Balloon-lifted Full Wave Loop Antennas

Jim DeLoach, WU0I

jim@deloach.net

https://www.deloach.net/balloons.htm

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Introduction

- My amateur radio club* has flown balloon-lifted antennas since 1994 for Field Day and other contests, and you can too!
- This presentation:
  - Gives you the background you need to fly balloon-lifted antennas
  - Presents my design for a “Balloon-lifted Full Wave Loop Antenna”, as published in the July 2007 QST
  - Explains balloon launching technique
  - Shares some important balloon safety tips

Members of the ESL Amateur Radio Club and their kids pose with an eight-foot surplus weather balloon at the 1995 Field Day on Mora Hill in the Rancho San Antonio Preserve, Cupertino, CA. I’ll explain why this is *not* the best choice of balloon in this presentation!

* The West Valley Amateur Radio Association (WVARA), San Jose, CA, and its precursor the ESL Amateur Radio Club, Sunnyvale, CA.

Why Balloon Lifted Antennas?

- Because they are a great way to experiment with *big*, *interesting* antennas that just wouldn't fit at home
- Because they are a great way to achieve outstanding performance, particularly on the low-bands
- Because they are fun – particularly for Field Day!

Svend, KF6EMB, Jim, WU0I, and Jon, KF6WPR, tethering balloon at the WVARA 2008 Field Day. Photo by Bruce, KA6FBE.

Balloon-lifted antenna at the WVARA 2008 Field Day on Mora Hill in the Rancho San Antonio Preserve. Photo by Bruce, KA6FBE.

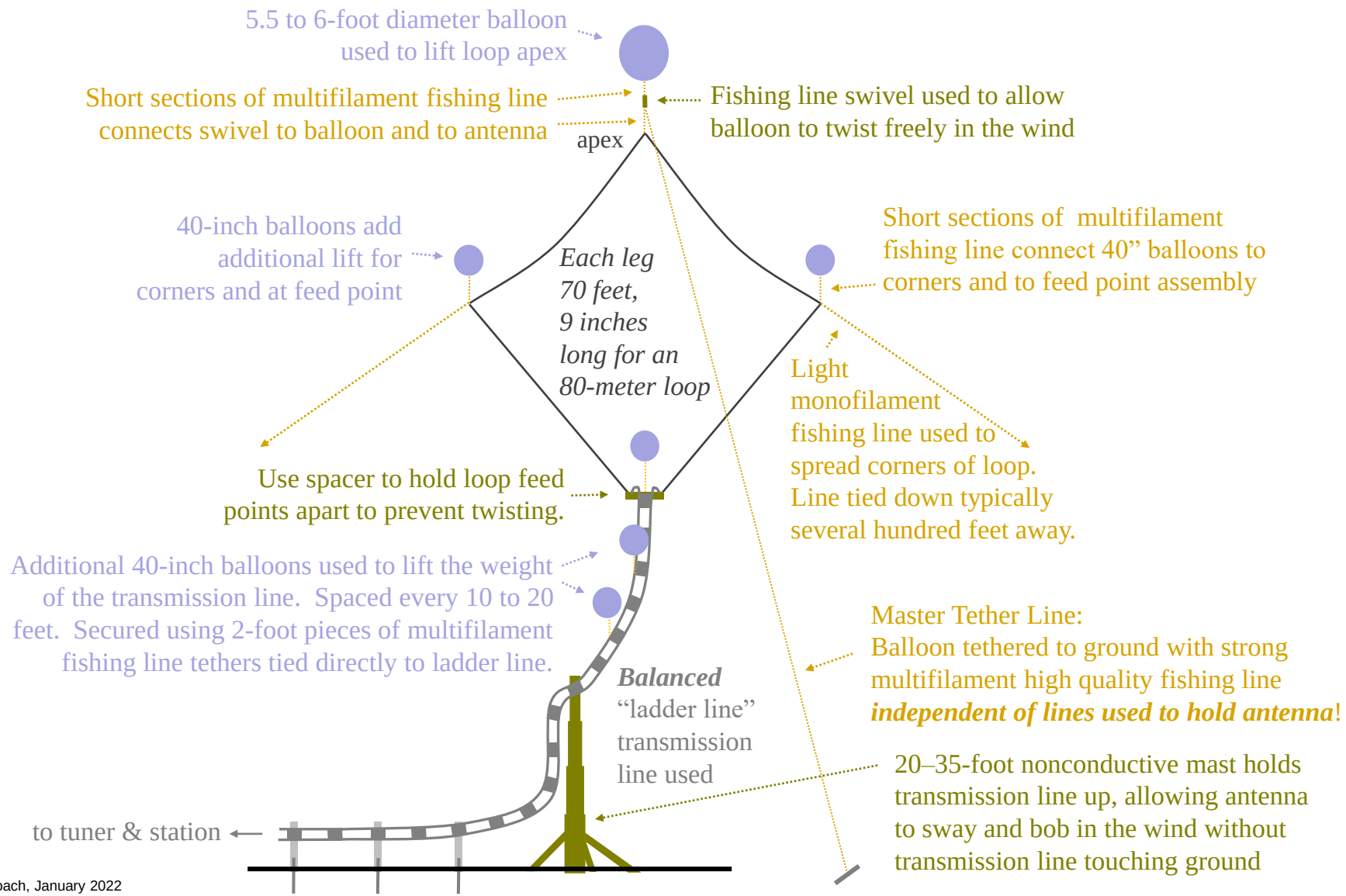
Why a Full-wave Loop Instead of Some Other Antenna Design?

