A 6m Hex Beam for the Rover

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The hex beam is now an established family of wire antennas that features excellent performance, lightweight construction, a small turning radius, and low and symmetrical wind loading. This article describes a simple, lightweight hex beam designed for contesting as a 6m rover. The antenna is small enough that it can be mounted on the front or rear of a vehicle and be rotated, in motion, while remaining within a 3' overhang limit.

Background

It was May of 2013, and I was thinking about the forthcoming June VHF contest. I was pretty happy with the stack of antennas mounted in the rear of my limited rover platform—a recently acquired 1988 Toyota pickup truck. The antennas were mounted near the middle of the bed, on a telescoping mast that could be raised to 25 feet at my rover stops. While driving, the mast was lowered and the bundle of antennas for 6m, 2m, 222 MHz, and 432 MHz were secured with straps and bungee cords.

The truck was wide enough that antennas for all four bands could be stowed without any disassembly while in motion. This was a big improvement over my previous rover platform, an econobox car, that required partial disassembly of the 6 meter Yagi while in transit.

What I mean is this: Washington state law places restrictions on loads affixed to passenger vehicles. Specifically:

- No more than 3' beyond the front bumper (RCW 46.44.034)
- No more than 4' behind the rear bumper without additional lighting (RCW 46.37.140).
- No overhang beyond the fender on the left side of the vehicle (RCW 46.44.060)
- No more than 6" of overhang on the right side of the vehicle (RCW 46.44.060)
- No more than 14' high (RCW 46.44.020)

The 6' boom length of the 3 element yagi allowed it to fit within the side overhang limits of the truck when stowed perpendicular to the direction of travel. Yagis for 2m, 222 MHz and 432 MHz were stowed pointing to the front or rear of the truck.

The rear stack satisfied my antenna needs while stationary. While in motion, however, the stowed stack of antennas were either unusable, owning to interactions among the nested antennas, or inflexible, at best, by being pointed in a fixed direction. For this reason, I had been using vertical antennas while in motion.

Magnet mount verticals are a quick and inexpensive solution for in-motion operations, but not ideal, since most fixed stations are using horizontally polarized antennas for contest activity. Clearly, I could improve the in-motion portions of my contesting with horizontally polarized antennas.

I imagined the possibilities. As series of halo loop antennas certainly would be a step up. But at least for the higher bands, wouldn't a series of short yagis mounted at the front of the truck be even better? How about gain antennas for all four bands?

I explored this last option in great detail. The three upper bands could easily be covered by a series of short-boom yagis. But 6 meters was more difficult. The workhorse for 6 meters roving directional antennas has been the Moxon. They are quite easy to build and, from reports on the VHF contest reflector and contest write-ups, work extremely well.

The difficulty with the Moxon for a rover platform is its size. The conventional 6 meter Moxon is about 7' wide, making it wider than my truck when pointed forward or backward. One can design a narrower Moxon, but it will still exceed the allowable front overhang limits when mounted at the front of a vehicle and rotated while in motion. Thus, it wouldn't work for my front-mounted application.

Next I considered the hex beam. I really like hex beams. I've built a couple of these for HF—one that is my "daily driver" at home, and a second one for Field Day use that folds up and fits in my car. They are simple, forgiving wire beams that have a small turning radius, and perform similar to a 2 element yagi or moxon.

The first design I considered is the broadband hex beam, developed by G3TXQ. This variant has some small advantages over the original "reflected W" design from Mike Traffie, N1HXA. Some quick calculation yielded an antenna with a diameter of about 5 ¾'. This could work for my set-up, but the center of the mast would have to be within 3" of the front bumper to keep the antenna street legal (i.e. antenna within 3' of the front bumper).

The original "reflected W" design is about 9% smaller, with a turning radius of just over 5 ¼'. This would give me some room between the mast and the bumper. The primary disadvantage of this design is the narrower bandwidth. But for 6m contesting, bandwidth requirements are minimal. In practice, my operations all take place from 50.080 MHz to about 50.200 MHz. This is well within the bandwidth of the original hex beam design.

That settled it. I set to work welding up a front antenna mount for my truck.

The resulting 6 meter hex beam can be seen (below) deployed during the 2013 Fall 6 meter sprint. As it happened, my stacked pair of 3-ele yagis quit working in the middle of the sprint. I didn't know why at the time, but I later learned the center connection to the gamma match on the upper antenna had vibrated apart—probably while driving down a washboard gravel road. That would have been a disaster in a four-hour sprint, requiring debugging time, and time to reconfigure the stack to a single good antenna. But I simply switched to the hex beam for the rest of the sprint, and all was good.

