Tower, Antenna and Feedline Maintenance and Improvements

Improving the competitive performance and long term reliability of your tower, antennas and coaxial cables

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W3LPL

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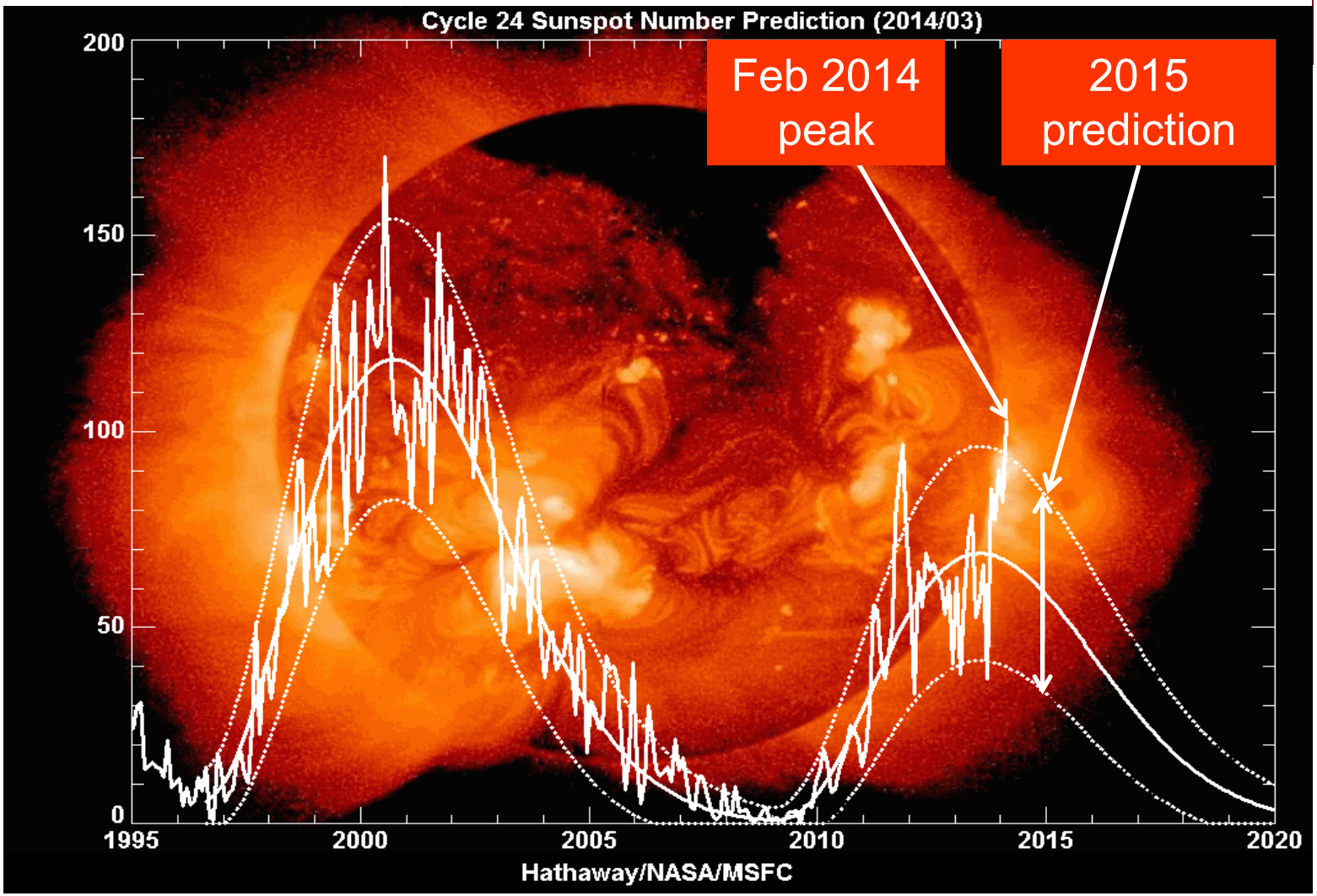
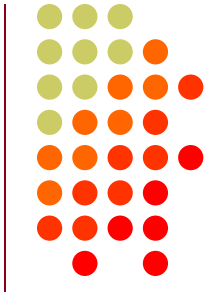
This is a Great Time to Improve and Maintain Your Antennas!



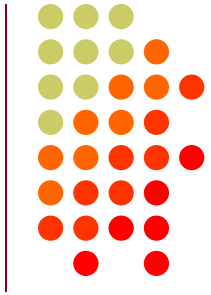
http://solarscience.msfc.nasa.gov/images/ssn_predict_l.gif

Improving the Competitive Performance of a Single Tower Station



- 50-60 foot tower and a small rotator (e.g., HyGain Ham-IV)
  - small tribander, Hex-beam or quad
  - 40 and 80 meter dipoles and a 160 meter inverted-L
- 70-80 foot tower and a medium rotator (e.g. HyGain T2X)
  - Cushcraft XM-240 two element 40 meter Yagi
  - large tribander such as the SteppIR 4 element Yagi
  - 80 meter dipole and a 160 meter inverted-L
- 100-140 foot tower and a large rotator (e.g., M2 Orion)
  - Cushcraft XM-240 two element 40 meter Yagi
  - monoband Yagis such as the HyGain LJ series on ring rotators
  - 80 meter dipole and a 160 meter inverted-L

