Building Antennas That Last!

Moderated By

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SEAPAC 2017

Building Antennas That Last!

We All Dream of
That Monster Array

Building Antennas That Last!

But the Reality is Often More Modest.

Building Antennas That Last!

And while this may seem like a great idea…

Building Antennas That Last!

Mother Nature is
The Great Equalizer!

Discussion Topics

- Avoiding Potential Failure Points
- Best Practices for Assembling Your Antenna
- Reinforcing Elements
- Back Braces (“Trusses”) for Your Beam
- Homebrew Element Mounts
- Homebrew Element Joints
- Homebrew Boom Splices
- Chip’s Tips

Avoiding Potential Failure Points

- Element Mechanical Failures
- Boom Mechanical Failures
- Electrical Breakdowns
- Design and Balun Surprises

Avoiding Potential Failure Points

Element Mechanical Failure is Caused By:

- **Poor joints between telescoping sections**
- **Incorrect taper schedule for telescoping elements**
- **Poor element mounts and/or hardware failure**
- **Insufficient reinforcing of elements, when needed**

Avoiding Potential Failure Points

Boom Mechanical Failure is Caused By:

- **Insufficiently robust boom design**
- **Insufficient reinforcement of boom at weak points**
- **Insufficient or improper boom bracing**

Avoiding Potential Failure Points

System Electrical Breakdowns May Include:

- **Hardware failures, including lack of weatherproofing**
- **Voltage-related breakdowns (California KW issues)**
- **Insufficient element stability (SWR and other issues related to varying spacing in wind, etc.)**

Avoiding Potential Failure Points

Other Surprises May Include:

- **Computer-generated design not same in real world**
- **Unforeseen interaction with antenna's environment**
- **Balun not working as expected—why?**

Best Practices for Building

- Use Stainless Steel Hardware. Period.
- Stainless Hardware must be treated properly or galling of nuts and bolts may occur.
- Proper lubrication of threads can virtually eliminate galling.
- All telescoping sections of aluminum must be lubricated to assist in assembly and disassembly, and to prevent water ingress that can compromise joint.
- After all testing is complete, all electrical connections must be sealed.

Best Practices for Building

Lubricants Are Your Allies; Use the Right Ones!

- **Noalox**
- **Penetrox**
- **Dow Corning High Vacuum Silicone Grease (*What?*)**

Noalox

- Anti-oxidant/Anti-seizing Compound.
- Reduces galling in SS parts.
- Suspended Zinc particles penetrate and cut Aluminum Oxide.
- Carrier medium seals out air.

Penetrox

- Anti-oxidizing compound
- Specified for aluminum to aluminum as well as aluminum to copper electrical connections.
- Also specified for telescoping aluminum tubing joints.

High Vacuum Silicone Grease

- Unmatched in sealing air out of telescoping tubing joints.
- Silicone nodules get out of the way when joint hardware is tightened.
- Maintains viscosity over long time.

Think about it: if your grease is making the connection, you have a problem!

Which Goo to Use?

- Noalox and Penetrox are great for stainless hardware.
- Silicone grease best for boom splices and telescoping joints.
- That said, Noalox and Penetrox do great for all applications.
- Silicone grease expensive.
  Noalox available at Home Depot.
  Penetrox available at Candy Store.

Protecting Feedpoint Connections

- First, wrap the feedpoint connection leads with electrical tape (half width works best). This reduces chance of water ingress and it reinforces the split to reduce chance of breakage.

Protecting Feedpoint Connections

- **Apply Liquid Tape over Feedpoint hardware, then cover entire area of feedpoint with GE Clear Silicone Sealant (available at Home Depot).**

Protecting Feedpoint Connections

The Liquid Tape helps secure hardware, seals air out of the connection, and is transparent to RF.

