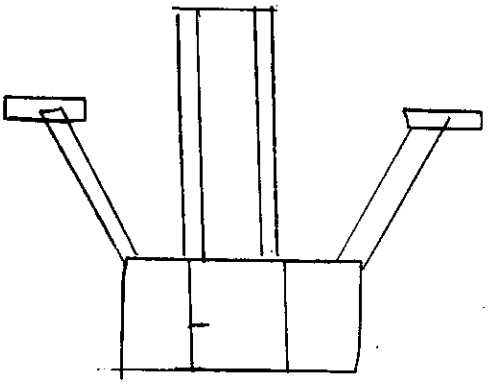
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

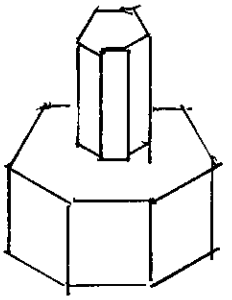
Airship Overview

Not to Scale

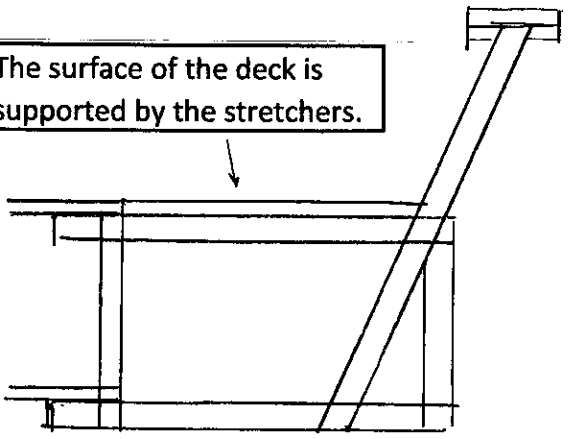
The airship consisists of a tall hexagonal steam tank, surrounded by a hexagonal deck, which in turn is surrounded by a hexagonal railing.



The steam tank is built up from pillars which fit into notches in hexagonal plates. The steam tank can be removed from the airship.



The surface of the deck is supported by the stretchers.



Diagonal supports radiate out to join the six corners of the steam tank, deck and railing.

Each diagonal support consists of a vertical pillar, vertical outer support and diagonal rail support - all joined by two stretchers, one at the ground (base) level, one at the level of the deck.

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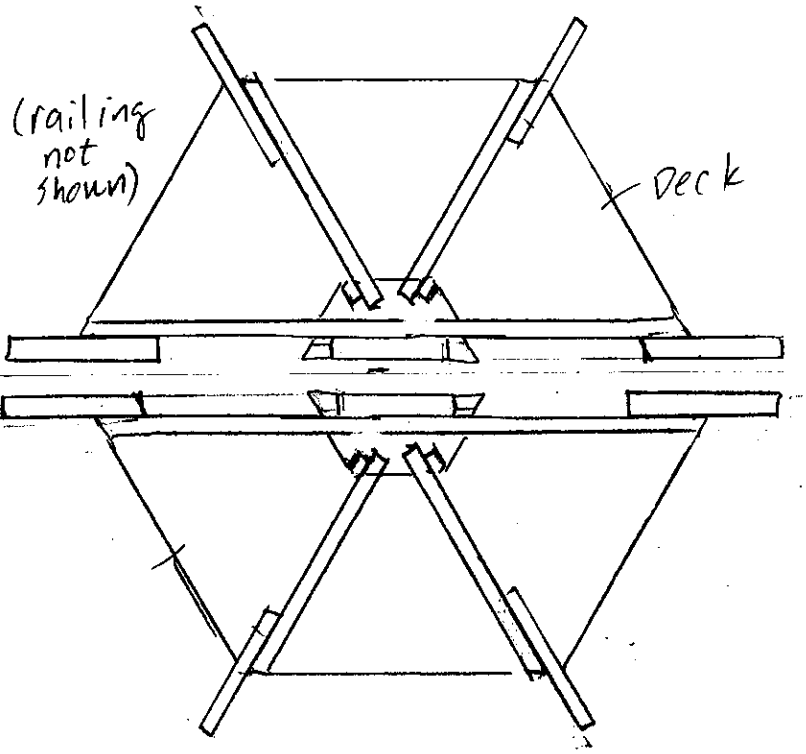
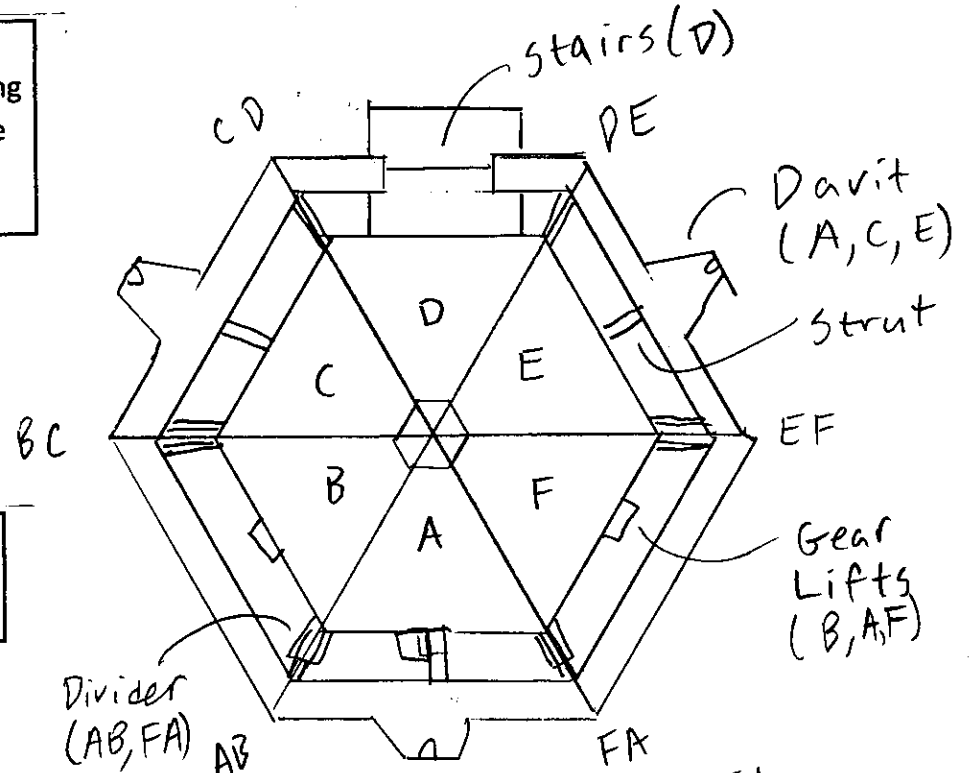
Airship Overview
Not to Scale

One pair of supports is bracketed by a double set of stretchers that extend from one side to the other. This double unit can be separated into two pieces, to allow the airship to be moved easily.



Rope lifts (davits) jut out from the center of the railing in three segments; the rope lifts are supported by diagonal struts.

Other elements attached to the air ship include gear lifts, dividers, stairs and rotors.



B A F = Alliance Side

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Options for simplifying Construction

As designed, this makes a full-sized hexagonal airship as close to FIRST standards as possible. I'm very proud of this accomplishment, but it's a LOT of work to build.

Here are some options for reducing the amount of work and materials:

Option A: No railing covers.

Covering the spaces between the railings is optional. It makes the railings stiffer and perhaps improves safety for the human players on the airship, but the covers themselves are quite tricky to make.

Also, the plywood is opaque, so the human players' visibility is reduced, compared to the clear covers in the actual game. We opted not to implement the covers.

Option B: No Steam Tank

The central steam tank is very impressive, but it doesn't do much and it's very heavy.

Option C: No steam tank, Hemi-airship

Most of the action during the game involves lifting the gears, so the non-alliance side of the airship really only comes into play for the last portion when the bots can shimmy up the ropes.

Building just the alliance side (and no steam tank) simplifies things!

If you only make half the airship and you implement the davit/rope lift there's a risk of tipping the hemi-airship, so support struts are added if this option is chosen.

Option D: No Davits

Making the davits strong enough to support the bots increases the complexity of the construction. You could skip the rope lift portion on the airship and implement the rope lift using the separate rope lift design from FIRST.

Option E: Static (single) touch pad.

The design has a two-part touch pad to detect when the bot has lifted the lower touch pad. This is optional.

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Fun with Hexagons

Be careful about which measurement to use - the WIDTH of a hexagon (from flat side to flat side) or the DIAGONAL (from corner to corner).

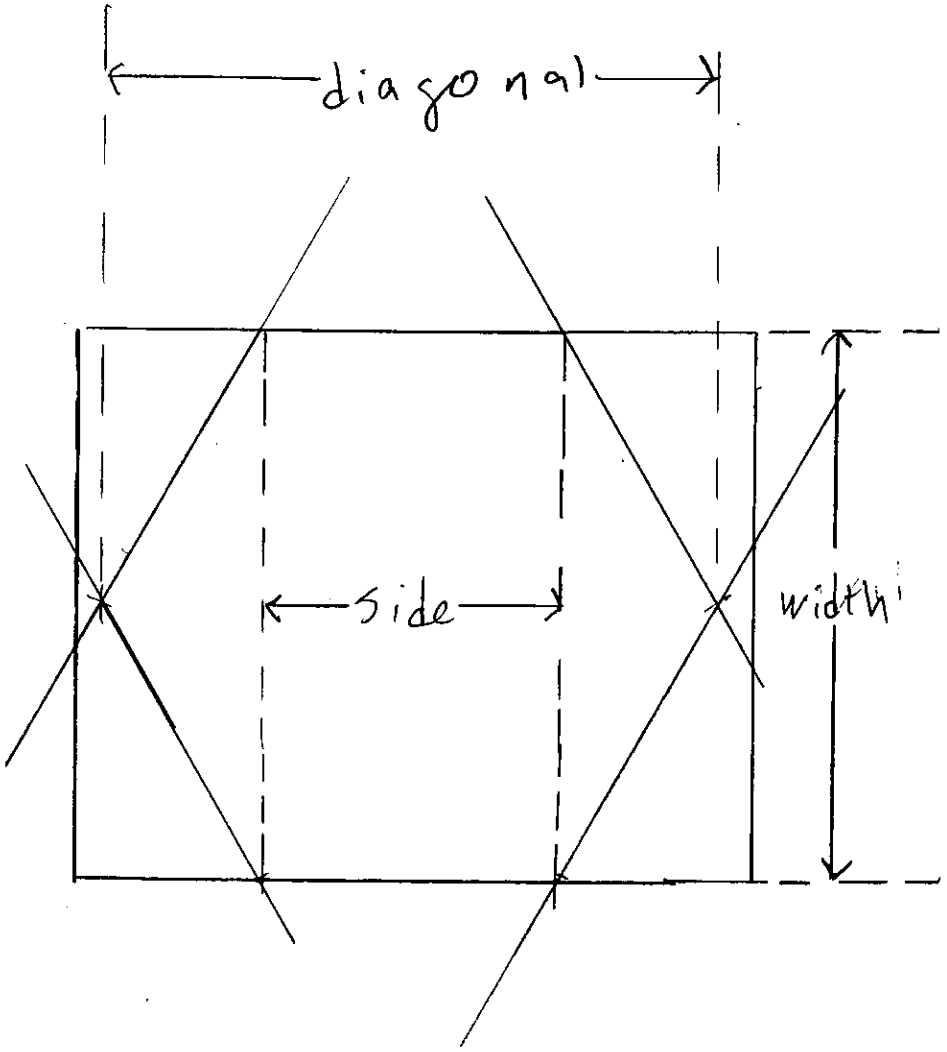
A SIDE of the hexagon is half the DIAGONAL, not half the WIDTH!

Oddly enough, FIRST specified the size of the airship deck and railing by width, but the size of the steam tank by diagonal!

To make a hexagon, cut a piece of plywood to the WIDTH of the hexagon, a little longer than the DIAGONAL of the hexagon.

Mark out the length of a SIDE on opposite edges of the piece. Extend lines 60 degrees from each end of each side.

Cut two sides on bandsaw, as straight as possible. Can cut opposite two sides on tablesaw, set to WIDTH as before.



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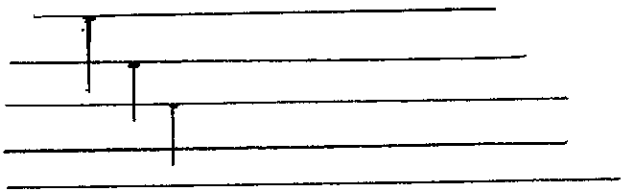
General Construction Notes

The airship is deliberately over-built to withstand bashing from the bots.

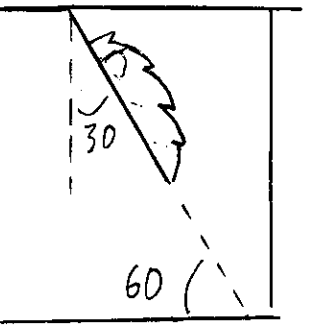
An air nailer is useful to align pieces for gluing or to hold them in place for screwing, but should not be relied on for strength.

Air nails can be driven at opposing angles to increase strength and avoid penetrating through to opposite side.

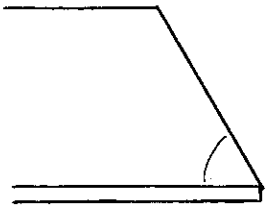
When making a multi-layer "sandwich" to cut out similar parts, resist the temptation to join all the layers with long nails. Instead, join two layers at a time with nails that extend only partway into the lower board. Of course, plan the nails to be in areas which are not being drilled or cut!



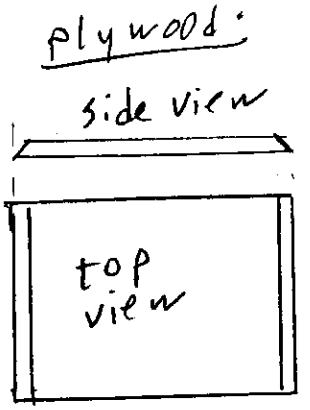
There are a lot of 30 and 60 degree angles in this project. Remember that woodworking tools regard a perpendicular cut as 0 degrees, so cutting a 60 degree angle (whether a bevel or a miter) always means setting the tool at 30 degrees!

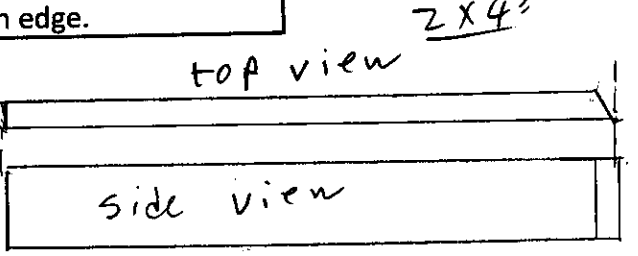


BEVEL vs. MITER: A miter refers to an angle cut across the flat surface of a board. Miters are generally cut with a chopsaw or with a tablesaw, using a MITER FENCE to make a crosscut.



BEVEL vs. MITER: A bevel refers to an angle along an edge. Bevels are generally cut by making a rip cut on a tablesaw with the blade at an angle or by tilting the table of a bandsaw. A bevel at the end of a board can be cut with a chopsaw, standing the board on edge.





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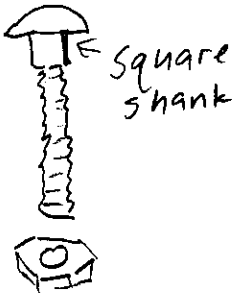
General Construction Notes

BOLTING PARTS TOGETHER: Carriage bolts are widely available. The heads protrude slightly from the workpiece. They work by anchoring a square shank in a round hole, so holes for carriage bolts should be as small as feasible - 9/32 for 1/4 inch carriage bolts. Try to avoid repeated assembly / disassembly.



BOLTING PARTS TOGETHER: Nuts and hex bolts are certainly an option, but require washers at both ends, protrude from workpieces on both sides and require holding the hex head in place while tightening the nut.

BOLTING PARTS TOGETHER: There are a lot of advantages to using T-Nuts and hex bolts: Only require access to one side when assembling / disassembling, only require one washer. Choosing proper size bolt and recessing T-Nut allows bolting with no protrusion on opposite side.

T-Nuts can be quite expensive from usual hardware sources, but are affordable in bulk from woodworking suppliers.

Clearance holes for T-Nuts should be 5/16 instead of 9/32.

BOLTING PARTS TOGETHER: The fastest way to drive lots of 1/4-20 hex bolts or hex nuts is to use a 7/16 socket with an adapter for a cordless drill or impact driver.

