

Build This Crossboom For Your Cheap and Easy Satellite Antennas

by Richard F. Crow, N2SPI, n2spi@amsat.org.

Author's Note: This is the final article in a series of three articles aimed at providing non-satellite hams, and others, an easy path to acquiring the antennas and information they need to work their first satellite. The first article in the series is "Build this Cheap and Easy Satellite Downlink Antenna" which was originally published in the July/August 2006 AMSAT Journal. The second is "Build this Cheap and Easy Satellite Uplink Antenna" originally published in the September/October 2006 AMSAT Journal. Please read my Author's Notes at the beginning of these other two articles for additional background on this series.

Introduction

As promised in my article "Build This Cheap and Easy Uplink Antenna", here are the plans for a crossboom to hold your uplink and downlink antennas. "Build This Cheap and Easy Uplink Antenna" is one of two companion articles to this one. The other is "Build This Cheap and Easy Downlink Antenna". Read the other two articles first, and build your antennas, before you read this one. If you can't find the other articles, e-mail me.

If you've already built your uplink and downlink antennas, as suggested above, you already understand the need for this crossboom. The design goal here was to use the same laminated foam board techniques as in the antennas but end up with a crossboom, which would be reasonably sturdy. It took a while, but I finally came up a suitable design. The general idea will be to laminate seven foam board strips together to produce a 40 inch long foam board "2x4" which we'll use to make a 3 foot antenna crossboom. Then, we'll attach the crossboom to an inexpensive, lightweight camera tripod. The resulting crossboom and tripod arrangement is surprisingly functional and robust. See Photo 1.

Step-by-Step Instructions

- 1) Read these instruction all the way through to get an idea of what's involved.
- 2) Referring to the list of materials in Table 1, acquire the necessary materials.
- 3) Referring to the list of tools in Table 2, make sure you have the necessary tools or suitable substitutes. If you use a 4-foot carpenter's level, position the

smaller-width side of the level against the foam board when using it as a straight edge. Refer to the uplink and downlink antenna articles for additional tool comments.

In the next 7 steps, make seven 3-1/2 inch by 40-inch foam board strips.

- 4) Position the foam board so a 40-inch edge faces you. Place the two pine boards under the foam board so it is elevated and lies flat and steady.
- 5) Adjust the combination square so 3-1/2 inches of the rule is sticking out of the attached head.
- 6) Then, place the head of the combination square against the 40-inch edge and, with the rule lying flat against the foam

a cutting board. Place the second pine board so the foam board lies flat and steady.

- 9) Be sure the X-Acto knife has a fresh, sharp blade. Now, carefully and patiently (take your time), trace along the line with the tip of the X-Acto knife. At first, just penetrate the surface paper. Repeat, cutting a little deeper each time, and as you can, gently bend back the foam board to expose the cut. Finally, cut through to make a foam board strip hereafter called a "strip". This general cutting procedure is hereafter called "using previous cutting methods".
- 10) Repeat steps 4 through 9 to produce six more 3-1/2 inch by 40-inch foam board strips for a total of seven strips.



Photo 1: The N2SPI Crossboom.

board, make two pencil marks, one 3-1/2 inches up the left side and one 3-1/2 inches up the right side from the edge.

- 7) Using the 4-foot level, or other 48-inch straight edge, draw a 40-inch line between the two marks. The general measuring procedure described in steps 4 through 7 is hereafter called "using previous measuring and marking methods".
- 8) Now, place the first pine board under the line on the foam board so as to act as

In the next 6 steps, locate and mark the center point for circles to be drawn at each end of each strip.

- 11) Adjust the combination square so 1-3/4 inches of the rule is sticking out of the head.
- 12) Then take one of the foam board strips, and using previous measuring and marking methods, place a first mark 1-3/4 inches in from left edge, which is also centered between the top and bottom edges. See Photo 2.