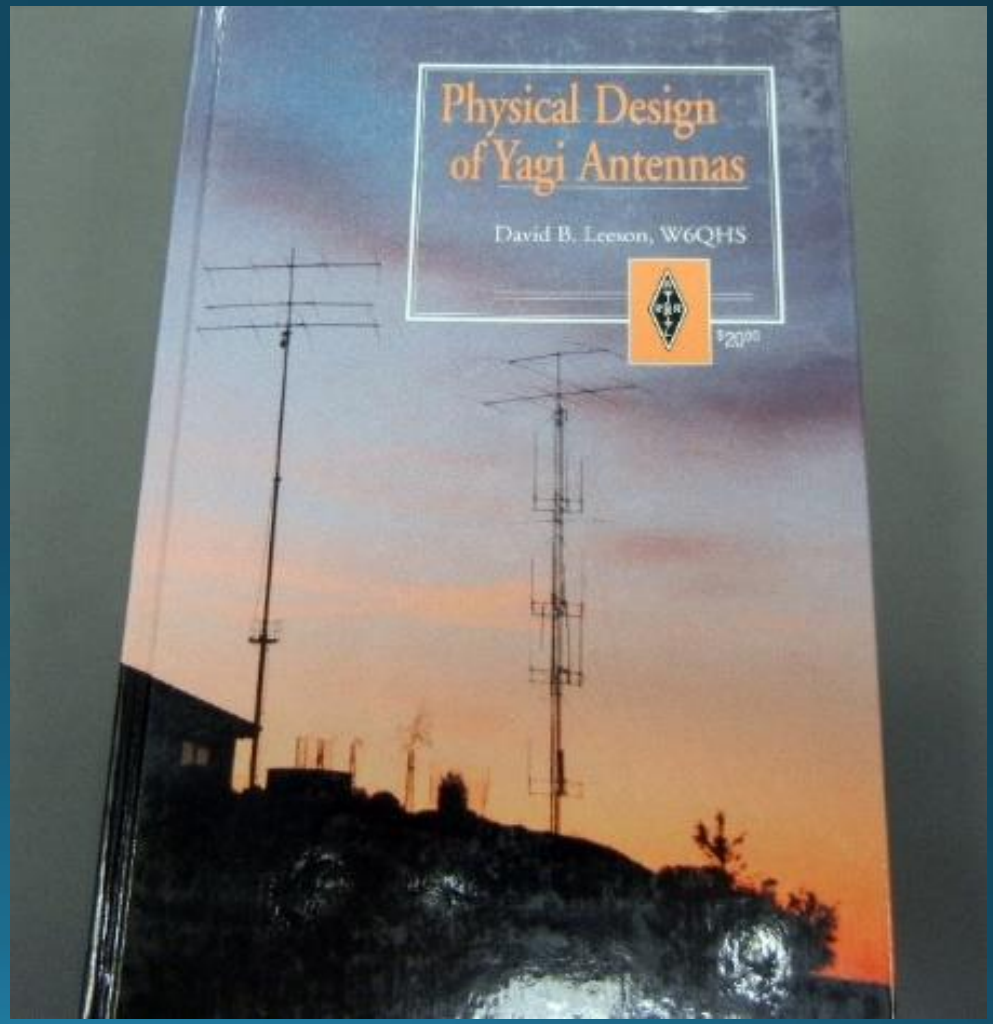
Taping Coax Connector Joints

- Wrap connection tightly with black electrical tape. Overlap half the width of the tape. If coax is hanging vertically, wrap from bottom to top. Tape 1” - 2” beyond connector.
- Apply coating of Scotchkote. Extend another 1” - 2” beyond end of tape.
- When Scotchkote is dry but tacky, apply another wrap of tape. This wrap bonds to the Scotchkote and will not become loose.

Making Robust Booms and Elements

The definitive text on how to build and/or reinforce a Yagi antenna is *Physical Design of Yagi Antennas* by Dr. David Leeson, W6QHS (now W6NL).

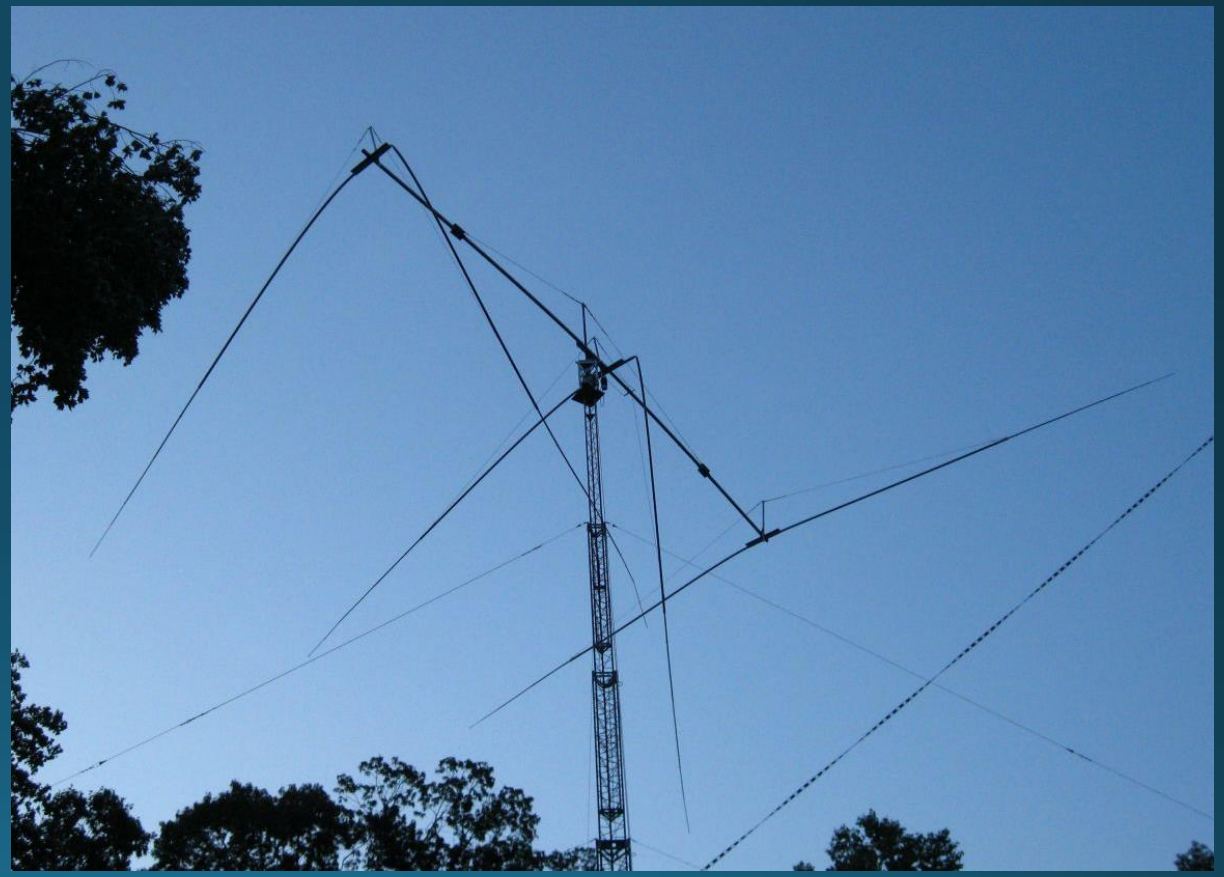
A rigorous treatment of the subject derived from First Principles, this book belongs in your library.



Making Robust Booms and Elements

- Leeson's book prevents things like this!

- Includes details of the only mechanical mods you should ever consider to a manufactured beam.



Supporting the Boom (Back Brace)

Some booms require a little support in order to survive…

Supporting the Boom (Back Brace)

There are four common types of boom bracing:

- Rigid support from below (underwire boom bra)
- Single support from above
- Dual side-stabilizing truss from above
- Single support from above with lower side supports

Supporting the Boom (Back Brace)

Potential dangers involved in boom bracing:

- Metallic truss cables can affect pattern and/or SWR.
- Insufficient elevation of upper guy—can put boom into compression, leading to failure.
- Stretching or slippage of guys under tension—reduces effectiveness of truss and looks sloppy.
- Some truss turnbuckle adjustments can be scary!