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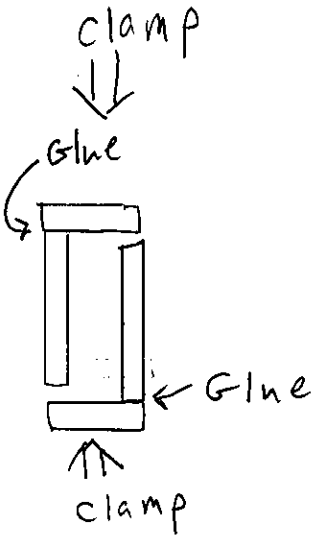
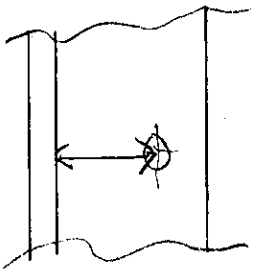
Construction Preparation: Templates

The overall airship structure depends on the very precise placement of bolt holes.

The time spent making drilling / marking templates is well worth it! Using 1/2 inch MDF, cut six 48 x 3.5 inch strips and seven 2 inch strips. (The extra 2 inch strip is to cap the ends.) Glue up as shown, making two lengths of angle material at a time. Use only glue, clamp until dry. Cap one end of each piece, using the extra 2-inch wide material



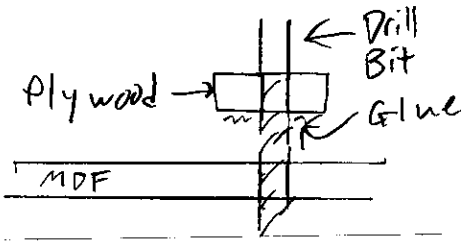
Mark the measurements carefully on the 3 1/2 inch surface - remember to measure from the seam, not from the edge of the 2 inch strip!



Drill 9/32* holes with a drill press to get the holes precisely placed and precisely 90 degrees.

* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.

MDF is quite soft, so the holes should be reinforced - this also helps make perfectly perpendicular holes in the piece. Drill 9/32* holes in 3/4 inch plywood, then cut out 1 1/2 x 2 1/2 inch blocks with the hole off-center.



Apply glue to the underside of the block, then use the drill bit to align with the hole in the template. Use the air nailer to drive in a couple of angled nails to hold the square in place.

Write on the template to mark which end and which side registers where (i.e. "Bevel on this side").

Clamp the template to the board to drill. Results are actually better with a hand-held drill than with a drill press, since the large workpieces are unwieldy to manipulate into place on the drill press table.

Construction Preparation: Templates

Make marking / drilling templates for:

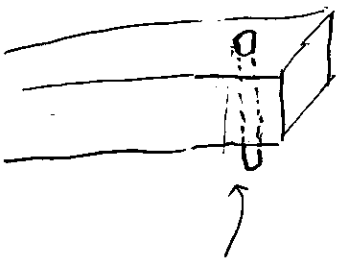
Lower steam tank pillar

Rail Diagonal

Stretchers - can use one template for single and double deck and base stretchers. Be sure to cover holes carefully, since some of the holes are different for deck and base stretchers.

Rope Holder Strut - mark angles and pattern to cut out bottom. Don't need full-length template.

For various other pieces, use the first piece made as a template for the rest of the pieces - or attach several layers together and cut out all at once.



What if I goof? Make some "goof plugs" - start with 5/16 dowels. Trim them down a little for 9/32 inch holes (I used a block plane), cut to 2 1/2 inch lengths and taper one end slightly with a pencil sharpener. If you drill a hole wrong, hammer in a glued "goof plug", then cut off the ends and re-drill.

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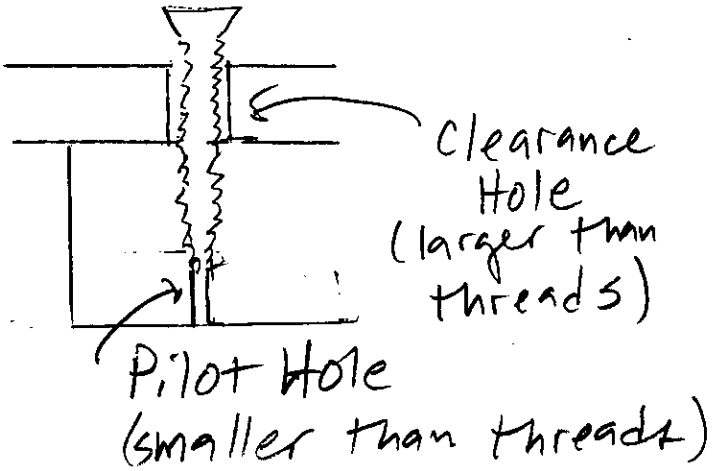
Gluing and Screwing

Screws hold best when they have a clearance hole in the upper workpiece, so threads only bite into the lower workpiece.



Use pilot holes for screws if workpieces are prone to splitting, such as near the ends of 2 x 4 boards.

#8 deck screws of different length are appropriate for most screwing. Heads will bury into face of plywood. Washerhead screws are also useful for locations where the screwheads can protrude from the surface.

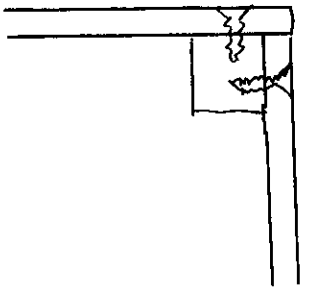
For driving all these screws, do yourself a favor and get an impact driver instead of using a cordless drill.

Use a fresh bit, especially with Phillips-head screws. Consider using deck screws with a star bit.

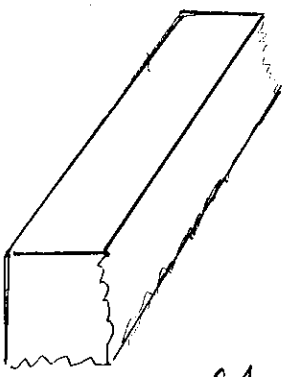
Learn from my mistakes! Don't try to use up random leftover screws - just get deck screws of the lengths you need, then set up a CORDED drill for the right clearance-hole bit size and a cordless drill or impact driver with the right driving bit. Choose deck screws with a star-drive instead of a Phillips drive.

Gluing and screwing

Screwing into the edges of construction-grade plywood does not work well. For extra strenth, reinforce the joint with a "glue block", which is attached to each surface with screws, with or without glue.

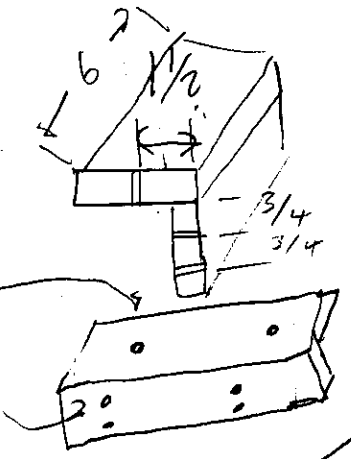


Glue blocks need to have two absolutely smooth sides at a particular angle. Start with a scrap piece of 2 x 4 and rip two edges at the approriate angle to make an approximately 1 1/2 x 1 1/2 strip with two adjacent freshly-cut sides. (Drill appropiate clearance holes, usually 5/32 for #8 screws.)

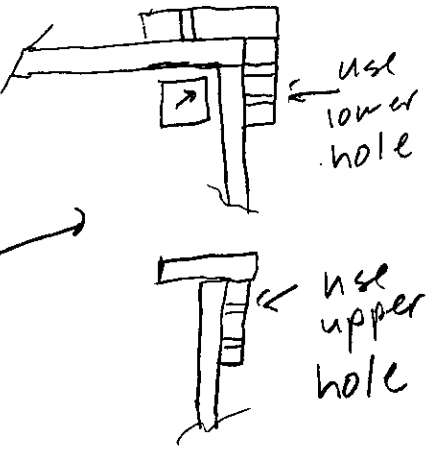


Quick bulletproof joint: Apply glue to block. Use template to drill clearance / pilot holes 3/4 inch from edge of vertical sheet, screw block to vertical sheet. Apply glue to seam and top of block, use nailer to tack horizontal board in place, then use template to drill pilot/clearance holes 1 1/2 inch from edge. Screw to block.

Make a drilling template as shown. Note that the holes for each surface are offset from each other, to reduce splitting the glue block.



Note the spacing varies depending on whether or not the sheets are already connected.



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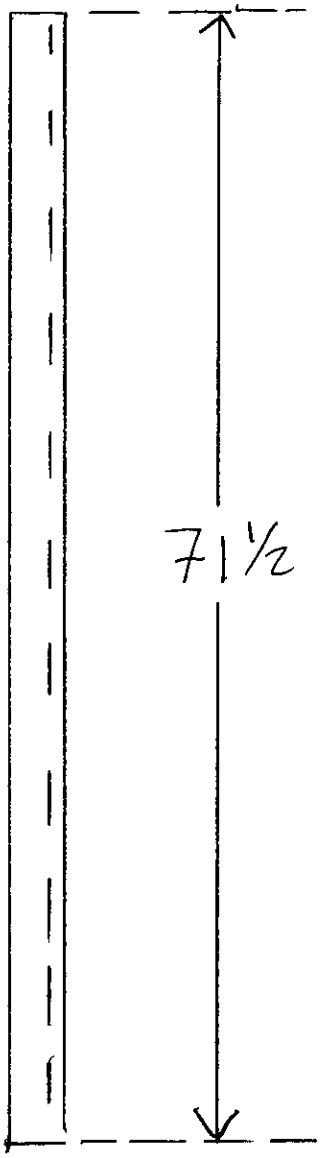
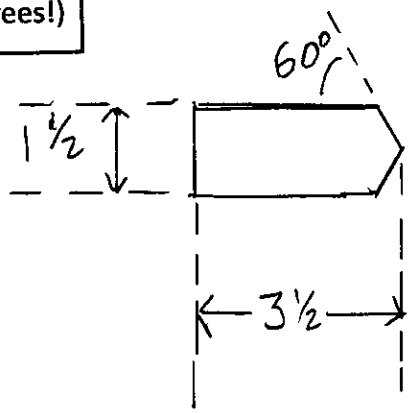
Part Sparta-997-1 Airship Steam Tank Upper Pillar
6 | Sc 1 in = 1 ft | 2x4 board 71 1/2 long
Tools: Chopsaw Table Saw (Rip)

Fits into notches in hexagon plates top and bottom, covered by hexagon plate at top. Covered with plywood skin.

Option B: Omit this part if not making steam tank.



Double Bevel Edges to 60 degrees as shown (remember set sawblade to 30 degrees!)



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Part Sparta-997-2 Airship Steam Tank Lower Pillar

8 | Sc 1 in = 1 ft | 2x4 board 36 1/4 long

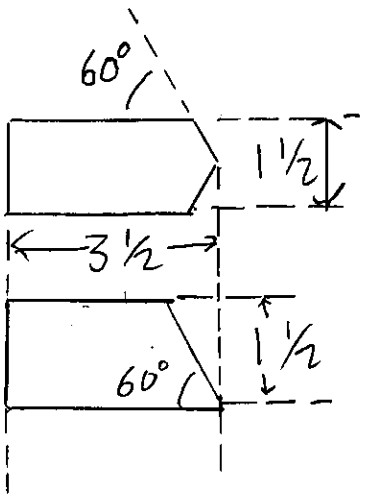
Tools: Chopsaw Table Saw (Rip) Handheld Drill

Option C: Only make 4 for hemi-airship.

Fits into notches in hexagon plates at base and deck. Attaches with carriage bolts to stretchers at base and deck.

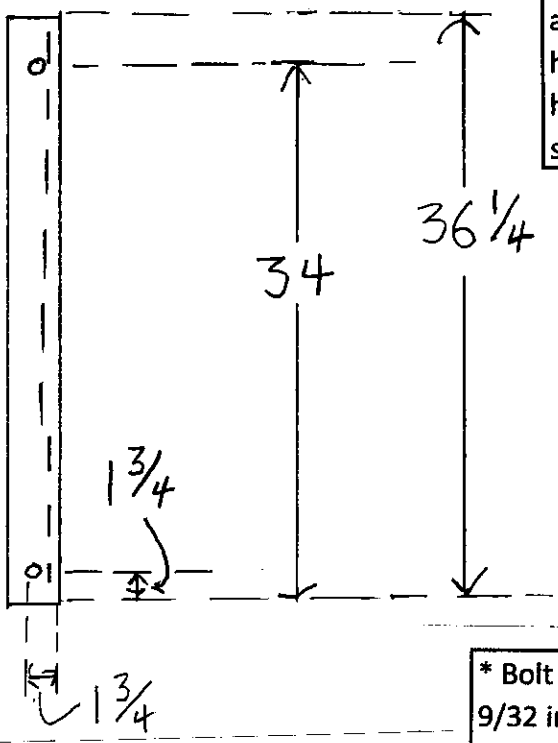
Make four pieces double-beveled as shown.

Make four pieces with single bevel as shown.



Caution: when drilling holes, remember the single beveled pieces are mirror images and are not interchangable - drill half with bevel on one side, half with bevel on the other side!

Note pillar is slightly under-length so it will not protrude from deck plate.



9/32 inch clearance holes for carriage bolts are located 1 3/4 inches from beveled edge (since board width may vary). Use MDF template for accuracy.

Mark top of pillar to avoid installing upside-down!

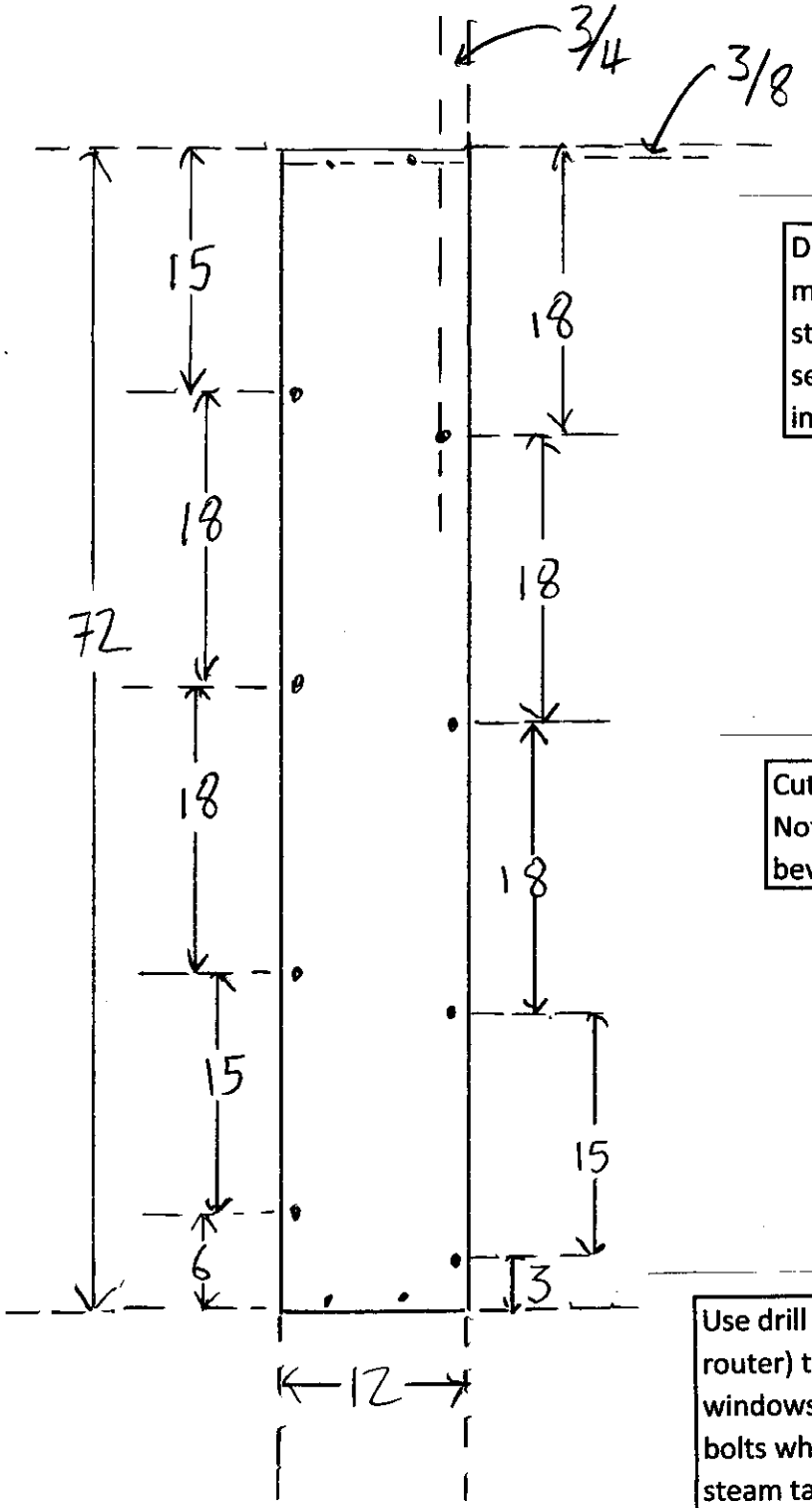
* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.

TOOLS/CONSTRUCTION: Cut to length with chopsaw, bevel edges with tablesaw, drill holes with handheld corded drill and template.

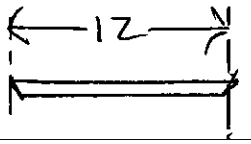
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-3 Airship Steam Tank Skin
6 | Sc 1 in = 1 ft | 1/2 Ply, 12 x 72
Tools: Handheld Drill

Covers steam tank pillars

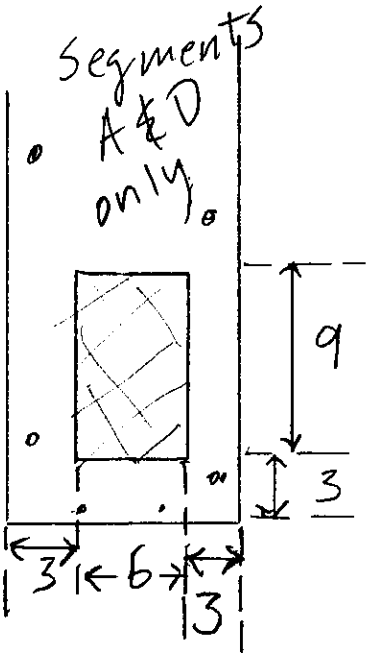
Option B: Omit this part if not making steam tank.



Drill clearance holes as marked. Holes are stagggered so adjacent sections of skin do not screw into same spot on pillar.



Cut beveled edges as shown. Note 12 inch width incudes bevels.



Use drill and jigsaw (or router) to cut out two access windows - used to access the bolts which attach the steam tank to the deck plate. Be sure the windows are large enough to fit your impact driver!

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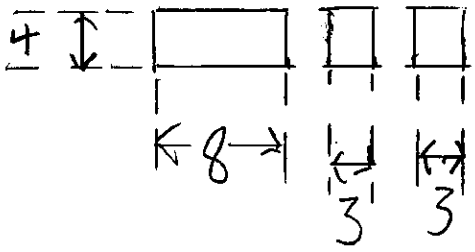
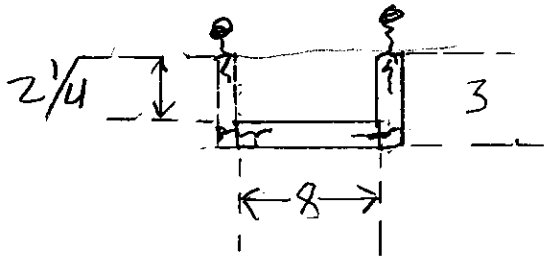
Part Sparta-997-4 Airship Steam Tank Gear Bracket
1 | Sc 1 in = 1 ft | 3/4 Ply 4 x 15
Tools: Table Saw (Crosscut) Handheld Drill

Holds Starting Gear

Option B: Omit this part if not making steam tank.





Cut and screw as shown to make 2 1/4 by 8 space to hold gear.

Screw and glue to steam tank skin Segment A

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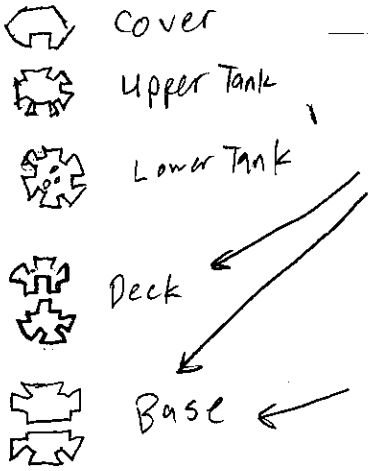
Hexagonal Plate Overview

A total of five hexagon plates are used to construct the steam tank and form the center of the deck.

The hexagons have 23 inch DIAGONALS so that adding a skin of 1/2 inch plywood makes a 24 inch DIAGONAL steam tank.

The hexagon plates that form the core of the deck are cut into two pieces to allow the airship to be separated into different pieces.



Option B: Only need 2 hexagon plates if not building steam tank.

Option C: Only need one hexagon plate if only building hemi-ârship (and no steam tank)

TOOLS/CONSTRUCTION: Use table saw to cut sheets 20 inches wide, about 25 inches long: 1 layer of 1/2 inch plywood, 4 layers of 3/4 inch plywood.

TOOLS/CONSTRUCTION: Use air nailer or screws to make a sandwich of all 5 layers, avoid nailing into corners.

TOOLS/CONSTRUCTION: Draw sides of 11 1/2 inches in hexagon shape. Cut two sides with bandsaw. (Can cut parallel sides with table saw set to 20 inches.) F

TOOLS/CONSTRUCTION: Remove 1/2 inch plywood cover plate and set aside rest of stack.

TOOLS/CONSTRUCTION: Carefully lay out notches at corners, 1 1/2 inches wide, 3 1/2 inches deep. (Check steam tank upper pillars - if beveling reduced width, adjust depth accordingly.) Drill large holes in corners of notches with drill press, then cut out notches with bandsaw. (Holes allow bandsaw to make cuts without dangerously backing out of a cut.)

TOOLS/CONSTRUCTION: Remove 3/4 inch plywood upper plate and set aside rest of stack.

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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Part Sparta-997-5 Airship Tank Cover Hex Plate

1 | Sc 1 in = 1 ft | 1/2 Ply, 20 x 25

Tools: Table Saw (Rip) Bandsaw Handheld Drill Drill Press Nailer

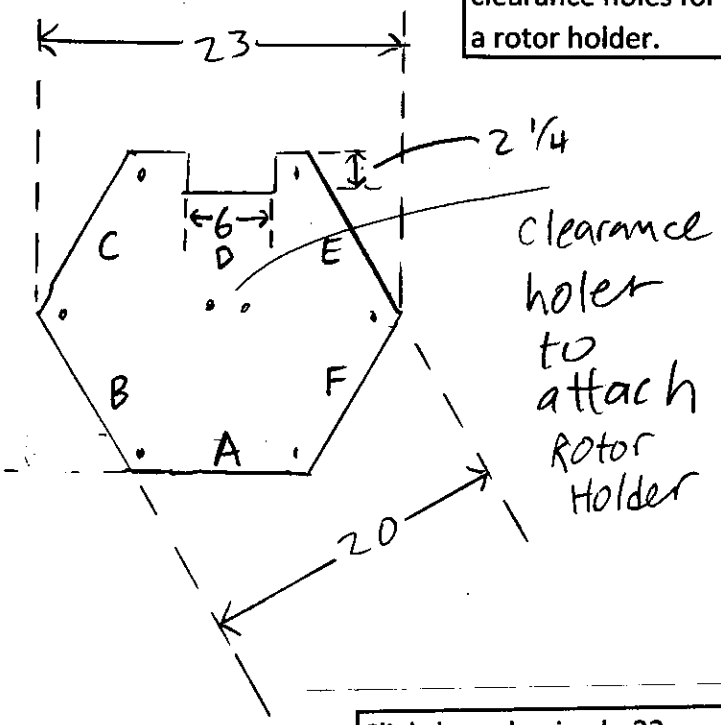
TOOLS/CONSTRUCTION: Once the rest of the stack is notched at corners, mark the notch for the gear in cover plate and upper plate. Cut sides of notch on tablesaw using crosscut sled, then cut bottom of notch on bandsaw. (Or drill large turnaround holes with drill press and cut out all sides with bandsaw.)

TOOLS/CONSTRUCTION: Drill 5/32 inch clearance holes in corners to attach to pillars.

Glue and clamp to laminate with upper plate.

Option B: Omit this part if not making steam tank.

The steam tank cover plate has a notch for a gear and clearance holes for attaching a rotor holder.



Slightly undersized - 23 inches corner-to-corner to fit inside steam tank skin and make 24 inch corner-to-corner steam tank.

No notches at corners.

5/32 inch clearance holes at corners to attach to steam tank pillars.

Notch cut into one side for gear.

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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-6 Airship Tank Upper Hex Plate
1 | Sc 1 in = 1 ft | 3/4 Ply 20 x 25
Tools: Table Saw (Rip) Bandsaw Handheld Drill Drill Press Nailer

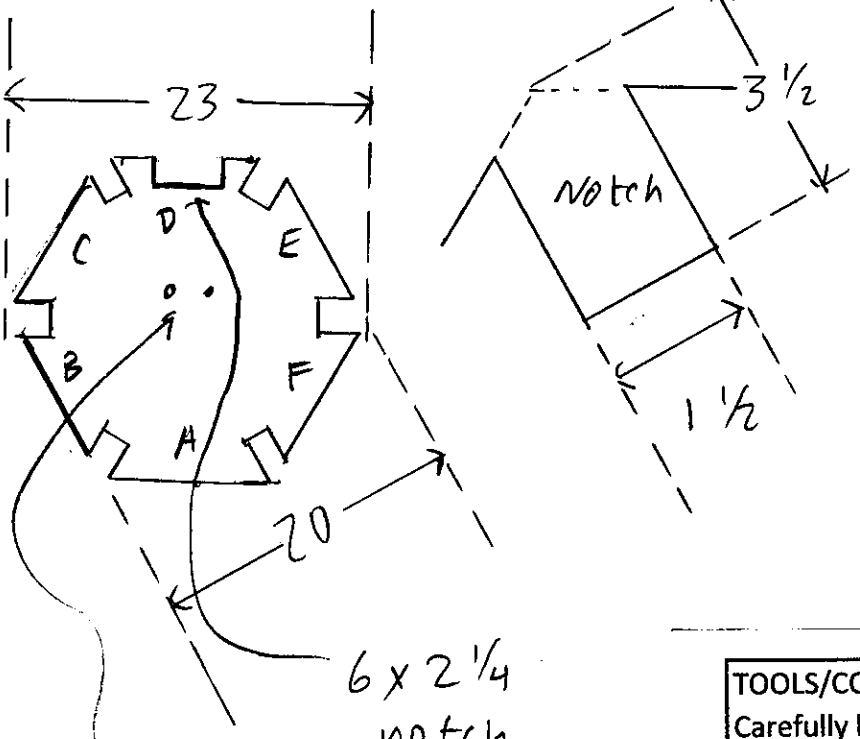
Option B: Omit this part if not making steam tank.

Holds pillars in place. Laminated to cover plate.

Slightly undersized - 23 inches corner-to-corner to fit inside steam tank skin and make 24 inch corner-to-corner steam tank.

Notches at corners to accommodate steam tank pillars - remember pillar beveling may decrease pillar width slightly.

Notch cut into one side for gear.



Glue and clamp to laminate with cover plate.

TOOLS/CONSTRUCTION:
Carefully lay out notches at corners, 1 1/2 inches wide, 3 1/2 inches deep. (Check steam tank upper pillars - if beveling reduced width, adjust depth accordingly.) Drill large holes in corners of notches with drill press, then cut out notches with bandsaw. (Holes allow bandsaw to make cuts without dangerously backing out of a cut.)

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TOOLS/CONSTRUCTION:
Remove 3/4 inch plywood lower plate and set aside rest of stack.

Mark sections A - F

Once the deck plate is complete, align with deck plate and drill 5/16 holes for connection to deck plate, 3/4 hole for alignment dowel. Remove deck plate and enlarge to 1/2 and 1 inch respectively.

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Part Sparta-997-7 Airship Tank Lower Hex Plate

1 | Sc 1 in = 1 ft | 3/4 Ply 20 x 25

Tools: Table Saw (Rip) Bandsaw Handheld Drill Drill Press Nailer

Option B: Omit this part if not making steam tank.

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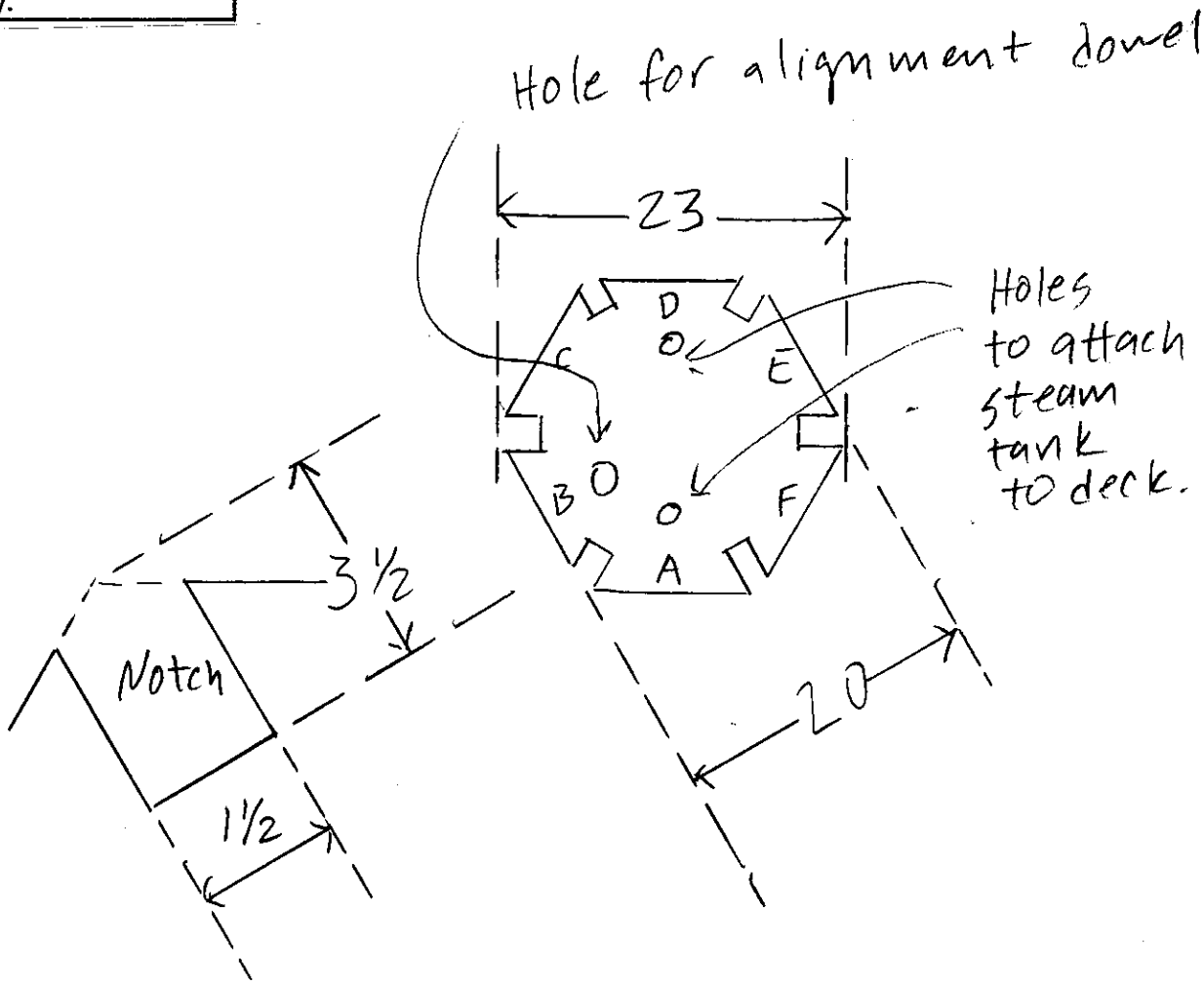
Holds steam tank pillars in place, covered with skin to make steam tank. Bolted to deck plate to attach steam tank to airship.

Oversize 1/2 inch holes to bolt to deck plate.



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Aligns lower tank pillars, attaches to deck stretchers.

Option C: Omit this part if making hemi-airship.

Aligns lower tank pillars, attaches to base stretchers.

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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Part Sparta-997-8 Airship Deck Hex Plate

1 | Sc 1 in = 1 ft | 3/4 Ply 20 x 25

Tools: Table Saw (Rip) Bandsaw Handheld Drill Drill Press Nailer

Part Sparta-997-9 Airship Base Hex Plate

1 | Sc 1 in = 1 ft | 3/4 Ply 20 x 25

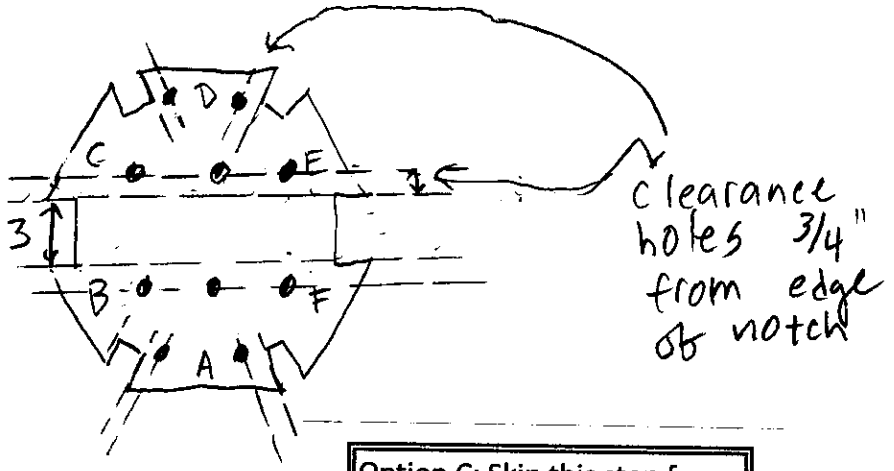
Tools: Table Saw (Rip) Bandsaw Handheld Drill Drill Press Nailer

Leave Deck and Base Plates attached to each other.

Mark sections A - F

Enlarge two notches on Deck and Base Plates to be 3 inches wide.

Drill clearance holes to attach to stretchers.



Option C: Skip this step for hemi-airship

deck plate

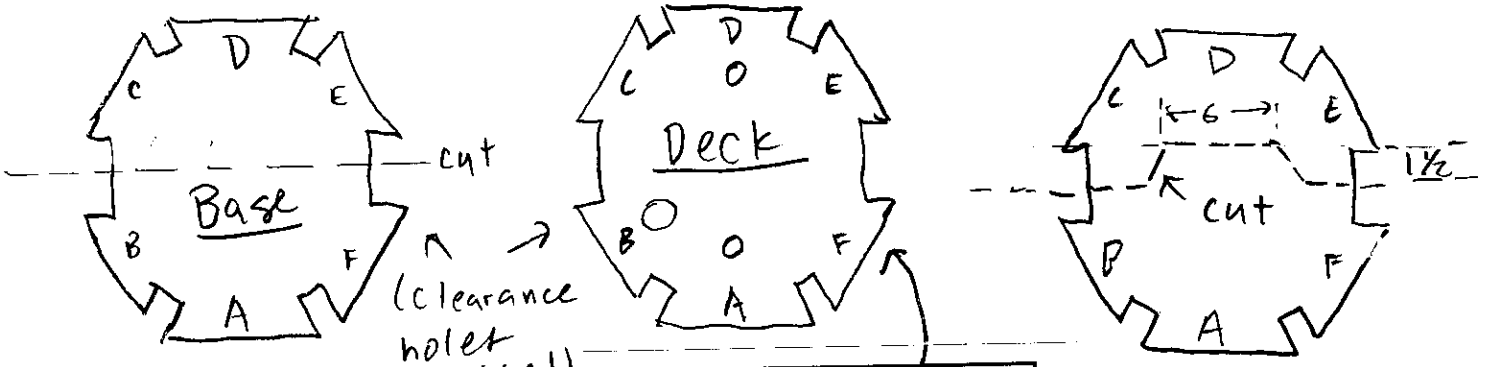
Align with lower tank plate and drill 5/16 holes for connection to deck plate, 3/4 hole for alignment dowel. Insert T-nuts on underside of 5/16 inch hole, glue alignment dowel into 3/4 inch hole.

Using bandsaw for minimum possible kerf, cut deck plate in half from corner to corner, with center section offset as shown.

Separate base and deck plates.

Using bandsaw for minimum possible kerf, cut base plate in half from corner to corner.

Deck



Option B: No need to register if not making steam tank.

Assembly - Steam Tank:

Laminate the Tank Cover Hex Plate and Tank Upper Hex Plate together with glue and clamps.

Drill 5/32 clearance holes, attach Rotor Holder to top.

Rout handhold in top or attach handle to top.

Be sure attachment holes and alignment dowel hole are done in Tank Lower Hex Plate.

Arrange Steam Tank Upper Pillars in Tank Lower Hex Plate and Tank Upper Hex Plate / Tank Cover Hex Plate. Screw in place through clearance holes at corners of Tank Cover Hex Plate.

Attach Gear Holder to Steam Tank Skin for segment A.

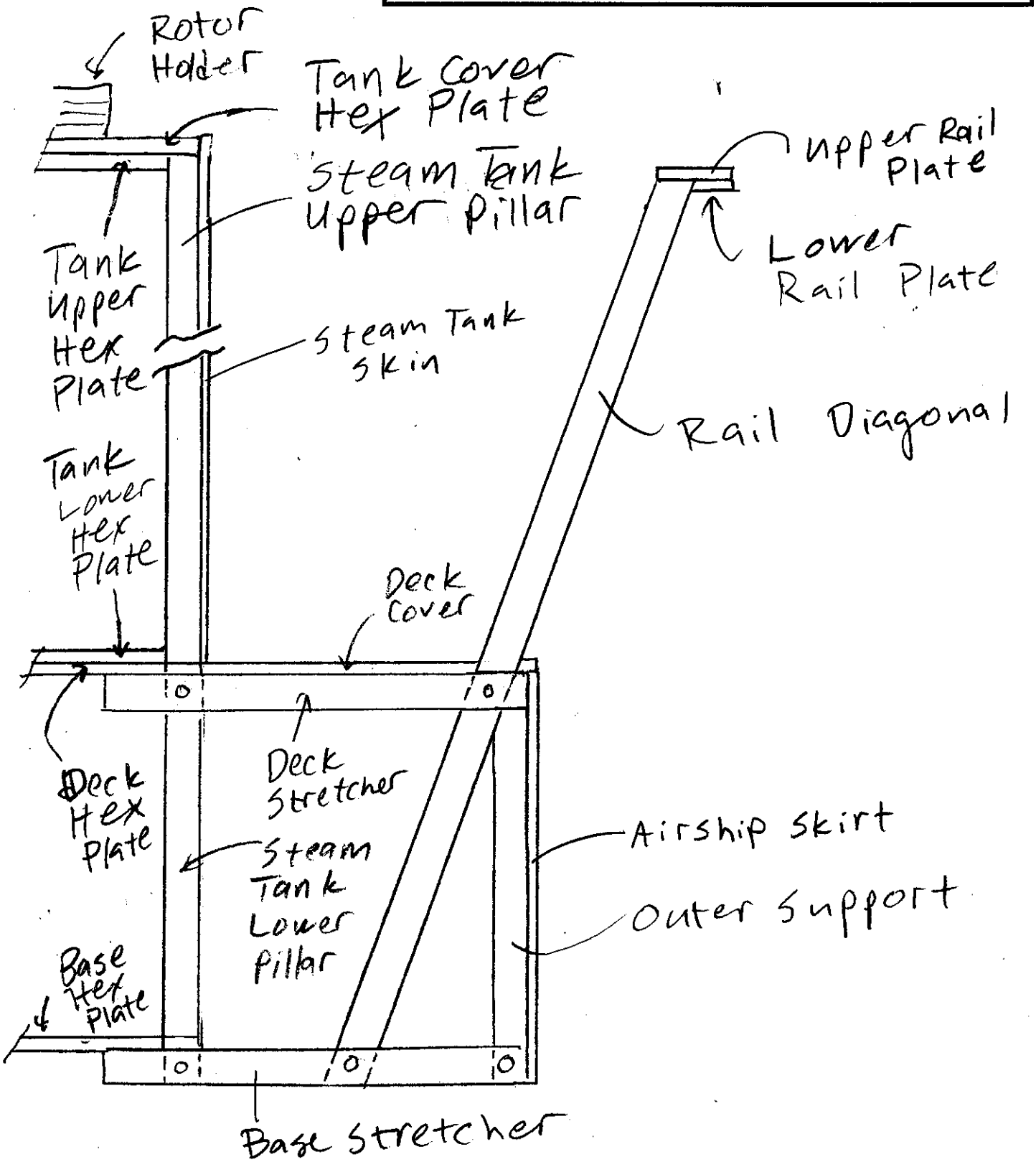
Check that there are access windows in Steam Tank Skins for segments A and D.

Attach Steam Tank Skins, screwing to Steam Tank Upper Pillars, Steam Tank Lower Hex Plate, Steam Tank Upper Hex Plate.

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Segment Junction Overview Parts

Scale: 1 inch = 1 foot



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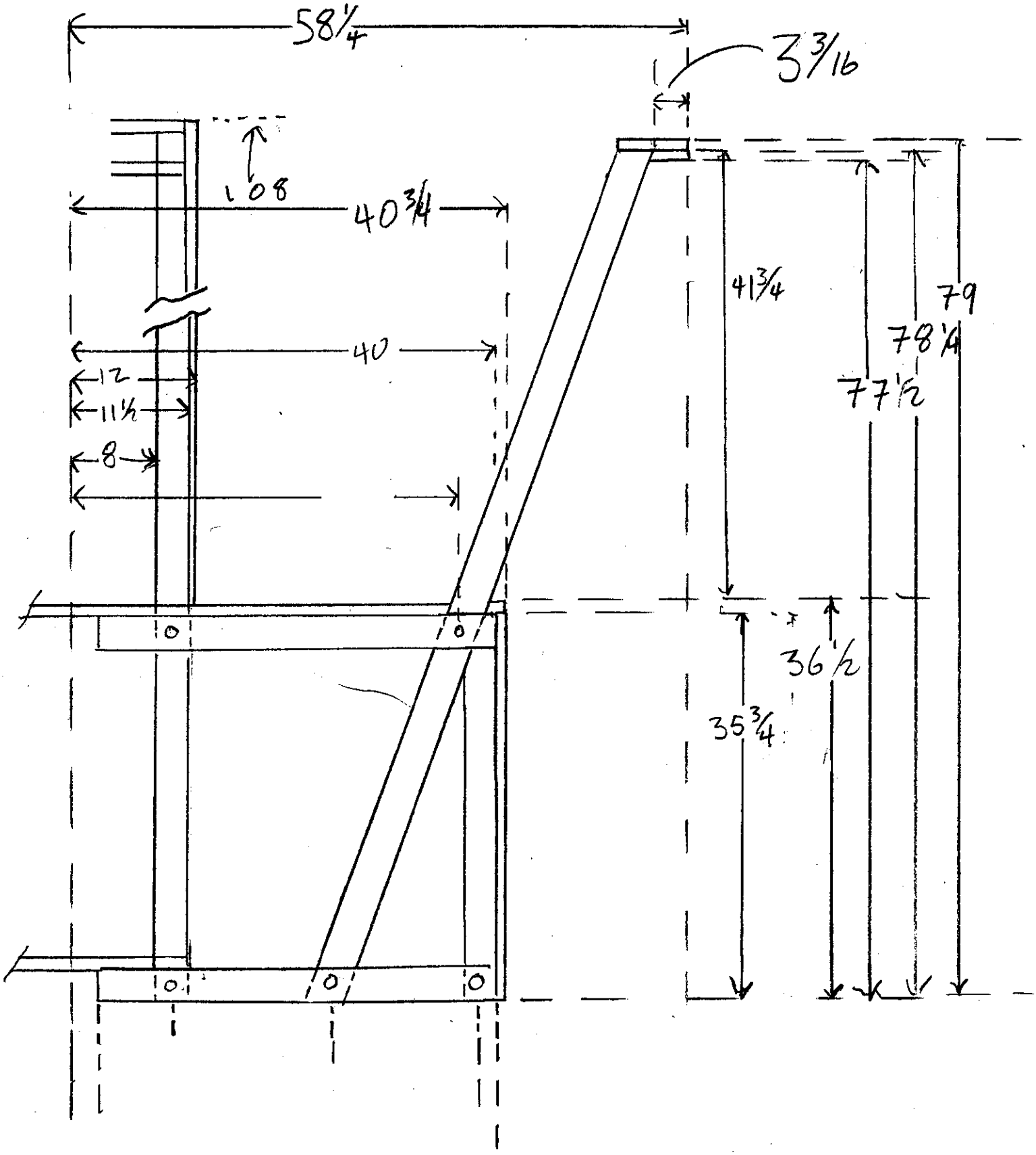
← center

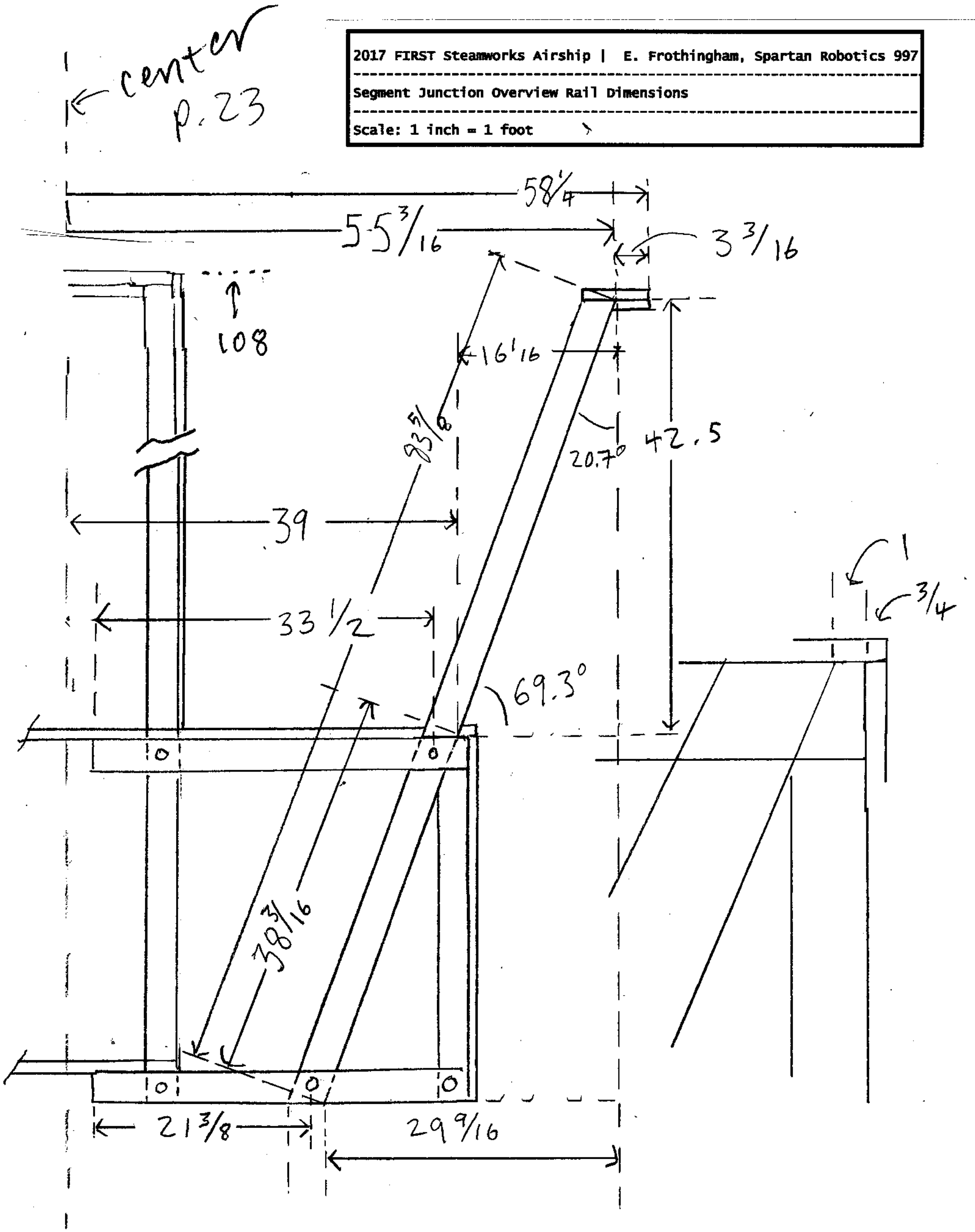
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Segment Junction Overview Dimensions
Scale: 1 inch = 1 foot



2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Segment Junction Overview Rail Dimensions

Scale: 1 inch = 1 foot

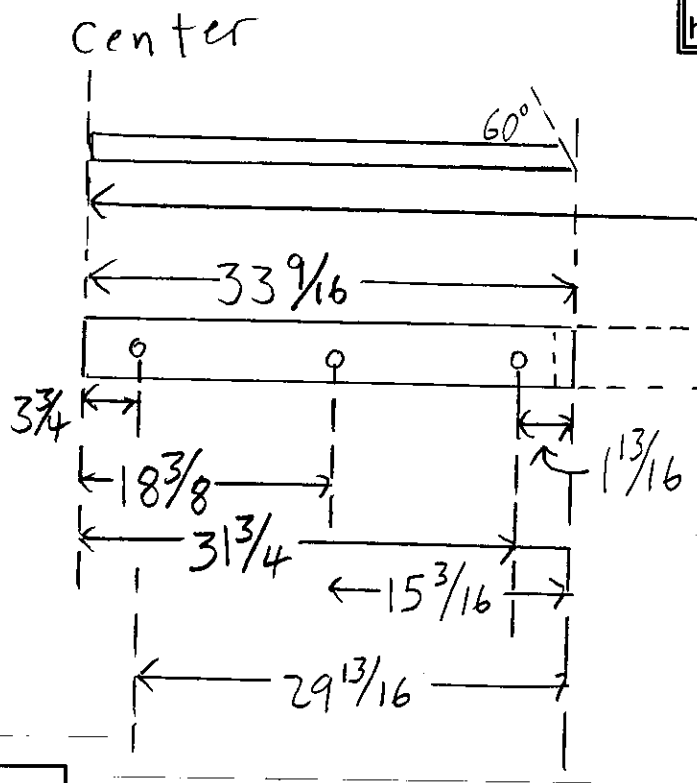


2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-11 Airship Base Single Stretcher
4 | Sc 1 in = 1 ft | 2x4 board 33 9/16 long
Tools: Chopsaw Handheld Drill

Attached to the Base Hex Plate, but stops short of the center.

Ties together Steam Tank Lower Pillar and Outer Support, anchors Rail Diagonal.

Option C: Only make 2 for hemi-airship.

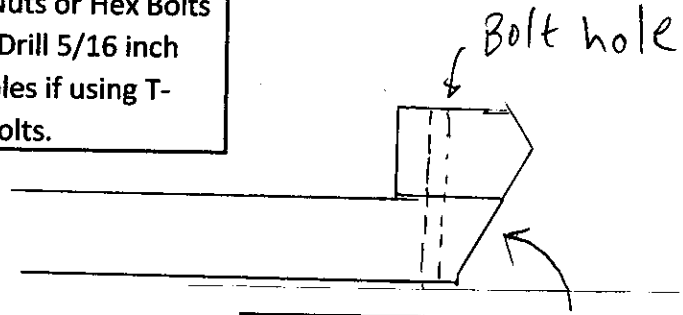


Option C: For a hemi-airship WITH A DAVIT, make the two base stretchers 56 inches long, so they can act as struts to prevent the hemi-airship from tipping.

Cut to length with chopsaw.

Use MDF drilling template to drill THREE holes, registered from the center. Be careful to cover the holes in the drilling template that apply to the DECK stretcher.

* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.



Beveled end extends the beveled edge of the Outer Supports.

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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-12 Airship Base Double Stretcher
2 | Sc 1 in = 1 ft | 2x4 board 79 1/4 long
Tools: Chopsaw Handheld Drill

For placing the holes with the template, mark a length 12 inches long in the center of the piece and align to each end as the "center" for drilling holes.

* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.

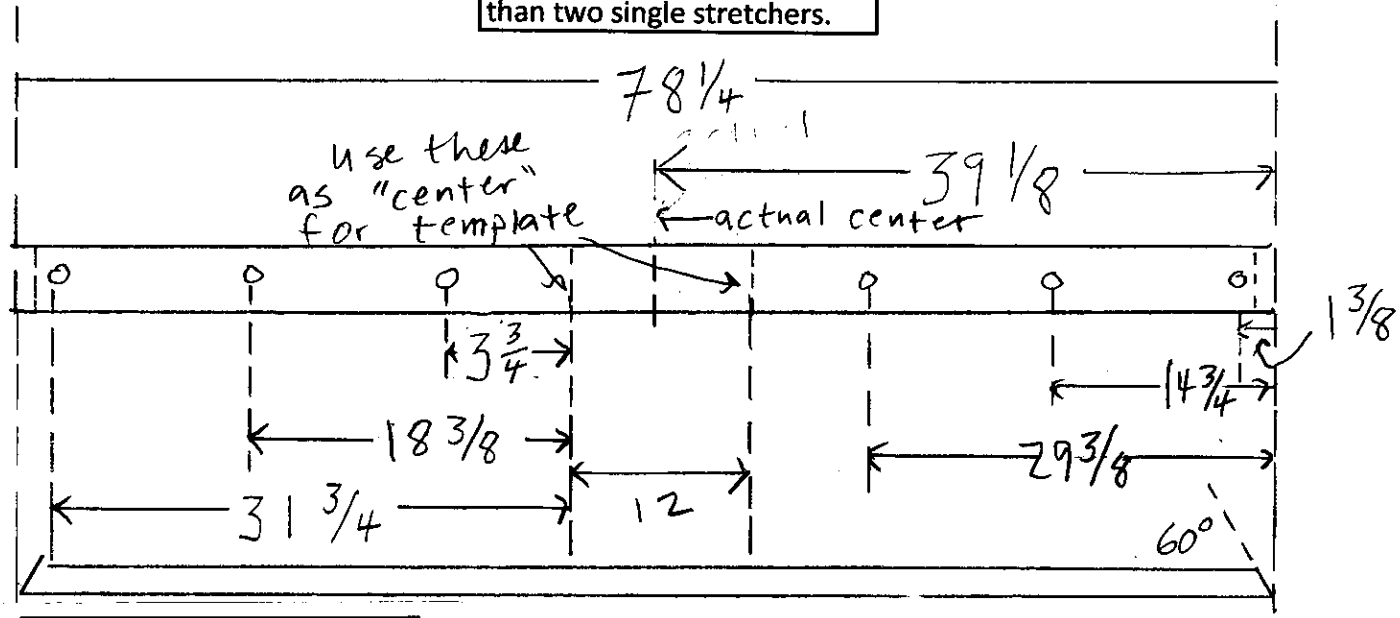
Ties together Steam Tank Lower Pillar and Rail Diagonal.

Attached to a pair of Steam Tank Lower Pillars, a pair of Outer Supports and a Pair of Rail Diagonals.

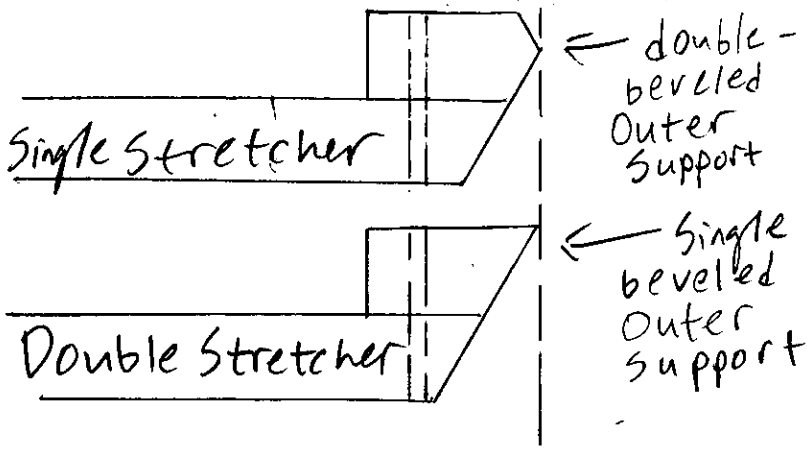
Use MDF drilling template to drill SIX holes, registered from the "center" lines, as described above. Be careful to cover the holes in the drilling template that apply to the DECK stretcher.

Option C: Only make 1 for hemi-airship.

Since they do span the middle of the plate, the double stretchers are longer than two single stretchers.



Beveled ends extend the beveled edges of the Outer Supports. Length at the end (past the hole to connect to the Outer Support) is slightly shorter than for the Single Base Stretcher, since its Outer Support is single beveled.



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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Part Sparta-997-13 Airship Deck Single Stretcher

4 | Sc 1 in = 1 ft | 2x4 board 33 9/16 long

Tools: Chopsaw Handheld Drill

Option C: Only make 2 for hemi-airship.

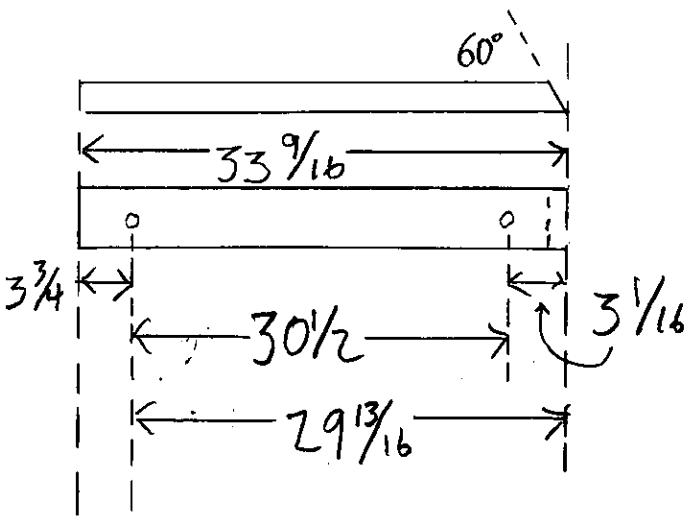
Ties together Steam Tank Lower Pillar to Rail Diagonal.

Connected to the Deck Hex Plate, but stops short of the center.

Beveled end extends the beveled edge of the Outer Supports.

Cut to length with chopsaw.

Use MDF drilling template to drill TWO holes, registered from the center. Be careful to cover the holes in the drilling template that apply to the BASE stretcher.



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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-14 Airship Deck Double Stretcher
2 | Sc 1 in = 1 ft | 2x4 board 79 1/4 long
Tools: Chopsaw Handheld Drill

Part Sparta-997-15 Airship Stretcher Support Brace
1 | Sc 1 in = 1 ft | 2x4 board 18 long
Tools: Chopsaw

Option C: Omit this part if making hemi-airship.

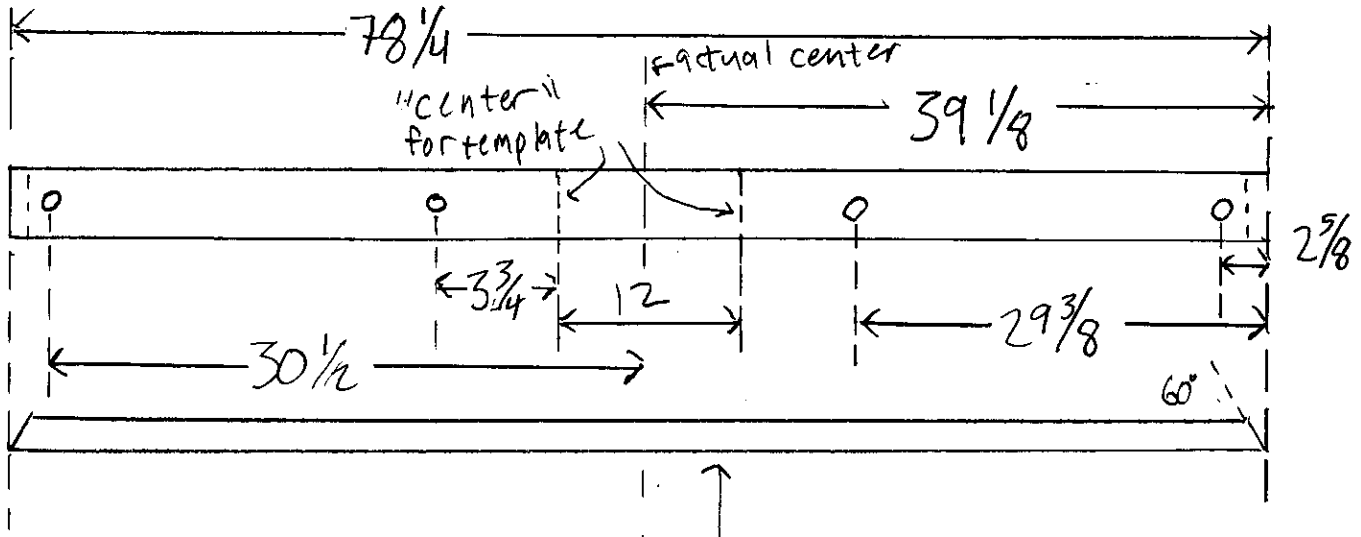
Cut to length with chopsaw.

Use MDF drilling template to drill FOUR holes, registered from the "center" lines, as described above. Be careful to cover the holes in the drilling template that apply to the BASE stretcher.

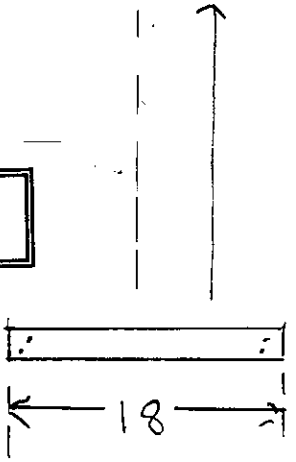
Ties together Steam Tank Lower Pillar and Rail Diagonal.

Attached to a pair of Steam Tank Lower Pillars and a pair of Rail Diagonals.

Option C: Only make 1 for hemi-airship.

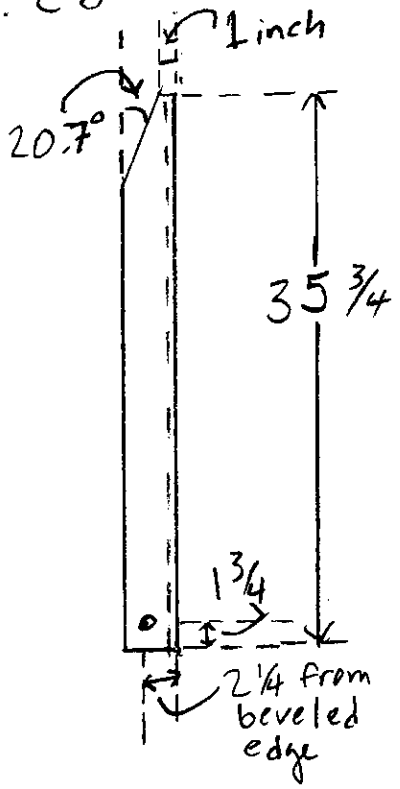


Option C: Skip this step for hemi-airship

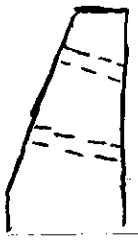


Stretcher support Brace attaches to Base Double Stretcher on non-Alliance side

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-16 Airship Outer Support
8 | Sc 1 in = 1 ft | 2x4 board 35 3/4 long
Tools: Chopsaw Table Saw (Rip) Handheld Drill



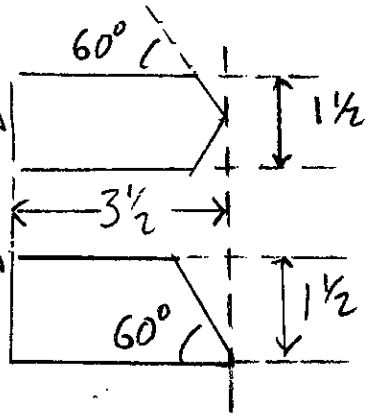
Option C: Only make 4 for hemi-airship.



Drill 5/32 clearance holes in angled portion to screw to rail diagonal.

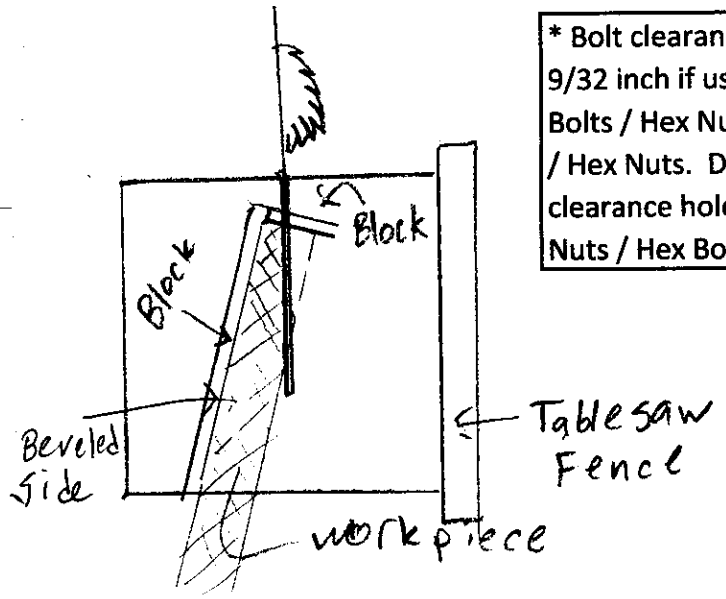
Make four pieces double-beveled as shown.

Make four pieces with single bevel as shown.



Caution: when drilling holes, remember the single beveled pieces are mirror images and are not interchangable - drill half with bevel on one side, half with bevel on the other side!

TOOLS/CONSTRUCTION: Make a fixture as shown to hold workpiece to make angled rip cut on tablesaw. Be careful!



Forms corners of airship deck, connects to base stretcher and is glued and screwed to rail diagonal.

Outer edge is beveled; airship skirt connects to beveled edges.

Ripped at an angle to meet rail diagonal.

TOOLS/CONSTRUCTION: Cut to length with chopsaw, bevel edges with tablesaw, drill holes with handheld corded drill and template.

9/32 inch clearance hole for carriage bolts are located 2 1/4 inches from beveled edge (since board width may vary). Use MDF template for accuracy.

* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.

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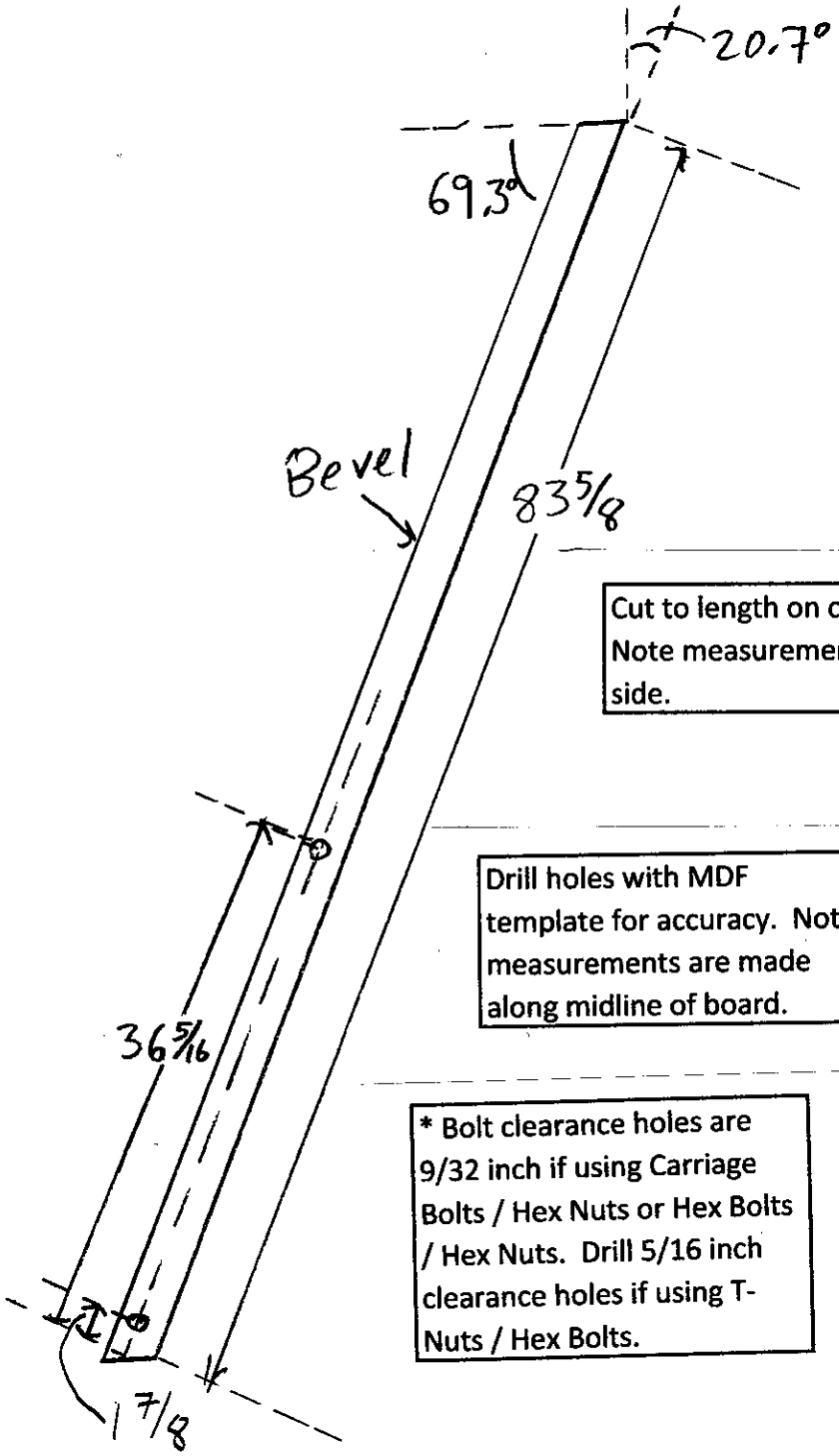
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-17 Airship Rail Diagonal
8 | Sc 1 in = 1 ft | 2x4 board 85 long
Tools: Chopsaw Handheld Drill



Supports railing, connects deck to railing. Railing cover attaches to inside of rail diagonal.

Slopes at angle of 69.3 degrees.

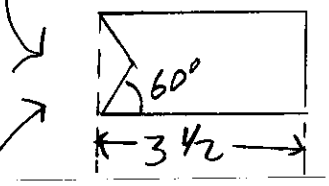
Option C: Only make 4 for hemi-airship.

Cut to length on chopsaw. Note measurement is along side.

Drill holes with MDF template for accuracy. Note measurements are made along midline of board.

* Bolt clearance holes are 9/32 inch if using Carriage Bolts / Hex Nuts or Hex Bolts / Hex Nuts. Drill 5/16 inch clearance holes if using T-Nuts / Hex Bolts.

Bevel board as shown to make a groove along inner edge. Cut carefully to preserve maximal width of board.



Option A: No need to bevel the rail diagonals if not making railing covers.

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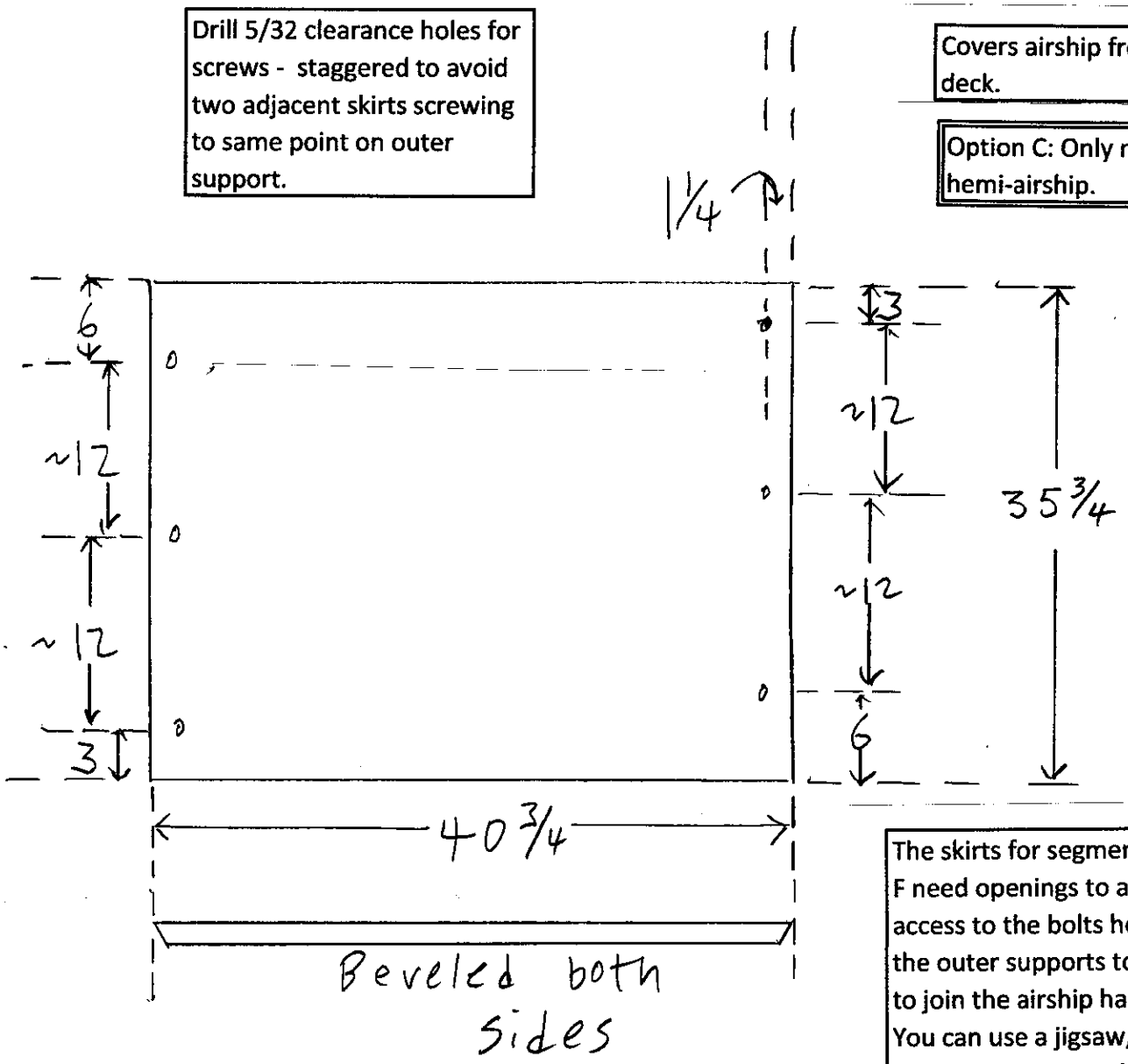
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-18 Airship Skirt
6 | Sc 1 in = 1 ft | 3/4 Ply 35 3/4 x 40 3/4
Tools: Table Saw (Rip) Bandsaw Handheld Drill Router

Drill 5/32 clearance holes for screws - staggered to avoid two adjacent skirts screwing to same point on outer support.

Covers airship from base to deck.

Option C: Only make 3 for hemi-airship.



The skirts for segments B and F need openings to allow access to the bolts holding the outer supports together to join the airship halves. You can use a jigsaw, hole saw or router to make holes located 12 and 24 inches from the ground.

Option C: Skip this step for hemi-airship

These pieces are actually quite challenging to cut, since the beveled sides are not parallel.

P3

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-19 Airship Plain Railing cover
2 | Sc 1 in = 1 ft | 1/2 Ply, 43 x 51 1/2
Tools: Table Saw (Rip) Bandsaw Handheld Drill

Start by using the tablesaw to rip the top and bottom, setting blade at 20.7°

Mark a midline and measure to the corners, then connect them to create the overall shape.

Cut the beveled sides with a bandsaw, jigsaw or skilsaw, depending on your level of comfort with each tool.

Best results are probably cutting using a skilsaw and a cutting guide.

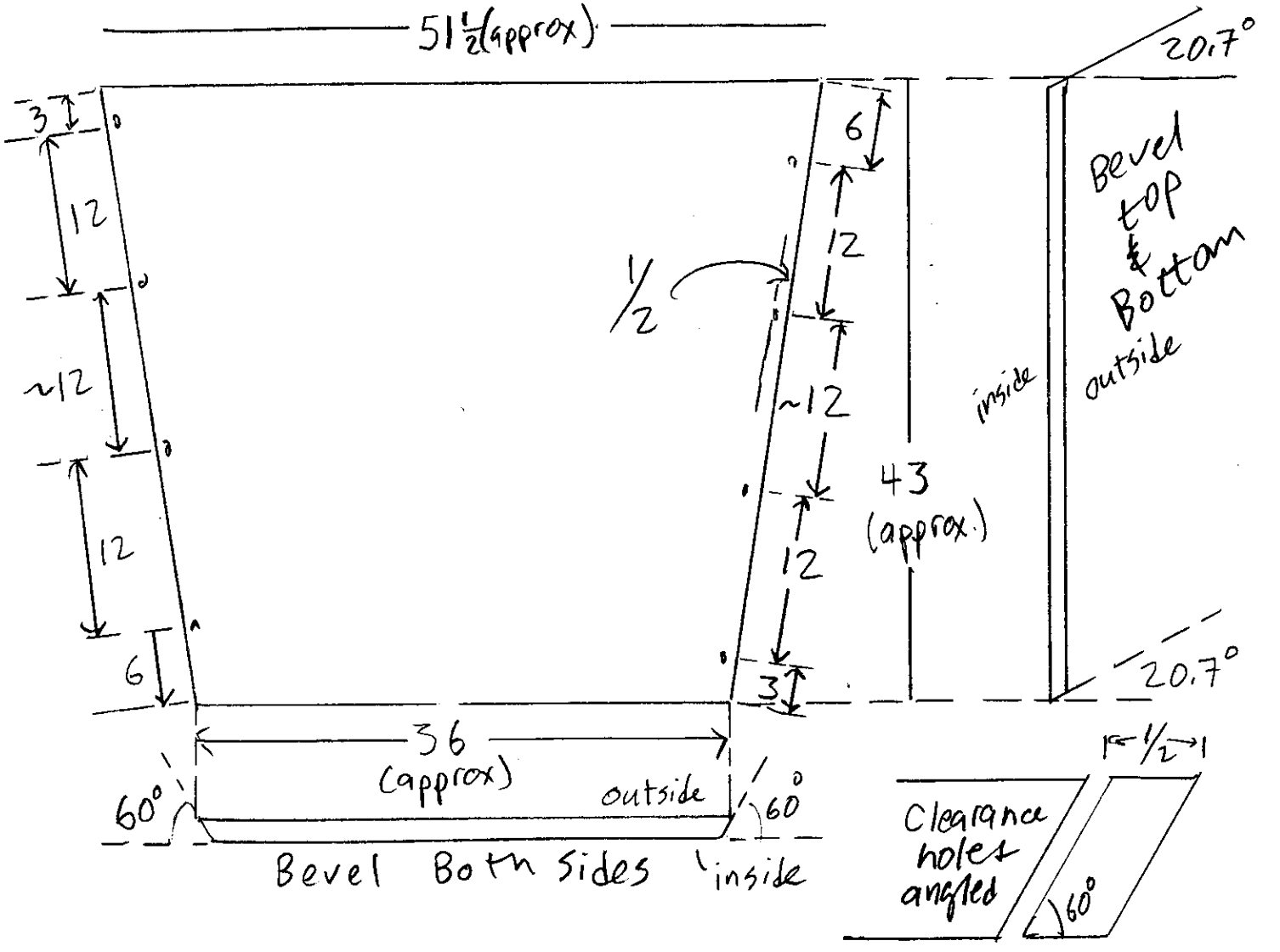
Use the first piece cut as a template for marking susequent ones.

Drill 5/32 clearance holes as marked; drill holes at an angle.

Covers space between railings.

Check measurements before cutting.

Option A: Omit this part if not making railing covers.



Option A: Omit this part if not making railing covers.

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Option A: Omit this part if not making railing covers.

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-20 Airship Fenestrated Railing Cover
3 | Sc 1 in = 1 ft | 1/2 Ply, 43 x 51 1/2
Tools: Table Saw (Rip) Bandsaw Handheld Drill

Part Sparta-997-21 Airship Gateway Railing cover
2 | Sc 1 in = 1 ft | 1/2 Ply, 14 3/4 x 43
Tools: Table Saw (Rip) Bandsaw Handheld Drill

Covers space between railings with opening for gear lifter.

Check measurements before cutting.

Covers space between railings, with space in center for gateway.

These pieces are actually quite challenging to cut, since the beveled sides are not parallel.

Note start with one railing cover, then split in two to make the two pieces on either side of the gateway.

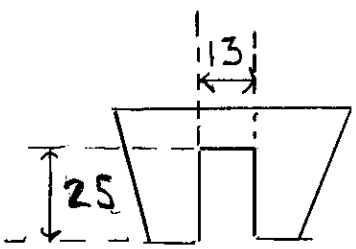
Start by using the tablesaw to rip the top and bottom, setting blade at 20.7

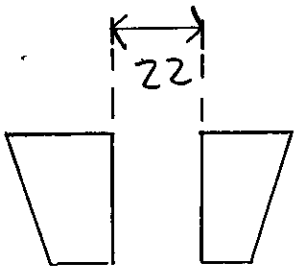
Mark a midline and measure to the corners, then connect them to create the overall shape.

Mark a midline and measure to the corners, then connect them to create the overall shape (22 inches less than the plain railing cover).

Cut out opening as marked (for gear lifting). Drill large turnaround holes, then use bandsaw. or jigsaw

Split the railing to create two gateway railings



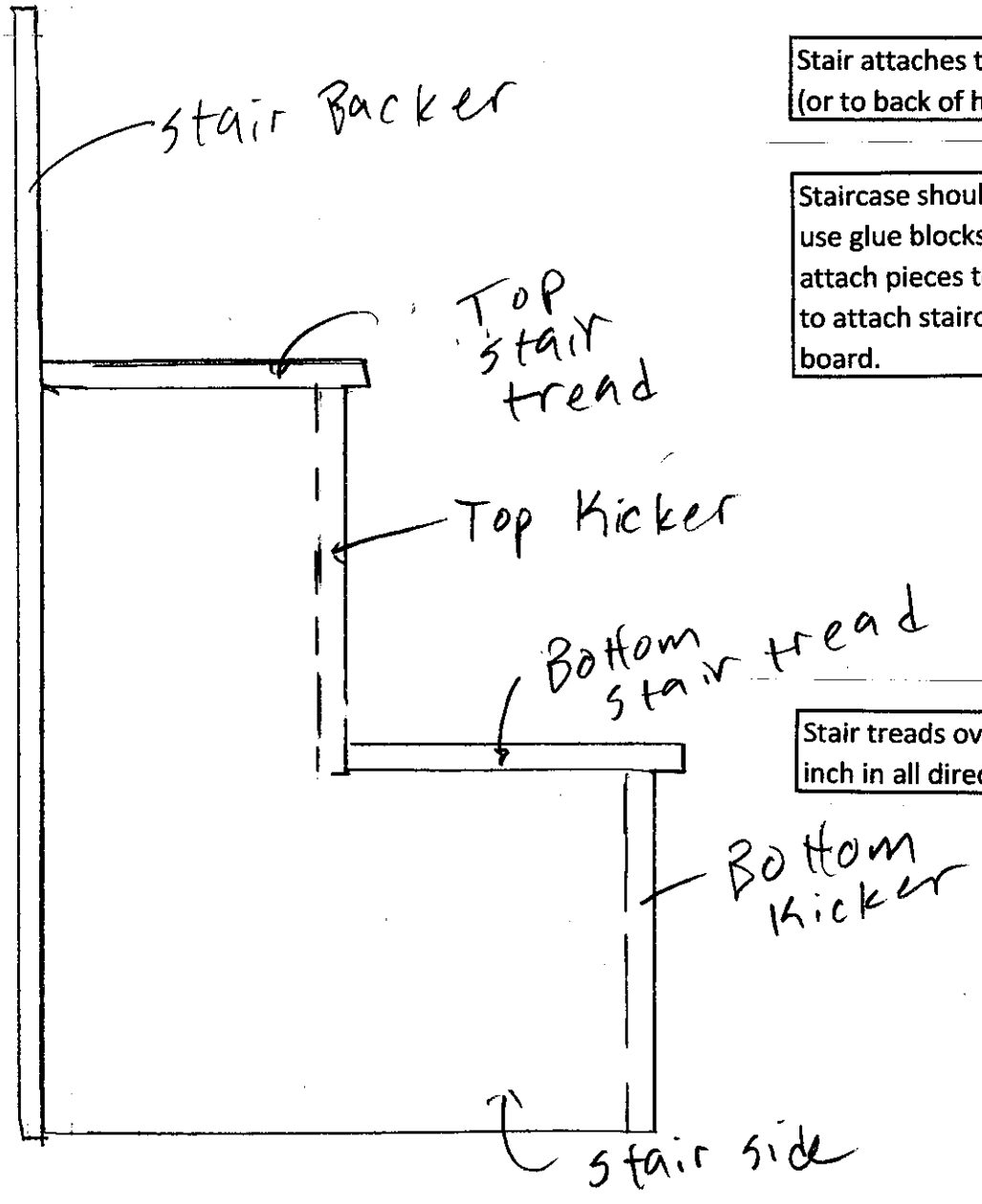


Drill 5/32 clearance holes as marked; drill holes at an angle.

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Stair Overview

Scale: 1 inch = 1/2 foot



Stair attaches to segment D (or to back of hemi-airship).

Staircase should be strong, so use glue blocks and screws to attach pieces together, and to attach staircase to backer board.

Stair treads overhang by 1/2 inch in all directions.

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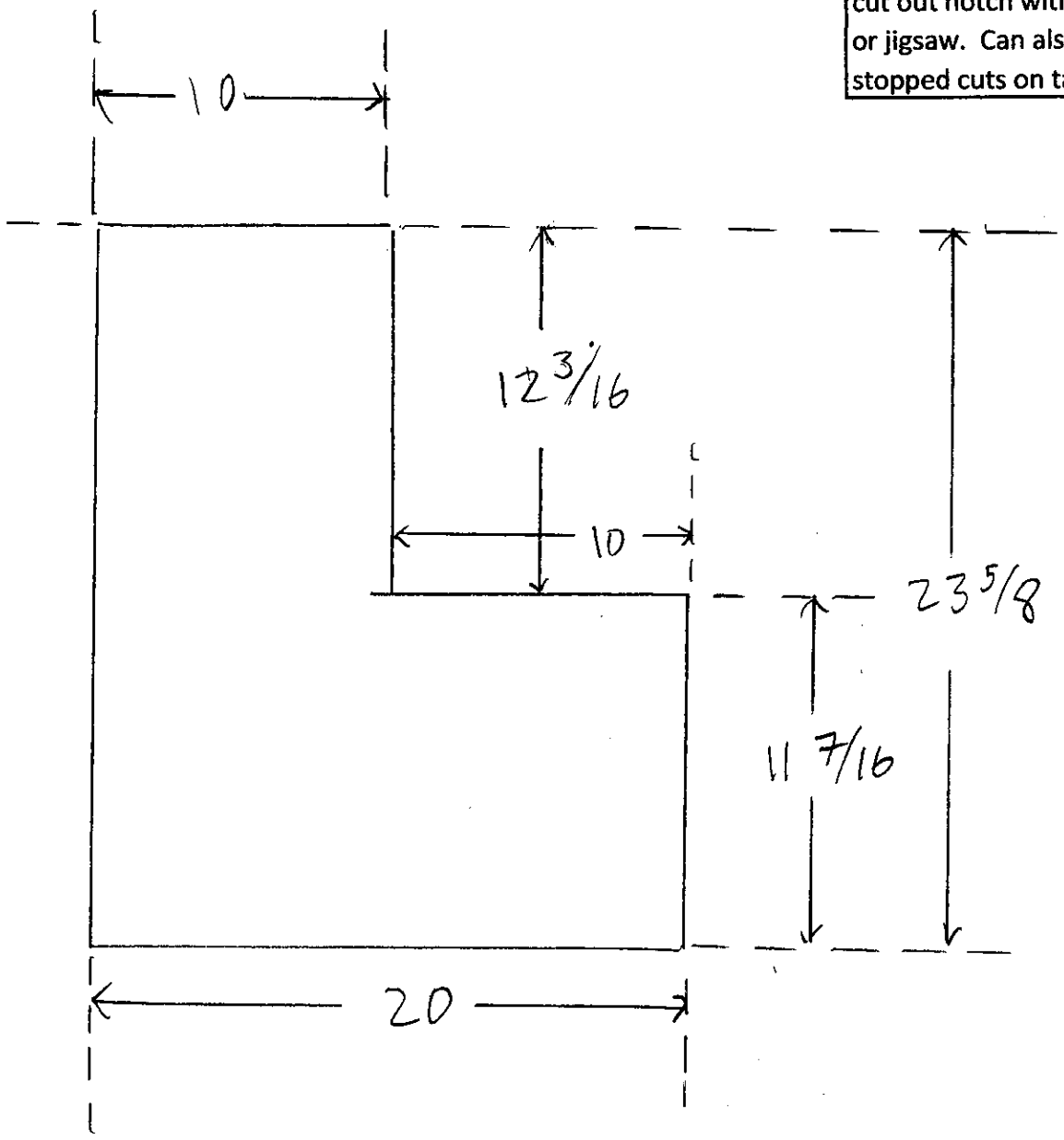
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-22 Airship Staircase Side
2 | Sc 1 in = 1/2 ft | 3/4 Ply 20 x 23 5/8
Tools: Table Saw (Rip) Table Saw (Crosscut) Bandsaw

Cut out sheets with table saw, then tack together and cut out notch with bandsaw or jigsaw. Can also do stopped cuts on table saw.



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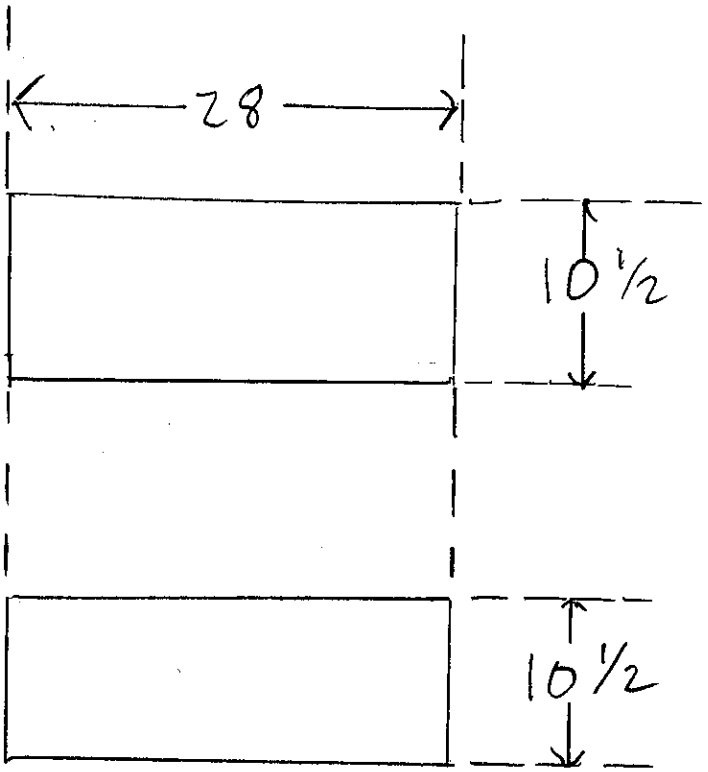
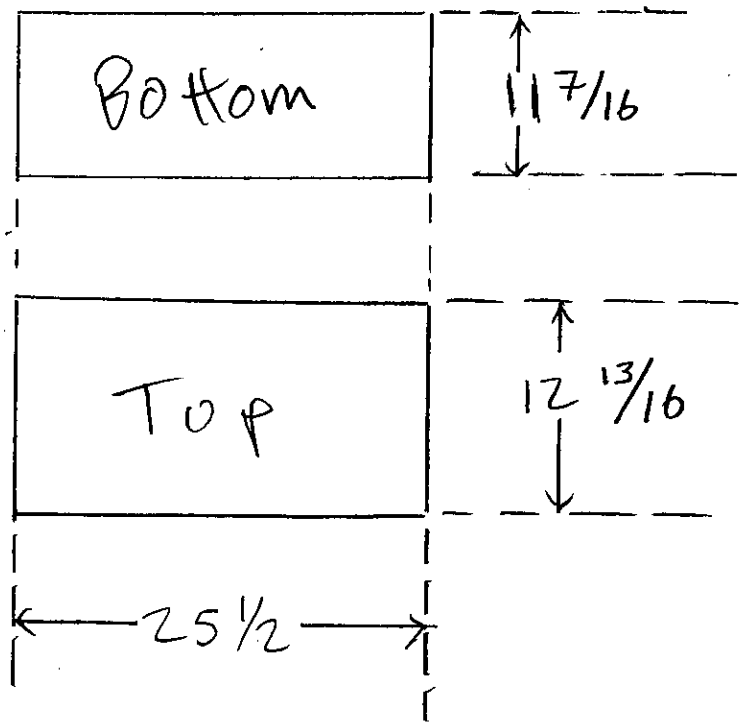
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-23 Airship Bottom Stair Tread
1 | Sc 1 in = 1 ft | 3/4 Ply 10 1/2 x 28
Tools: Table Saw (Rip) Table Saw (Crosscut)
Part Sparta-997-24 Airship Top Stair Tread
1 | Sc 1 in = 1 ft | 3/4 Ply 10 1/2 x 28
Tools: Table Saw (Rip) Table Saw (Crosscut)

Round off edges of stair treads with belt sander or handplane.



* Yes, they're identical. In a previous version they were different!

2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-25 Airship Bottom Stair Kick
1 | Sc 1 in = 1 ft | 3/4 Ply 11 7/16 x 25 1/2
Tools: Table Saw (Rip) Table Saw (Crosscut)
Part Sparta-997-26 Airship Top Stair Kick
1 | Sc 1 in = 1 ft | 3/4 Ply 12 13/16 x 25 1/2
Tools: Table Saw (Rip) Table Saw (Crosscut)



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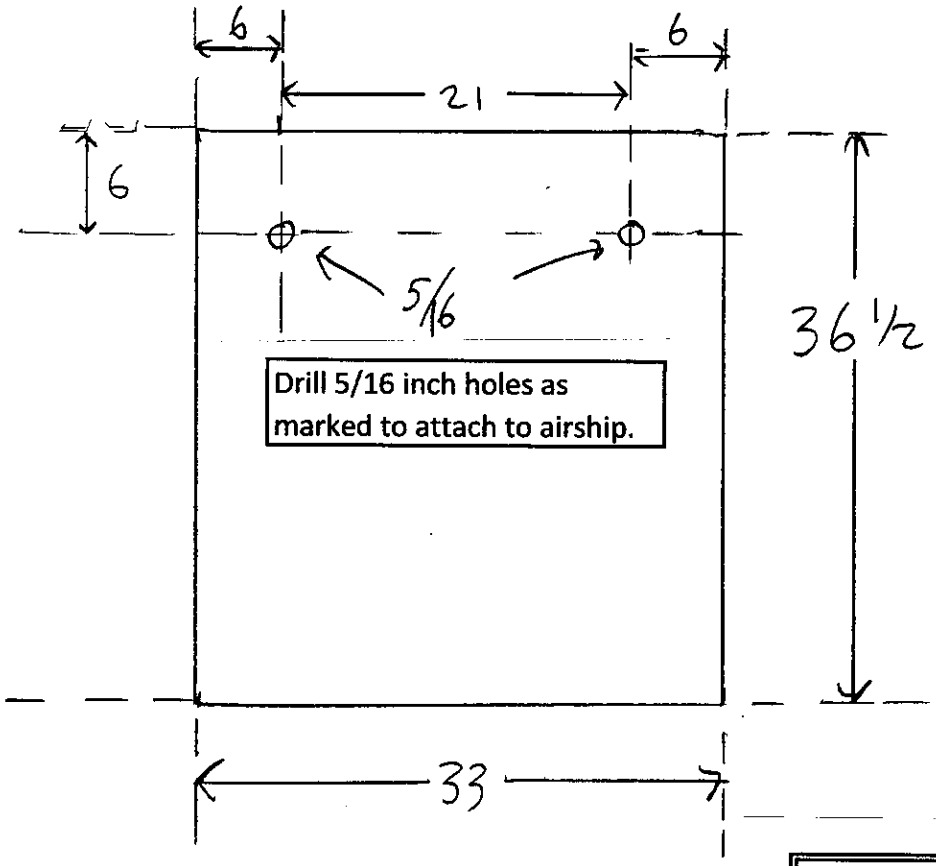
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-27 Airship Stair Backer Board
1 | Sc 1 in = 1 ft | 3/4 Ply 33 x 36 1/2
Tools: Table Saw (Rip) Table Saw (Crosscut)



Drill 5/16 inch holes as marked to attach to airship.

Option D: For hemi-airship, the backer board will attach to two lower tank pillars, not to the airship skirt.

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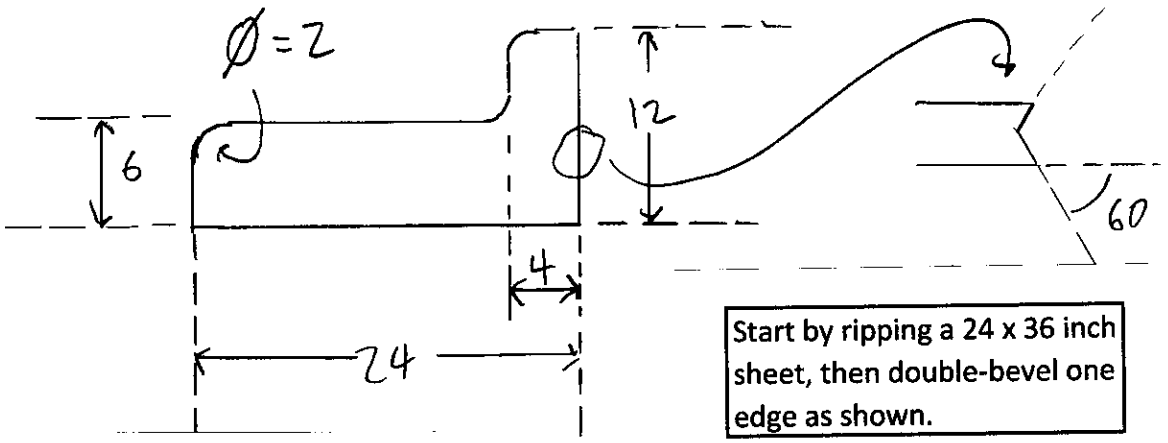
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-28 Airship Divider
2 | Sc 1 in = 1 ft | 3/4 Ply 12 x 24
Tools: Table Saw (Rip) Table Saw (Crosscut) Bandsaw
Part Sparta-997-29 Airship Divider Base
2 | Sc 1 in = 1 ft | 3/4 Ply 6 x 26
Tools: Table Saw (Rip) Table Saw (Crosscut) Bandsaw

Option C: Omit this part if making hemi-airship with davit

Juts out from two corners of airship to protect zone around one rope hoist.