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Design

There are three major subsystems to consider:

- A hub that supports the antenna and attaches it to the mast
- The spreaders that support the wire elements
- The wire elements

The hub

I wanted a non-conductive hub that was strong and extremely lightweight. Whenever I want these two characteristics in anything, I imagine how an airplane designer would build it.

The answer was wood. I built the hub out of two 6.5" plywood disks, with spruce stiffeners laminated as "spokes" in between the disks. I used 4mm Okoumé A/B grade marine plywood, which uses water and boiling proof glues (WBP) for marine applications. You can substitute any other marine-grade WBP plywoods like Sapele A/B and Merranti (or Meranti) A/B, if your antenna will be exposed to water or extreme heat. Marine grade plywoods can be found at marine suppliers and some home building suppliers (for use as outdoor "mahogany" paneling). An alternative to marine grade plywood is aircraft grade plywood. Disks of marine grad or aircraft grade plywood can sometimes be found in the scrap pile of the airplane homebuilder near you. (In fact, my disks were scraps created by cutting lightening holes in wing ribs.)

Realistically, you can get away with any high grade 1/8" (or so) plywood. Provided you treat it well against water, it will work for occasional use in the elements. Low grade plywood could prove troublesome, as your hub pieces may end up with voids in the laminate that will be weak. There is no need to use anything thicker than 1/8" or 4mm plywood.

Are there alternatives to plywood? Sure…one could make a fancy laminated hub from thin sheets of foam and fiberglass (perhaps with wood spokes). Or make the entire hub out of a solid block of foam and fiberglass over it. You could make a hub out of Plexiglass® pieces or other plastic, but it will weigh more. (Perhaps a pair of old 8" LaserDiscs left over from the 1990s?) Basically, almost anything can be made to work, although it should be made of nonconductive materials. An aluminum disk, for example, would structurally work, but almost certainly cause interactions between the driven element and reflector that may substantially affect the tuning.

You will need some way to mount the hub to the mast. I chose to put a large hole in the hub to slip the mast through, and then use u-bolts around the mast through angle aluminum pieces—one on top, one on the bottom of the hub.

The spreaders

Spreaders of fiberglass are readily available and not too expensive. Tap Plastics carries some, and an internet search for kite building materials will turn up other suppliers.

I found a supplier in Mt. Vernon, WA called Goodwinds (goodwinds.com) and ordered 3 pieces of E-40 .298" x 32.5" filament wound epoxy tubing and three pieces of their XL-11 .392" x 34" filament wound epoxy tubing for about $35. I cut them in half and glued the smaller piece into the larger piece. The end with the larger diameter tube is glued into the hub.

These spreaders are a little pricy, and possibly overkill, but the system works very well. The spreaders are nearly indestructible in ordinary use (I base this on experience with low-hanging vegetation!). In fact, I think six pieces of the E-40 .298" x 32.5" filament wound epoxy tubing would probably suffice and cost a few dollars less.

Alternatives include bamboo or fiberglass sections from fishing poles or bicycle flags, wooden dowels, anything straight, nonconductive, reasonably stiff and about 2 ¾' long.

In picking spreader material, you should consider the type of service the antenna will see. For my purposes, I wanted an antenna that would survive hitting small branches hanging down along forest service roads and streets in sleepy, overgrown neighborhoods. Thus, the fairly thick fiberglass that I used was much preferred to wood, that would snap quite easily. Unlike multiband hex beams, where the spreaders are under tension, I chose to make the antenna, essentially, flat; the spreaders just stick straight out of the hub. Very thin tapered fiberglass spreaders, like the smallest section from crappie fishing poles could work under tension and make for an extremely light weight (but frailer) antenna. (With a bit of modeling or experimentation, a multiband version could be built this way.)

The wire elements

The type of wire used and its gauge is not overly critical. I used uninsulated Davis RF Flex-Weave® FW14B 14 gauge wire. This is available from Radioware (radio-ware.com), HRO (hamradio.com/), Universal Radio (universal-radio.com), the Wireman (thewireman.com/) and other fine purveyors of ham warez. I never imagined I would say this about *wire*, but this Flex-

Weave® stuff is a joy to work with. Feel free to use something else—another gauge of wire or insulated instead of bare wire. Some adjustment to the element lengths may be needed.

