

# Cohoe Radio Observatory, Alaska ~ Part 3, Guyed Tower Installation

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## 1. Introduction

This article series describes construction of a new radio observatory in Cohoe, Alaska. In Part 1, I described the radio frequency interference survey performed at Cohoe in summer 2012 [Reeve1]. Part 2 described construction of the foundation for a 60 ft guyed lattice tower during summer and fall 2013 [Reeve2]. In the current part, Part 3, I describe the installation of the tower. The tower's primary use will be to support an azimuth/elevation antenna rotator and two log periodic dipole antennas and associated tower-mounted amplifiers for the e-CALLISTO solar radio spectrometer network. In the future it also will support other antenna types for radio observing and monitoring, a weather station and weather/security video camera.

## 2. Cohoe, Alaska

CRO is located in a rural area about 1 km southwest of where the Kasilof River flows into Cook Inlet and about 125 km southwest of Anchorage (figure 1). Coordinates for the site are 60° 22' 4.93"N, 151° 18' 55.76"W and elevation is approximately 21 m above mean sea level (AMSL). The site is near the old town of Cohoe.



Figure 1 ~ Aerial imagery of Alaska's Cook Inlet from an altitude of 180 km showing CRO (below-left of center). The outlet of glacier-fed Tustumena Lake into the Kasilof River is about 10 miles southeast of CRO. (Image courtesy of Google earth).

**Units of measure** ~ As I stated in Part 2, I seldom use non-metric units of measure in my articles but this one is an exception. Metric units are not used in the materials and tools associated with tower construction in the USA at this time. Trade sizes are given in inches (in), feet (ft), pounds (lb), cubic feet (cu ft) and cubic yards (cu yd). Writing with both non-metric and metric units soon becomes quite awkward. As in Part 2, to help readers familiar only with metric units, I have provided a conversion table at the end of this article and a link to an online units converter.

## 3. Tower height determination

One of the first tasks when planning a new antenna supporting structure is to choose the height. For CRO, the most important requirement is to exceed the tree height. I determined tree height with a shop-built triangular sight-gauge made from 1/4 in plywood (figure 2). The sight angle was set to 45° to simplify the calculations. While holding the bottom of the gauge level, I moved toward or away from the tree being measured until the

tree-top was in-line with the gauge. At this point the tree height equaled the distance to the tree plus 5.5 ft (the approximate distance from the ground to the sight-gauge). The tallest trees, all scraggly black spruce, were found to be 56 ft high. Based on these measurements I decided to build a 60 ft tower. All trees are old growth and probably will not get much taller.



Figure 2 ~ Left: Plywood sight-gauge for determining tree height. Right: Tree height measurements were made in April 2012 as the winter snows were melting. The tallest trees measured 56 ft. A partially buried camp trailer is in the foreground. (Image © 2014, W. Reeve)

#### 4. Tower order and delivery

While planning this project in late 2011, I contacted a firm specializing in tower erection that happened to be located about a mile away across the Kasilof River from CRO. They agreed to install the foundation and tower for me in 2012, but when it came time to actually do the work they stopped returning my phone calls and replying to my emails (I never bothered to find out why). I had no choice but to move forward on my own or try to hire another firm. However, by the time I was forced to abandon the first firm (or they abandoned me), it was too late to hire another for summer 2012 work. This delayed the project 1 year, so I decided to do all tower work myself in 2013.

I ordered the tower from American Tower Company in Shelby, Ohio USA in April 2012. I asked for export packing because of the distance involved. The tower was delivered in a crate in late May 2012. Logistics were typical for delivery to a location in Alaska near the road and highway system: I had the tower manufacturer deliver the crate by truck to a freight forwarder in Seattle, who brought it to Anchorage by container-ship and then delivered the crate by truck to CRO, a total distance of slightly more than 4000 miles (and an average cost of US\$0.44/mile). I was ready with tools when the shipment arrived. The trailer-tractor was too large to negotiate the sharp turns in the narrow driveway, so I disassembled the crate and the driver helped me stack everything near the entrance to the driveway. After he left, I loaded everything in my SUV and moved it to a winter storage location (figure 3). I inventoried everything as I unloaded and put the cardboard boxes holding the hardware inside one of the on-site cabins.