Improving the Competitive Performance of 10 Meter Antennas

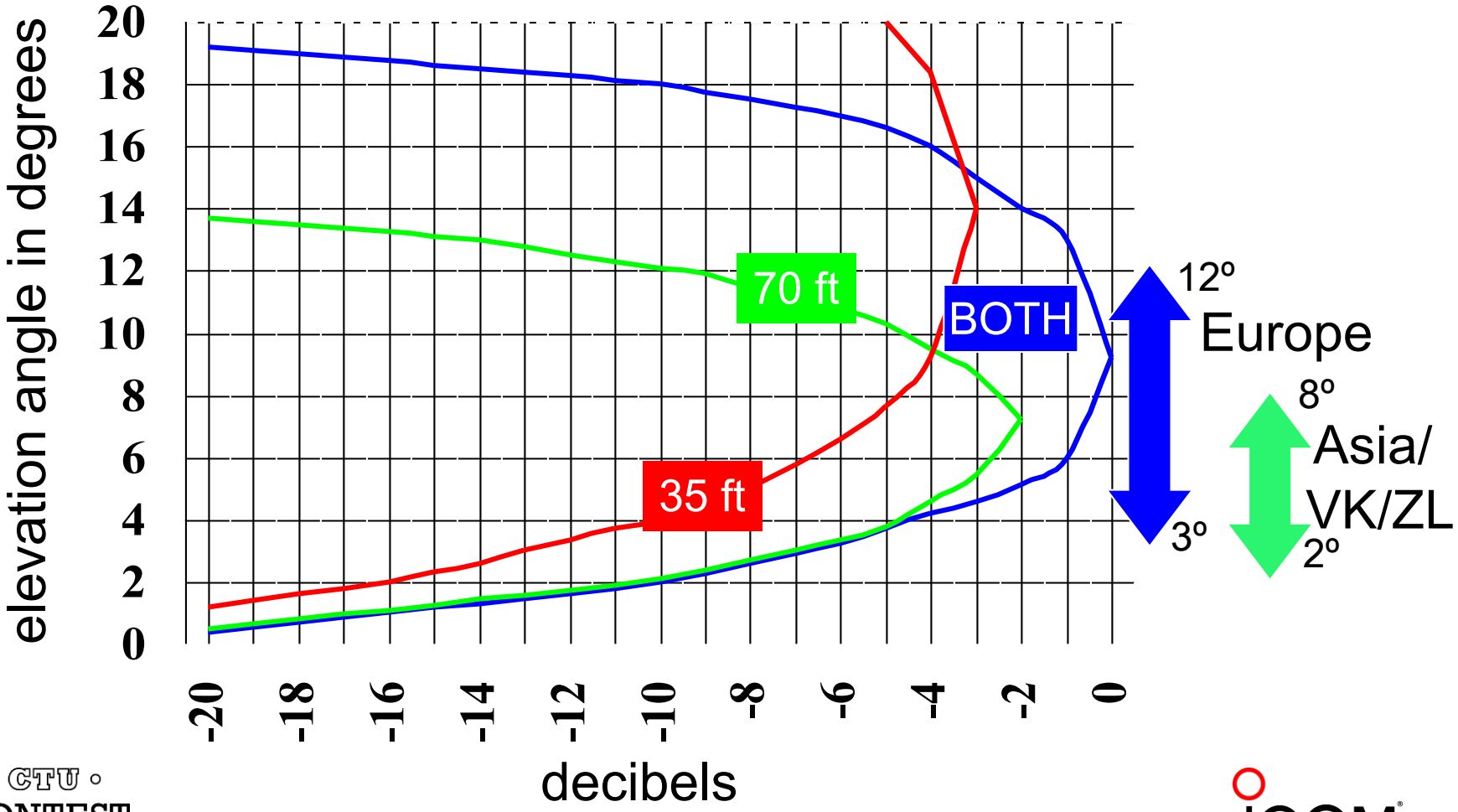


- Horizontal polarization is always your best choice
  - if you can install your antenna only 25 feet high or higher
  - otherwise use a four-square vertical array with extensive radials
- Moderate gain: a tribander, small Yagi, Hex-beam or quad
  - a small Yagi 25-50 feet high will produce good results
  - a small Yagi at 30-50 feet high for Sweepstakes and Field Day
- High gain: a full size tribander, small monoband Yagi or quad, at 50-70 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 60-70 foot tower (or 90-120 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