Dangerous Boom Truss

Back Brace center is too close to boom; a tight pull on cables will put boom into severe compression.

Suspicious Metal Boom Truss

Metal boom trusses are bad news. Look at interaction potential with the upper beam!

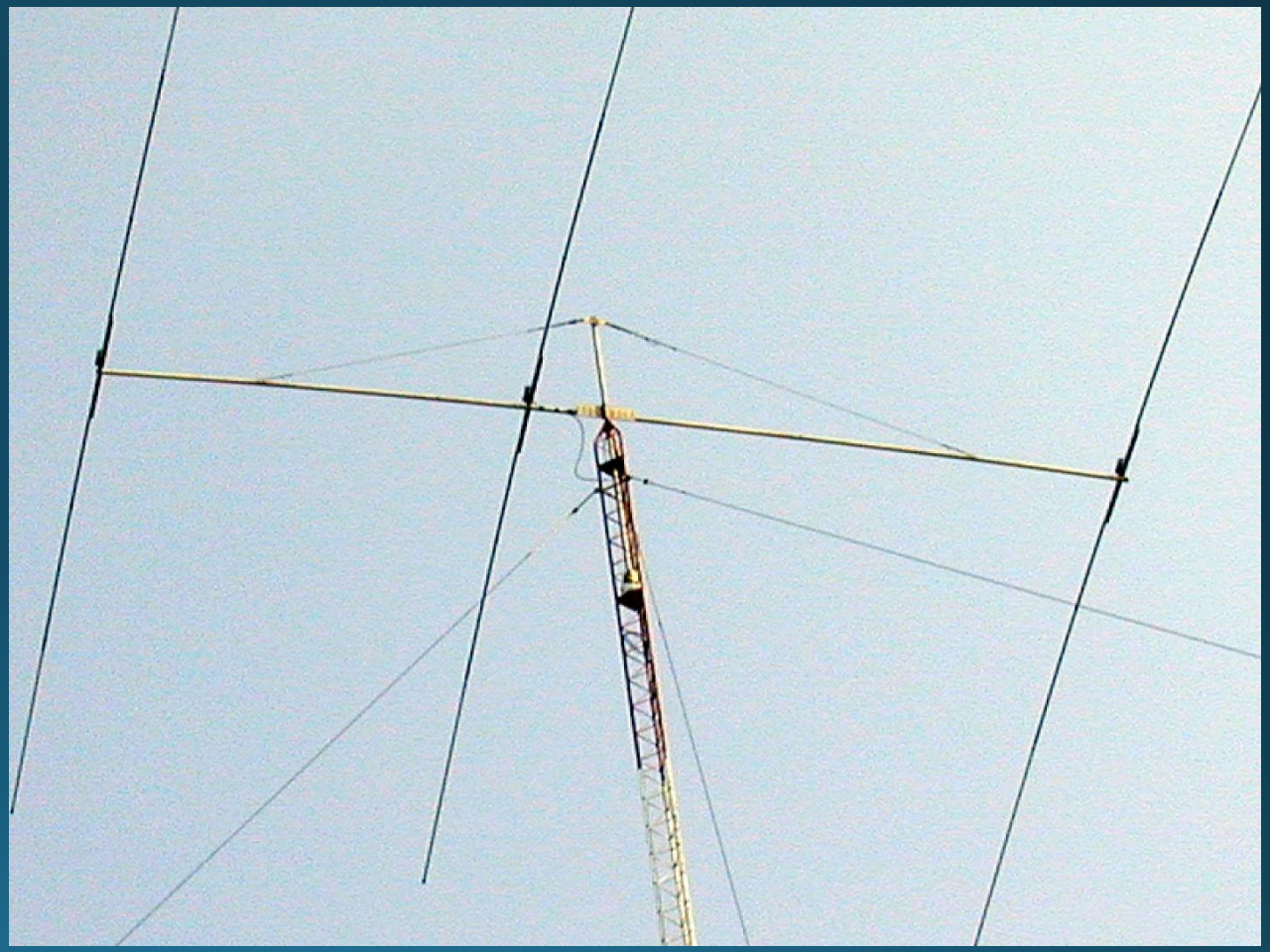
Supporting the Boom (Back Brace)

Tubing is sometimes used as a lower boom support. Seldom practicable below VHF-size beams.

Supporting the Boom (Back Brace)

Single upper support guys are often sufficient if boom is stout relative to its length.

Adjustment of turnbuckles not too scary.



Supporting the Boom (Back Brace)

For VHF and other light beams, a piece of angle aluminum or steel may be bolted to boom to mast bracket. Turnbuckles are hooked to eye bolt at top of angle brace.

Supporting the Boom (Back Brace)

Eye bolt fitted to boom serves as attachment point for top support.

Boo-boos in this technique will be shown next…

Supporting the Boom (Back Brace)

Doing the boom truss end the right way:

- **Use Eye Bolt as one of the bolts securing the boom splice.**
- **Put the Eye Bolt through the larger tube to do this!**

Supporting the Boom (Back Brace)

Upper double boom truss provides both vertical and horizontal stabilization.

Supporting the Boom (Back Brace)

Eye bolts mounted at ends of cross-arm allow precise setting of tension on boom guys.

Note: Your body is the hypotenuse of a triangle during turnbuckle tweaks. Like to hear the angels singing?

Supporting the Boom (Back Brace)

Nice upper double boom truss: Cross bar is high enough and wide enough to create good pulling geometry. Intermediate boom guys provide additional tweaking of boom straightness.

Supporting the Boom (Back Brace)

Chip's Favorite for long Booms: Three way Boom Truss.

Single upper support brace is augmented by side stays just below boom.

Homebrew Element Mounts

- Angle Aluminum from Home Depot with Stauff Insulating Clamps can provide a strong mount for Yagi elements.

- Note the position of the element center is marked to ensure accurate positioning.

