[CapeDX] Laser Based Determination of Antenna Support Heights

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Date: Tuesday, August 5, 2025 at 02:32 AM EDT

Laser Based Determination of Antenna Support Heights
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A common task in antenna projects is evaluating support heights. It's also helpful to determine location coordinates with reasonable accuracy to figure distance and bearing to other supports that may be used. Most of the time trees are the supports but posts, buildings, and other structures are sometimes used instead.

Laser range finders have been proposed as a way to measure distance as well as angle from the horizon. When viewing a potential support one can possibly measure distance from viewer at eye level (0° from horizon), distance from viewer to support top (or just below it), and angle of top above the horizon line.

Sometimes, due to vegetation or structures in the way, one cannot measure viewer to support eye level distance. This can still be determined if the viewer to top distance and angle to top can be found.

In other cases the support top is too thin to get a reliable laser reflection but if the angle can still be determined, there's hope.

Besides viewer to support eye level distance measurement via the laser range finder, there are other ways to get that with a fair degree of accuracy. This would be via entering the latitude and longitude values of the viewer and support positions in a spreadsheet to compute distance. Coordinates can be determined in a couple of ways. One is to use Google Maps satellite view zoomed in on the location. If you can see the positions of the viewer and support you can click on them to get the coordinates. You can also use your

own handheld GPS. In my case I have a phone app called "Geo Tracker" which gives degrees-minutes-seconds coordinates readout. It's easy enough to convert those to more useful decimal form latitude and longitude. When one can't get right to the base of the support object, one can go a bit north or south of it to get a reasonable longitude (E/W) value and then go a bit east or west to read the latitude (N/S).

For this project I procured two different items from Amazon:

Mileseey S7 laser distance measure with camera
https://www.amazon.com/dp/B0BVY9J5C6?ref=ppx_yo2ov_dt_b_fed_asin_title&th=1
$169.99
Range ~ 330 ft., full angle measurement

Revasri NKG-1000 Golf/Hunting Rangefinder
https://www.amazon.com/dp/B09GLP62SS?ref=ppx_yo2ov_dt_b_fed_asin_title&th=1
$29.99
Range ~ 1800 ft., angle measurement limited to +/- 30°

Both of these proved useful and they can be considered somewhat different tools that complement each other.

Advantages (+) / disadvantages (-) of each:

Mileseey S7
(+) Full +/- 90° angle measurement from horizon line
(+) Built in image capture, calculations, computer interfacing
(-) Hard to see screen in bright sunlight

Revasri NKG-1000
(+) Optical viewer easier to use in strong light
(+) Greater distance measuring range
(+) Inexpensive and compact for backpacking
(-) Does not measure angle above 30° or below -30°

Three of the taller trees in the yard were selected for measurement testing.

For measuring a structure, the mast used by 103.9 FM WKPE and cellular services, was used. This is just short of a quarter mile away: beyond the reach of the Mileseey unit but within range of the Revasri.

Case studies below illustrate how these devices as well as GPS fixes can be used for antenna support height determination.

(1) Norway Spruce (Picea abies): GC = 41.69319 N, 70.19093 W
Future site for north end of ham dipole.

Viewer position - gate post left: GC = 41.69299 N, 70.19092 W

Viewer to tree eye level laser measurement not feasible because of vegetation blocking view of the trunk.

Mileseey S7 measured 30° elevation angle of tree top relative to viewer. A stable reading of viewer to tree top distance could not be obtained. By loading the viewer and tree coordinates to a spreadsheet (*geocalc1.xls*, sheet 2, link ' http://www.qsl.net/wa1ion/geocalc1.xls ') the straight horizontal distance viewer to tree calculates to 72.96443 ft. With that distance and the top angle known, the spreadsheet calculation shows 42.12603 ft. tree height from viewer eye level to top. The eye level height above the bottom of the tree is about 10 ft. so total tree height is about 52.12603 ft. / 15.888m.

Approaching the situation with the Resvasri NKG-1000, a fairly steady viewer to tree top measurement of 92.7 ft. could be obtained. A 30° elevation angle, in agreement with the Mileseey, was measured. Since those two values were known, it was then possible to compute straight horizontal distance viewer to tree 80.28055 ft., tree height from viewer eye level to top 46.35 ft. and, with eye level height above the bottom of the tree about 10 ft. as noted previously, the total tree height is about 56.35 ft. / 17.175m.