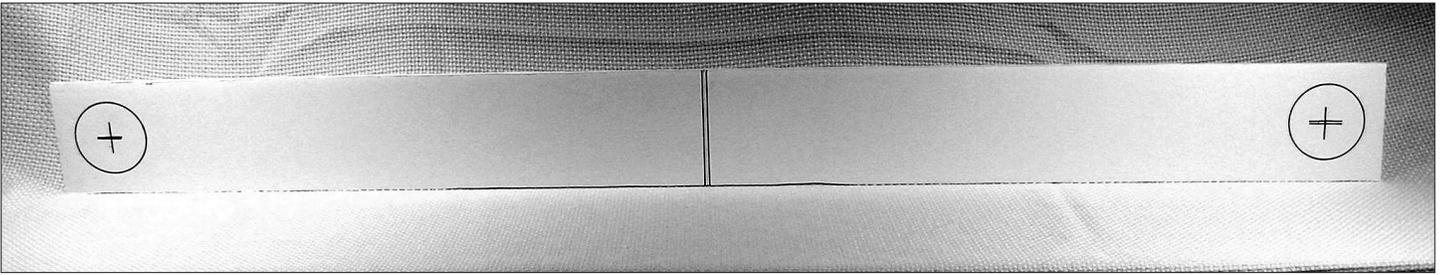


Photo 2: A strip marked up to show the two sets of marks for locating the centers of the two circles (holes) and a pair of lines in the center used to make the 3/16 inch wide slot.

- 13) Then make a second mark 1-3/4 inches down from the top edge, which crosses the first mark. If the two marks don't cross, extend the first mark.
- 14) And finally, make a third mark which is 1-3/4 inches up from the bottom edge, which also crosses the first mark. The idea here is to make a set of marks which will locate the center point of a circle that is 1-3/4 inches in from the left edge and centered between the top and bottom edges. Note that if the strip is exactly 3-1/2 inches wide, the second and third marks, measured from the top and bottom edges, will overlap. Otherwise, the middle of the space between the two resulting marks will indicate the exact center between top and bottom edges.
- 15) Using a procedure similar to that in steps 12 through 14 above, make a second set of marks which is 1-3/4 inches in from the right edge of the strip and is centered between the top and bottom edges. See Photo 2.
- 16) Repeat steps 12 and 15 until all seven strips are marked the same way. These marks are hereafter called "center marks".

In the next 4 steps, draw two 2-1/4 inch diameter circles at each end of five strips.

- 17) Adjust the compass to draw a 2-1/4 inch diameter circle.
- 18) Pick one of the strips. Using the center marks at the left end for the circle center, use the compass to draw a 2-1/4 inch diameter circle at the left end of the strip. See Photo 2.
- 19) Using the center marks at the right end, use the compass to draw a 2-1/4 inch circle at the right end of the strip.
- 20) Repeat steps 18 and 19 until a total of five strips have identical sets of circles drawn on them. Set aside the other two strips for making the side panels later.

In the next 3 steps, cut out the circles in each of the five strips from above to make 2-1/4 inch diameter holes. Ultimately, these holes will hold the antennas.

- 21) Pick one of the five strips worked on above. Using previous cutting methods, and the circle drawn at the left end, cut a 2-1/4 inch diameter hole in the left end of the strip. See Photo 3.
- 22) Using previous cutting methods, and the circle drawn at the right end, cut a 2-1/4 inch diameter hole in the right end of the strip. When done, there should be two holes, one at each end of the strip. Don't fret too much over cutting these holes super accurately. The finished diameter of these holes is not critical as they are clearance holes for the PVC pipe inserts to be installed in the crossboom later. Nonetheless, try to keep the finished diameter of these holes accurate to +/- 1/8 inch. The critical diameter holes will occur in the two side panels of the crossboom, which will be fabricated later.
- 23) Repeat steps 21 and 22 until all five strips have identical sets of holes cut into them. These five strips will make the inner core of the crossboom and are hereafter called "inner core strips".