Stacked 6 Element 10 Meter Yagis

36 Foot Booms

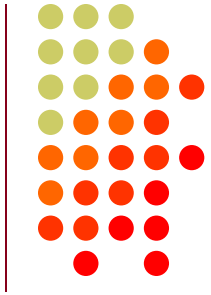
35 and 70 Feet High



The Array Solutions Stack Match

www.arraysolutions.com/Products/stackmatch.htm

Improving the Competitive Performance of 15 Meter Antennas

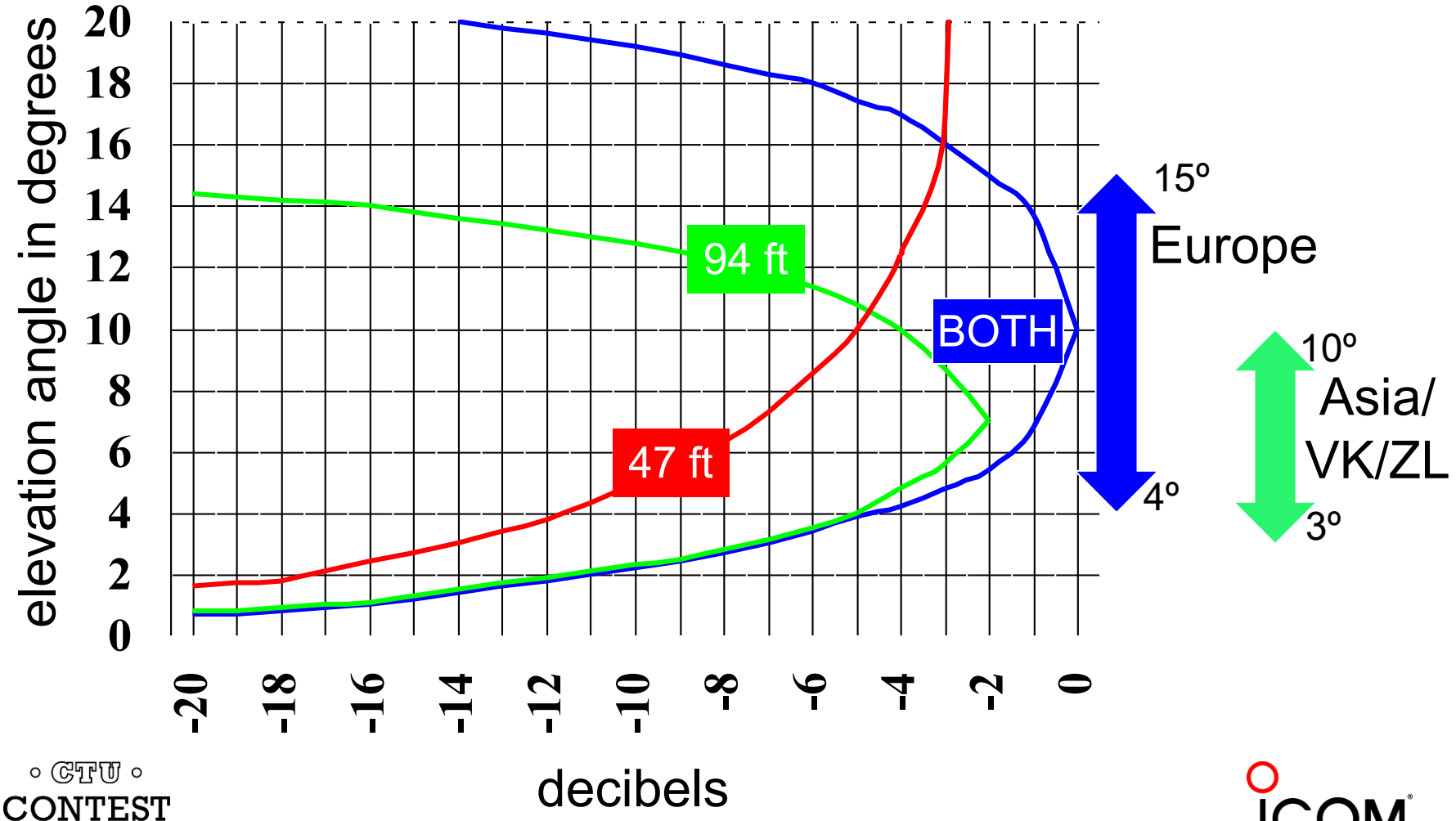


- Horizontal polarization is always your best choice
  - if you can install your antenna 35 feet high or higher
  - otherwise use a four-square vertical array with extensive radials
- Moderate gain: a tribander, small Yagi, Hex-beam or quad
  - a small Yagi at 35-50 feet high will produce good DX results
  - a small Yagi at 35-50 feet high for Sweepstakes and Field Day
- High gain: a full size tribander, small monoband Yagi or quad at 70-90 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 80-100 foot tower (or 120-140 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