- Loops are balanced and don't require a ground plane
- Loops can be horizontally polarized, so they have less noise – a key advantage on the lower HF bands
- Loops perform well when low to the ground – much better at heights <1/4λ than any other balanced antenna type
- Loops are broad-banded, easier to tune, and far more likely to stay in tune as the antenna is blowing around in the wind
- A loop's radiation pattern is quite broad and thus remains consistent as the antenna shape, altitude, and orientation shifts in the wind
- Loops can be tuned to other bands when fed with balanced transmission line, and typically perform well on these bands
- Loops have good anti-static characteristics

Design of the 80-meter Balloon-Lifted Full-Wave Loop

from my July 2007 QST article

80-meter Balloon-lifted Full Wave Loop Design Overview

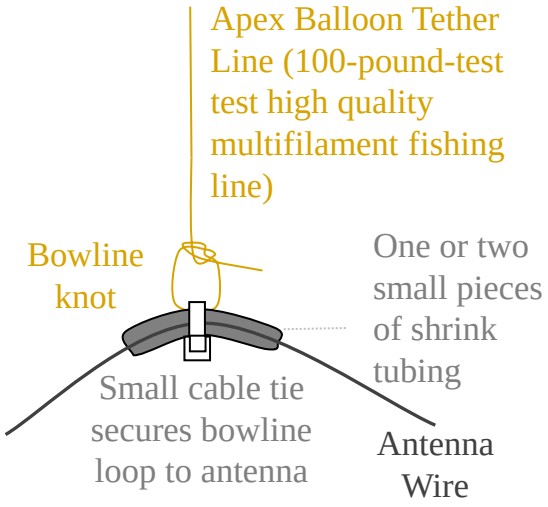


Constructing the Loop

- The size of a full wave loop antenna is given by the ARRL Antenna Book as:

  Circumference (feet) = 1005/Frequency (Mhz)
- Use small, light wire to keep the loop's weight down (see 'Materials' slide)
- Strip and tin about an inch from each end, if stranded wire is used.
- The fishing line tethers themselves serve as the insulators for this antenna, and these tethers are simply cable tied to the antenna wire during the lifting phase.
- To strain-relieve the loop wire at these tether points, pre-position one or two ~1-inch sections of shrink wrap at the top and side corners of the diamond, as shown in the apex & corner figures
- Feed one or two pieces of shrink tubing down the loop wire for each corner

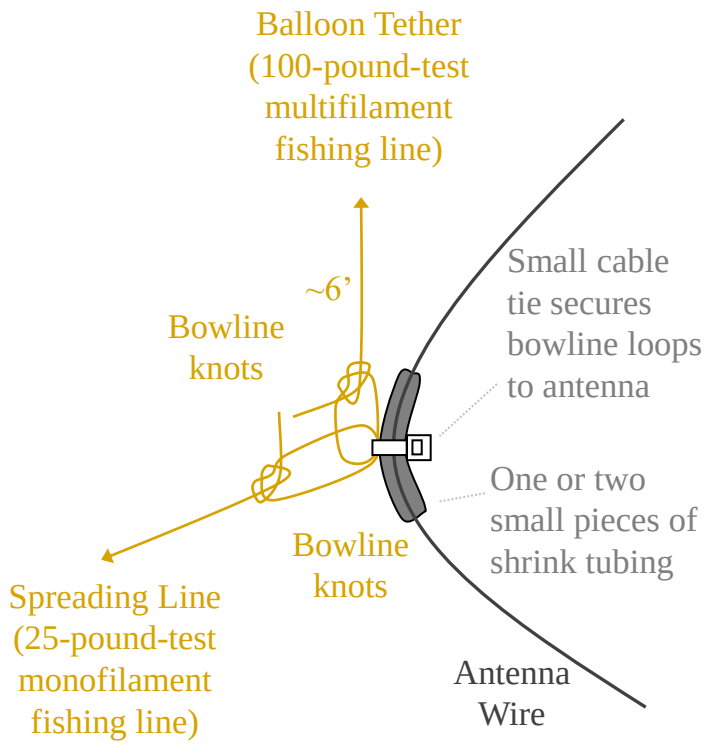
Apex Tethering Approach



Constructing the Loop (continued)

- Gently fold the wire in half to identify the apex corner position (be careful not to kink or bend the wire!)
- Shrink the tubing at this halfway point (this is the apex corner)
- Again, gently fold the antenna in quarters to identify side corner positions
- Shrink tubing at these two positions
- Spread the wire out again halved, with the two feed points side by side
- Roll up the loop wire, starting with the two feed ends
  - This will put the apex corner on the outside of the roll (which helps when deploying the antenna)
  - Be careful not to kink, bend, or knot the wire when rolling it up