In the next 5 steps, make preparations for a 3/16-inch slot in one of the inner core strips. Later, this slot will accommodate the 1/4-20 bolt which fastens the crossboom to the tripod.

- 24) Take one of the inner core strips and locate the center of the strip between the left and right edges. To do this, use the tape measure to measure along the bottom edge and make a mark 20 inches in from the left edge. Then measure along the bottom edge and make a mark 20 inches in from the right edge. If the strip is exactly 40 inches long, these two marks should overlap. But if they don't, the middle of the space between the two

resulting marks is the center position of the strip.

- 25) At this center position, use the combination square to draw a line perpendicular to the bottom edge across the strip from the bottom to the top edge. This line will be called "the center line".
- 26) Measuring carefully, draw two lines parallel to the center line, one 3/32 inches to the left, and another 3/32 inches to the right. The distance between the two 3/32 inch lines will be 6/32 inches which is the same as 3/16 inches. Later, these two lines will be cut to make a 3/16-inch wide vertical slot in the center of this strip. Double-check this, and if necessary, re-draw the lines that define the 3/16-inch slot to make sure this width is accurate to within +/- 1/32 of an inch. See Photo 2.
- 27) Flip the strip over and, using the same procedure as above, make a second set of lines for the 3/16-inch slot. When done, both sides of this strip should have lines for cutting the 3/16-inch slot. These lines should line up.
- 28) Using previous cutting methods, cut halfway along one set of lines to start making the 3/16-inch slot. IMPORTANT: Cut only halfway through the strip.

In the next 9 steps, laminate the first two strips to start forming the inner core of the crossboom.

- 29) Take the strip with the partial, halfway cuts and place it flat on the work surface with the side with the cuts facing up. IMPORTANT: The side with cuts must face up.
- 30) From the left end of this strip, lay down a first piece of double-sided tape near the top edge for approximately the first 20 inches stopping just short of the slot. Then, cut the tape neatly with the X-Acto knife. In a similar way, starting



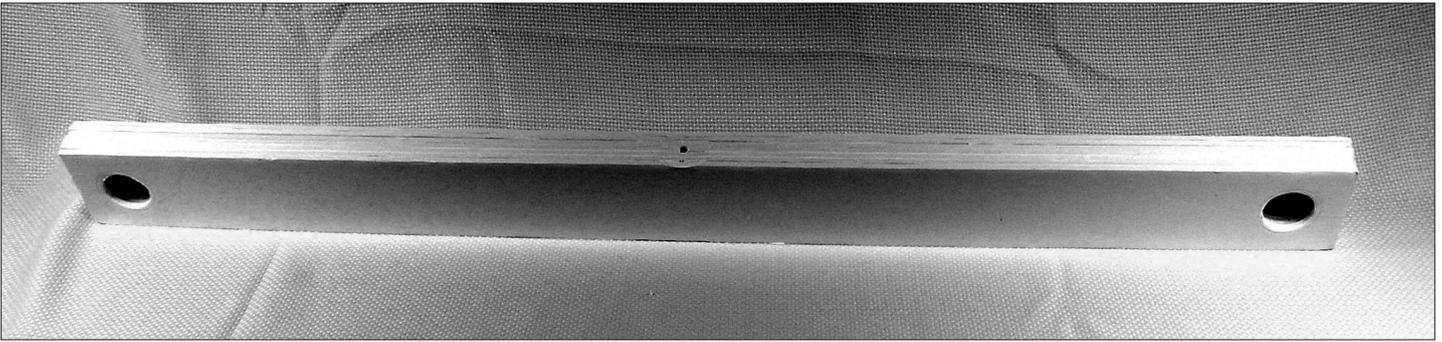


Photo 3: A crossboom with all holes cut and all seven strips laminated together. Note this particular version has side panels with 1 1/2 inch diameter holes, which can hold the antennas directly thereby eliminating the PVC inserts. The crossboom described in the text is exactly the same except that it has larger diameter holes for the PVC inserts.

