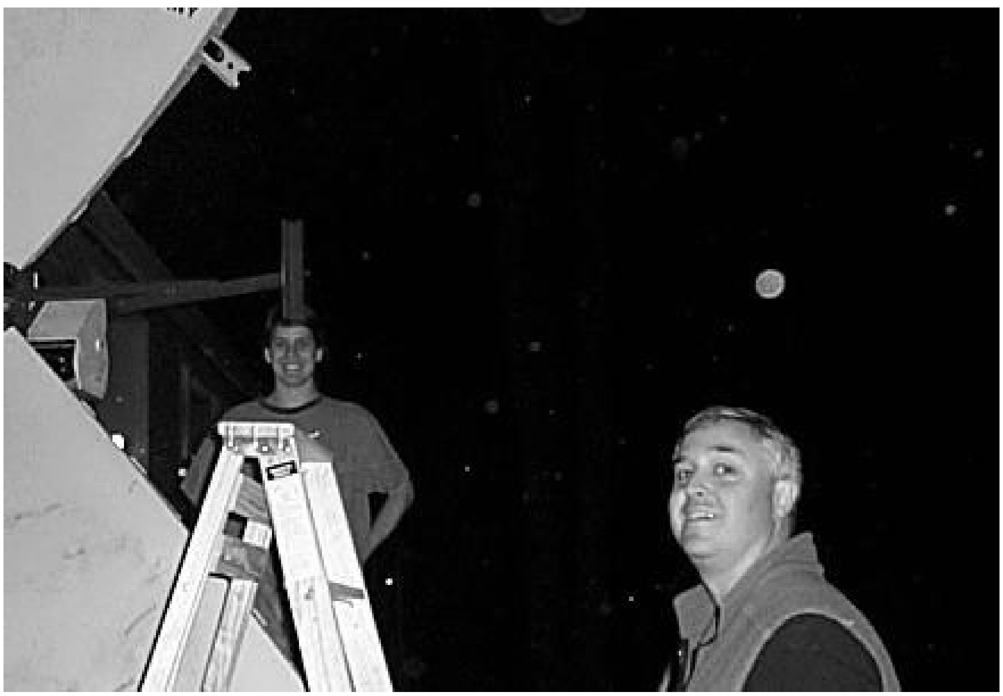

Figure 14: Kathie and Matt with the moon in the background. Note the dish support brace over Kathie's head.

<< Lesson 8: Sometimes your non-ham friends will be willing to help out. Spread the fun – invite non-ham participation. >>

Figure 15: Matt, Kathie, and Gill adding the third quadrant. The lower and upper quadrants are already in place. Anne is behind the camera.

Figure 16: Wedging the third quadrant into place

Dynamics and the Dish as a Sail

So, won't this thing blow over?

Yes, it will. But not in any wind that it will be exposed to.

Studies conducted by the MIT Radiation Laboratory folks in the 1940s and again by Andrew Corporation in the 1960s concluded that the peak pressure on a dish amounts to 40 lbs per square foot in a 100 mph wind. Force is proportional to the square of wind speed, so a 50 mph wind will produce a pressure of 10 lbs per square foot. The dish is 10 feet in diameter, or approximately 80 square feet. (In round number – rules of thumb rarely warrant more than one digit of precision.) In a 50 mph wind this translates to 800 lbs of force. Pointed at the tongue of the trailer, the moment is 4000 lbs-ft about the axel. So, when parked, the trailer has two jacks at the rear edge that hold the tail up. With a gross weight of 1800 lbs or so over the axel, and four feet in front of the jacks, the downward moment (holding the trailer to the ground) is over 7000 lbs-ft. Similar analysis of the transverse forces leaves the trailer stable when at rest in winds below 70 mph or so. If the forecast suggests we're in for a bigger blast, the dish will get disassembled and brought into the garage. (The wheels are chocked when the trailer is parked – we don't want the trailer to become a two-wheeled wind racer.)