Homebrew Element Mounts

- Larger “Guillotine” U-bolts will hold larger elements for 10-15 meters stoutly in place on 3” boom.

  Available from McMaster-Carr.

Homebrew Element Mounts

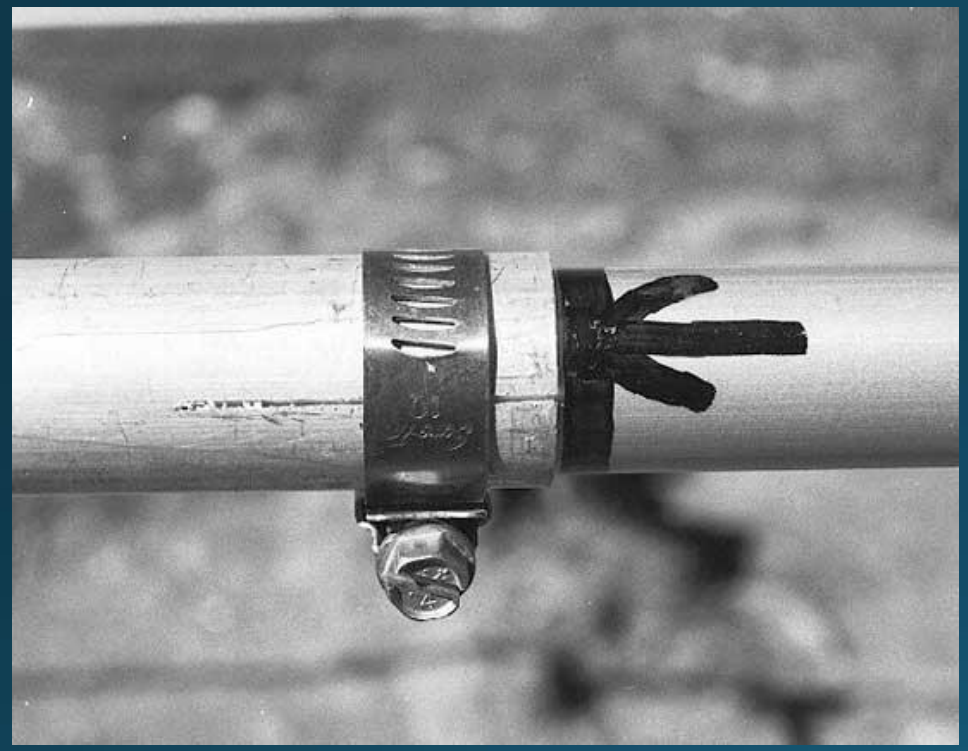
Capacitive coupling to angle aluminum and boom are minimal, and Stauff insulating clamps are invisible to RF.

Homebrew Element Mounts

These “Home Depot” element mounts kept these elements straight for five years.

Hated to take this beam down. But R.I.P 10 meters.

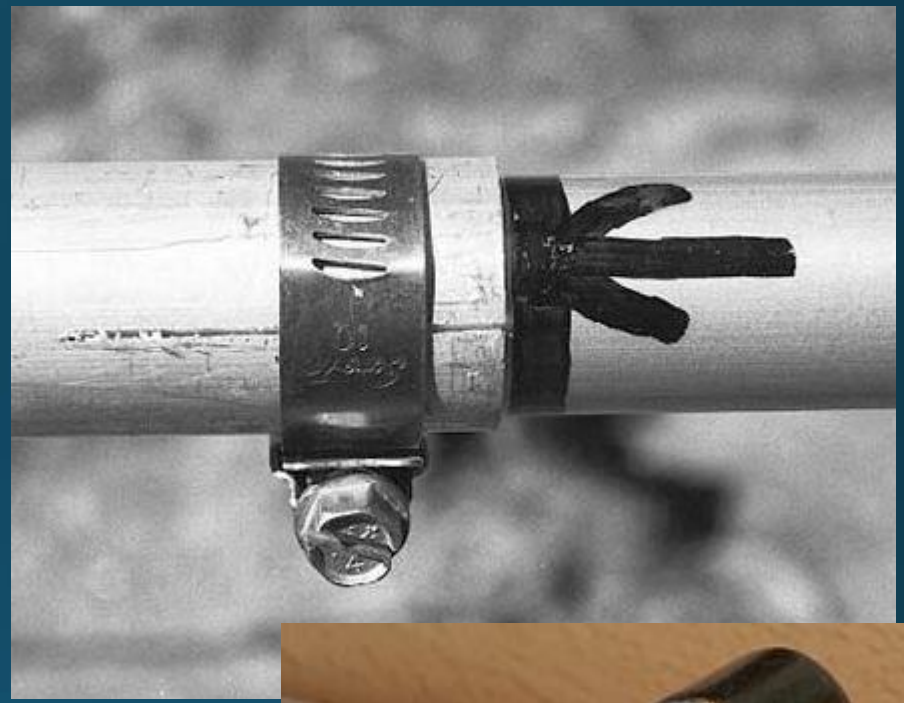
Joining Tapered Elements



Which method is best?

Joining Tapered Elements

- Slit tubing with hose clamp(s) provides complete pressure around smaller tubing; tends to keep water out well.
- Permits tweaking of element lengths during tuning.
- Can always be reinforced by screws or rivets.



Joining Tapered Elements

- Rivets: favored by Force 12 for years.
- Multiple rivets ensure good metal to metal connection.
- Doesn’t squeeze tubes.
- Needs good protection.
- Must use good rivets!

Joining Tapered Elements

- Bolts are stronger than rivets.
- Better for reinforced elements with multiple layers.
- Tends to squeeze tubes out of round. Bad.
- Requires good protection.

Joining Tapered Elements

- Before lubricating and joining element sections, gently polish the inner tube with a non-metallic scrubber (like Scotch-Brite™) or a fine grit sandpaper. Steel wool is not advisable, as it leaves very fine steel particles, which have a lower conductivity than does aluminum.

- If more than two hours have elapsed between polishing and mating of the sections, do it again. Oxidation can set in that quickly!

Joining Tapered Elements

Cardinal Rule: Don't change the joining method of a manufactured antenna.

Weatherproof it, as always, but go with what the engineers deemed to be necessary to meet their wind survival specifications.

Homebrew Boom Splices

Booms may be round or square, but for either type nuts and bolts will always provide a robust joining method.

Homebrew Boom Splices

- An inner sleeve, carefully cleaned and drilled, makes a very sound splice.
- Additional sleeves or a hardwood dowel may be further inserted to strengthen the joint.
- Lubricate everything!

Homebrew Boom Splices

Surprise: use *ROUND* tubing to splice *SQUARE* tubing in boom construction.

Homebrew Boom Splices

Round splice tube may be reinforced via inner sleeve(s).

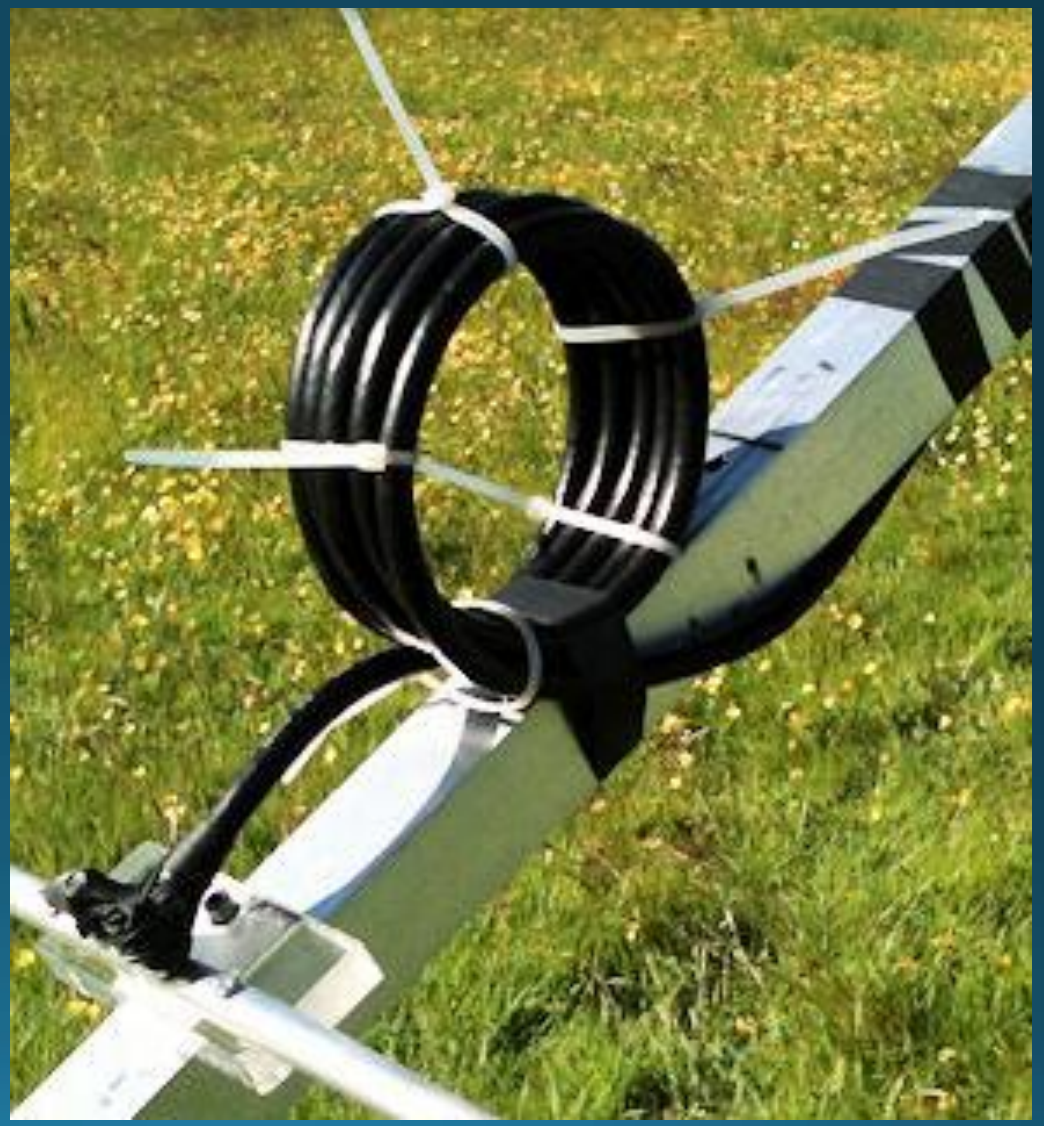
Reinforcing Elements (ala Leeson)

Make an element stronger at a stress point just as you reinforce a boom.

Don’t Mess Up Your Balun

Allowing choke balun coil to touch boom creates lower Impedance through insulation of coax.

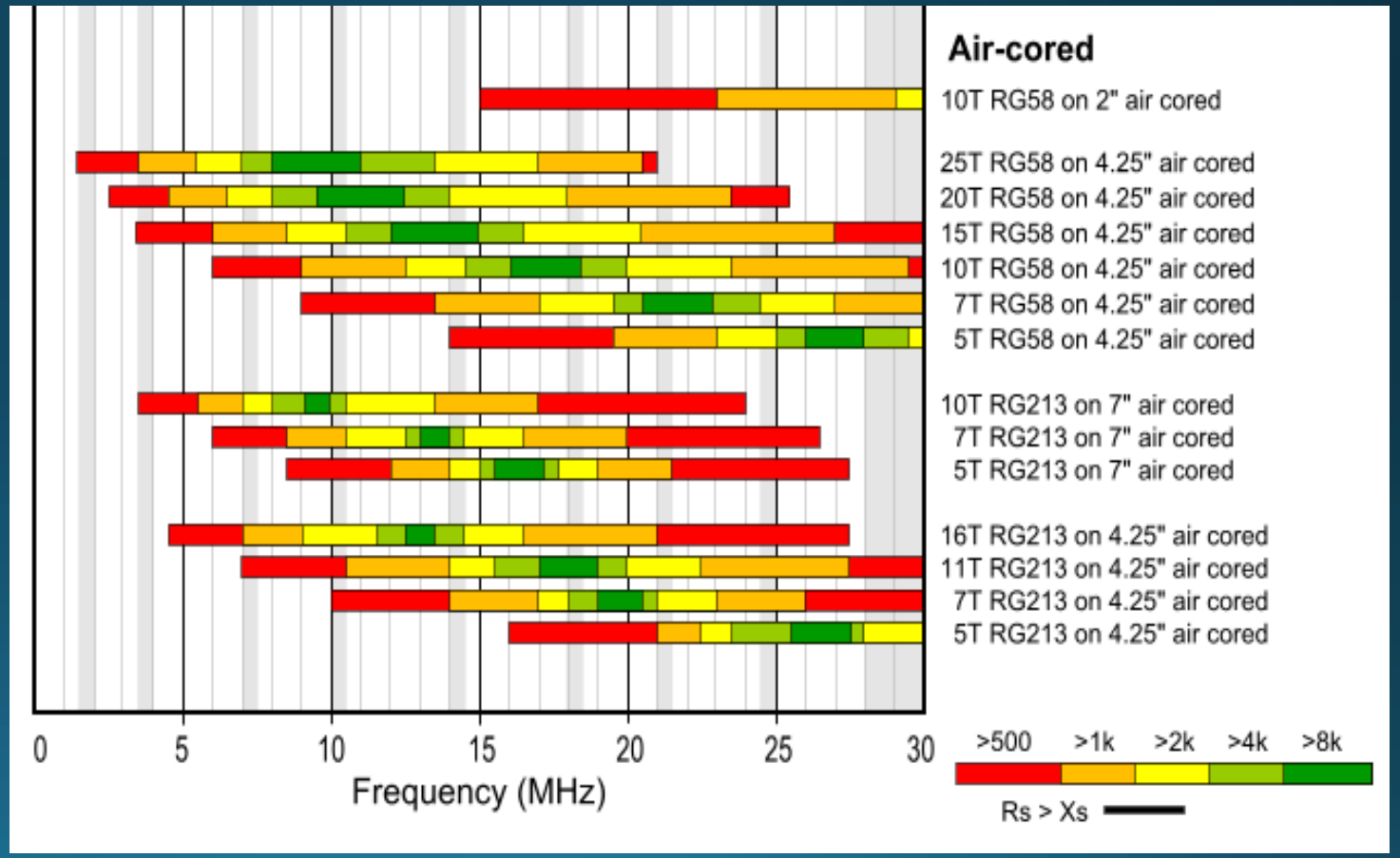
This shifts peak of choking action away from where you want it. Balun is not disabled, but is much less effective.



Don't Mess Up Your Balun

Float baluns off boom to preserve specified choking resonance!

G3TXQ Choke Balun Data



Don't Mess Up Your Balun

This Balun looks like it is improperly taped to the boom…but there is a flat rock between the coils and the metal boom, so Balun specifications are preserved!

Don't Mess Up Your Balun

Use the minimum possible length of pigtails from Balun; apart of the driven element total length!

If building a manufactured beam, follow the maker's recommendation for pigtail length—they (we hope) have included that in the design.

Chip's Tips

When designing your own beams using EZNEC or other *NEC2*-based software, beware of bent elements, especially the driver.

Pattern may come out OK, but feed impedance tends to show (false) positive *j*.

***NEC4* is fine, if you have it.**

Chip's Tips: Antenna Tuning

- It's always best to check beam performance with it mounted at least ½ wavelength high. If not possible, point it at the sky.
- If using a manufactured beam, look not just for SWR but for the shape of the SWR curve; you want it to match the shape and position of the dip shown in the beam manual.
- When tuning up a triband or multiband beam, start with the lowest frequency band first (usually 20m), as it will affect the other bands more than they will affect 20.
- Now check and, if necessary, tweak 15 meters, then 10 meters, then go back to 20 to ensure that interaction of adjustments hasn't upset the original 20-meter results. Interaction should be very slight.