Corner Tethering Approach



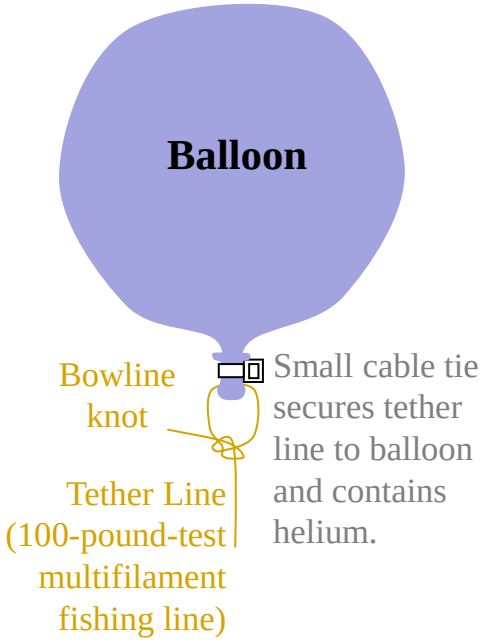
Preparing Balloons

- My preference is to use one 5.5 to 6-foot balloon at the apex, along with several smaller 40-inch balloons at additional locations to lift the loop
- Use only helium gas to inflate balloons!
  - Hydrogen is explosive and not worth messing with!
- Before inflating balloons, prepare all tether lines.
  - Cut pieces of 100-pound-test multifilament fishing line to lengths shown
  - Make a bowline knot with a loop at least as big as a fist on one end
  - Tie a simple slip knot on the other end to prevent unraveling
- Now inflate the balloons
- Have one person tightly hold the lip of the balloon over the tank nozzle while a second person carefully holds the tank steady and gently opens the valve
  - Have a third person judge the size of the balloon and warn the inflator when it is time to stop
  - Inflate balloons only to about 80% of rated size to allow for some expansion and to prevent popping
  - Keep in mind however that balloons pop! Always have spare balloons and helium to cover this eventuality

Preparing Balloons (continued)

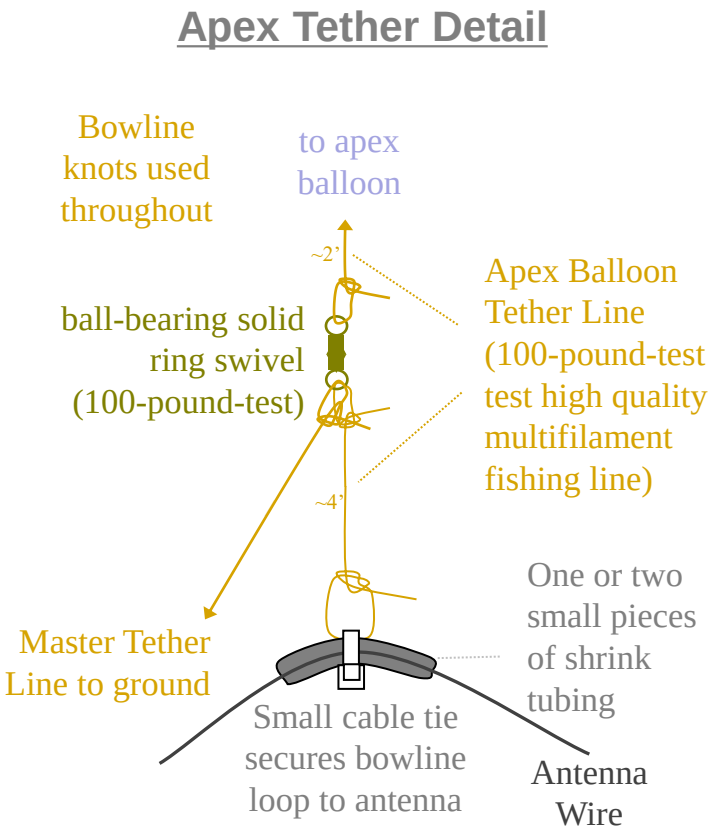
- Note that a crack in the nozzle assembly can cause the helium tank to become a dangerous projectile!
  - Any time the protective cover is off, be very careful not to let the tank fall, and consider securing the tank to a solid object
  - Keep the protective cover screwed on tightly when not inflating
- Once inflated, secure each balloon to a tether line
  - Fold the balloon neck over a bowline loop
  - Cinch a cable tie around both sides of the neck fold
  - Trim excess cable tie
- Tie each balloon to something solid until you are ready to lift the antenna
- After use, the cable tie can often be snipped off without damaging the balloon, but note that used balloons are far more prone to popping