Traveling is another story entirely. Frankly, that story hasn't been written yet.

There is one obvious problem. As any sailor will tell you, the maximal force on a sail is *not* when the wind is directly behind the sail. Most sails exert maximal thrust when they are used as airfoils rather than bags.[3] Wind tunnel studies show that this is true for dishes as well.

With the dish pointed over the left side of the trailer, being towed behind a vehicle, one could anticipate a transverse force to push the trailer to the right. This would be truly spectacular at 50 mph with the trailer sailing off to the shoulder, dragging the towing vehicle by the hitch.

Pointing the dish forward would kill the transverse force, but induce a great deal of drag and create a moment that would lift the tongue off the hitch. Again, one could anticipate a rather exciting time in the driver's seat as the vehicle's tail lifts and the front pitches down.

It seems that there are only three solutions for highway driving with the dish on the trailer.

1. Don't drive on highways and don't drive at highway speed. At 30 mph the forces involved (ignoring headwinds!) are low enough that traveling shouldn't be a problem.
2. Disassemble the dish when it is being transported.
3. Cover the dish with a large tarp to kill any tendency to form an airfoil.

I'll be looking into engine jack type solutions to facilitate easier assembly. Until then, most trips will be very local. I'll try solution 3 on a limited basis to see if it actually works.

<< Lesson 9: Sometimes those courses you thought were useless exercises can come in handy twenty or thirty years later. Oh, yes, and Newton was a pretty smart guy. >>

Every Good Project Is an Excuse to Buy More Tools

This project has been better than most at generating excuses to buy tools. As noted, I learned to weld as part of the process. That meant buying a really cool welding setup to do some flux-core

---

[3] Sailors will note that a spinnaker seems to be an exception to the rule. I won't argue the point – I said "most sails" anyway.

welding. Once you have something like this, you begin to wonder what you did *before* you could stick big hunks of metal together without using bolts.

Once you get a welder, you need wire brushes, face shields, hats, fireproof sleeves. (The latter is really quite useful. Molten blobs of metal have a nasty way of burning through even the thickest work clothes without losing a whole lot of heat. Then the blobs roll around under the cloth.)

And then, of course, a compressor is a really big help. The fiberglass dish has more than 100 bolts that hold it together. An air ratchet is pretty handy. On top of that, you're likely to have to cut a weld or two while you're learning.

But the mother of all power tools that I'm now convinced should go into my doomsday toolkit: the Milwaukee Sawzall. Given a roll of duct tape, a swiss army knife, a can of WD-40, a box of matches, and a Sawzall, I'm convinced that any of us could not only re-create western civilization, we could tear it down again when we were done.

Forging Bonds of Inter-cultural Communication

I didn't realize it when I started, but the whole project offered numerous opportunities to bridge gaps between cultures.

The Lawn Guy

I hate mowing my lawn. So, each week a crew of folks sweep through the neighborhood and on their way, they mow my lawn. The guy who runs the landscaping service is named Moe. Pretty cool.

But there was one part of the lawn that the crew kept missing. They apparently thought it belonged to the neighbors. I waited one Monday morning for the lawn guy to arrive. At noon, he still hadn't showed, so I gave up and drove to work.

A few miles from home, I passed the lawn truck coming the other way. I turned around, followed him to the lunch place where he was going to stop and hopped out.

"Hi! Are you going to be mowing up in Harvard Acres?"

The driver looked plaintively at me, shrugged his shoulders, and in a heavy accent let me know that he didn't speak English.

I don't speak Portuguese. We were even.

So, I smiled and started to draw a map as we stood by my truck. Then he looked at the truck, looked at me, and made a motion with his hands as if to describe something really big and round. "Big? Round?" he said.

"Yup, that's the house" I said nodding enthusiastically.

"I eat lunch, see you 15 minutes" he said. His English was much better than my Portuguese.

So I went home knowing that he'd be arriving at my house in fifteen minutes, or at the house of the fattest person in town.

Fire On the Roof

Anne and I got engaged in July of 2000 and were married in May of 2001. The months leading up to a wedding are a frenzy of preparation. So, on a bright Saturday in April, I was in the garage working on the dish. The day had gone pretty well. I'd done a bunch of welding, fixed a couple of bad welds and pretty much had all the toys, that is, tools, laid out around me. At one point I got out the die grinder and cut through a weld to separate two pieces that didn't really belong together.

About fifteen minutes after the die grinder adventure, Anne walked in and said, "hmmm, what's that nasty smell?" I was about to be offended but remembered the mishap. I explained to her.

"Well, I was grinding off a weld and the sparks were shooting up into the ceiling and I guess a few of them fell in my hair and set it on fire."

This was a learning experience for her. For me too.

<< Lesson 10: Sometimes a hat is an important piece of safety gear. >>

Fitting In With the Neighborhood

The dish is ugly. It sits on the trailer in the driveway or beside the house. Someday it will get its own parking space somewhere else. (Alas, it won't fit in the garage.) Still, being ugly is no excuse not to dress up now and then. Figure 17 shows the first object mounted at the focus. (This picture looks quite cool in color.) Note that I took care to ensure that the sun never passed within the dish aperture – I wasn't sure how the wreath would react. While the dish is not likely to ever win a neighborhood beautification award, the neighbors appreciated that I was at least making an attempt.

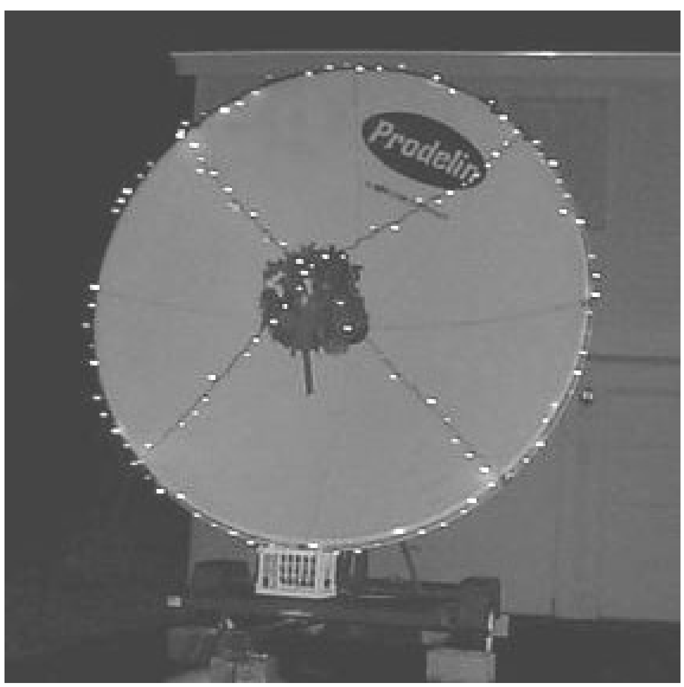

Figure 17: The dish with wreath and Christmas decorations -- December, 2001

Getting It On the Air

On August 27th of 2002, the moon tracking program I use indicated that the moon would be passing through the gap in the trees above the driveway. (My QTH sees only a small slice of the sky due to dozens of very tall pines. Another reason for a portable EME system.) The pass would begin at about 5 A.M. and last for an hour.

At 4:30, Anne woke me up and said "It's 4:30, you mentioned that you wanted to try some EME." Wow. Is life good, or what?

I got dressed, rubbed the sleep from my eyes and stumbled into the garage to get things setup. Figure 18 shows the AZ-EL power supplies on the left (in front of the ladder), the video monitor (used for steering the dish), the power supplies for the amplifier and other gear, and all the miscellaneous cables that hold everything together. It was a mess.

But it was my mess.

The ladder was quite handy. Earlier experiments with the feed bucket indicated that sun noise peaked when the shadow of the bucket was directly over the center of the dish. That meant that I could use the moon shadow to initially aim the dish, then mark the position of the moon on the video screen. The ladder allowed me to peer over the edge of the dish to see the shadow. As long as the moon continued to sit in the correct position on screen, the dish was aimed properly. (See Figure 19.)

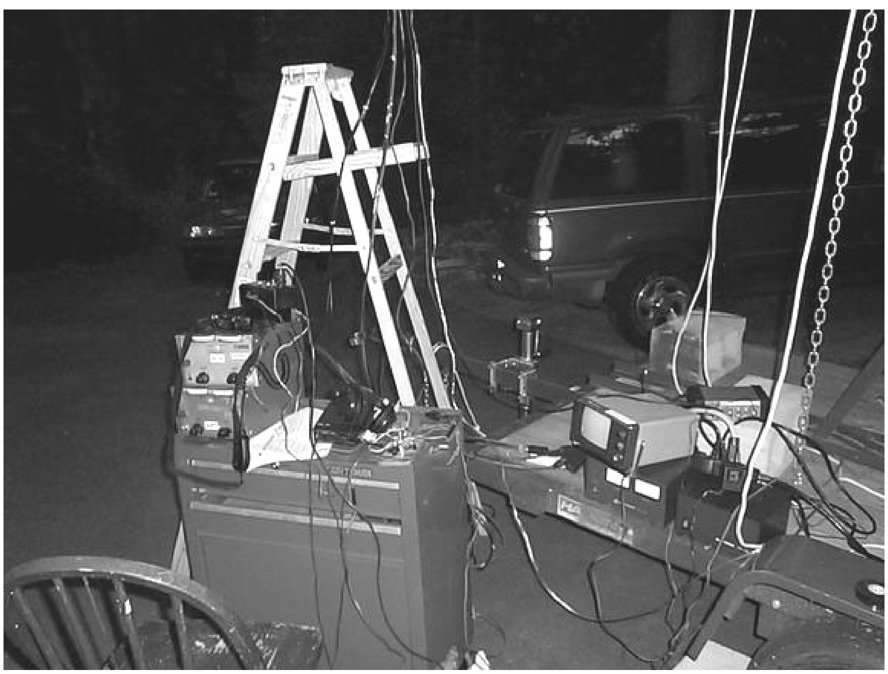

Figure 18: The EME setup at KB1VC

Like most things, the first time didn't bring success. That's ok. I learned a bunch of things along the way. First, I need to do a better job of mounting the video camera. Second, I'll finally get that DSP-10 hooked up to the transverter – its Doppler tracking mode and automatic sequencing should eliminate one more degree of freedom (a polite term for "opportunity for screw-ups").