- on the other side of the slot, lay down another piece of double-sided tape along the remaining 20 inches of the top edge. In this step, and the steps that follow, don't let any tape get between the lines that define the slot. If any tape gets into the slot, trim it away before it gets buried in the laminations.
- 31) In a way similar to the step above, lay down two more 20-inch pieces of double-sided tape across the center of the strip. This tape should be centered between the top and bottom edges. For now, lay the tape across the holes at either end of the strip. It will be trimmed out later.
 - 32) In a way similar to the step above, lay down two more 20-inch pieces of double-sided tape along the bottom edge of the strip.
 - 33) Now, lay down a first strip of double-sided tape, from the top edge to bottom edge, along the left side of the slot, but not in the slot.
 - 34) And finally, lay down a second strip of double-sided tape, from the top edge to bottom edge, along the right side of the slot.
 - 35) Take a second inner core strip. Check for a warp, if any. If any warping is detected, combine the warp of one strip with an opposite warp from the other strip, so they cancel out. Then, line up one end and the bottom edge of the new strip with one end and the bottom edge of the strip on the work surface.
 - 36) Then, starting at the one end, progressively press the second strip onto the first keeping the bottom edges lined-up.
 - 37) Use the X-Acto knife to trim the tape out of the 2 1/4 inch diameter holes.
- In the next 3 steps, complete the 3/16-inch wide slot.*
- 38) Flip laminated strip assembly over to gain access to the lines for the 3/16-inch slot, which have not yet been cut.
 - 39) Finish cutting the other half of the 3/16-inch slot being careful not to nick the uncut strip, the strip without a slot.
 - 40) Remove the foam board material in the slot to complete the fabrication of the slot. Note that the strip with the 3/16-inch slot will be the center strip within all the strips laminated together to make the crossboom. Be sure to check and make sure this strip will end up at the center of the crossboom as each additional strip is added.
- In the next 5 steps, laminate an inner core strip to the other side of the laminated strip assembly with the slot.*
- 41) Take the current laminated strip assembly and place it flat on the work surface with the 3/16-inch slot facing up. IMPORTANT: The 3/16-inch slot must be facing up.
 - 42) Using the procedure in steps 30 through 34 to lay down three rows of double-sided tape across the laminated strip assembly plus two more strips of tape on either side of the slot. Again, don't let any tape get into the slot.
 - 43) Get another inner core strip. Check for a warp and, if any, cancel it out as explained above. Line up the one end and the bottom edge of the new strip with one end and the bottom edge of the strip assembly lying on the work surface.
 - 44) Then, starting at the one end, progressively press the new strip onto the laminated assembly keeping the bottom edges lined-up.
- 45) Use the X-Acto knife to trim the tape out of the holes. When done you should have the three strips laminated together with the slotted strip in the center.
- In the next 7 steps, laminate the remaining inner core strips to the inner core assembly.*
- 46) Take the current laminated strip assembly and place it flat on the work surface.
 - 47) Using a procedure similar to steps 30 through 32 to lay down three rows of double-sided tape across the laminated assembly. No need to worry about the slot anymore. The double-sided tape should now go all the way across the strip, from the left edge to the right edge.
 - 48) Get another inner core strip. Check for a warp and, if any, cancel it out. Line up the one end and the bottom edge of the new strip with one end and the bottom edge of the laminated assembly.
 - 49) Then, starting at the one end, progressively press the second strip onto the laminated assembly keeping the bottom edges lined-up.
 - 50) Use the X-Acto knife to trim the tape out of the holes.
 - 51) To prepare for laminating the last remaining inner core strip to other side of the assembly, flip the laminated strip assembly over.
 - 52) Repeat steps 46 through 51 to laminate the last inner core strip to the laminated strip assembly. When done you should have the five inner core strips laminated together with the slotted strip in the center. This completes the fabrication of the inner core of the crossboom. The general procedure in steps 46 through 51 in hereafter called " using previous

laminating methods”.

In the next 4 steps, make the holes in the remaining two strips, which will become the side panels for the crossboom.

- 53) Adjust the compass to draw a 1-7/8 inch diameter circle.
- 54) Pick one of the remaining strips, and using the marks made previously for the center; draw two 1-7/8 inch diameter circles, one at each end of the strip.
- 55) Using previous cutting methods, and the circles drawn in the step above, cut two holes, one in each end of the strip. Do try to draw and cut these holes accurately, say within +/- 1/32 of an inch. With careful workmanship, it is these holes, which will hold the PVC pipe inserts snugly.
- 56) Repeat steps 54 and 55 to draw and cut two 1-7/8 inch diameter holes in the other, remaining side panel strip.

In the next 3 steps, laminate the side panels to the inner core of the crossboom.

- 57) Using previous laminating methods laminate one of the side panels to one side of the inner core of the crossboom. Be sure to check for warping in the strips and use the procedures above to cancel it out.
- 58) Flip the current laminated strip assembly over to insure that the strip with the slot will remain at the center.
- 59) Then, using previous laminating methods, laminate the other side panel to the other side of the inner core. Again, be sure to check for warping. When done, the crossboom should be seven laminated strips wide with the slotted strip in the center. This completes the laminating of strips to form the crossboom.

In the next 8 steps, cut two 3-inch long PVC pipe inserts for the holes at each end of the crossboom.

- 60) If the length of PVC pipe you have is 5 or 10 feet, use your saw to hack off a 1-foot section, or so, which will be easier to work with. Make sure the 1-foot section includes one of the factory cut pipe ends.
- 61) Adjust the combination square so 3 inches of the rule is sticking out of the attached head.
- 62) From the factory cut end of the pipe, use the combination square to measure in 3

inches and make a mark.

- 63) Rotate the pipe about 1/8 inch and use the combination square to, again, measure in 3 inches and make a mark.
- 64) Repeat the step above until there are many marks at the 3-inch point all the way around the pipe.
- 65) Using the miter box and saw, cut the pipe at the 3-inch point keeping an eye on your marks as you cut. Hold the pipe firmly in the miter box as you cut. Even better, use suitable clamps to clamp the pipe in miter box, if you have them. If your cut isn't following the marks exactly, make adjustments in how you're ever-so-slightly tilting the saw. Don't "muscle" the saw. Your job is to guide it accurately back and forth. Let the weight of the saw do the cutting.
- 66) Use the flat mill file to smooth and bevel the rough edges, both inside and outside the pipe, produced by the saw. It's easier to smooth the inside edges of the pipe with a round file, if you have one. But with a little patience you can smooth the inside edges with a flat file too.
- 67) Repeat steps 60 through 66 to cut a second 3 inch PVC pipe insert using a 1 foot section of pipe which includes the factory cut end from the other end of the original pipe. If your PVC pipe doesn't have factory cut ends, do the best job you can making nice, square, perpendicular cuts. Note that you might be able to avoid doing steps 60 through 67, as well as purchasing the tools to cut the pipe, if you can find a store to buy the pipe from which will carefully cut the 3 inch lengths of pipe for you.

In the next 6 steps, install the PVC pipe inserts into the crossboom and cement them in place.

- 68) Adjust the combination square so 5/8 of an inch of the rule is sticking out of the attached head.
- 69) Take one of the PVC pipe inserts and, using the combination square, make two marks, one 5/8 inches in from one end of the insert, and another 5/8 inches in from the other end. These two marks will be used to center the insert in the crossboom.
- 70) Then, carefully insert the 3 inch PVC pipe into one of the holes at either end of the cross boom. Twist the pipe as you insert it, if that helps. The fit between the

PVC pipe and the crossboom should be tight. If not, try wrapping 2-inch wide "Scotch" type clear packing tape around the center of the PVC pipe until it fits tightly into the crossboom. See Photo 1.

- 71) Using the marks made above, center the pipe insert in the crossboom.
- 72) Then, place holt-melt glue around the PVC insert, on both sides of the crossboom, to cement it in place.
- 73) Repeat steps 69 through 72 to insert, center, and cement the other PVC pipe insert into the other hole in the crossboom.

In the next 6 steps, remove the rubber pad from the tripod's camera mount platform.

- 74) Place the crossboom assembly aside for now and get the camera tripod.
- 75) Locate the removable camera mount platform in the tripod. Install the camera mount platform back into the tripod, if it's not there already. Use the tripod as a work holder as you remove the rubber pad from it. If you have a bench vise, or some other work holder you'd prefer, then use that.
- 76) Gently use the 1/4-inch wood chisel to slowly and carefully pry pieces of the rubber pad out of the camera mount platform.
- 77) When enough rubber has been pried away, remove the 1/4-20 camera-mounting stud and all other metal parts in the camera mount platform.
- 78) When most of the rubber is gone, I use the tip of the chisel as a scraper to clean away the last few rubber remnants.

In the next 6 steps, install the crossboom on the camera tripod.

- 79) When all the rubber is gone, remove the camera mount platform from the tripod.
- 80) Insert the 1/4-20 by 4 inch long bolt through the hole in the camera mount platform that was formerly used by the 1/4-20 camera mount stud which came with the platform.
- 81) With the 1/4-20 bolt sticking out of the camera mount platform, stick the end of the bolt through the hole (3/16 inch slot) in the center of the crossboom. Twist the bolt, if it helps, while working it through the center of the crossboom.
- 82) Once the 1/4-20 by 4 inch bolt is through the crossboom, place the 1/4 by 1 1/2



inch fender washer over the top of the bolt.

- 83) Then screw the 1/4-20 wing nut (or hex nut) onto the 1/4-20 bolt. Tighten gently.
- 84) Place the tripod on a level surface or otherwise level-it-up. Adjust the tripod so the crossboom is in the 90-degree elevation position. This is the position where a raindrop, or vertical rod, will pass through the center of the PVC pipe inserts without touching any surfaces. Use the level to check that the cross boom is level. If you don't have a level then "eyeball-it".
- 85) Now, tighten the nut modestly, enough to hold the cross boom in place, but not so much as to crush the foam board destructively.
- 86) If the 1/4-20 bolt alone does not adequately hold the crossboom in place on the camera mount, then here is something to try: Remove the crossboom from the camera mount, fill the scraped out camera mount platform with quick set epoxy glue, re-assemble by repeating steps 80 through 85, and wait for the glue to set. This completes the fabrication and mounting of the crossboom.

And finally, test your new satellite antenna crossboom.

- 87) Insert the coax connector and coax from your Cheap and Easy Satellite Downlink Antenna through the PVC pipe insert at one end of the crossboom. See Photo 4.
- 88) Then, insert the handle of your downlink antenna into the PVC pipe insert at this end of the crossboom. The PVC insert should hold your antenna firmly while, at the same time, allowing you to rotate

it freely around its boom axis. If the fit is tight, you may have to rotate your antenna back and forth a few times to wear down the handle a bit and free it up. If the fit is loose, try wrapping 2-inch wide "Scotch" type clear packing tape around the antenna's handle to increase its size.

- 89) Insert the connector, coax, and handle of your Cheap and Easy Satellite Uplink Antenna into the PVC pipe insert at the other end of the crossboom.
- 90) Adjust the tripod's azimuth and elevation adjustments so they're tight enough such that the antennas hold their heading, but not so tight that you can't change the antenna's position with a modest push on the crossboom or the tripod's pan head handle. When you're working FM LEOs, you won't have time to repeatedly loosen and tighten the tripod's settings. One tightness setting for each axis of rotation will have serve from the beginning to end of a satellite pass.
- 91) Connect the downlink antenna's coaxial cable to your downlink receiver system.
- 92) Connect the uplink antenna's coaxial cable to your uplink transmitter system.
- 93) Then, point the antennas in the direction of the satellite and work it as described in previous write-ups for the uplink and downlink antennas.
- 94) Along the way, pick up some 5-pound ankle weights like those that aerobic exercisers use. If it is windy, wrap one or more of these weights around the legs of the tripod to keep it from blowing over.