The difference in horizontal distance of about 7.4 ft. between the two measurement methods is not surprising as the Mileseey couldn't get a steady hit on distance so GPS reckoning was substituted. This resulted in about 4 ft. of difference in tree height calculation.

(2) Pitch Pine (Pinus rigida): GC = 41.69285 N, 70.19090 W
Future site for south end of ham dipole.

Viewer position - driveway to west of tree: GC = 41.692858 N, 70.191099 W

The only good vantage point has an angle to top greater than 30° so the Revasri could not be used for the measurement.

Mileseey S7 measured 46° elevation angle of tree top relative to viewer. An eye level horizontal distance reading of 54 ft. was measured. This agreed with GPS coordinates derived distance. A stable reading of viewer to tree top distance could not be obtained but this wasn't necessary as it could be figured from the two known measurements. From loading in the known measurements to the spreadsheet, calculations show 77.73605 ft. viewer to tree top distance and 55.91864 ft. tree height from viewer eye level to top. The eye level height above the bottom of the tree is about 6 ft. so total tree height is about 61.91864 ft. / 18.8728m.

(3) Black Locust (Robinia pseudoacacia): GC = 41.69318 N, 70.1913 W
Support for west end of TA SuperLoop.

Different viewer positions were used for the different laser range measurement devices. The one used for the Mileseey that can accommodate high view angles was closer to the tree. Coordinates not recorded for these vantage points.

Mileseey S7 measured 56° elevation angle of tree top relative to viewer and a viewer to tree top distance of 62 ft. Eye level distance measurements were not possible because of intervening vegetation. The two known pieces of data were loaded to the spreadsheet to come up with 34.66996 ft. eye level viewer to tree distance and 51.40033 ft. tree height from viewer eye level to top. The eye level height above the bottom of the tree was about 7 ft. so total tree height is about 58.4 ft. / 17.8m.

The Revasri NKG-1000 at a view point farther from the tree measured 19.7° elevation angle of tree top relative to viewer and a viewer to tree top distance of 147.6 ft. Measured data loaded to the spreadsheet produce 138.961 ft. eye

level viewer to tree distance and 49.75526 ft. tree height from viewer eye level to top. The eye level height above the bottom of the tree was about 9 ft. so total tree height is about 58.75526 ft. / 17.9086m.

The two different measurement instruments operated from two well-separated vantage points produced height values that were quite close. Wind motion of upper branches and inexact aiming could even account for differences.

(4) WKPE mast: GC = 41.69056 N, 70.18861 W

Viewer position - driveway west side: GC = 41.69274 N, 70.19121 W

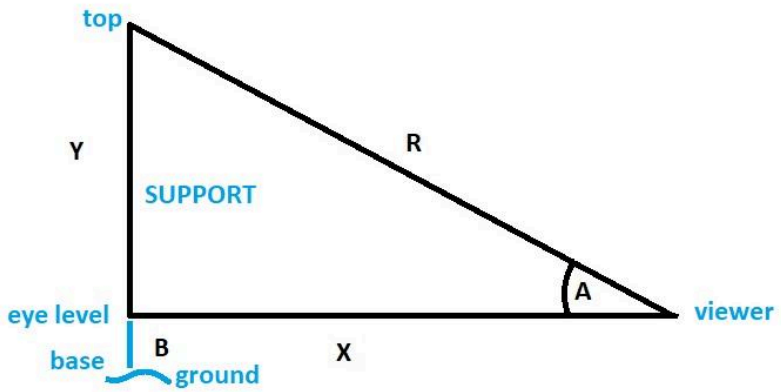
This is beyond the measurement range of the Mileseey S7 so only the Revasri could be used.

Distance based on coordinates 1066 ft. / 324.93m, bearing 142.7°

The Revasri NKG-1000 measured 16.5° elevation angle of mast top relative to viewer and a viewer to top distance of 1083 ft. Base height relative to viewer was unknown so set to zero. Measured data loaded to the spreadsheet produce 1038.4 ft. eye level viewer to mast horizontal distance and 307.58862 ft. mast height. It is quite likely that the reflection point was about 25-30 ft. below the extreme top of the tower. FCC data show 335 ft. / 102m height above ground for the WKPE transmitting antenna so not a bad swing at it accuracy-wise with an instrument costing less than $30 and mostly intended for golf course use.