Chip's Tips: Antenna Tuning

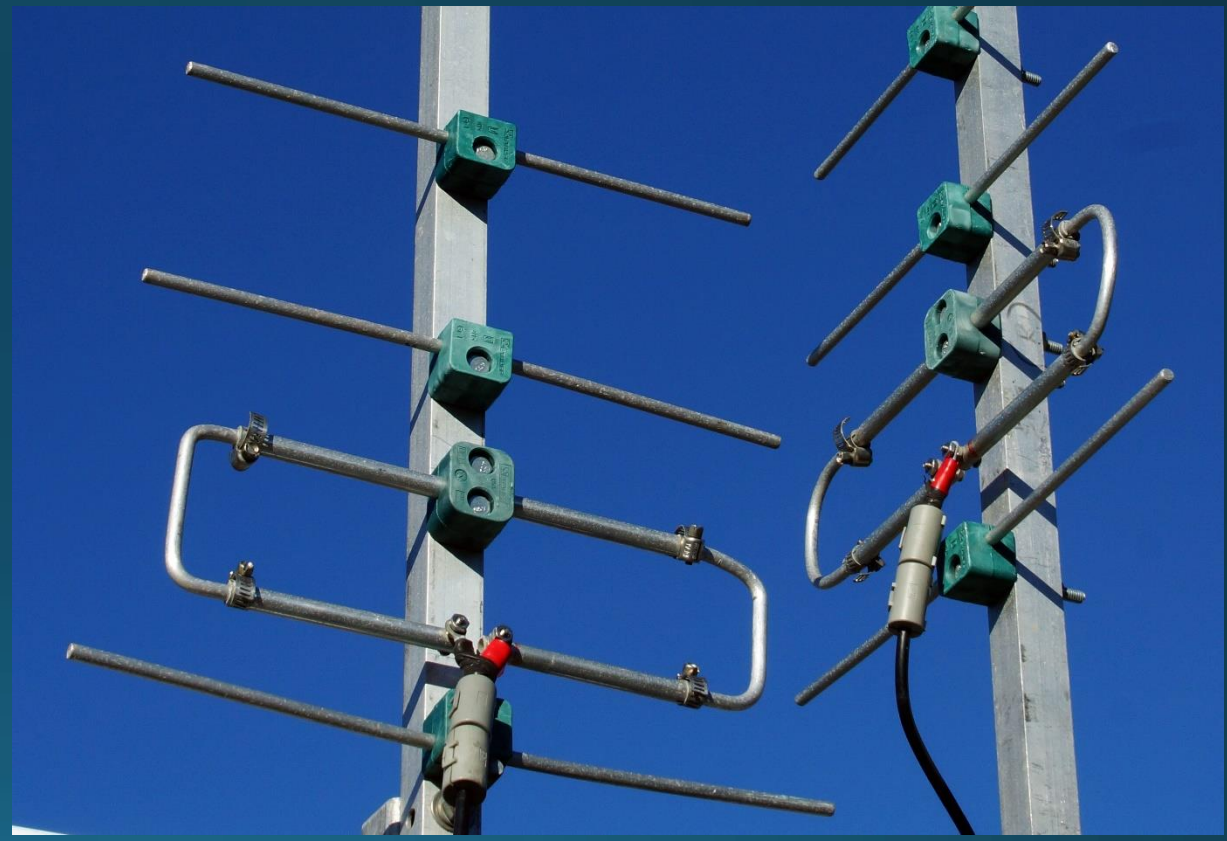
Pointing your beam straight up will nicely emulate its actual impedance once in the sky.

Works best if reflector end is sitting on a wood or plastic chair or empty cable spool.

Chip's Tips

Want to try Satellite Operation but not sure you'll like it?

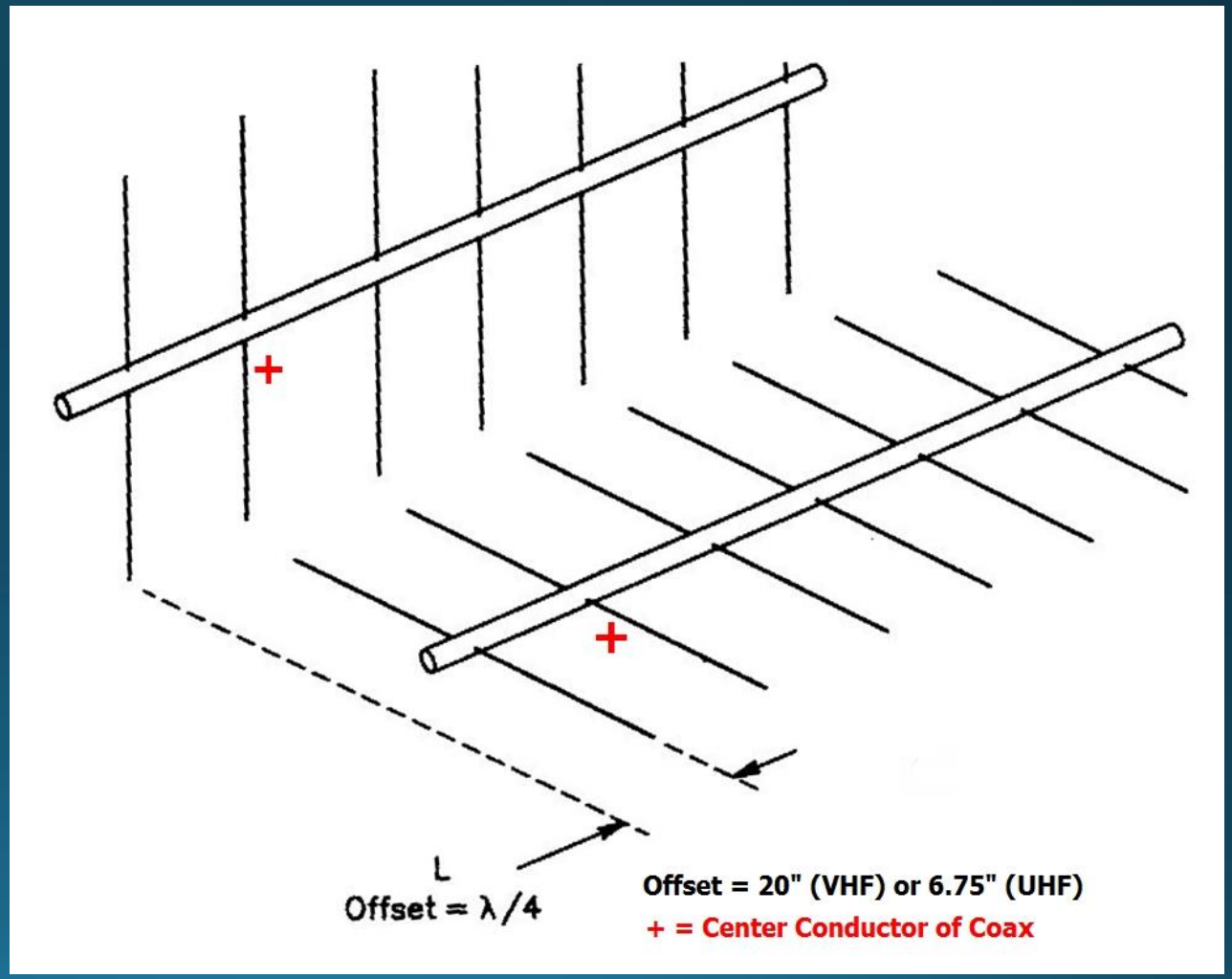
Use two existing beams, and offset them physically by ¼ wavelength and feed them in phase. Circular polarization (OK, elliptical) will be achieved!