Connecting Balloon to Tether Detail



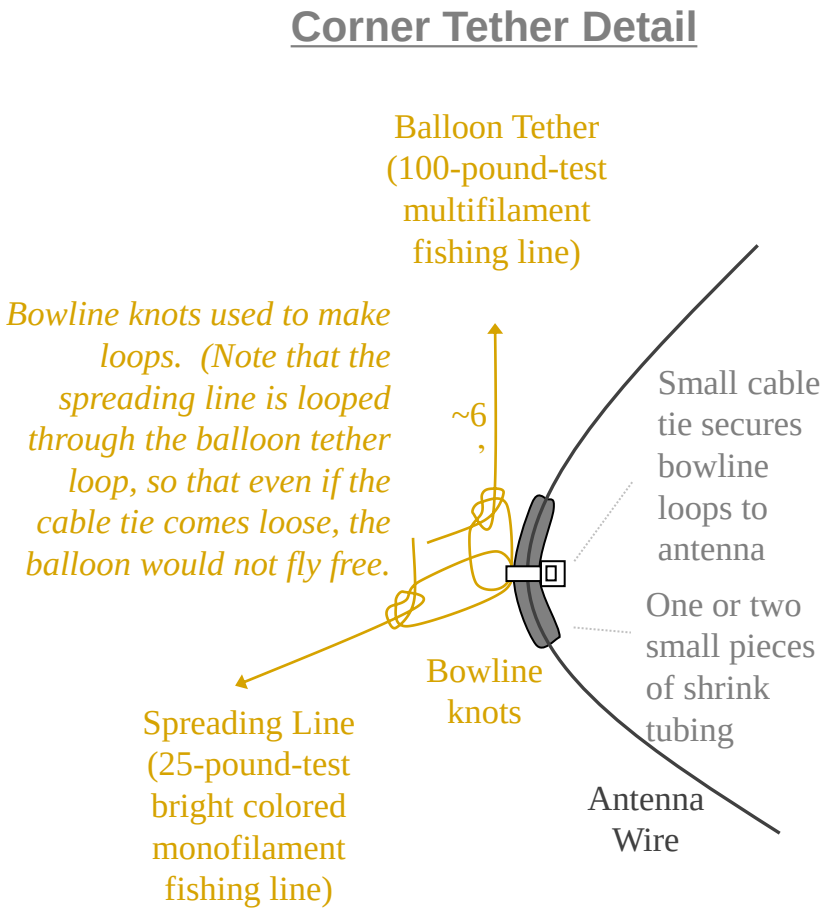
Raising the Antenna

- Once all balloons are inflated and tethered, you are ready to launch your antenna
- Connect the large balloon to the antenna apex as shown
- Also tie the master tether line to the bottom of the swivel
  - The master tether line holds the apex balloon independent of the antenna, so it should be kept clear of the antenna wiring and tether lines.
  - Typically, this means that it is secured a little upwind of the antenna.
- Use Bowline knots throughout
- Let the apex balloon slowly rise upward as you unwind the antenna wire and the master tether
- Be careful not to allow the two antenna wires to kink or knot, or to tangle with the master tether



Raising the Antenna (continued)

- Continue to unwind the antenna wire and master tether until you reach the corner tether points
- Secure the spreading lines and additional balloons to each corner
- Spreading lines pull the diamond apart, and they work best if they are very light (25-pound-test monofilament fishing line works well)
- Optionally tie colorful flag tape to the bowline loops to improve corner visibility once the antenna is lifted
- Continue to unwind the antenna wire, master tether, and two spreading lines while walking the spreading lines apart until you reach the ends of the loop antenna wires



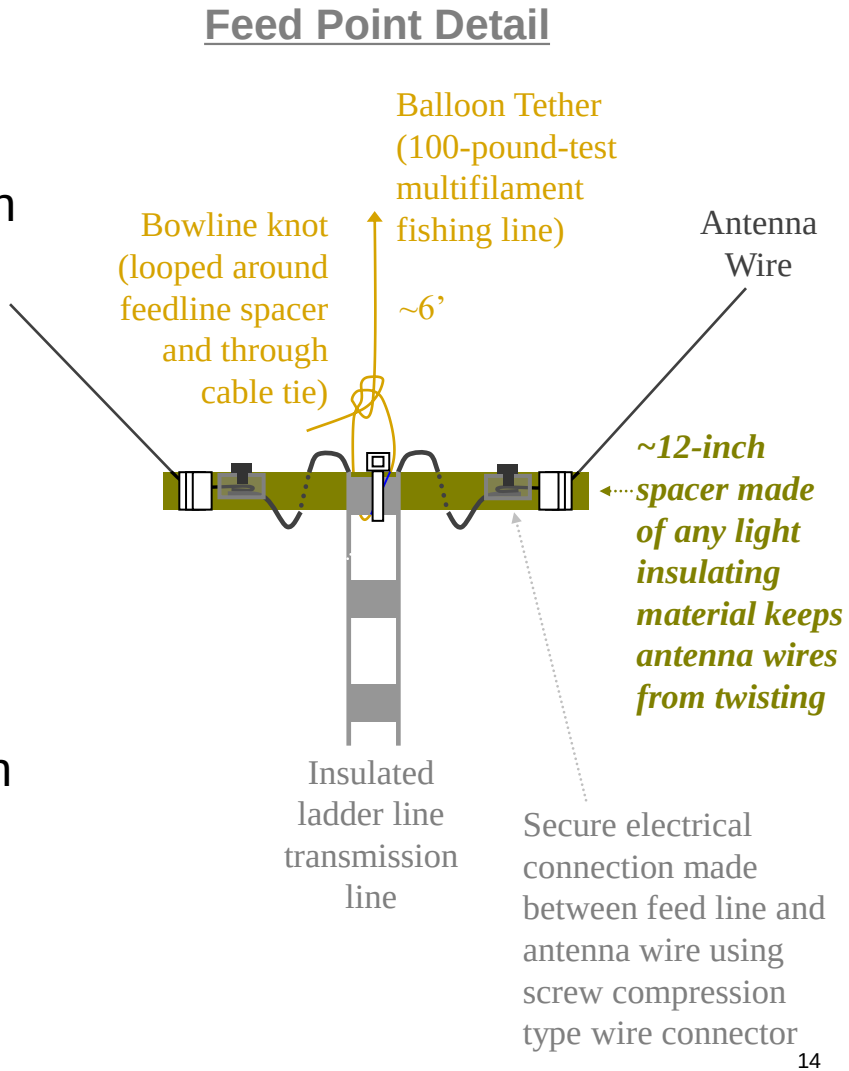
Balloon Lift

- Balloon lift is a function of size, weight, material type, altitude, pressure, and temperature
- Lift predictions have been published (see ‘Links’ slide), but in my experience, lift never quite matches up to predicted values
  - Probably at least partially because I never inflate balloons to their fully rated diameter to allow for expansion
- The typical lift I seem to get is shown in the table
- Your experience may vary, particularly at different altitudes