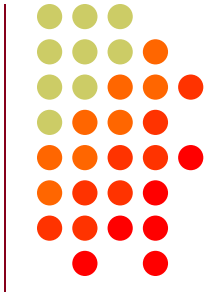
Stacked 6 Element 15 Meter Yagis

48 Foot Booms

47 and 94 Feet High



Improving the Competitive Performance of 20 Meter Antennas

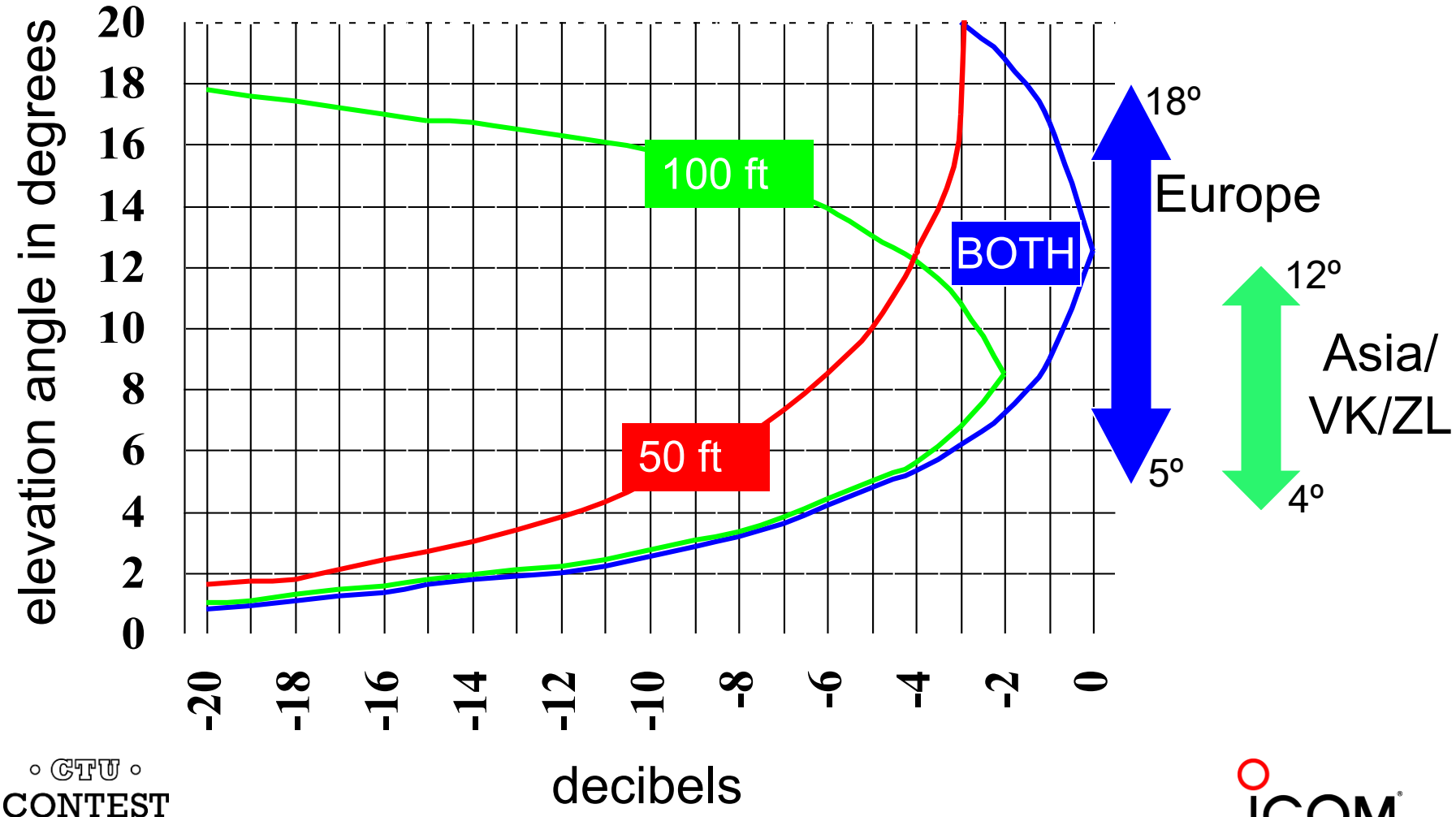


- A horizontal Yagi or quad is always your best choice
  - if you can install your antenna 50 feet high or higher
  - otherwise use a four-square vertical array with extensive radials
- Moderate gain: a small tribander, Yagi, Hex-beam or quad
  - a small Yagi at 50-70 feet high will produce good DX results
  - a small Yagi at 40-50 feet high for Sweepstakes and Field Day
- High gain: full size triband Yagi, small monoband Yagi or a quad at 70-100 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 100-140 foot tower (or 170-200 feet high for three stacked Yagis)
  - stack switching (a “stackmatch”) provides high payoff at low cost

Stacked 5 Element 20 Meter Yagis

48 Foot Booms

50 and 100 Feet High



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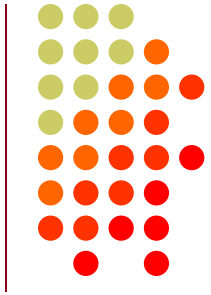
Improving the Competitive Performance of 40 Meter Antennas