It is hoped that this report will encourage others to research the topic and come up with more ideas. Also it is hoped that antenna projects will be improved by the use of these devices.

Appendix - Pictures:



tan(A)=Y/X
sin(A)=Y/R
cos(A)=X/R

Given X and R, get Y,A:
Y=((R^2)-(X^2))^0.5
A=atan(Y/X)

Given R and A, get Y,X:
Y=R*sin(A)
X=R*cos(A)

total height = Y+B

Range - height pictorial

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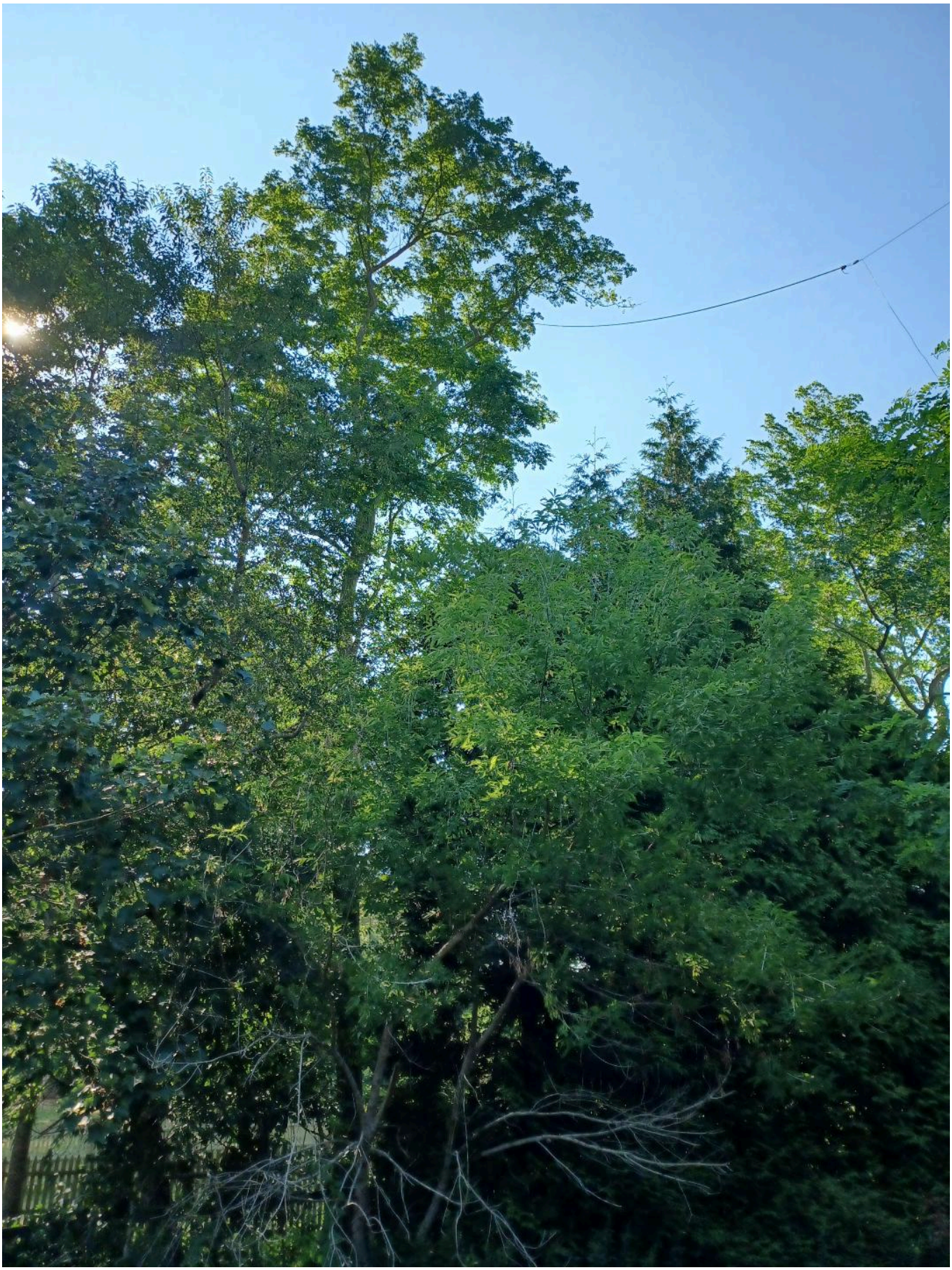
Norway Spruce