95) Being a load bearing structure made out of foam and paper, this crossboom may tend to sag slightly if it's left setup and holding the antennas for extended periods, such as a couple of weeks or more. If this happens, turn it over so it bows upward and leave it this way until it sags downward again.

96) If you don't want to leave the crossboom and antennas setup for extended periods, the antennas may be removed and stored on a wall using hooks or pegs. Also, the antennas can be suspended from the ceiling on hooks provided they are high enough overhead to be out of the way. As for me, I just shove the antennas between books on top of a tall bookcase and the ceiling.

97) In you want to add an elevation indicator to your crossboom, see "www.tiltmeter.com", for example. Sometimes I use the model #45 tiltmeter (\$29 at www.tiltmeter.com). I'll leave it to your ingenuity to devise a method for attaching it. Having an elevation indicator helps greatly in accurately pointing the antennas. The strength of the satellite's downlink signal varies so much that it's tough to accurately aim the antennas on a consistent basis by waiving them around to find maximum signal. I have noticeably better success when I know the elevation is correct and all I have to do is guesstimate the azimuth. To accomplish this, I bring with me a minute-by-minute printout of elevation and azimuth headings for the satellite which I get beforehand from my tracking program. The other part of this setup is a Timex 1440 Sports Radio Controlled (atomic) dual-time wristwatch (\$20 at www.campmor.com, Campmor No. 87244-P or 87245-P). I also have a miniature clipboard, which I attach to my wrist next to my wristwatch, and so it can hold the az/el printout. I fabricated the clipboard out of sheet of Lucite plastic (from Lowe's, Home Depot, etc.).

In Conclusion...

If you need assistance building or using this satellite antennas crossboom, or have other questions or comments, contact me at: n2spi@amsat.org. Please put the phrase "Antenna Crossboom, v2.0" somewhere on the email subject line. ☺



Photo 4: Crossboom and tripod with uplink and downlink antennas ready for action.



Table 1: List of Materials			
Quantity Used	Material Description *	Example Source	Example Source Item No. **
1	"Elmer's" 30 inch x 40 inch Foam Board	Staples	245563
720"	1/2" wide "Scotch 665" Double Sided Tape	Staples	130500
1	Camera Tripod	Wal-Mart	000659244
1	1/4-20 x 4" Machine Bolt or Screw		
1	1/4"x 1 1/2" Fender Washer		
1	1/4-20 Wing Nut (Hex Nut)		
2	3" Lengths of 1 1/2" Schedule 40 PVC Pipe		
* Name in "quotes" is the brand of product I used. "Equivalents" should be OK.			
** Some "Example Item No.(s)" come packaged in higher quantities than "Qty Used".			

Table 2: List of Tools		
Tool Description	Example Source	Example Source Item Number
12" or 16" Combination Square	Sears	00939681000
Small Tape Measure	Sears	00939697000
4 Foot Carpenters Level (or other 48"straight edge)	Sears	00939813000
1/4" Wood Chisel	Sears	00936850000
Miter Box with Saw	Sears	00936317000
Mill File	Sears	00931300000
"X-Acto" Knife with #11 Blade	Staples	506998
"X-Acto" #11 Blade Refills	Staples	428300
Compass (for drawing circles)	Staples	371130
Hot Melt Glue Gun with Glue Stick	Staples	508701
48" long 1 inch Pine Boards, Qty=2	Lumberyard	
Sharpened Pencil		