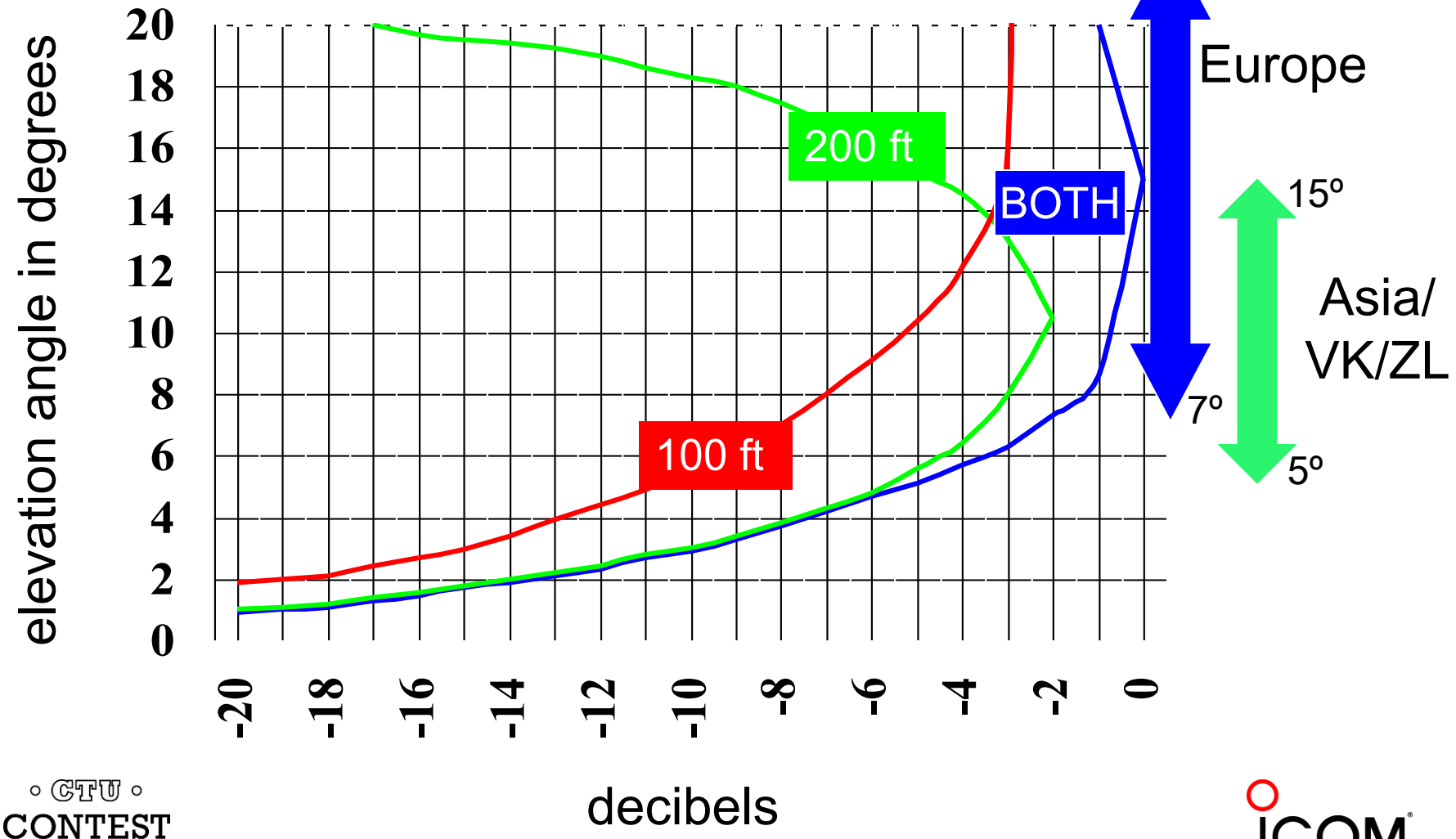


- High horizontal dipole at least 70 feet high for DX contests
  - otherwise use a four-square vertical array with extensive radials
  - a dipole at 35-50 feet high for Sweepstakes and Field Day
- Higher gain: 2 element Yagi at 70-100 feet high
  - significant improvement over a simple horizontal dipole for DX
  - a Cushcraft XM-240 at 70-100 feet high is very cost effective
    www.cushcraftamateur.com/Product.php?productid=XM-240
- Highest gain: full size 3 element Yagi at 100-140 feet high
  - but don't underestimate the high cost and complexity of the effort !
- High performance receiving antennas
  - Beverages and arrays of short verticals

Stacked 3 Element 40 Meter Yagis

48 Foot Booms

100 Feet and 200 Feet High



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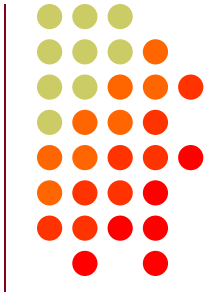
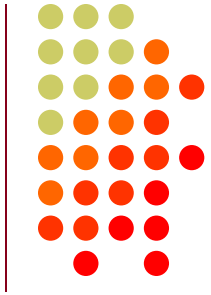
Improving the Competitive Performance of 80 Meter Antennas



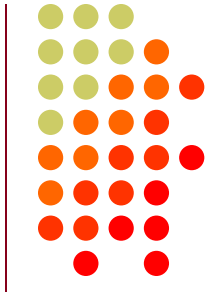
- High horizontal dipole, at least 70 feet high for DX contests
  - 50-70 feet high for Sweepstakes and Field Day
- A single full size vertical or a vertically polarized delta loop
  - well separated from all nearby tall towers
    - at least 70 feet from nearby towers over 40 feet tall
    - much more than 70 feet of spacing optimizes performance
- A short inverted-L or T-vertical is a very good alternative
  - as little as 25 feet tall
  - supported from a tower or trees
- Use at least 32-64 shallow buried radials
  - at least 70 feet long, or
  - at least two (but preferably four or more) elevated 65 foot radials
    - but only if buried radials are impossible

Improving the Competitive Performance of 160 Meter Antennas



- A single full size vertical or a vertically polarized delta loop
  - well spaced from all nearby tall towers
    - at least 140 feet from nearby towers over 80 feet tall
    - spacing much more than 140 feet optimizes performance
- A short inverted-L or T-vertical is a very good alternative
  - as little as 50 feet tall
  - supported from a tower or trees
- Use at least 32-64 shallow buried radials
  - At least 130 feet long
  - or at least two (but preferably four or more) elevated 125 foot radials
    - but only if buried radials are impossible

4-Square Vertical Array for 80 and 40 Meters



- A four square vertical array is very competitive with very high horizontal Yagis and quads on 80 meters and is also an excellent receiving antenna
  - install at least 70 feet from all other towers
    - more spacing will significantly improve its performance
  - at least 30-60 slightly buried radials under each vertical
    - at least 70 feet long on 80 meters
    - at least 35 feet long on 40 meters

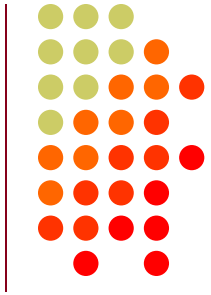
The Comtek 4-Square Controller

www.dxengineering.com/search/brand/comtek

Receiving Antennas for 160 and 80 Meters

- What happened to the Beverages at K3LR and W3LPL?
  - Large arrays of short verticals with performance similar to a five element Yagi
- High performance 4-square receiving antennas in a small space
  - Significantly better performance than Beverages
- See the separate receiving antenna presentation by W3LPL at this years Contest University

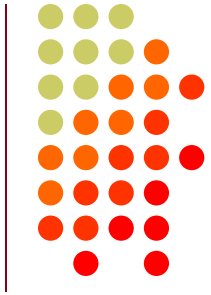
Coaxial Cables Can Make or Break Competitive Performance



- How well you select, install, waterproof and maintain your coaxial cables and connectors can make or break the competitive performance of your contest station