Balloon Diameter	Typical Lift I Get
40”	~1 lb
5.5-6’	~3-5 lbs
8’	~10-15 lbs

Secure Feed Line

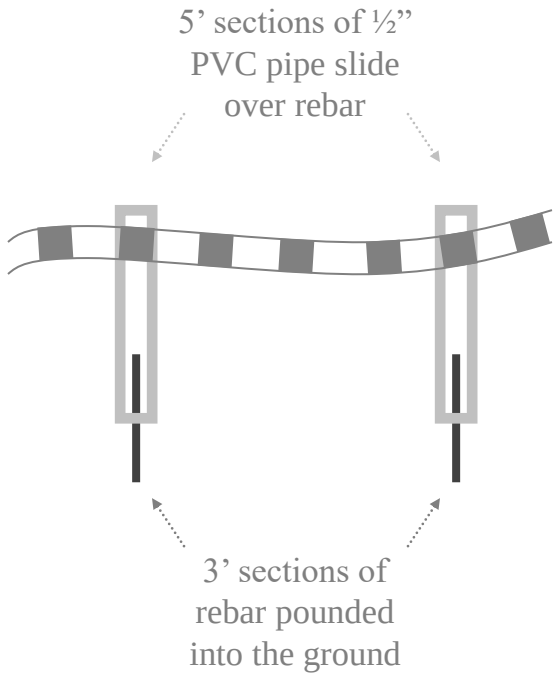
- A spacer is essential to prevent the feed wires from twisting
- Use any convenient light, nonconductive material about 12 inches long
- Cable tie ladder-line to spacer and balloon tether as shown
- Connect transmission line to antenna wires using screw compression type wire connectors (see Materials slide)
- Strain-relieve antenna wires to spacer using electrical tape
- Reel out feed line, tying on a 40-inch balloon every 10 to 20 feet
- Once antenna in position, experiment with tether and spreading line lengths to get loop to take on as close to a diamond shape as possible



Transmission Line

- Used balanced “ladder line” transmission line
  - Much lower losses enable easy tuning of the antenna to other bands
  - A great choice for temporary operations
- Ladder line needs to be kept away from metal objects and can not run along the ground
- Jim, K6EI, came up with a great way to further distribute ladder line for Field Day, using PVC pipe and small sections of rebar
  - Pound 3-foot sections of rebar in the ground
  - slip 5-foot sections of ½-inch PVC pipe over the rebar
  - Tape the transmission line to the top of the PVC
  - Space pipes every 10 or 15 feet to the balanced tuner

The K6EI Balanced Transmission Line Distribution Method



Static Build-up

- Wind-induced static build-up has been reported for large balloon-lifted monopole antennas
- Since loops present a short at DC, differential mode voltage build-up will not occur
  - However, common-mode build up is possible
- I have never experienced this phenomenon in dry, low-static California, but if you do, connect two 1MΩ, high wattage, non-inductive resistors between the tuner's balanced antenna terminals and ground to bleed off the static charge

Performance

- So how well do these antennas work?
  - Jim, K6EI, recalls creating a pile-up after calling CQ, holding a frequency through the contest, and even working Japan – all on 80 meters while running 5 watts!
  - Greg, N6GD, reports that “on 80 CW, there wasn't anybody I heard that I couldn't work with the loop. Pretty amazing considering we were running only 5 watts!”
- These comments are typical
- My Field Day experience has always been that if the balloons stay up, the antenna rocks, even running QRP!

So What's the Catch?

Why aren't Balloon-lifted Antennas More Common?

- Balloon-lifted antennas will only survive in ***light to moderate winds***
  - I've found that if you stick to times with low wind, latex balloons are used, and care is taken in assembly, three out of four balloon-lifted antennas will stay viable for the duration of the event
  - Here in the San Francisco South Bay, June winds tend to subside about dusk, and pick up by mid-afternoon, so I've typically put up the 80-meter loop right after dinner and used it through the next morning
- A balloon-lifted 80-meter loop is ***BIG***!
  - You need to allocate a ***LOT of space*** for the antennas & tethers
- Assembly is ***labor intensive***
  - I've found it takes three or four people ~two hours to launch the loop antenna (pulling down the antenna is much quicker)
- ***Cost*** – helium has become more expensive

Safety Precautions

1. Make sure you have plenty of space! Never fly a balloon antenna where it could possibly come down on a power line, any other wire, any structure, roads, or rail lines.
2. Fly balloon antennas only in light to moderate winds. Pull the antenna down when winds rise and wait for the winds to subside.
3. Use tether lines sizes appropriate for the possible wind load. Do not used frayed or damaged tether lines.
4. Wear gloves when handling tethers or antenna wire.
5. Never fly a balloon antenna in a thunderstorm!
6. Inflate with Helium only!
7. Always tether the balloon to the ground with a line separate from the antenna support structure. Tether lines should be stronger than balloons. Use good knots like the bowline.
8. Be careful with helium tanks. When transporting, secure tanks so that they can not role around in a vehicle. Tanks are heavy, so always have enough people around when lifting. Always keep the valve closed and the nozzle cover secured when not actually inflating balloons. Never let tanks fall – particularly when the nozzle is exposed!

“Moored Balloon” Regulations

- In the United States, regulations for ‘moored balloons’ is given in Title 14, Chapter I, Subchapter F, Part 101 of the Code of Federal Regulations
- A moored balloon appears to be exempt from these regulations if it is not operated “in a manner that creates a hazard to other persons or their property”, it is ***not more than then 6 feet in diameter***, and its gas capacity is not greater than 115 cubic feet
- Larger balloons must comply with additional requirements: distance to nearest airport, ground visibility, automation deflation mechanism, etc.
  - Operation at heights greater than 150 feet trigger onerous additional advanced notification, lighting, and visual warning requirements, and operation above 500 feet is banned outright
- Keeping balloon size to 6 feet in diameter or less is clearly the easiest way to comply with federal regulations

Materials

Antenna Wire	I have use surplus stranded 22 AWG wire from Fair Radio Sales in the past. DX Engineering has an intriguing 26 AWG stranded copper-coated steel, PVC-insulated wire in hi-vis colors, part # DXE-VIZ26, which looks quite promising for lower power applications.
Helium	Helium can be purchased, from local party balloon suppliers, industrial gas, or welding supply shops. Cost has increased noticeably over the years – to about \$1/ft^3 of helium. My preferred supplier is People Greeters in Sunnyvale, CA (www.peoplegreeters.com). Tank sizes vary widely. I have used 176 ft^3 tanks that weigh ~80 pounds. I have never needed a regulator given the types of tanks I use but check with your supplier. Balloon volume is given by $(4/3)*\pi*(\text{diameter}/2)^3$, but I typically only inflate to 80% of balloon capacity. Thus a 40" balloon needs 15.5 ft^3 and a 6' balloon needs 90.5 ft^3. If one 6' and five 40" balloons are desired, and you want to have double the helium just in case, then you need 336 ft^3. I typically get 2 176 ft^3 tanks.
Balloons	I use latex or chloroprene "car dealer" balloons from my local helium source (www.peoplegreeters.com) or the web. Balloons last longest when stored in a cool, dark place. Place a drop cloth under vinyl balloons when inflating. *Avoid surplus weather balloons*, as they tend to be fragile and pop easily when moored.

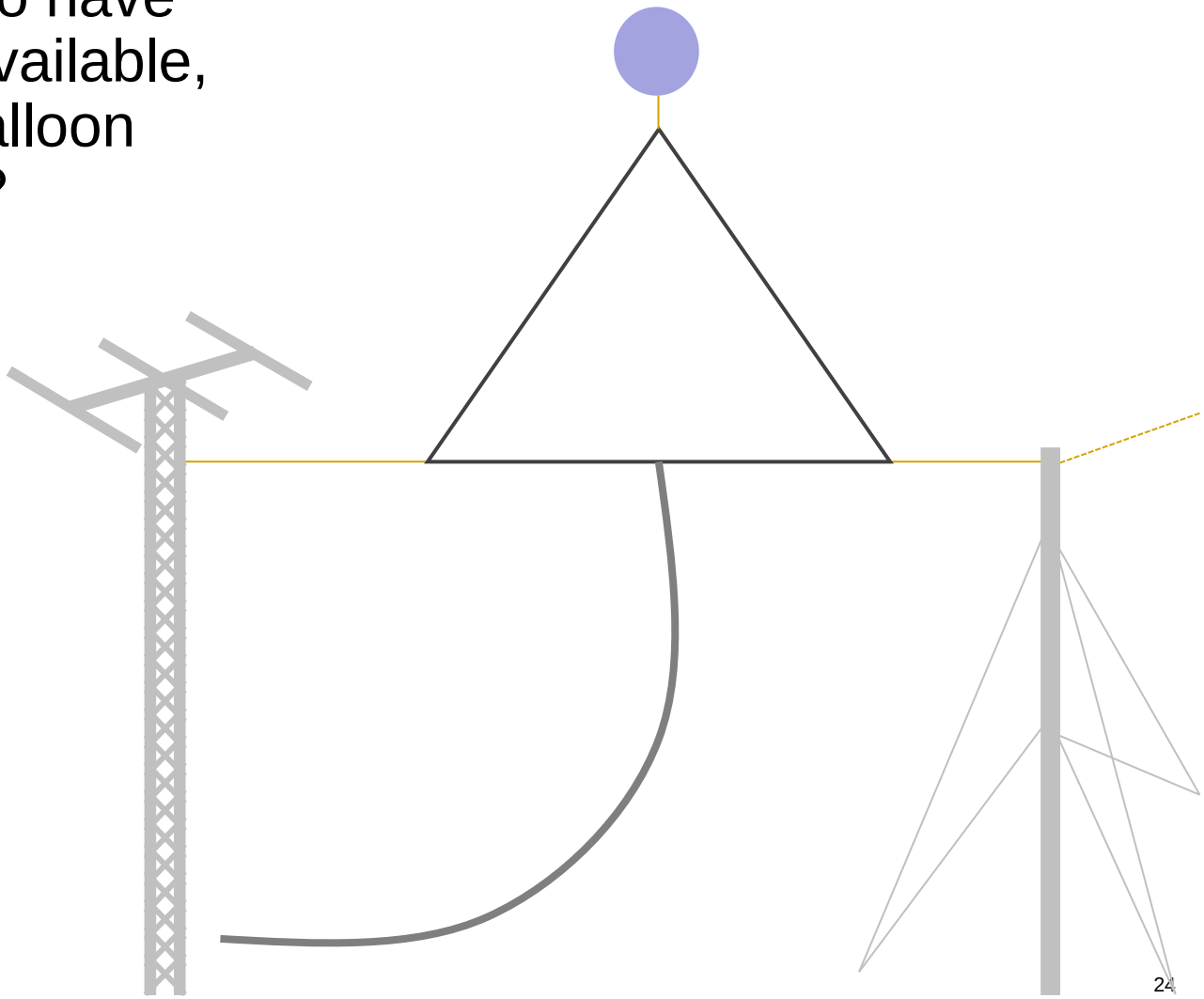
Materials (continued)

Nonconductive Mast	The MFJ-1910 33' telescopic fiberglass pole or the Heavy Duty 32' Mast from The Mast Company should work well for this purpose. High voltage "hot sticks" also work. I have used the tripod from an AS-2236 militlog-periodic antenna to hold the mast.
Wire Connectors	Screw compression type wire connectors taken from terminal blocks (example) work well. Cut the terminal block into single connection sections. 
Tether Lines & Swivels	100-pound-test tether lines are sufficient for balloons up to 6 feet in diameter. Any fishing store can sell monofilament line, multifilament line, and swivels.
Tuners	I have used tuners specifically made for balanced lines (e.g., the MFJ-974HB or an old Johnson Matchbox) but lately I've simply connected the balanced transmission line to a 4:1 balun, then tuned with my rig's built-in tuner, which seems to work fine.
Static Bleed-off Resistors	1MΩ or more, non-inductive power resistors rated for over 2 watts should do for up to 100 Watts radiated power (e.g., Digikey PPC1.0MW-3JCT-ND).

Other Balloon-lifted Designs

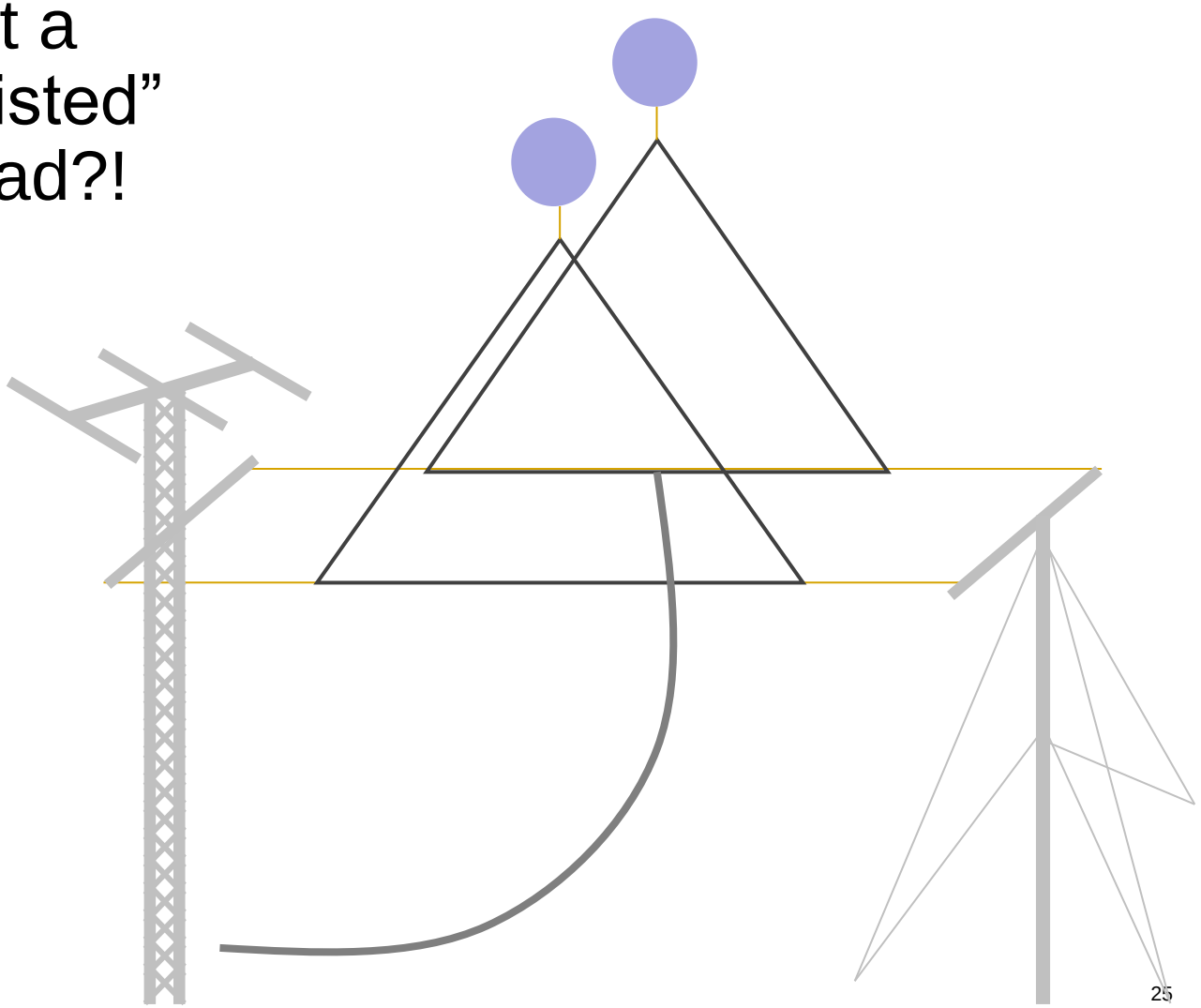
Balloon-*assisted* Loop

- If you happen to have two supports available, how about a balloon '*assisted*' loop?
- Greatly simplifies balloon logistics
- Single balloon is all you need
- See my Jan. 2009 QST article



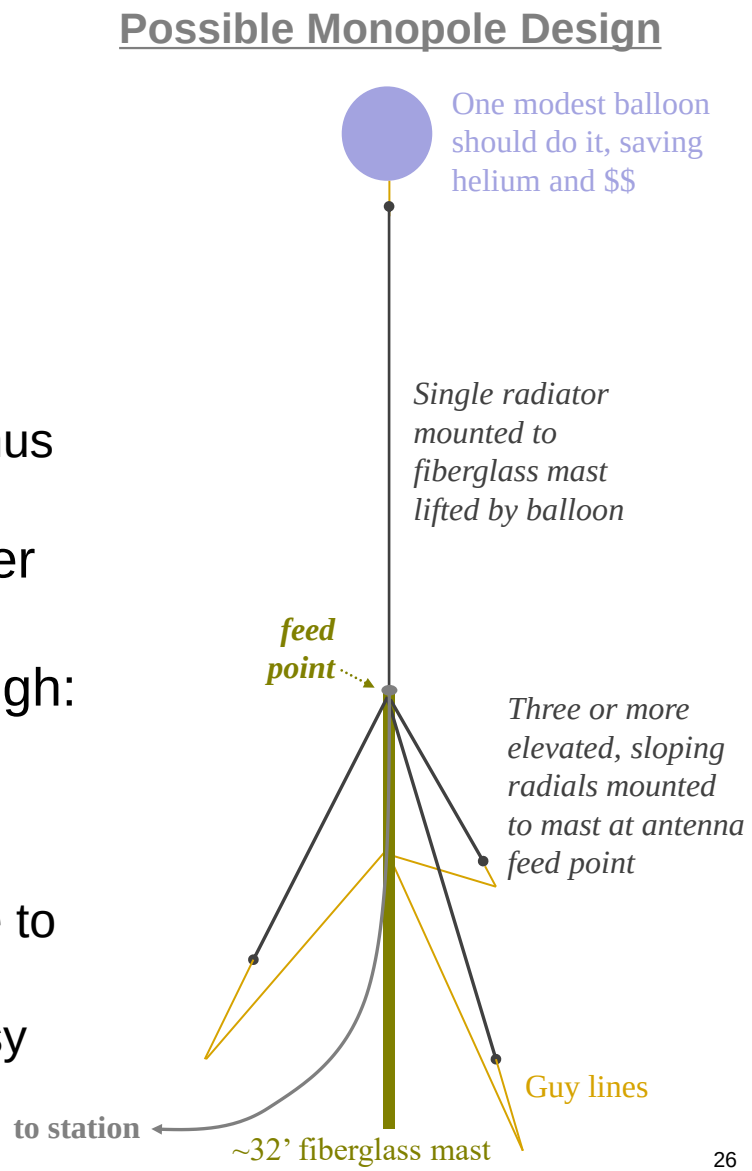
40-meter Quad?

- Or how about a "Balloon Assisted" 40-meter Quad?!



Vertical Balloon Antennas

- The holy grail of balloon-lifted antennas is a vertical with a single balloon
  - Only need to lift one wire straight up
  - Much smaller footprint needed onsite
  - Smaller balloon / less helium needed
  - Good low-angle radiation
  - Disadvantage: vertically polarized and thus noisier – thus site selection is critical
- I've tried several wire J-pole designs over the years, but they have never worked
- This leaves monopoles, but they are tough:
  - Require an extensive ground system to perform consistently well – difficult to achieve at Field Day
  - Tuning and performance highly sensitive to asymmetries, shifting orientations, etc.
  - Bottom line is that loops are far less fussy



Conclusion

- Balloon-lifted antennas are only limited by your imagination!
- So for your next Field Day or other remote contest event, give a balloon-lifted antenna a try!
- See what it’s like to have the big signal!

Links

- I keep a list of balloon-lifted antenna links at: https://www.deloach.net/balloons.htm
- Good tutorial on helium lift: https://science.howstuffworks.com/helium2.htm
- Federal regulations concerning “moored balloons”
  - Code of Federal Regulations, Title 14, Chapter I, Subchapter F, Part 101: “*Moored Balloons, Kites, Unmanned Rockets and Unmanned Free Balloons*”
  - https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-101
- My balloon articles can be found on the ARRL Periodicals Archive and Search page: http://www.arrl.org/members-only/Page/1857
  - Balloon-Lifted Full-Wave Loop Antennas, QST, July 2007
  - The Quick and Easy Balloon Assisted Low Band Loop Antenna, QST, January 2009

(must be an ARRL member and log in – search for my call ‘WU0I’)

Questions?

Thank you!

Jim DeLoach, WU0I

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