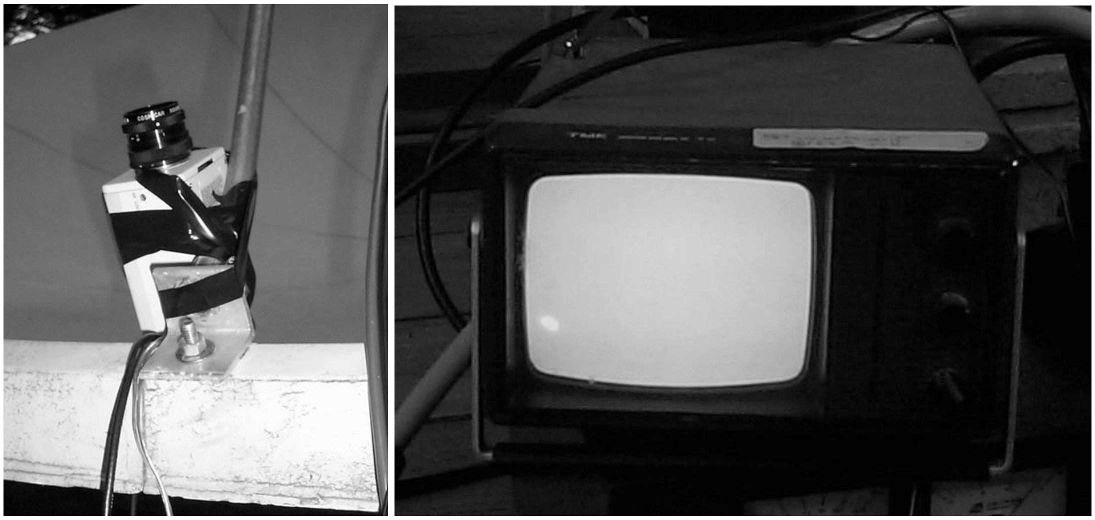

Figure 19: The video camera and mount (left) and the monitor (right)

As an aside, and in keeping with the rest of the story, the reader will note that the garage door in Figure 1 was open. As I was tapping at the key and listening intently, I noticed some motion out of the corner of my eye.

“Hey,” I said to myself, “that is one really bushy cat that’s poking around the garage door.”

“Wow, it has a really pointy nose.”

“Hmmm… black coat with a wide white stripe down the back.”

Then I made that noise that Moe, Curly, and Larry used to employ to signal recognition of impending doom. I got up, ran to the front door, down to the garage, and hit the up/down button. Something was blocking the light sensor that keeps the door from clobbering folks standing in the doorway.

There’s a lot of gear in the garage, so I couldn’t actually see the garage door from where I was standing.

I flashed the lights on and off. I shouted.

I figured that would be enough, and the moon wasn’t going to stay over the driveway forever, so I risked it.

I haven’t seen the skunk since.

<< Lesson 11: Concentrate on the signal, but keep your eyes open. >>

Figure 20: The moon passes across the narrow window over the driveway

Epilogue

After that first morning, I decided to leave the transverter and camera mounted on the dish, as the next morning's window would occur close enough to sunrise as to make it difficult to line up the camera using the moon shadow. Forecasters were speculating on rain, so I covered the dish and feed with a tarp. I'll never know quite why, but I left the dish pointed almost straight up. That was dumb.

The tarp was lumpy and, as tarps do, it collected lots of rainwater. Water weighs about 64 pounds per cubic foot. A tarp can collect lots of cubic feet of water. The weight bore down on the struts holding the feed up, and broke three of them loose from their brackets. The plastic feed bucket twisted a little bit and the whole thing looked like a real mess when I got home on Thursday night.

Viewed in the light of a new morning, the damage wasn't that bad. It was mostly limited to some broken EMT clamps. I was relieved to see that the electronics had stayed dry. I learned yet another lesson from this one:

<< Lesson 12: Structures that bear their operating load without trouble or worry may not be up to the task of bearing a load from collected rain or snow. Minimize the opportunities for any structure to collect rain and snow. (Pointing at the horizon is a good way to do that.) >>

The damage, as little as it was, will be repaired with a few hours work and, perhaps, a trip to the local hardware store. Which leads us to another lesson:

<< Lesson 13: Any setback that can be fixed with a few hour's work and a trip to the hardware store isn't worth agonizing over. >>

Conclusion

So far, the project has been a real hoot. It has been (and continues to be) a great mix of engineering, physical labor, high finance (higher than I'd hoped), machining, and education. It all adds up to fun and all the things that make ham radio enjoyable.

Over the next few months, I'll continue trials on 3456 EME and terrestrial. A 10GHz system is in the works and will probably be ready to go "in about two weeks."

Acknowledgements

I'd like to thank all the folks who have supplied parts, advice, encouragement, and good natured ridicule in the course of this project. A few have risked life and limb – thanks to Paul Wade (W1GHZ), Gill and Kathie Watt, and my wife Anne. Thanks to Anne also for her patience and disinclination to fall down on the ground in hysterical nose-snorting laughter at the sight of a self-inflicted bald spot.