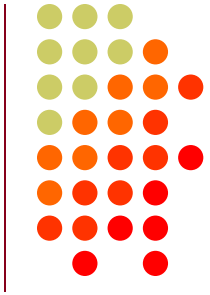
- Cross-station interference in multi-operator and SO2R stations is often caused by
  - inappropriate coaxial cable
  - inappropriate or incorrectly installed connectors
  - loose connectors
  - improper installation practices such as bundling cables
  - failure to perform annual inspections

Improving the Competitive Performance of Coaxial Feedlines



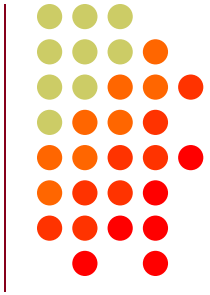
- Coaxial cable loss, proper connector and cable installation and annual inspections are the most important concerns
  - Andrew LDF4-50A 50 ohm Heliax and connectors are commonly available at hamfests and eBay for ~ $1.00/foot
    - Less than 1 dB of loss on 10 meters for lengths up to 300 feet
  - If flexible coaxial cable must be used on your tower, Davis RF Bury-Flex is an acceptable alternative for single operator stations only, at about the same price
    - Never use any other type of foam dielectric flexible coaxial cable
  - Non-flooded coax such as RG-213 and LMR-400 has a short service life in the harsh environment of a tower
    - Never use for direct burial or laid on wet ground

Improving the Competitive Performance of Coaxial Cables for SO2R and Multi-Op Stations



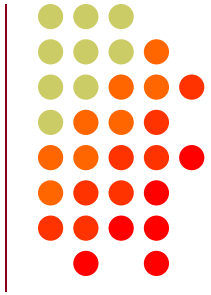
- Andrew LDF4-50A Heliax is an ideal choice for lengths up to
  - 300 ft on 10 meters, 400 ft on 20 meters, 600 ft on 40 meters
- Eliminating common cross-station RFI sources:
  - Use Heliax to avoid RFI caused by the dissimilar metals in the aluminum foil and tinned braid shields of Davis RF Bury-Flex cable
  - Signal coupling between RG-213 single braid shielded coaxial cables when they are bundled or run together in conduits
  - Never use nickel plated connectors and adapters
  - Install connectors properly
  - Minimize the use of connectors and adapters as much as possible
    - use only brand name silver plated connectors and adapters

Improving the Competitive Performance of Coaxial Cables for Multi-tower Stations



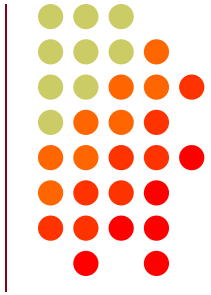
- Coaxial cables longer than 300 feet are often used in multi-tower stations
  - Andrew LDF5-50A Heliax is an ideal choice for lengths up to
    - 600 feet on 10 meters
    - 700 feet on 15 meters
    - 900 feet on 20 meters
    - 1200 feet on 40 meters
- Be cautious of the windload and weight (including ice load) of large Heliax cables mounted on towers

Coaxial Cable Inspections



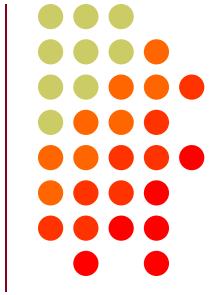
- Inspect all indoor and outdoor coaxial cables, connectors and waterproofing for evidence of damage, cuts, cracks, moisture intrusion or improper installation
  - antenna feedpoint connection (wear and water intrusion)
  - antenna rotation coaxial cable (chaffing and wear)
  - tower top connectors and bonding to tower
  - tower base connectors and bonding to tower
  - all coaxial cable connectors in your station
  - all SO-239 chassis connectors on equipment in your station
  - if in doubt, remove the connector for detailed inspection
  - verify that all indoor and outdoor connectors are wrench tight
    - ¼ turn

Selecting and Maintaining Low Loss Coaxial Cables



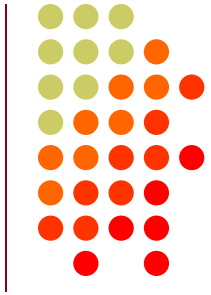
- Select appropriate low loss coaxial cables for each antenna
- Preserve your investment
  - water and moisture entry is a persistent threat
- Hard-line (e.g., Heliax or 75 ohm CATV) coaxial cables are the best choice for cable runs longer than 100 feet
  - RG-213 and other flexible jacket coaxial cables are very susceptible to physical damage and water entry
    - a pin hole can quickly cause a high loss cable
    - carefully protect your coax cables from physical damage and water entry
- Preserving long term performance
  - test and inspect your cables and connectors annually

Maintaining the Competitive Performance of your Antennas



- Annual inspections are the most effective step you can take to maintain the competitive performance of your tower, antennas and feedlines
  - the environment continually attacks and degrades tower, antennas and coaxial cables
  - degradations are often gradual and not noticed for years
  - inspections can help avoid unplanned mid-contest and mid-winter emergency repairs