Figure 3 ~ Tower sections were moved a couple hundred feet in the back of my SUV (left) and restacked for the winter (right). The hot-dipped galvanizing used on all steel components was very shiny when delivered but it oxidized and dulled over the winter, as I expected. (Images © 2014, W. Reeve)

### 5. Raising the first four tower sections

The tower uses a concrete base and three anchors, which were constructed during summer and fall 2013 as described in Part 2. The concrete was allowed to cure for 2 weeks before I started to erect the tower.

When I ordered the tower I decided to use a hinged base (figure 4). This would allow me to preassemble the first four 10 ft tower sections on the ground and then raise them as a unit. All six tower sections are identical except that guy brackets (figure 5) are placed at specific locations, 28 ft above ground level (near top of the 3<sup>rd</sup> section) and 58 ft above ground level (near top of the 6<sup>th</sup> section), as specified in the manufacturer’s documentation. My brother-in-law, a retired electrical lineman, and my son helped me raise the tower. We cut the six guy wires to length and pre-installed them on the guy brackets using Preformed Line Products “Big Grips” (figure 6), three at each level.



Figure 4 ~ Left: The hinged base plate is held with six J-bolts embedded in the concrete. The two hinges on the right side of the base are installed with 1/2 in fasteners. After the tower is rotated to vertical, the base is held closed by two brackets

and additional 1/2 in fasteners at left. The hinged base is rated to raise a maximum tower length of 40 ft, so if the tower is ever lowered in the future, the top two sections will have to be removed first. Right: Four 10 ft tower sections assembled on hinged base ready to be raised. The loose sections seen on the ground next to the assembled tower sections will be raised with a gin pole as described later. (Images © 2014, W. Reeve)



Figure 5 ~ Left: Guy strands were pre-installed on the lower guy brackets by two helpers who knew what they were doing. Right: Lower guy bracket and block-and-tackle immediately after raising the four tower sections. The guy wire to left is under tension while it is being installed, and the other two are still slack while awaiting installation. (Images © 2014, W. Reeve)



Figure 6 ~ Left: Preformed Line Products “Big Grip” deadend. The grip is wrapped around the guy strand and, after installation, has a breaking strength that exceeds the strand. The holding force is the rough galvanizing on the two surfaces. The grips can be removed and reapplied twice for guy adjustment and re-tensioning but must be discarded if removed a third time. The grip uses a thimble (not shown) to prevent damage from chafing where it is looped around the guy bracket or turnbuckle pin. Right: A cable hoist and Klein “Chicago”-style wire pulling grip were used to tension the guy strand while the deadend was installed. (Images © 2014, W. Reeve)

I thought about using the so-called “falling boom” method to raise the tower but decided against the extra work and expense of building a boom. Instead, I devised a plan to have my helpers progressively lift the four sections (about 160 lb total weight), pivoting the assembly on the hinged base, while I kept it from falling back with a simple block-and-tackle arrangement. Once raised above a certain angle (about 30 to 40°), the tackle would be used to continue raising the tower assembly to vertical. This plan worked perfectly.

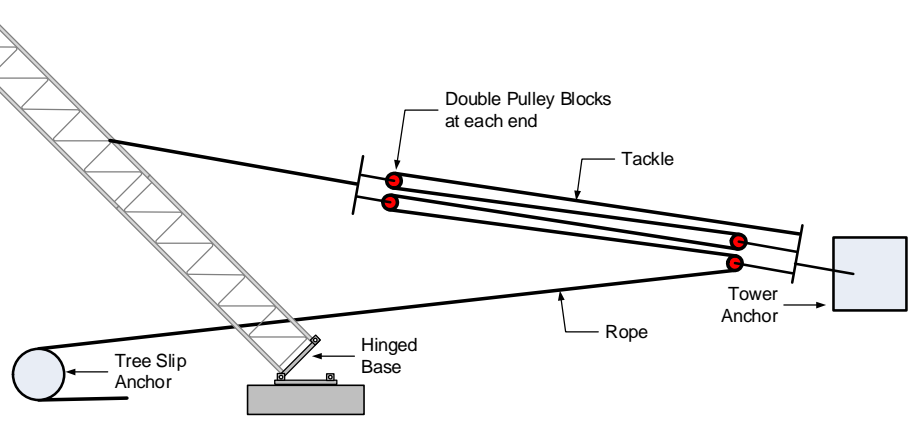
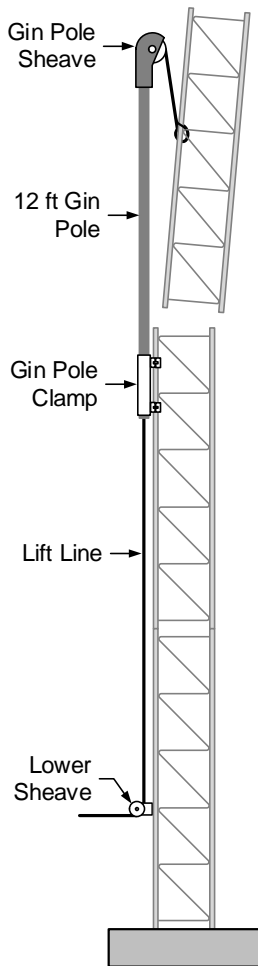


Figure 7 ~ Block-and-tackle schematic (no scale). (Image © 2014, W. Reeve)

I used two double-pulley blocks, one on the tower about 2/3 distance from the base and one on the south anchor, which also served as a holdfast for the tackle (figure 7). I threaded the blocks with double loops of 3/8 in polyester rope and then wrapped the free end of the rope around the base of a tree for a slip anchor. The tackle arrangement had considerable mechanical advantage and I could easily hold the tower assembly when my helpers moved to a new position. After raising the first four sections, we then attached the three guy wires to the anchor rod turnbuckles and adjusted the initial tension to hold the tower while I climbed it as described in the next section.

### 6. Upper two tower sections



I have an Elk River, Inc. four D-ring tower harness, which I purchased in 2008 when I erected the 40 ft tower at my Anchorage observatory. When climbing above the 10 ft level, I use a double lanyard (one 2 ft and one 4 ft long) such that at least one lanyard always is connected from the harness chest D-ring to the tower. When at a working level, the shorter lanyard attaches the chest D-ring to the tower and then I wrap the longer lanyard around the tower and attach it to the two hip D-rings.



Figure 8 ~ Gin pole setup (left). The gin pole is schedule 15, hot-dipped galvanized pipe purchased at a fence company in Anchorage, which cut it to length for me. The sheave at the top of the gin pole is part of my gin pole kit that includes the pipe, clamp and upper and lower pulleys (above right). (Images © 2014, W. Reeve)

After the lower guy wires were attached to the anchor turnbuckles, I climbed the tower to the 40 ft level and setup a pulley block for raising the tool bag and gin pole assembly.

The gin pole is 12 ft long and is attached to the tower using a purpose-built clamp (figure 8). The gin pole has a sheave (shaped like a cobra head) at the top and another sheave directly below it and clamped to the tower a few feet above ground level. The lower sheave keeps the lift line (raising rope) in line with the gin pole and allows the helper at ground level to stand away from the tower and anything that might fall while pulling. The weight of the gin pole, tower clamp and top sheave is about 35 lb.

The last two tower sections were raised individually. One helper on the ground attached the section to the lift line and raised the section while the other used a 1/4 in tag line to keep it from swinging and banging into the tower. This operation required only a few minutes. When the tower section was raised far enough I guided it to slip onto the swaged legs at the top of the tower. I used a set of 1/4 and 5/16 in diameter drift pins to align the tower bolt holes (figure 9).

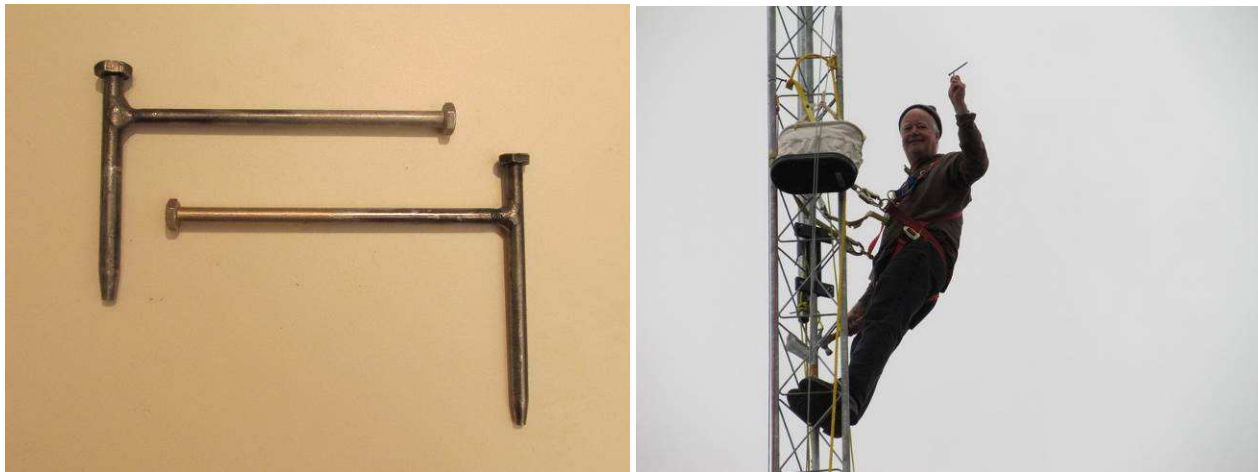


Figure 9 ~ Left: 1/4 and 5/16 in diameter drift pins, which I originally fabricated in 1970 for removing and replacing the wings of light aircraft. Right: I am holding a drift pin at the 50 ft level, ready to insert it in a bolt hole to align the tower legs for the last tower section. The black gin pole clamp can be seen on the far side of the tower immediately below the tool bag. (Images © 2014, W. Reeve)

I inserted the pins into the tower bolt holes to align the sections and then installed the supplied fasteners (bolt and nylon lock nut). Each leg on a tower section has two fasteners, and these are tightened to the point where the outer tower leg just starts to compress (figure 10). Lock nuts are far better than the fasteners supplied with my Anchorage tower – flat washer, lock washer and ordinary hex nut.



Figure 10 ~ Left: Each tower section leg is held to the section below it with two bolts, 1/4 in and 5/16 in diameter, and nylon lock nuts. Right: Tower bolts before the four tower sections are raised. (Images © 2014, W. Reeve)

After I installed the tower bolts at the bottom of the new 10 ft section, we raised the gin pole to the top. We then lifted the last 10 ft section and I repeated the bolt hole alignment and fastener installation process (figure 11). Since the guy wires were already attached the upper-most tower section, my work was limited to installing the tower leg bolts and then lowering the gin pole, tool bag, tag ropes and myself to the ground. We then attached the upper set of guy wires to the anchor turnbuckles and started the tower alignment process.



Figure 11 ~ Left: Guiding the last tower section into place. Right: Tower assembly at full height while guy wires, barely visible against the overcast sky, are being tightened. (Images © 2014, W. Reeve)

## 7. Tower alignment

We adjusted the lower guys so the first three sections were perfectly vertical as seen with a string and plumb bob held about 40 to 50 ft away. We then adjusted the upper guys so the sight-line along each tower leg was perfectly straight (standing at the tower base, I looked up along each tower leg from eye level to the top). This brought the entire tower into alignment (figure 12). After re-checking with the plumb bob, we temporarily looped the guy wire tails through the turnbuckles so they could not turn. We had cut the guy strands about 5 ft longer than necessary so there would be enough to secure the turnbuckles.



Figure 12 ~ Upper tower sections showing the guy brackets and wires. (Image © 2014, W. Reeve)

We worked from about 0900 to 1700 local time – most of the day – raising the tower. About two-thirds of our time was spent preparing and installing the tower sections and the remaining time adjusting the guy wires for tower alignment. We had a small amount of rain during the day but the temperature was good for physical labor, about +7 °C.

## 8. Bonding and grounding

The tower package included bonding and grounding hardware and wire for the tower and guy wires, including one 8 ft copper-clad steel ground rod for the tower base and one each for the three anchors. The rods were installed using the “Armstrong” method (10 lb sledge hammer, two arms, one back and an extra hand to hold the rod steady, the latter requiring a lot of faith in the person swinging the hammer). There was considerable driving resistance below the clay and each rod required about 30 minutes of hard work (figure 15). My son volunteered (really) to do this. Because there presently is nothing to electrically protect, I decided to defer bonding the ground rods to the tower and anchor rods until spring 2014.





Figure 15 ~ Left: The tip of the ground rod (arrow) for the tower base is visible poking out of the quickly freezing ground. In spring 2014, it will be cleaned with emery cloth and painted with anti-oxidant before attaching the ground rod clamp and 6 AWG bonding conductor. The closest tower leg will be similarly prepared for a bonding clamp. Right: The ground rod clamp (left) and tower bonding clamp (right) ready for installation. (Images © 2014, W. Reeve)

### 9. Final work in fall 2013

I returned to the site in late fall to permanently secure the turnbuckles (figure 13). This arrangement can be disassembled and reassembled quite easily when I return in spring 2014 to make final adjustments to the guy wire tensions. I also installed the anti-climb panels and stored the temporary work platform (figure 14). The anti-climb panels are three galvanized steel sheets with the edges bent 30°. When assembled, the panels wrap around the base of the tower and are held together with nine 3/8 in fasteners.



Figure 13 ~ Guy anchor and guy strand. Left: Turnbuckles at the anchor rod plate are prevented from turning by looping the guy wire tails through them and then clamping with guy clips. Right: Yellow guy markers improve visibility of the almost invisible guy strand. (Images © 2014, W. Reeve)

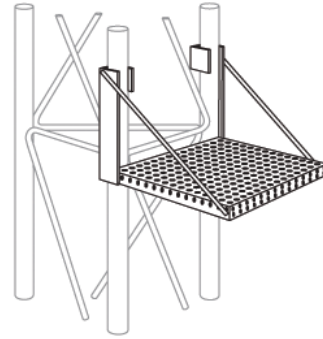


Figure 14 ~ Left: Anti-climb panels are 8 ft long. The tower cannot be climbed without using a ladder or removing the panels. Right: Work platform can be temporarily installed at almost any location on the tower. The work platform at first seemed to fit like socks on a rooster but once figured out it easily clips on. (Image on left © 2014, W. Reeve, source of image on right unknown)

I purchased a climbing safety (fall protection) cable with the tower but have not yet installed it. One of the anti-climb panels will have to be modified to accommodate the lower safety cable bracket, and I will do that work in 2014. I also purchased a work platform to make it easier to install and work on the antenna and rotator system.

### 10. Costs (USD)

60 ft guyed lattice tower	\$1600
Safety cable, anti-climb and work platform accessories	\$1420
Shipping and delivery	\$1770
Travel (gasoline)	\$150
Installation labor (not including foundation), 25 hours	<u>\$0</u>
Total	\$4940

### 11. Next step

Part 3 described tower erection in fall 2013 and a few deferred items. Next in this series is Part 4, which describes the fabrication of the Callisto antenna system. The antenna system consists of cross-polarized log periodic dipole antennas, support booms and an azimuth/elevation rotator. This work also includes extending the tower with a 5 ft lattice section and a 2 ft aluminum mast (figure 15). Installation is planned for summer 2014 and will be described later in this series.

### 12. References:

[Reeve1] Reeve, W., Radio Frequency Interference Survey at Coho Radio Observatory, Alaska, Radio Astronomy, Society of Amateur Radio Astronomers, September-October 2013



Figure 15 ~ Pile of parts – Callisto antenna system components to be described in Part 4. Components include dual horizontal support booms (on saw horses), two log periodic antennas (pointed left and right on top of support booms), rotator (black object at right) and tower extensions (on left) that will raise the tower height about 7 ft above the 60 ft height described in Part 3. (Image © 2014, W. Reeve)

### 13. Units of measure conversion

Many unit converters can be found online, for example: <http://www.digitaldutch.com/unitconverter/volume.htm>, but for convenience conversions of the non-metric units used in this article are shown below.

Convert from	To	Multiply by
inches (in)	millimeter (mm)	25.4
feet (ft)	meter (m)	0.305
pound (lb)	kilogram (kg)	0.454
mile (mi)	kilometer (km)	1.6

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