Chip's Tips

Two inexpensive 2M Yagis, like Cushcraft 124WB, work great as a Satellite array. Then, for VHF Contests, stack 'em normally and use the same phasing cables!

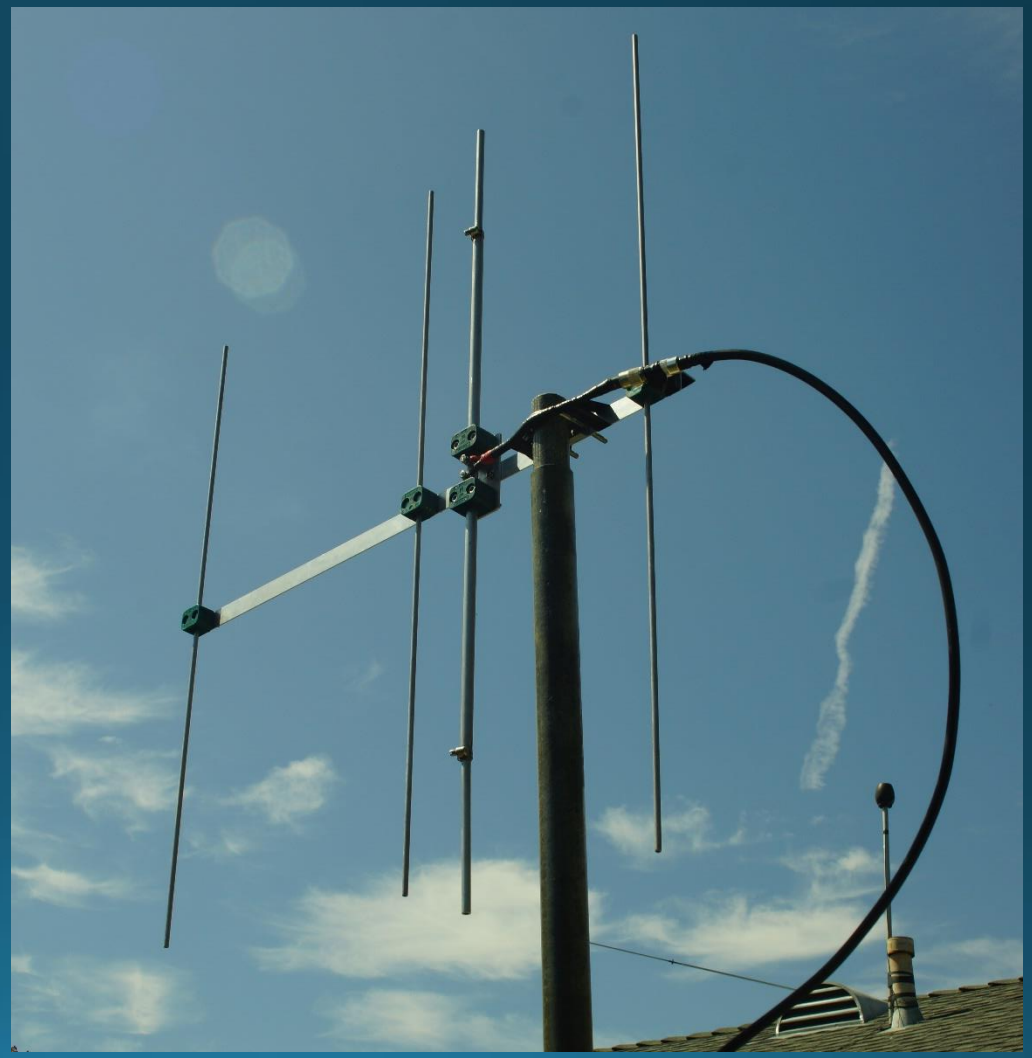
QST article later this year.



Chip's Tips

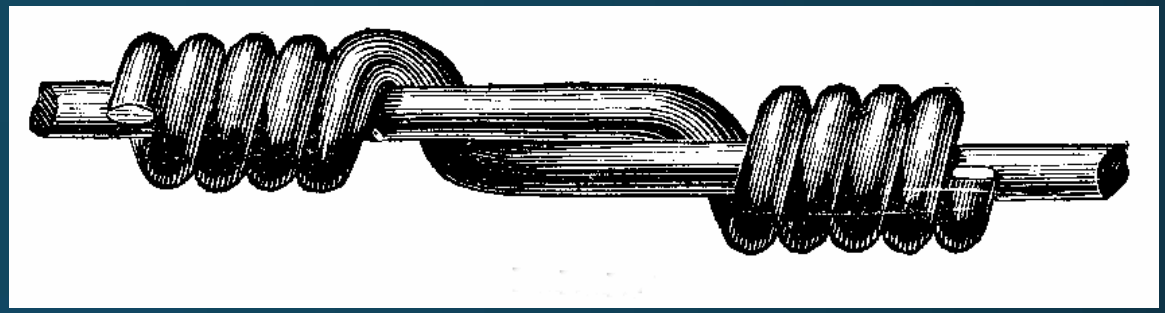
When installing a vertical or cross-polarized beam:

- **Use an insulated mast like fiberglass.**
- **Route the coax out the rear of the boom to avoid pattern degradation and SWR surprises.**



Chip's Tips

We haven't talked about wire antennas so far, but. . .



When splicing copper wire, after you've soldered it (or joined with a Nicopress tool), spray the joint with Krylon Clear Acrylic Spray (thanks: Don Wallace, W6AM)

Chip's Tips

Don't over-tighten Yaesu Rotator clamps—they are made of pot aluminum and will fracture if you over-tighten nuts.

Tighten until lockwasher is flat, and *no more*!

In Closing. . .

Building Antennas That Last!

Whether you're creating a monster. . .

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Or something more modest…

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There's no reason not to do it the right way!

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Be sure that rotator cables are de-energized before you work on them!

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Never *TILT* up
a *PUSH* up mast!

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Always use hardware that's big enough!!

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And, most importantly. . .

Go Huskies!!!