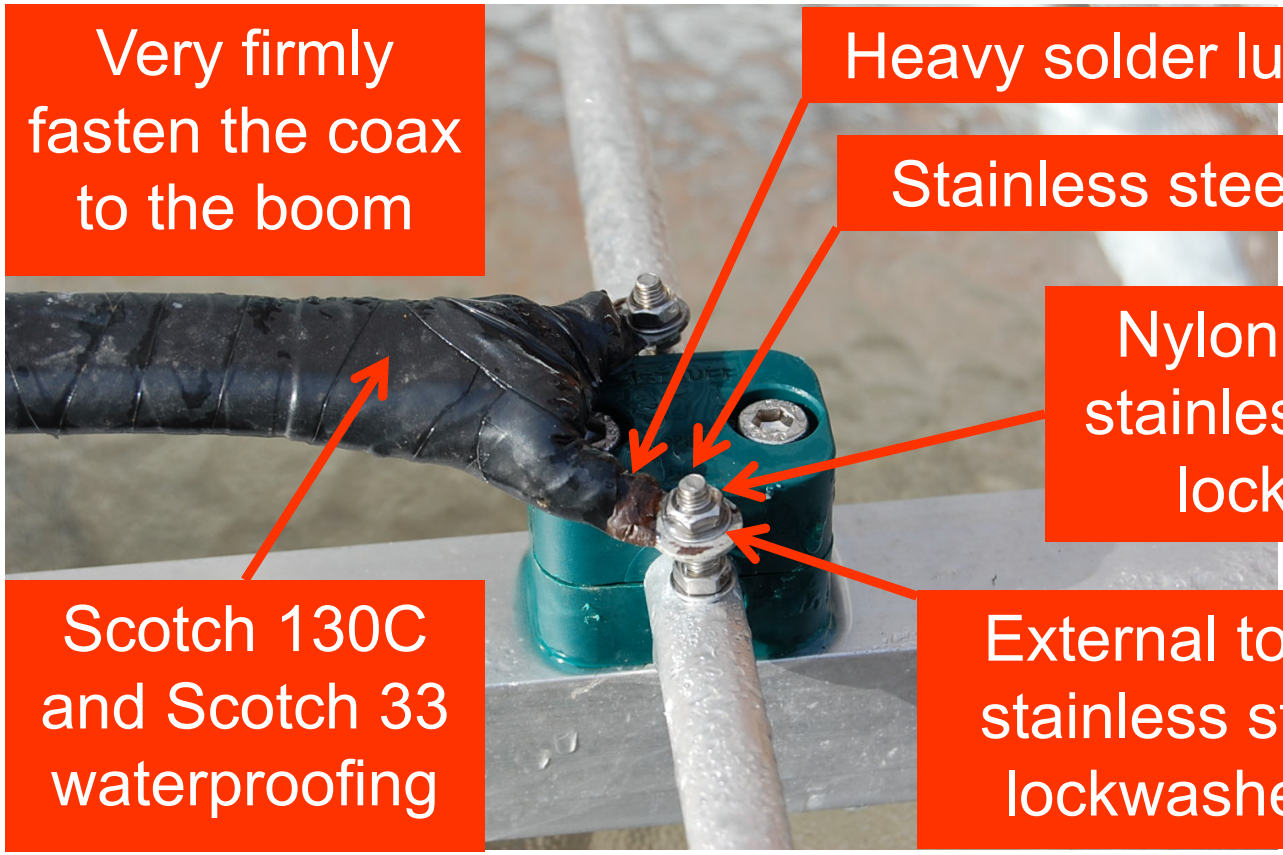
Antenna Performance Measurements Inside Your Shack



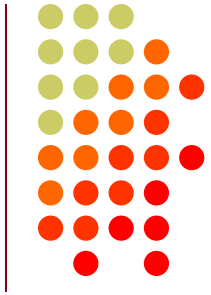
- Immediately after installation, make a record of the following measurements at the hamshack end of every coaxial cable:
  - VSWR across the entire band(s)
  - Coaxial cable resistance
    - typically either a fraction of one ohm or many megohms
  - TDR and/or VNA plots
    - you should own at least one of these excellent tools!
- Well before your next competitive contest, repeat your measurements on every coax and verify that your measurements:
  - have not changed relative to your records
  - are not erratic
  - any change (better or worse) requires detailed investigation

Antenna Feedpoint

Waterproof and Shakeproof Connections

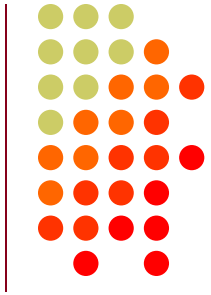


Antenna Rotation Coax Cable Installation and Inspection



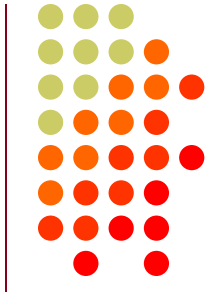
- Your antenna rotation coaxial cable is exposed to the most extreme environmental conditions in your station
- Carefully prevent the coax from rubbing or pulling against the tower or any other objects that could damage the coax jacket
  - rotators with more than 360 degrees of rotation make this extremely difficult to achieve
- Name brand, high quality RG-213 is a good choice
  - 95% shield, stranded center conductor, solid dielectric
  - black UV-resistant jacket
- Replace the coax whenever you discover abrasion or damage during annual inspections
- Replace the antenna rotation coax at least once every ten years

Coaxial Cable Installation on your Tower



- Wind, ice, water, condensation, heat, cold, ultra-violet radiation and lightning strikes are important concerns
  - If any of these concerns are unusually severe in your environment, implement additional protective measures
- Heliax and CATV hardline must be firmly fastened to the tower at least every to five feet to protect them from wind and ice damage
- Flexible coaxial cables (e.g. RG-213) should be firmly attached to the tower at least every two or three feet to protect them from wind and ice damage
- Use electrical tape to cover plastic tie-wraps to protect them from ultra-violet radiation