Pitch Pine



Black Locust

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WKPE mast

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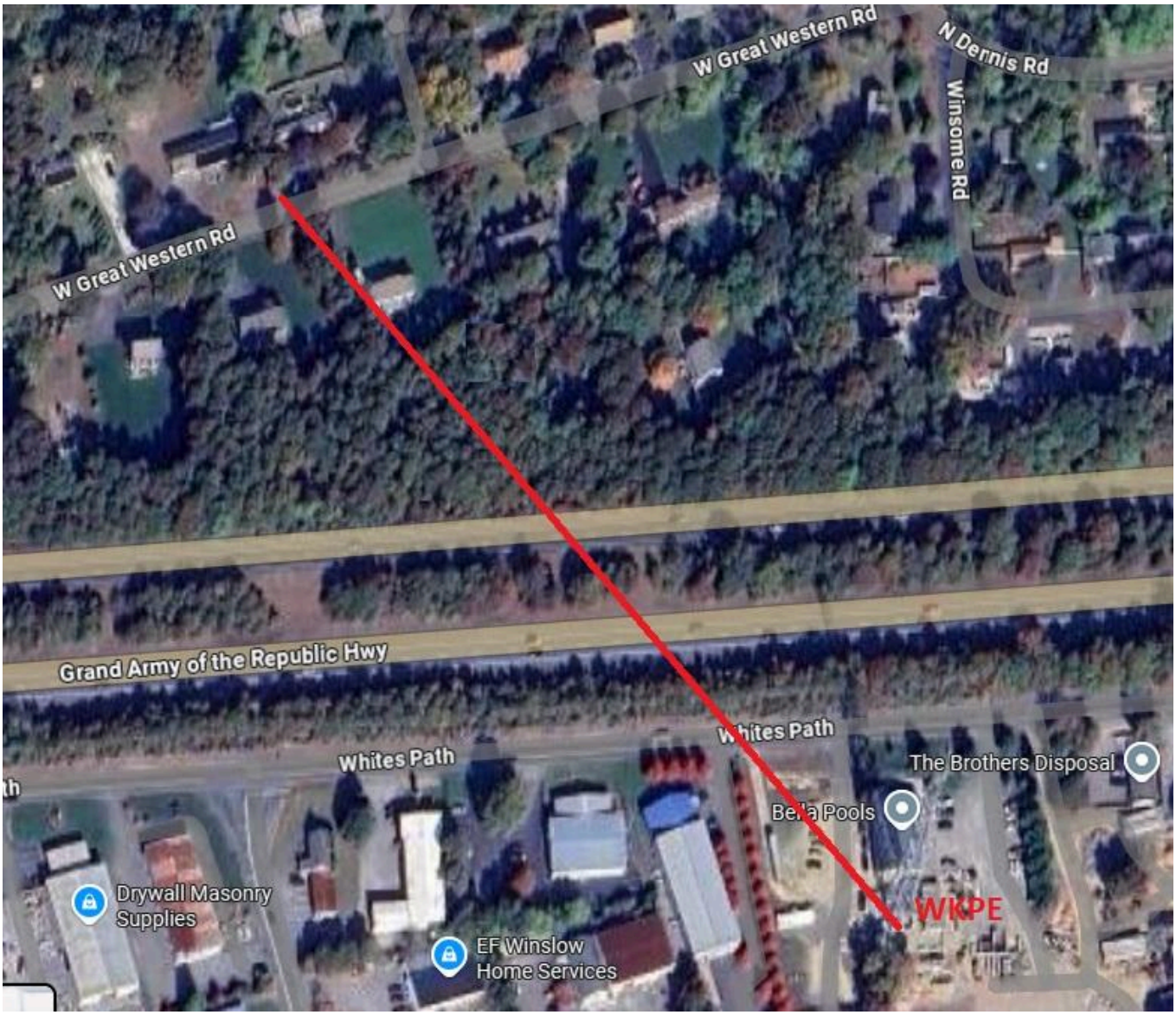

Route to WKPE mast

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Groups.io Links: