Use of the MCACS Sectional Mast Kit

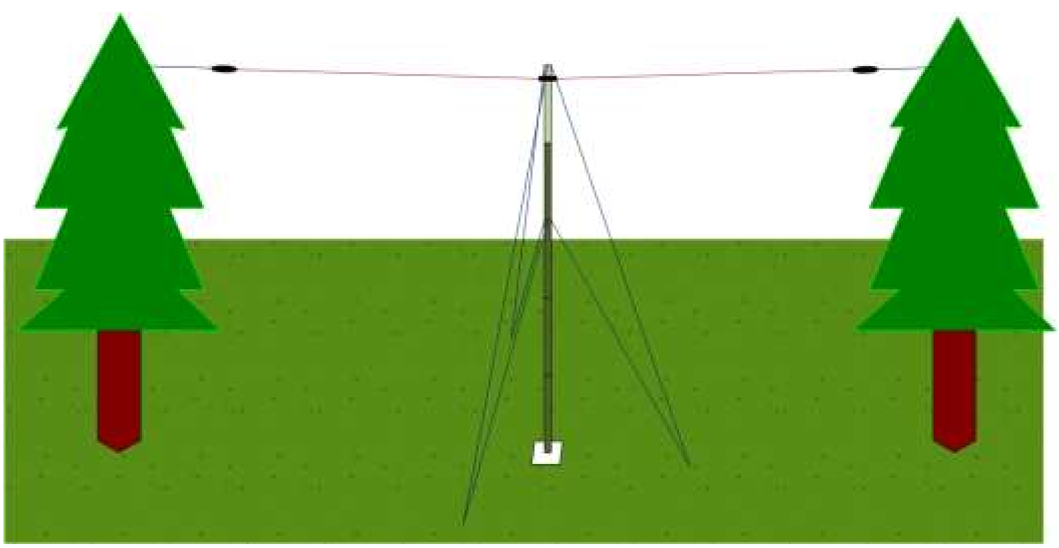
Al Taylor, KN3U (updated 8/15/2024)

MCACS has assembled a sectional mast system that can be configured in a variety of ways to serve different purposes. The system is based on military surplus 4-foot aluminum mast sections that fit end to end to make a mast of up to 40 feet. The original military version of the kit was designated as AB-86/GRA-4.[1] The MCACS kit includes a range of accessories, including base plates, a tripod adapter, guy rings, guy ropes, ground stakes, a halyard with pulley, and a small sledgehammer.

Each mast section is 48 inches long, but overlaps the next section by 3½ inches, so the effective height of the assembled mast is a multiple of 44.5 inches. Thus, for example, a nominal 20-foot mast is just under 19 feet tall:

$$4 \times 44.5 \text{ in.} + 48 \text{ in.} = 226 \text{ in.} = 18 \text{ ft.} 10 \text{ in.}$$

The original and most common use of the mast kit is to support the ends or center of a dipole antenna in a flattop or inverted-V configuration. The following diagram shows one possible arrangement.



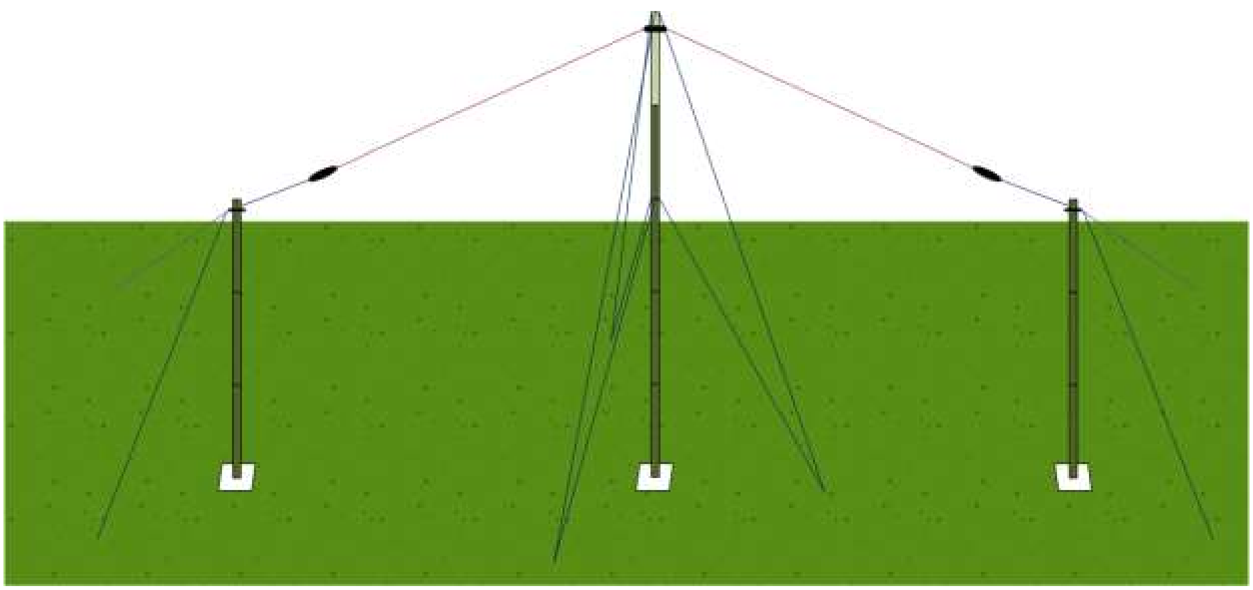
[1] A similar mast kit, designated AB-155/U, can also be found on the surplus/used market. The mast sections in this kit are longer and slightly smaller in diameter than the AB-86 mast sections we have in the MAIPN van. The AB-155 mast sections and hardware are not interchangeable with the AB-86 components, but work equally well as a self-contained system. You can google any of the military designations mentioned in this document for more information.
You might have seen a similar sectional mast system that employs fiberglass mast sections that are the same size as the AB-86 aluminum mast sections. These were originally designed to support camouflage netting and are only marginally strong enough for use as antenna support masts. In addition, they are hazardous when damaged. However, they can be used in low-load applications, as will be described subsequently.

A simple dipole might not need a center support, if suitable end supports are available. But is often helpful to have a center support to minimize sag. That is especially so when using a broadband terminated folded dipole, whose balun and load resistor assembly adds considerable weight to the feed point.

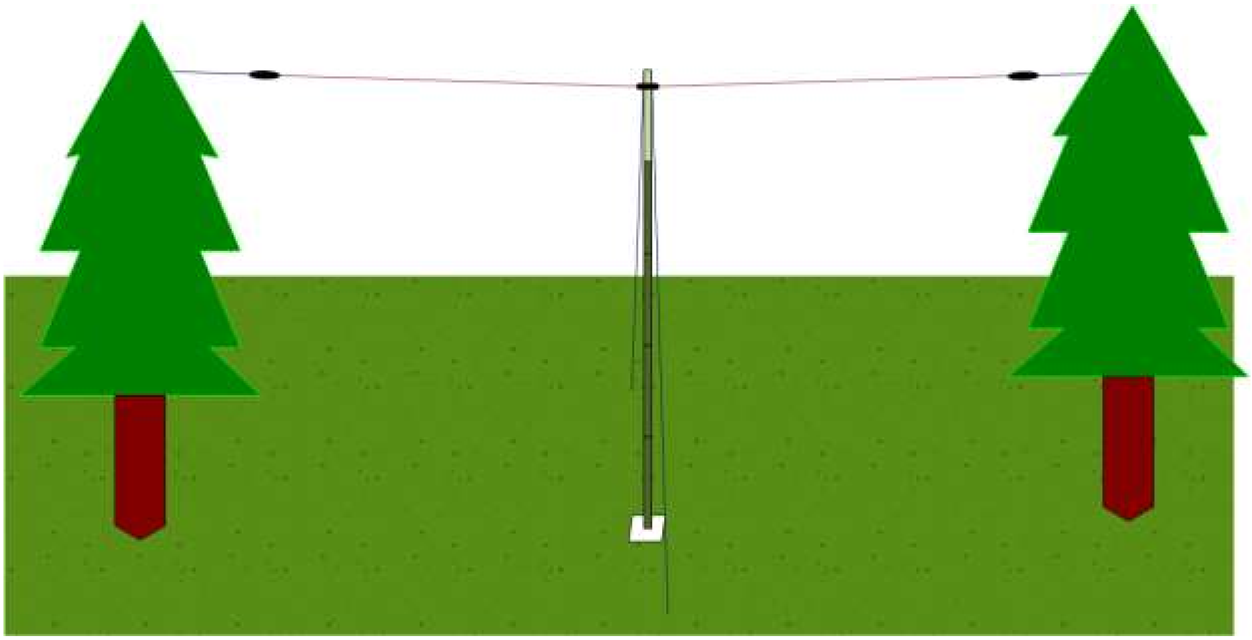
For long-distance HF communications, we usually want the center of the dipole to be as high as the mast will permit. When used for this purpose, the mast needs to be guyed every three or four sections, depending on antenna weight and wind load. The guy lines have two purposes – to keep the mast from tipping over, obviously, but more importantly, to keep it from bending in the middle. Although the individual mast sections appear to be rigid, the assembly as a whole is surprisingly flexible, and it doesn't take a lot of force to cause the mast to bend past the point of failure. The guy lines at intermediate heights limit the amount of bending to a safe value.

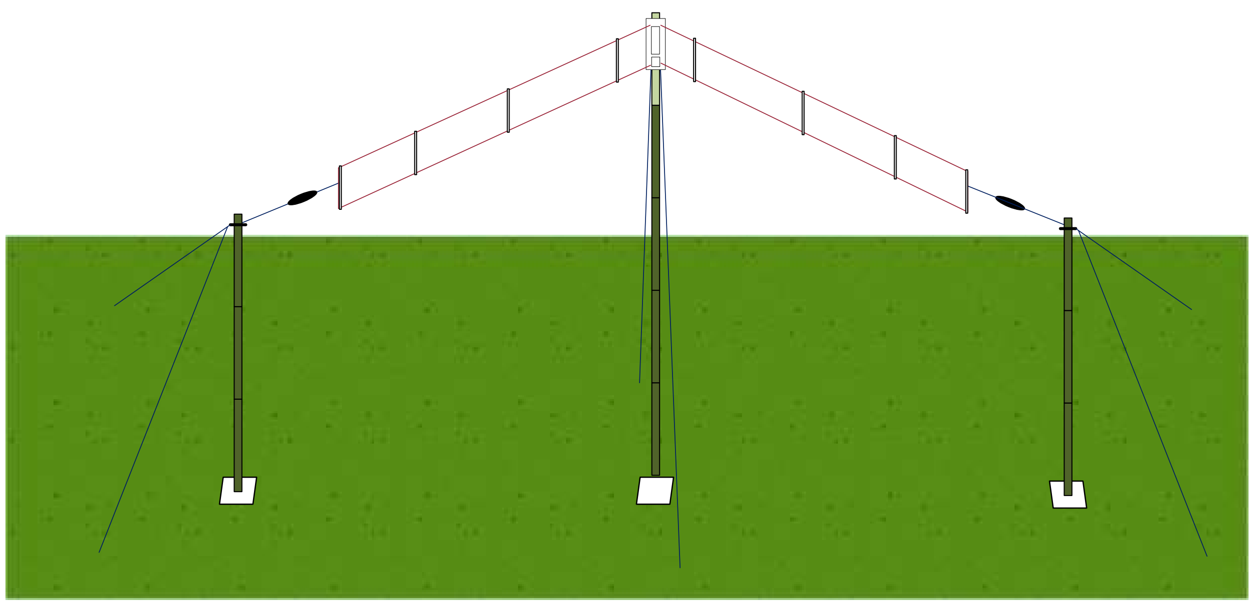
A fiberglass mast section is used for the top section of the mast in this arrangement so that the center of the dipole has a few feet of separation from the metal mast.

There are a number of variations on this basic arrangement. If trees are not available to support the ends of the dipole, the antenna can be erected in an inverted-V configuration with little loss of performance, as shown below. Use additional mast sections to keep the ends of the antenna a safe distance away from people, animals, and vehicles since high voltage may be present on the antenna when transmitting. You will need two guys at each end of the antenna; the antenna support rope itself can serve as one of the guys if it is long enough to reach the ground after wrapping around the end support mast. Use a clove hitch to keep it from slipping.



For near-vertical-incidence skywave communications on HF frequencies, a height of 15 to 20 feet is a good compromise.[2] At this height, a single set of guy lines at the top of the mast is sufficient. In fact, only two guy lines are needed, oriented at right angles to the antenna. It takes a bit of juggling to raise the antenna in this configuration, as the mast will not be stabilized until both the antenna and the guys are under tension. But given the modest height, it isn't difficult to get everything in balance.





[2] Some experts recommend an even lower antenna height for optimal performance, but we want the antenna to be well out of reach for safety's sake. We'll explore this concern further in a later section.

Components of the MCACS Mast Kit

Now, let's take a look at the components included in MAIPN's version of the sectional mast kit. Here are the mast sections along with their tote bag. Note the two fiberglass mast sections included in the kit.

The spool shown below carries three sets of guy lines, two antenna end support ropes, and a halyard with attached pulley for raising the center of the antenna. (Note how the spool is held during use.) Two guy rings are shown on the right. They slip over the top of a mast section. A tripod adapter, orange in color, is visible in the background.

The ropes, by the way, are made by Mastrant, and of very high quality.

The guy lines and antenna end support ropes in our kit have closed loops on the "business end" – the end toward the mast or antenna – and are equipped with tensioning devices (shown in use in Photo F) at the far end. The lines are color-coded by tape or shrink tubing over the crimp sleeves used to form the loop, and each line is also furnished with a color-coded carabiner that enables the line to be quickly clipped onto a guy ring or antenna end insulator. The carabiners should remain attached to the closed loop at all times – for example, when you are reeling the lines off the storage reel – so they are there when you need them.

(A)

(B)

(C)


(D)

(E)

(F)


Photo	Use	Length (ft.)	Color	Reel	Quantity in Kit
A	Top Guy Line	50	Blue	1	3
B	Middle Guy Line	43	Red	1	3
C	Lower Guy Line	32	Green	2	3
D	Antenna End Support	61	Black	2	2
E	Halyard (w/ pulley)	120	Yellow	2	1

It is recommended that the lines be placed on the reels in the order shown in the table above, as they are most likely to be used in the reverse order. Load the tensioner end first, attaching the end loop to the carabiner of the previous line.

Setting Up the Mast To Support a Dipole

CAUTION

- Please handle the mast sections carefully to avoid dinging them, especially the mating ends.
- The joints between mast sections are pinch points. Keep fingers, hands, and cables clear when fitting mast sections together. Better yet, wear gloves.
- The mast sections are just friction-fitted together. And there isn't a lot of friction. Always lift an assembled mast by the bottom section. If you should lift the mast above the level of the first joint, the bottom section is likely to fall out. You might consider using gaffers tape to prevent separation during the erection process.[3]
- When overstressed, the fiberglass mast sections may shatter, producing very sharp shards. Moreover, these mast sections may shed glass fibers from their surface with normal handling. We have applied several coats of paint to minimize shedding, but with wear, it is an ongoing issue. The use of gloves is recommended when handling fiberglass materials.

Don't erect antennas near or underneath power lines.

When using a sectional mast to support a dipole, it is often best to raise the mast first, then use a pulley and rope (called a halyard when used for this purpose) to raise the antenna to the top of the mast after it has been securely guyed. While it might seem like a good idea to assemble the mast sections on the ground and tilt the mast into place, this can lead to excessive bending of the mast, possibly causing permanent damage to one or more mast sections. It is sometimes better to build the antenna from the top down using the "push-up" method. (I'll have more to say about the tilt-up method later.)

[3] The November 2020 issue of *QST* carried an excellent article by Bob Dixon, W8ERD, describing how he drills holes in sectional masts and associated accessories so they can be securely joined together using hitch pins. The hitch pins also prevent the inadvertent rotation of directional antennas supported by a mast in windy conditions.

Start by spiking the baseplate to the ground. The baseplate is a flat piece of steel (heavy-gauge aluminum would work equally well), about 6” square, with a ¾” hole in the center. Position it where you plan to place the center of the dipole. Drive a ground stake vertically into the ground through the hole and leave it sticking out several inches. (A 2-foot piece of rebar works well for this.) The bottom mast section will eventually be placed over that stake to keep it from slipping sideways. The base plate keeps the mast from sinking into the ground and getting plugged up with dirt.

Next, take the top (fiberglass) mast section. Place a guy ring over it, and attach guys lines and the pulley for the halyard. Temporarily tie off the two ends of the halyard to something near ground level so that they won't inadvertently be pulled up out or reach in subsequent steps. If you want other equipment – such as a VHF/UHF antenna or floodlights – at the top of the mast, attach them now, perhaps adding a single mast section above the guy ring to support them.

Then lift this top section and place it on top of another mast section. Continue to lift the mast straight up and insert new sections underneath, adding a guy ring and a new set of guys for each three or four mast sections. When lifting the mast to add a new section, keep just enough tension on the guys to avoid bending the mast. Since there is no antenna attached to the mast at this point, the weight is manageable. If there are antenna feedlines or other cables running down the mast, use tape to secure them at suitable intervals, leaving enough slack to allow for movement.

While not necessary, a tripod provides a bit of stability as the mast is being assembled, when there is likely to be slack in the guy lines. Placing the mast on the tripod allows you to relax and perhaps tweak the guy line tensions in between lifts. When ready, stand up the next mast section alongside the tripod, transfer the mast to that new section, then lift and place the new section atop the tripod.

The following photo shows several sections of mast being lifted onto the tripod. The antenna is supported loosely by the ends and hangs in the background. The halyard is slack as the mast is being raised into position.

At this stage, with or without the tripod, the lifting is easily accomplished by two persons. Beyond five or six mast sections, the mast will become unwieldy and volunteers might be needed on each of the guy lines to keep the mast upright. Since any tension on the guys makes it more difficult to raise the mast, the volunteers need to pay out guy line in synchrony as each new mast section is added. It takes practice for a team do this smoothly. However, it is not necessary to keep the mast perfectly vertical during the erection process. It is only necessary to maintain a near-vertical orientation and limit bending to a safe value.

When the mast is at the desired height, place the bottom mast section on the baseplate and tie off the guy lines securely. The tripod is no longer needed and may be disassembled for use elsewhere.

Next, use the halyard raise the center of the antenna to the top of the mast, adjusting the length of the end support ropes as needed to position the antenna feed point close to the mast. Finally, tension the end support ropes to raise the antenna ends to the desired height. Note that the antenna needs to be routed *under* the top set of guy lines and *over* any lower guys.

You need two persons viewing the mast at a distance at right angles in order to ascertain whether the mast is vertical. In some situations, the volunteers handling the guy lines can do this, but if you have enough people, it might be better to have one or more independent observers fulfill this role. These observers are also well-positioned to watch out for developing problems. In any case, figure out who is going to fulfill these roles before starting the lift.

The following photo shows the end result – in this case, a 90-foot long terminated folded dipole supported by five sections of sectional mast. One end of the antenna is tied off to a two-story house (out of view in the photo) near the peak of the roof; the other end to a mast located in a far corner of the back yard. The halyard is coiled and tied off to a guy line. Unlike the previous photos, this is a fixed installation. But many of our field installations look about the same.

Other Uses

There are many other possible uses for the mast kit. Imagine that you are setting up a station under a pop-up canopy at a public service event. You can use four mast sections to support a VHF/UHF base station antenna at a height of approximately 15 feet. The antenna can be as simple as a J-pole taped to a fiberglass mast section, or it could be a commercial omnidirectional gain antenna or even a small Yagi. The mast can simply be strapped to a leg of the canopy – no guys needed.

While the mast kit is great for putting a variety of antennas in the air, it can be used for other purposes. For nighttime operations, having elevated floodlights is useful for providing illumination over a wide area. Mounting the floodlights well above the line of sight helps to minimize glare. LED floodlights that operate on 120 VAC are lighter, cooler, and more robust than the traditional incandescent floodlights. LED floodlights designed for 12 VDC operation are also widely available.

For one event, I managed to get a two-foot microwave dish up to a height of 50 feet using a sectional mast kit with three sets of guys. In that case, I adjusted the elevation of the dish before raising it. I taped the mast sections together so that I could rotate the entire mast to make the final azimuth adjustment. This was at the extreme limit of what was possible using sectional mast, and would not have succeeded in windy conditions. In general, for any directional antenna, you are better off using a tower or heavy-duty surplus military mast system such as the AB-577 or its even bigger brother, the AB-621, which can support large antennas at heights of up to 50 and 100 feet, respectively. Those are overkill for most disaster communications scenarios, although they are sometimes used by the more ambitious Field Day teams.

A Tripod Variation to Consider

Suppose you need a standalone mast for a VHF/UHF antenna at a height of 20 feet or less? Consider using the tripod adapter to make a tripod having two mast sections per leg instead of one. This gives the mast a wider footprint for added stability. You will also need two mast sections running vertically through the center of the tripod adapter to start the assembly process.

Mount the antenna to what is going to become the top section of the mast and place this top section on the tripod. Don't forget to attach the feedline! Now slide the mast up vertically through the tripod adapter until it is high enough off the ground to add a mast section underneath. Repeat until the antenna has reached the desired height. Use gaffers tape to secure the feedline to the mast at intervals.

Finally, screw a spiral tiedown anchor into the ground directly below the center of the tripod and use a rope to secure the tripod adapter to the anchor. This will secure the tripod from tipping over in anything less than a gale. If the ground is not level, place cribbing under the legs to level the tripod. Scraps of plywood about one foot square are useful for this purpose.

The following photo montage shows the basic concept. The tiedown anchor was only screwed in halfway for clarity.

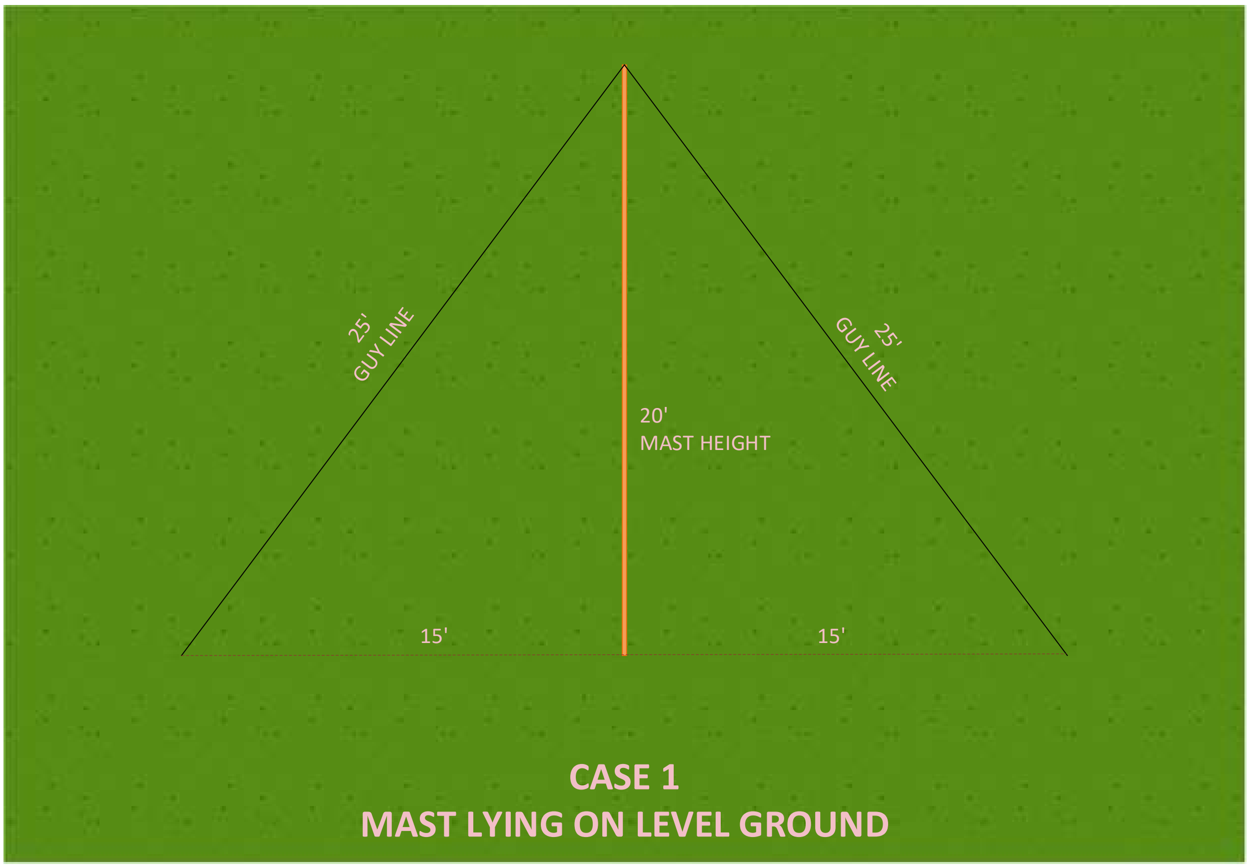
Tilt-Up vs. Push-Up Method

Some folks recommend using the tilt-up method to erect the mast rather than pushing it up and adding section beneath, as I have described herein. On level ground, the tilt-up method is an alternative, particularly for short masts (or towers that are rigid enough to avoid bending in the middle). The tilt-up method is especially advantageous if you are short-handed. A variation on the tilt-up method is “falling-derrick” technique, which is best understood by watching some of the excellent videos available on the web. The falling-derrick technique is particularly useful when dealing with a tall or top-heavy tower. It is of less use with sectional masts, which are generally used for lighter loads.

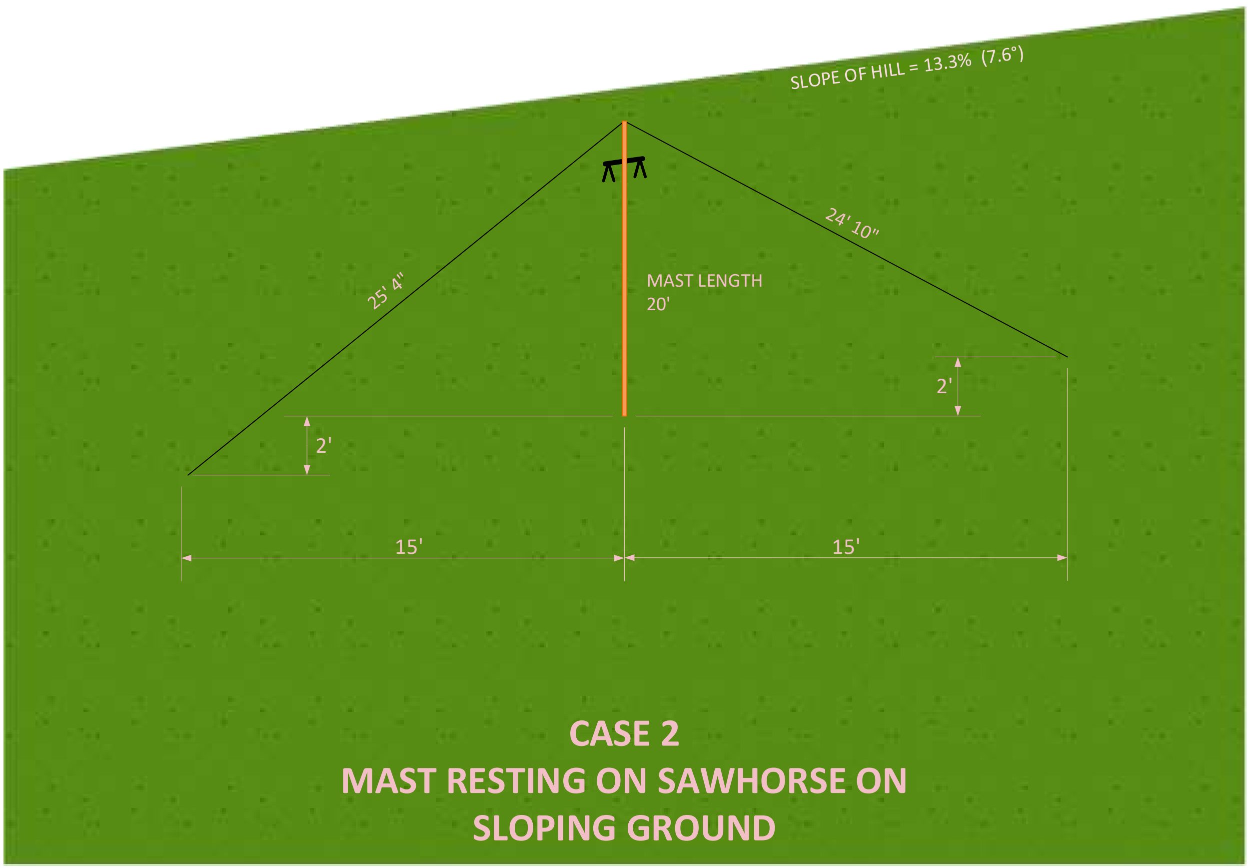
When using the tilt-up method, the first thing you need to do is to ensure that the base of the mast cannot scoot across the ground midway through the lift. There will be a strong lateral force acting to uproot the base. This is best countered by constructing a hinged base and ensuring that it is securely anchored to the ground. If you attempt to have a volunteer “foot the mast” while lifting, they may be surprised by the amount of effort needed to prevent the base from sliding out of position, with catastrophic results.

When the tilt-up method is used, it is best to use four guy lines at 90° rather than three at 120°. The guys that are perpendicular to the direction of lift must be staked off such that their stakes are equidistant on either side of the mast, and form a line with the base of the mast that is at right angles to the direction of lift.

Picture the mast lying flat on level ground, as shown below. The guy lines are staked 15 feet to either side of the mast forming an isosceles triangle, with each side a right angle in the Pythagoras ratio of 3:4:5. The beauty of this method is that these guy lines can be tensioned prior to the lift and will maintain the correct tension as the mast is rotated upward. The back guy line can also be staked off exactly 15 feet behind the mast with 25 feet of rope to ensure that the mast cannot tilt past the vertical when lifted. With three of the four guy lines (or sets, if guys are used at intermediate levels) secured ahead of time, and the mast base securely hinged to the ground, it is feasible for just one or two persons to erect the antenna while maintaining good control.

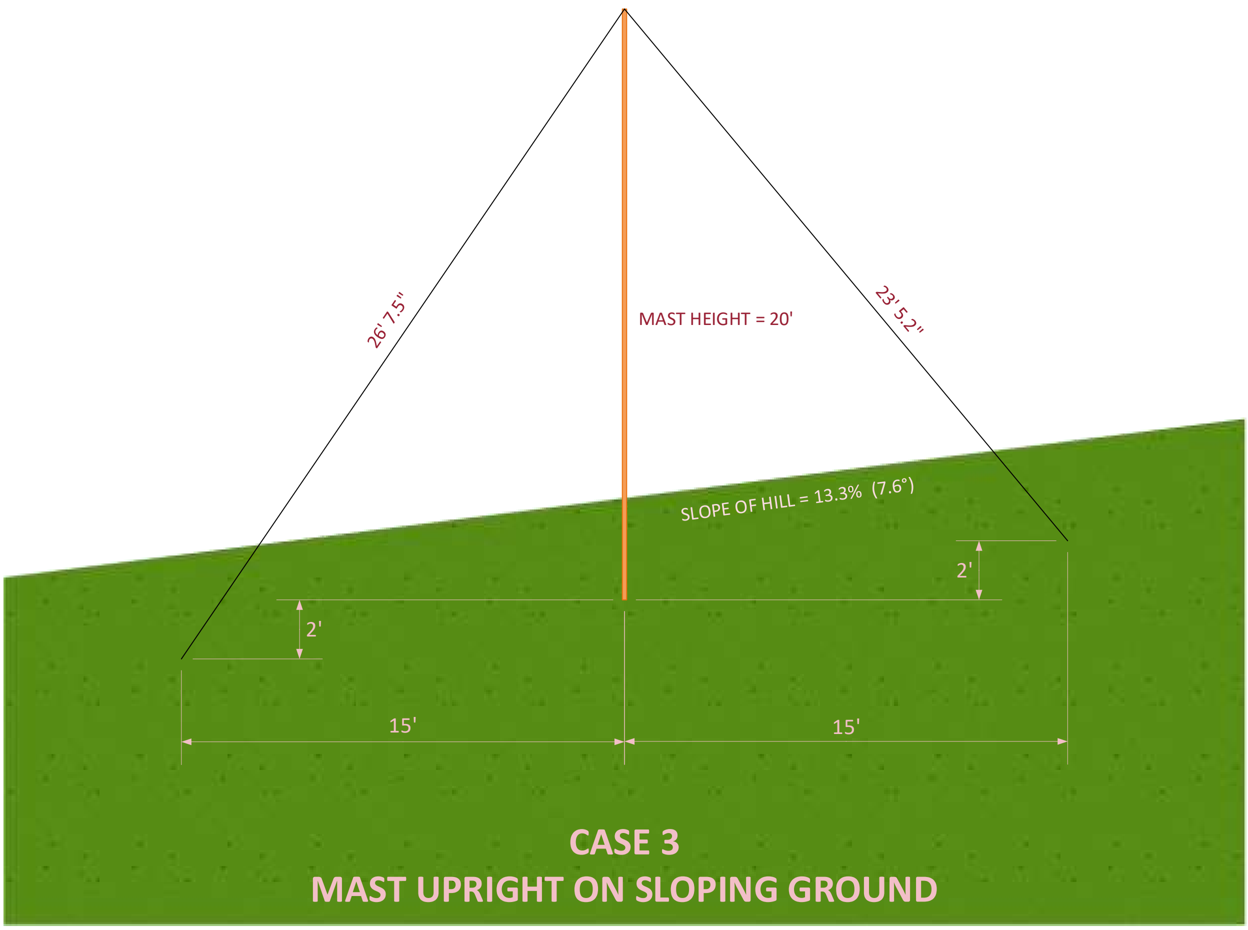


However, this method is problematic on a hillside. The following diagram illustrates the problem. Picture the ground sloping uphill from left to right from the point of view of the diagram. Assume that the mast is propped up on a sawhorse to facilitate attaching the antenna(s) at the top. Thy guy lines are staked 15 feet horizontally to either side of the base of the mast as before, but now the lefthand stake is 2 feet downhill (that is, lower in elevation) than the base of the mast while the righthand stake is 2 feet higher. Under these conditions, the lefthand guy is a few inches shorter than the righthand guy.



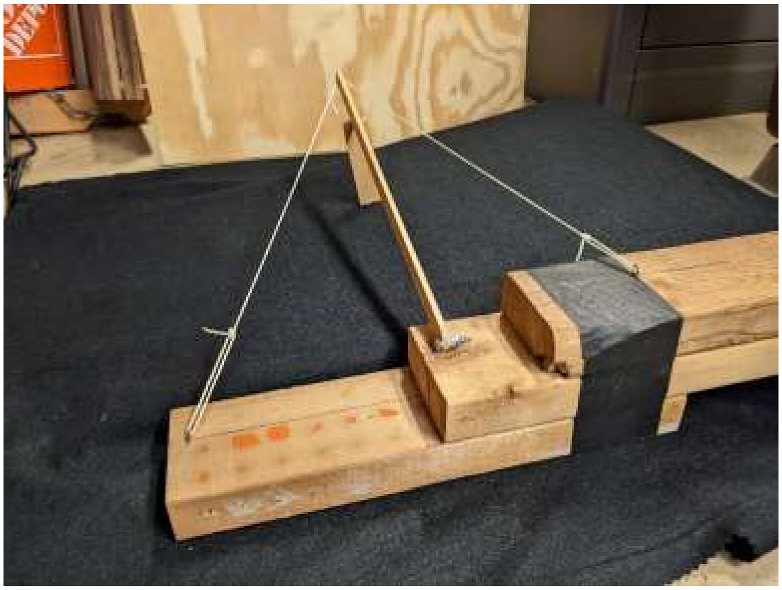
At first glance, it seems that few inches of difference won't matter much, but let's see what happens when the mast is raised to the vertical position. The following diagram shows the required geometry.

To account for the slope, the lefthand guy line now needs to be roughly 2 feet longer than the right. If the guy lines are pulled taut while the mast is lying on its side, The lefthand guy line is will be too short when the mast is raised. The mast will be pulled well off vertical in the direction of the downhill guy line, while the righthand guy line will be slack.



The following two photos provide a physical model to further illustrate this situation. The lefthand photo shows a simulated mast lying on its side on sloping ground and propped up on a simulated sawhorse. The guy lines have been staked at equal distances on either side of the base of the mast, but at different elevations. The guy lines were tensioned with the mast lying in this position.

The righthand photo shows what happens when the mast is rotated to the "vertical" position. You can clearly see that the mast is tilted to the left, while the righthand guy line is visibly slack.



The moral of the story is that, if erecting a mast on a hillside using the tilt-up method, you either have to do some advanced trigonometry when pre-tensioning the guy lines or be prepared to make some adjustments as the antenna is raised.

If the mast can be oriented so that it is pointing directly uphill when lying on its side, the geometry simplifies to the ideal (isosceles triangle) situation. In that case, the front and back guys will be of different length, but that is less problematic than having to adjust the side guys while raising the antenna. Sometimes, however, the terrain is too uneven to find a convenient orientation. In that situation, it is a good idea to raise the mast with no weight on it to determine experimentally the needed lengths for the guy lines. Then lower the mast, attach the antenna, and tilt it back up.

Additional Safety Concerns

There are several overarching safety concerns with an installation of this type.

- First, there is the mechanical hazard should the mast, or anything attached to the mast, fall on someone. Good judgment should be used in planning the installation, and hard hats should be worn by members of the setup crew. Check to see that hardware is tightened before raising the mast and antenna.

- Prior to conducting a lift, pause to ensure that everyone understands their role in the process. Request that everyone looks around to determine the best escape route should something go wrong. Emphasize that, in the event that there is a loss of control, damage to the antenna is preferable to personal injury. No one should try to be a hero and save the antenna. Instead, ensure that you are clear of the falling equipment.

- Only one person should be giving orders. We are privileged to have many MCACS members who are leaders in their professional lives, and who also have expertise in the putting up antennas. The downside is that many of these folks are accustomed to being the decisionmaker in their accustomed environment. Given that there are many ways to accomplish a given task, things go more smoothly if just one person is designated to lead, and everyone else defers to that individual. I have been involved in antenna-raising parties in which two individuals were giving contradictory orders at the same instant of time. At best, this causes confusion and impedes progress. At worst, someone may get hurt.

- We also need to be concerned with electrical shock. With a 100-watt transmitter and a resonant half-wave dipole, the peak voltage at the ends of the antenna approaches 1,000 volts. If the antenna is not operated at its resonant frequency, voltage peaks will be present at different points along the length of the antenna. That is why we recommend that wire antennas be installed high enough to preclude inadvertent contact by persons, animals, or vehicles.

- You must also ensure that a safe separation distance as required by FCC RF exposure rules is maintained. The ARRL RF Exposure Calculator provides an easy way to determine the minimum necessary separation distance and is easy to use. Be conservative in your choice of parameters. For example, consider the case where a 100-W transmitter will be used with a dipole antenna on an HF or 6-meter frequency, a common scenario. A reasonable worst-case analysis would include the following settings in the calculator.

Parameter	**Value**	**Notes**
Power into antenna	100 W	Assumes no feedline loss
Mode duty cycle	100%	Choose FM or AFSK mode to be on the safe side
Transmit duty cycle	TX=30 min RX=0 min	This extreme duty cycle provides an extra margin of safety
Antenna gain	2.15 dBi	Appropriate value for a half-wave resonant dipole
Operating frequency	54 MHz	6 meters represents a worst case for HF

  With these parameters as input, the calculator gives 13.4 feet as the minimum separation in an uncontrolled environment (that is, untrained people in the vicinity). If the dipole is installed at a height of 20 feet above ground, someone could set up a tent and sleep directly under the antenna without incurring unsafe RF exposure. Even so, you might wish to string barrier tape around the entire antenna site for an extra margin of safety (and to avoid questions about safety). Keep in mind that people routinely ignore such protective measures, so barrier tape should not be your first line of protection.

  We recommend that you experiment with the RF Exposure Calculator to get a feel for different situations. For instance, if the operating frequency is below 4 MHz and all other parameters remain the same, the minimum separation distance drops below 2 feet. But you would still need to prevent people from coming into direct contact with the antenna.

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Photo	Use	Length (ft.)	Color	Quantity in Kit
A	Top Guy Line	50	Blue	3
B	Middle Guy Line	43	Red	3
C	Lower Guy Line	32	Green	3
D	Halyard (w/ pulley)	75	Silver	1
E	Antenna End Support	61	Black	2

Load the lines on the spool in the order shown in the table above.

Load the tensioner end of each cable first, attaching the end loop to the carabiner of the previous rope.

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