Improving the Reliability of Coaxial Cable Connectors



- N and UHF connectors are the most common choices
- Insignificant loss in both N and UHF connectors at HF
- Insignificant difference in the VSWR of N and UHF connectors at HF
- High quality silver plated UHF connectors provide much more center pin mating force than N connectors
  - eliminates cross-station interference and connector failures from frequently unreliable N connector center pin mating force
  - avoid saving a few dollars on cheap unbranded hamfest connectors
- Avoid use of adapters, but if necessary be sure they are name-brand silver plated adapters, not nickel plated
- Always use a wrench to tighten UHF connectors 1/4 turn

Coaxial Cable
Amphenol 83-1SP PL-259 Connector

Shell labeled exactly:
Amphenol 83-1SP

Silver Plated
Center Pin

Silver Plated
Body

Mouser Electronics part number 523-831SP

http://www.mouser.com/MobileCatalog.aspx?page=1369

This is not the place to save money

High Reliability Coaxial Cable 83-1SP Connector Installation

www.k3lr.com/engineering/pl259

An unconventional but superior method

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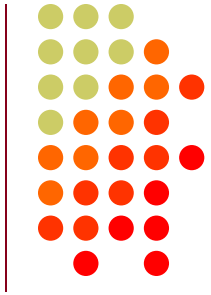
Coaxial Cable Connector Waterproofing

Cover the connectors with two 50% overlapped layers of Scotch 130C stretched to 50% of its original width, sticky side facing out

Cover the Scotch 130C with two 50% overlapped layers of Scotch 33+ or Scotch 88

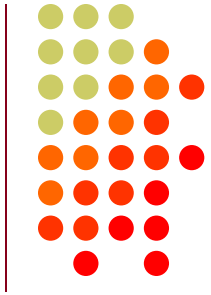
Tower
Maintenance and Inspections



- Inspect all tower sections one year after installation
  - then at least once every three years
  - after every serious storm
  - after any structural damage to the tower
- Check plumb and twist of the tower
- Pay special attention to damaged, loose, missing or corroded:
  - diagonal and horizontal trusses, welds and hardware
  - especially at and close to the guy attachments

Regular inspections are key to safety and long term tower survival

Tower Base Maintenance and Inspections

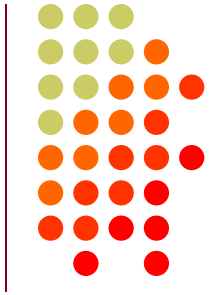


- Inspect at least once every three years

- Pay special attention to:
  - corrosion at the tower-to-concrete interface
  - standing water on the foundation
  - dirt and debris accumulated on the foundation
  - settling and cracks

Dirt and debris accumulation on your tower foundation can lead to catastrophic tower failure

Guy Anchor Maintenance and Inspections



- Inspect at least once every three years
  - dig down at least six inches to inspect for anchor rod corrosion
  - missing hardware
  - loose hardware
  - corroded hardware

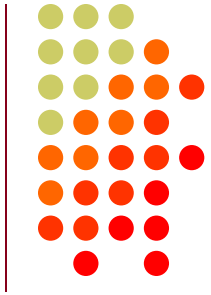
Anchor rod corrosion is a very serious threat to tower safety survival

Guy Wire Maintenance and Inspections

- Inspect at least once every three years
- Inspect after all serious storms
- Check guy wire tension (7-15% of breaking strength)
- Check for:
  - damage from rubbing of chaffing of guy wire
  - corrosion
  - loose hardware

Corroded guys and hardware risk catastrophic tower failure

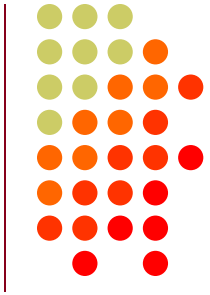
Guy Attachment (tower and anchor) Maintenance and Inspections



- Inspect guys attachments at least once every three years
- Check all guy attachment hardware
  - missing or loose turnbuckle safety wires
  - loose, missing or corroded hardware
  - guy wire chaffing or rubbing
  - integrity of the tower structure in the vicinity of each guy attachment
    - damaged tower structural components
    - broken welds
    - loose or missing hardware

Replace all degraded or missing guy attachment hardware

Lightning Protection Maintenance and Inspections



- Inspect all ground wire connections at least once every three years
  - loose or missing hardware
  - missing wires
  - broken wires
  - corrosion

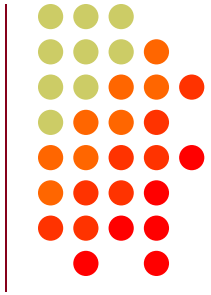
Repair all damaged or missing ground wires and connections

Rotator
Maintenance and Inspections

- Inspect three months after installation
- Inspect every three years
- Check for:
  - excessive mechanical play in the wind
  - corroded hardware

An under rated rotator will be a major maintenance problem

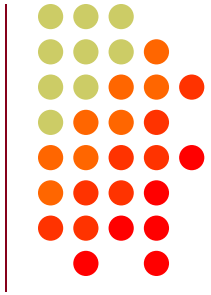
Antenna and Mast Maintenance and Inspections



- Inspect at least once every three years
  - loose or missing antenna hardware
  - loose or missing boom truss hardware
  - corroded hardware
  - ultra violet radiation damaged hardware
  - coaxial cable electrical connection to the antenna
    - water entry is a persistent threat
  - coaxial cable physical connection to the antenna
  - damaged structural components

Coaxial cable connections to your antenna are easily damaged by wind, rain and UV

Tower, Antenna and Coaxial Cable Inspections Summary



- Annual inspections are essential to long term tower, antenna and coaxial cable safety, reliability and station competitiveness
- Conduct major inspections
  - during the first year after construction or major modifications
  - at least every three years
  - after serious storms or damage

Annual inspections are essential to tower, antenna and coaxial cable safety, long term reliability and competitiveness