The ends of the driven element are attached to the ends of the reflector with an insulator to form a continuous length. The length of the insulator is critical. I used parachute cord for making the end-insulators.

Attaching the insulators to the element ends can be done in many ways. I used crimp type ring terminals on the rope and the wire (soldered and crimped), with a small stainless steel screw holding the terminals together. I did this during development to make design changes easier, and then just left it in place. This is more complicated than it needs to be.

Parts List

The parts and materials needed for this project are in Table 1.

Qty	Description	Purpose
2	1/8" or 4mm marine plywood	Hub body
1	4' x 0.4" x 0.4" spruce or pine	Hub spokes
1	Epoxy	Hub, spreaders
1	Pint spar varnish or equiv.	Hub sealant
1	SO-239	RF connector
2	1/2" #6 SS machine screws	SO-239 to bracket attachment
1	1" x 1" x 1" aluminum angle	SO-235 bracket
2	3/4" #8 SS countersunk machine screws	SO-235 bracket mount
2	#8 SS self locking nuts	SO-235 bracket mount
2	3" length of 2" x 2" aluminum angle	Hub to mast bracket
2	3/8 x 3/4" SS bolts	Mast bracket
2	3/8" SS self locking nuts	Mast bracket
2	1 5/8" (or as required for mast) mast or muffler clamps (galvanized, SS or zinc plated)	Mast bracket
3	Goodwinds E-40 .298" x 32.5" filament wound epoxy tubing	spreader
3	Goodwinds XL-11 .392" x 34" filament wound epoxy tubing	spreader
1	13' of Flex-Weave® FW14B 14 gauge (or similar) uninsulated wire	Elements
1	7" of parachute chord	End insulators
1	Crimp ring connector, small, blue	SO -235 Ground connection
4	Crimp ring connector, medium, blue	Element ends
4	Crimp ring connectors, medium yellow	Insulator ends
1	Crimp but splice connector, yellow	Supports wire to SO-235
4	3/8" #6 SS machine screws	Element ends
6	Small wire ties	Insulator attachment

Construction

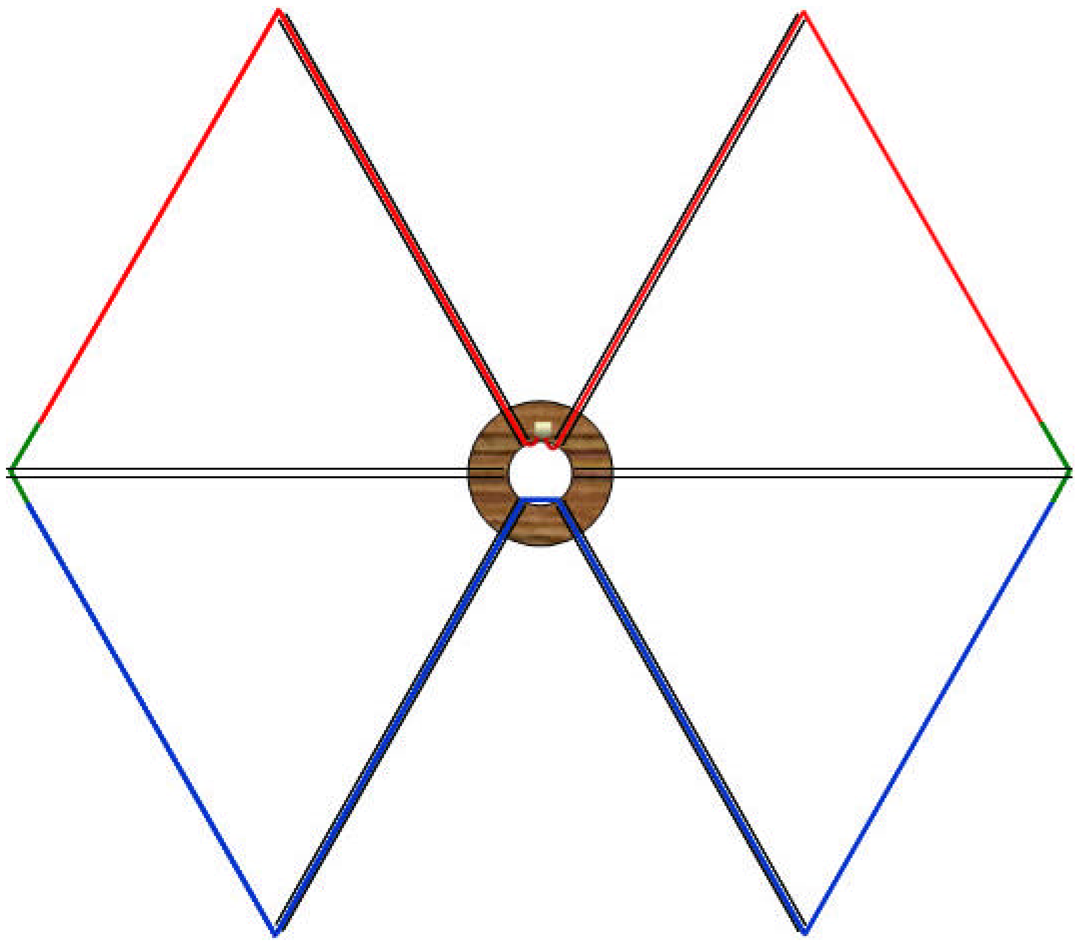
The following figure shows how the components go together. The driven element is shown in red, and the reflector is shown in blue. The end-insulators are green. Spreaders are pairs of black lines. Note that each element passes through two of the tubes. Construction is pretty straight-forward, but don't hesitate to go with your own improvements or modifications.

The disks for my hub were fly-cut from 4mm marine plywood. In fact, these were left-over material from drilling lightening holes in plywood wing ribs for an airplane project, so they were lying around in my scrap heap. It is also perfectly reasonable to cut a 6” to 7” hexagonal shapes out of a plywood sheet.

Use a hole saw or fly-cutter to put a 1.5" to 2.5" hole through the center of each disk. The hole only needs to be big enough for the mast to slip through.

Carefully lay out lines for the radials. Hexagons have the property that, an equilateral triangle is formed between every pair of adjacent radials at equal distances along the spreaders. Thus, the radius of the disk is the same length as the distance between pairs of radials on the outer perimeter of the disk. This little factoid makes the layout task easy. If *r* is the radius, measure six points along the outer circle that are length *r*. If you’ve done it right, a seventh mark will be right on top of the first mark.

The stiffening spokes serve the purposes of aligning and supporting the radials and adding strength to the hub. The height of the spokes should be equal to the outer diameter of the spreaders at the base.



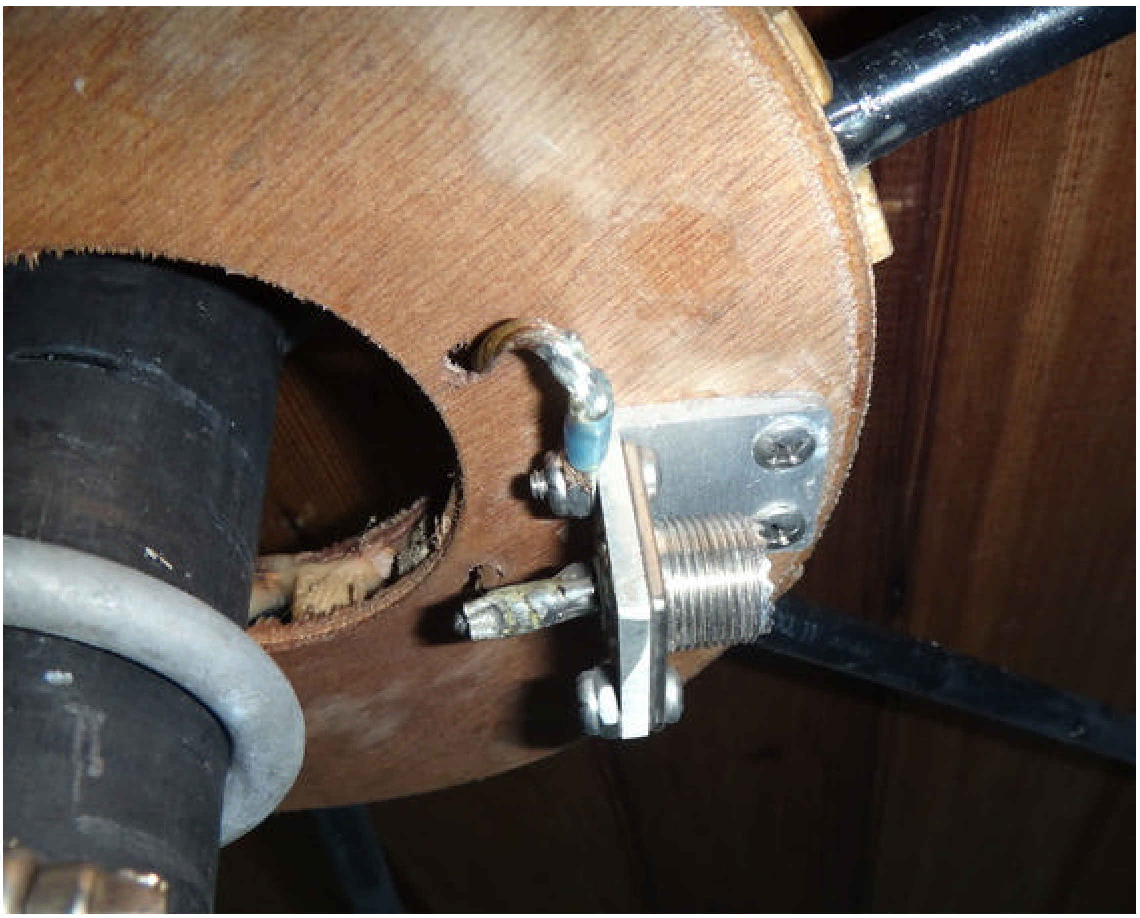
Place each spreader, in turn, and a place a pair of spokes on each side. Mark the outer spoke locations. When mark-up is complete, use a high quality epoxy to glue the stiffeners to one of the hub halves (see the hub photo above). You can glue the spokes in pairs, or all at once if you have enough clamps to keep everything in place. (I recommend clamps over using tacks.) Alignment is important—a couple of mm off at the hub translates to large errors at the distal ends of the spreaders.

If you use the same pair of fiberglass tubes that I did, cut all six pieces in half. The final spreader will consist of the larger tube glued into the hub, and the smaller tub slipped into and glued in position in the end of the larger tube. Glue the tubes together last, in order to take up any slack in the element assembly.

The next step is to glue the spreaders into the hub and glue the “cap” (other half of the hub) on.

After this, the wood components are assembled, so this is a good time to treat everything with spar varnish or the like. If you do this now, be sure to varnish any holes or cuts you make during the finishing steps.

Cut a driven element 10’ 2.79” (122.79”) long, and then cut it in half.



Cut the reflector to 10’ 7.8” (127.8”) long.

Cut two end insulators (parachute rope) to 3.43” long each, plus any extra length needed for tying knots and the like.

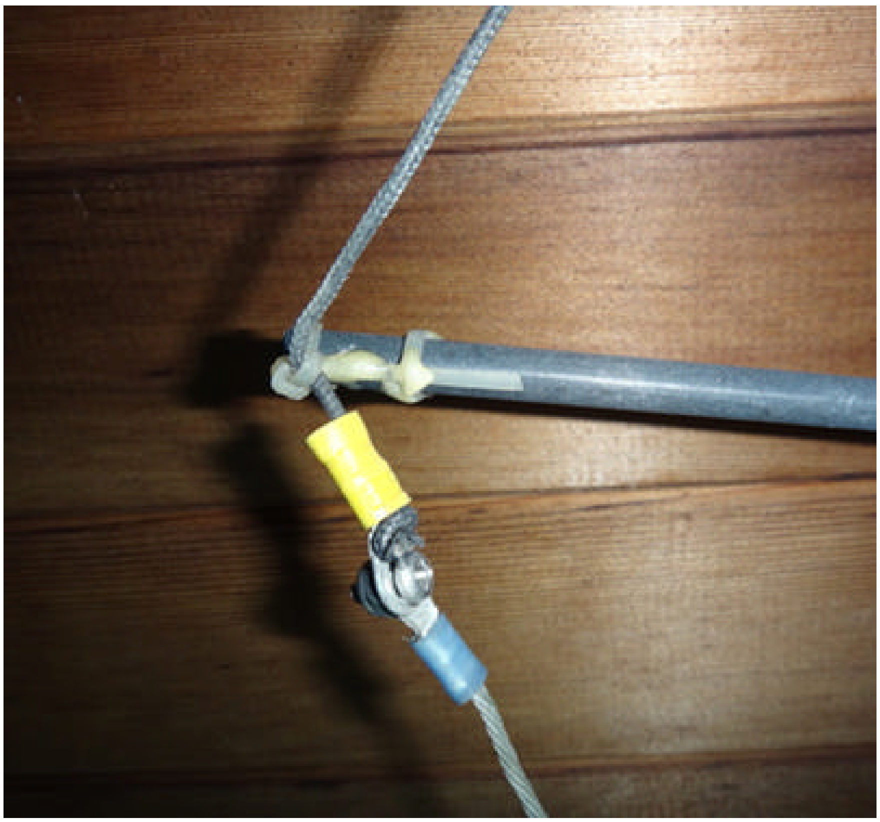
Nest the spreaders pieces and temporarily hold them in place with masking tape.

Now thread each wire through the opposite pairs of spreaders. I drilled a pair of small holes in the hub and fished through the driven element ends in order to keep the wire away from the mast (don’t forget to treat the edges of the hole with varnish). For the reflector, a couple of inches of heat-shrink tubing located right at the center does the trick.

Build a bracket out of aluminum to hold the SO-235 or N connector. I like using 1" aluminum angle. A step drill bit works very well for drilling the 5/8" center hole. Use #6 stainless steel machine screws with self-locking stainless nuts to connect the SO-235 to the bracket. I use countersunk stainless screws to mount the bracket to the hub.

The ground connection is made using a crimp ring terminal. Solder after crimping, but don't wick up too much solder into the wire. Connection of the wire to the center conductor of the SO-235 is done with the assistance of a butt crimp splice stripped of its plastic. The idea is to solder to wire into the center of the connector and solder the butt splice to the wire and the outside of the center conductor. This makes a robust connection that can withstand the vibration and stresses of roving.

Now that the elements are in place at their centers, connect the insulator between the end of the driven element and the reflector on each side. If you use ring terminals, take account of the length of the metal parts of the connectors in order to get the element lengths right. Spacing between the elements is critical.



I attach the insulator to the side spreaders in a way that allows them to break away. A small cable tie is put around a apex point on the cord. That cable tie is anchored to the end of the spreader with two more cable ties. A couple dabs of glue will anchor everything into place. This system will allow the element to break away from the spreader in the event it gets snagged on a branch. And it works quite well. I carry extra cable ties to facilitate field repairs.

At this point you should test the antenna with an antenna analyzer (or SWR meter) in a position (height above ground) similar to the intended use. If the resonant frequency is too low, trim the elements; too long, add length. The formula $length \times (f_{resonant}/f_{target} - 1)$ will tell you by how much. For negative values cut that much off, and for positive values add wire back on. In the formula, *length* is the current element length that resonates at $f_{resonant}$. Of course, f_{target} is the desired resonant frequency.

The last detail is a system to mount the hub to a mast. I used some larger (and overly thick) aluminum angle, one on top, one on the bottom. My brackets are a bit over-engineered for the task, but the material was on hand. Something substantially lighter would be appropriate.

In Practice

I've now used the antenna for an entire contest season, and it has worked extremely well. It has certainly allowed me to make more 6m QSOs in motion, sometimes into grids that I would have missed. And it has saved my bacon a couple of times, like during that Fall Sprint mentioned earlier. Or during the January 2014 VHF contest, when my rear rotor box quit working. I still set up the large array at stops, but I put up the front mast as well and used that for stations coming from "off directions." It saved me dozens of trips to the back of the truck to swing the rear mast by hand.

Remember that first June VHF contest that the antenna was built for? The first thing I noticed during the competition was an increase in 6m QSOs while in motion with the local "regulars". This doesn't necessarily help my score—I most likely would have worked them while stationary. But catching stations while in motion increases the chances of catching a transient operator. And catching stations while in motion shortens the time needed at a stop.

Here is a concrete example of where the hex beam really helped that June. I had just left a 3,200' spot in the relatively rare CN96. Just as I hit CN86, I heard AA7A calling from DM43 (Scottsdale, AZ). I quickly worked him in CN86 off the hex beam, turned the truck around and went back into CN96 to work him again. I'm sure I wasn't the only one with a big grin after that!

Sometime later I had just finished working out of the southeast corner of CN87 and was ready to move on to CN97. The rear mast had been lowered and secured when a brief sporadic E (Es) opening occurred to Montana. W7YM created an instant pile-up, with a couple dozen Seattle stations pouncing on his CQs. I turned the hex beam, sitting only 11 feet above the ground, in his direction and worked him on the second try, and continued on my way to CN97.

The next month, during the CQ WW VHF contest, I was driving on the same road through CN86 on my way to CN96. A Es opening to California ensued, and in the 10 minutes in transit, I made CW QSOs with four stations in DM14, three in DM03, and one locally. One of those QSOs was with my friend John, W6MU, who I had worked numerous times in HF contests. When I got to CN96, I worked 7 more stations in DM03, DM34, DM14, DM03, CM95 and a few locals off the hex beam before I took 5 minutes to set up the rear mast. John caught me on phone an hour later just to complement me on a great signal I had into Southern California.

The following day, something similar happened when I was driving between CN98 and CN97—again, I worked a bunch of Southern California stations (including W6MU again) off the hex beam, this time while going 55 MPH on a rural highway, in a north-south valley, and at no more than 300' above sea level.

Naturally, during an Es opening, it doesn't take a fantastic antenna to hop from Seattle to California or Arizona. Still, I had roved during plenty of contests with Es openings and made plenty of Es QSOs on beams. I don't recall ever making such a contact using a quarter wave vertical. That the first two contests after deployment yielded numerous in-motion DX QSOs seems telling.

The hex beam has been extremely useful in two of my high-elevation rover locations near the Washington-Oregon border. The Seattle metropolitan area is to the north, and the Portland metropolitan area is to the south. There is excellent “reach” into both locations, but it used to require a lot of antenna spinning. Now I put up both masts and point the antenna stacks in opposite directions. An antenna switch makes it easy to catch stations in both places, with minimal antenna aiming.

Closing thoughts

The hex beam is a simple, effective antenna for 6 meter roving. The antenna can be rotated in motion without exceeding the front vehicle overhang limits when mounted close to the front of the vehicle. The hex beam is extremely lightweight and is able to endure some punishment from low hanging vegetation. This gives it great flexibility for a rover station.

The antenna can be used as a primary 6m antenna in place of a moxon or yagi. Or it can be used as a second antenna for an in-motion stack of directional antennas.

I can imagine variants of this antenna for portable and mountain top expeditions, and grid dxpeditions—perhaps something that can fold up into a small package for hiking.

Appendix NEC file

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CM 6m classic hex beam by Darryl Holman.
CE
SY freq=50.15      'Design freq
SY len=32.91247    'Length of spreader from center
SY cl=1.374858     'Center hub radius, where reflector center stub is
SY dl=4.799041     'Radius from center where middle stub of driven is
SY rl=2.034063     'Driven end insulator length
SY sl=1.229595     'Reflector end insulator length
SY rad=0.03205     'Wire radius
SY elev=600 'Elevation in inches
SY sq3=3^0.5
GW  1      6      -dl/2   sq3*dl/2      elev    -len/2  sq3*len/2     elev    rad
GW  2      6      -len/2  sq3*len/2     elev    -(len-rl/2)    sq3*rl/2      elev    rad
GW  3      6      dl/2    sq3*dl/2      elev    len/2   sq3*len/2     elev    rad
GW  4      6      len/2   sq3*len/2     elev    len-rl/2       sq3*rl/2      elev    rad
GW  5      3      -dl/2   sq3*dl/2      elev    dl/2    sq3*dl/2      elev    rad
GW  6      6      -cl/2   -sq3*cl/2     elev    -len/2  -sq3*len/2    elev    rad
GW  7      6      -len/2  -sq3*len/2    elev    -(len-sl/2)    -sq3*cl/2     elev    rad
GW  8      6      cl/2    -sq3*cl/2     elev    len/2   -sq3*len/2    elev    rad
GW  9      6      len/2   -sq3*len/2    elev    len-sl/2       -sq3*sl/2     elev    rad
GW  10     1      -cl/2   -sq3*cl/2     elev    cl/2    -sq3*cl/2     elev    rad
GS  0      0      0.0254
GE  -1
LD  5      1      0       0      58000000
LD  5      2      0       0      58000000
LD  5      3      0       0      58000000
LD  5      4      0       0      58000000
LD  5      5      0       0      58000000
LD  5      6      0       0      58000000
LD  5      7      0       0      58000000
LD  5      8      0       0      58000000
LD  5      9      0       0      58000000
LD  5      10     0       0      58000000
GN  2      0      0       0      13     0.005
EK
EX  0      5      2       0      1      0      0

FR  0      0      0       0      50.150  0
EN
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