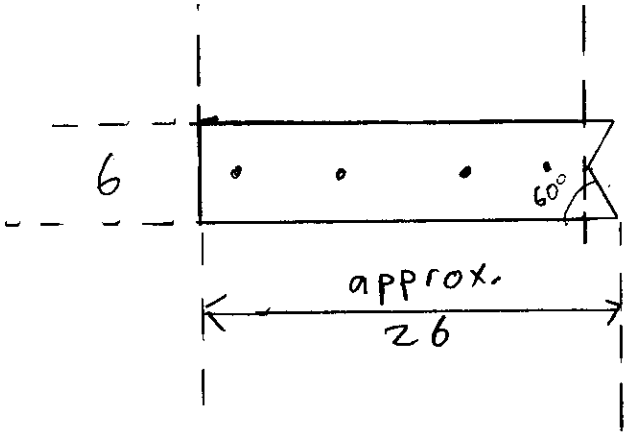


Start by ripping a 24 x 36 inch sheet, then double-bevel one edge as shown.

Option D: For hemi-airship, the dividers attach to the (extended) base stretchers, so don't need to make divider brace, divider brackets or glue blocks.

WITH DAVIT

Divide into three pieces 12 x 24, tack together and cut out shape on bandsaw



Cut out shape as shown on table saw and bandsaw

Drill 5/32 clearance holes as shown.

Option C: Omit this part if making hemi-airship. w/davit

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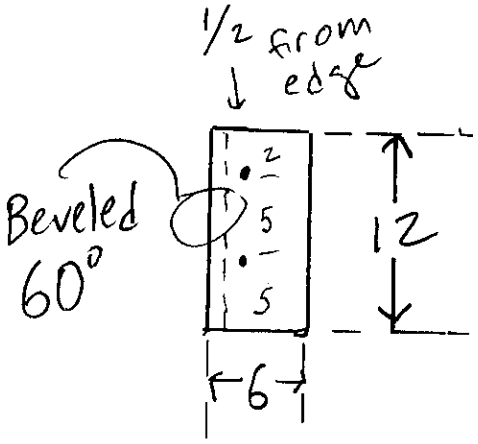
Option C: Omit this part if making hemi-airship. w/davit

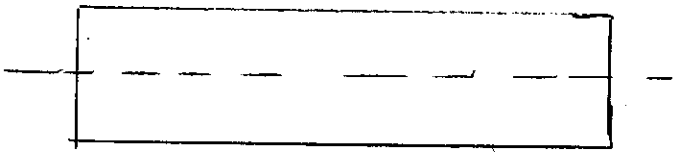
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-30 Airship Divider Brace
4 | Sc 1 in = 1 ft | 3/4 Ply 5 x 12
Tools: Table Saw (Rip) Table Saw (Crosscut)

Part Sparta-997-31 Airship Divider Glue Block
4 | Sc 1 in = 1 ft | 2x4 board 24 long
Tools: Chopsaw Table Saw (Rip) Handheld Drill

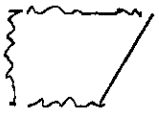


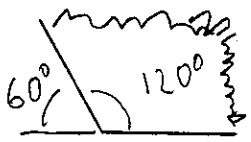
Cut beveled edge.

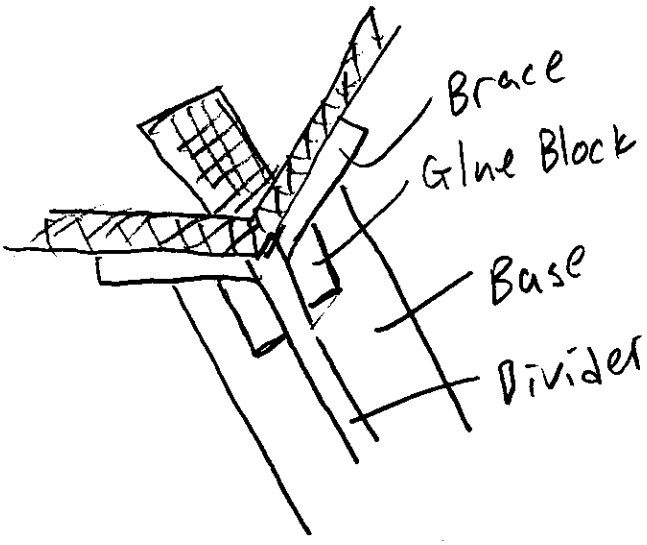
Drill 5/16 clearance holes as marked.



Cut to length and rip on table saw to yield approx 2 x 2 inch block with 2 smooth sides that meet at 120° angle







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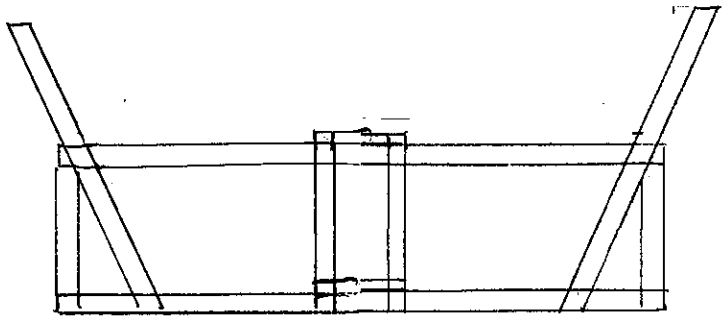
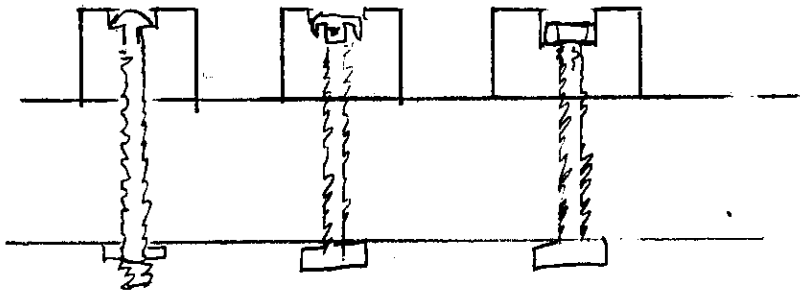
Assembly - Base and Deck

Choose out the four straightest Rail Diagonals.

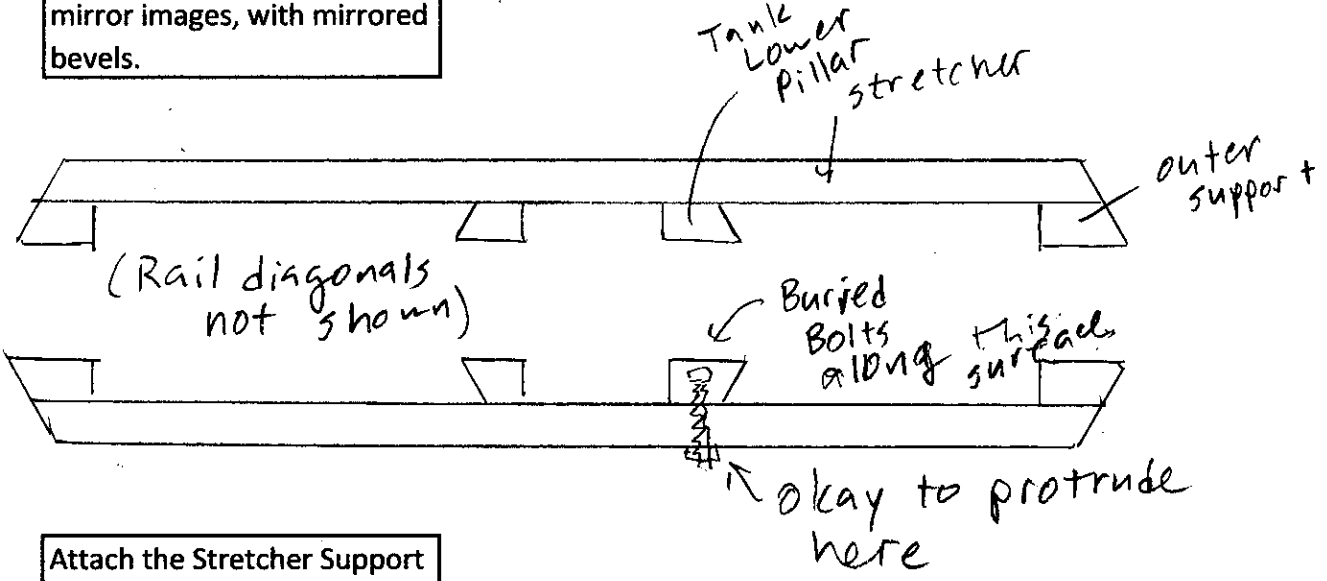
Assemble the two central units which correspond to BC and EF junctions - Deck Double Stretcher, Base Double Stretcher, single-beveled Lower Steam Tank Pillars, Single-Beveled Outer Supports, Rail Diagonals.



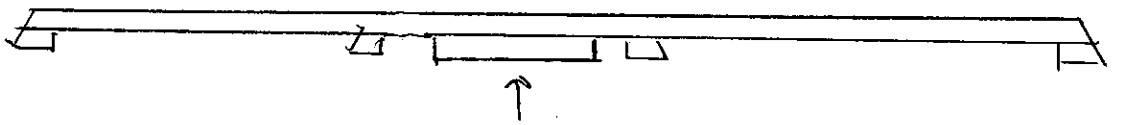
Whichever bolting method you are using, counter-sink so the matching surfaces can meet in the middle with no gap.



The two central units are mirror images, with mirrored bevels.



Attach the Stretcher Support Brace to the middle of the Deck Double Stretcher on the non-alliance side.

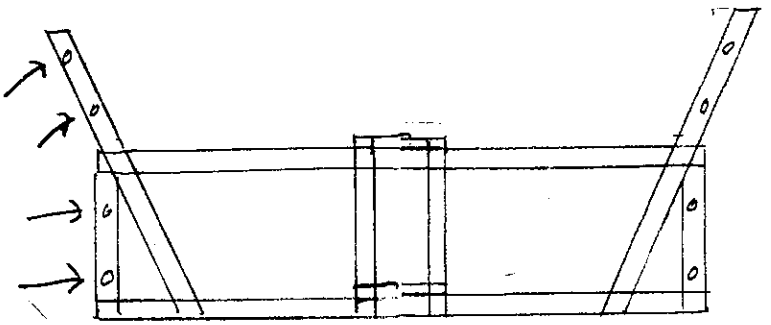


Since you'll be gluing each Outer Support to a Rail Diagonal, insert some wax paper between the two Outer Supports and between the two Rail Diagonals before you bolt them together in the next step.

Assembly Instructions

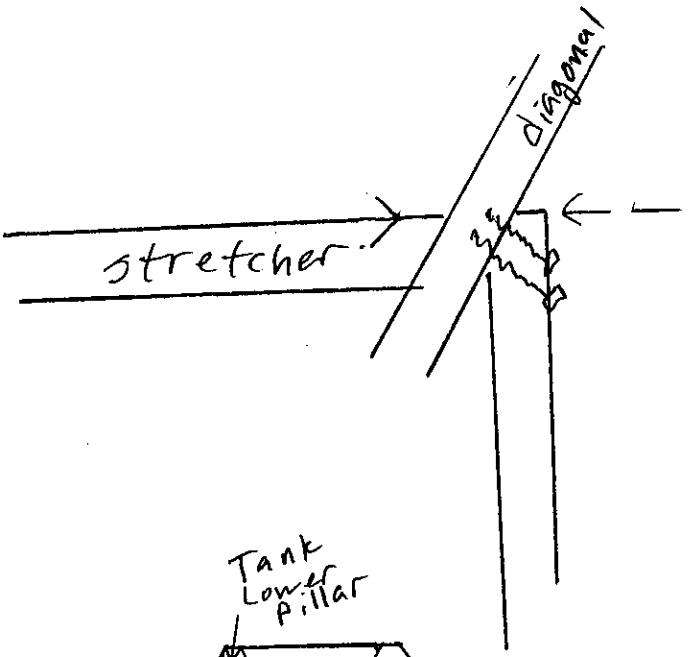
Not to Scale

Drill 5/16 bolt clearance holes 12 and 24 inches high through the paired Outer Supports and bolt together with T-Nuts and hex bolts.



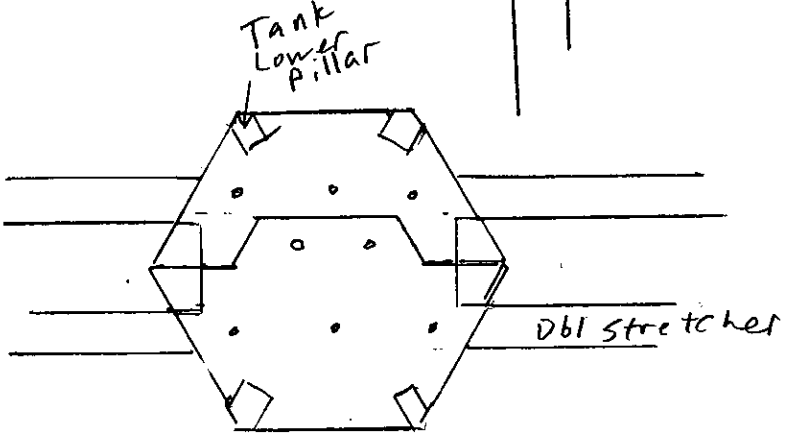
Do the same for the two Rail Diagonals, bolting them together 12 and 36 inches from their upper ends.

Attach the Outer Supports to the Rail Diagonals with glue and screws. The top of the outer support should be even with the top of the stretcher.



Attach the two halves of the Base Hex Plate and the Deck Hex Plate, screw to the Deck Double Stretchers and the Base Double Strechers

Screw the "bumped out" portion of the Deck Hex Plate to the Stretcher Support Brace.



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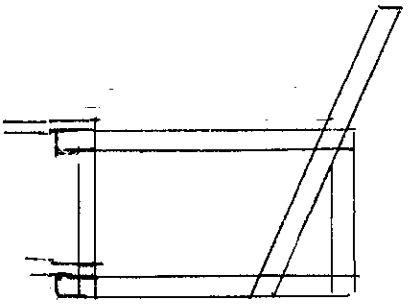
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

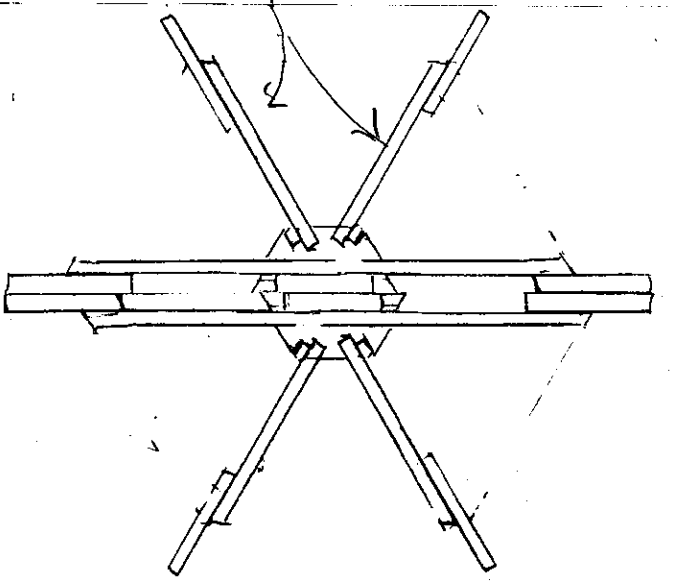
Assembly Instructions

Not to Scale

Assemble the four single units corresponding to junctions AB, CD, DE and EA - double-beveled Steam Tank Lower Pillar, Deck Single Stretcher, Base Single Stretcher, double-beveled Outer Support.



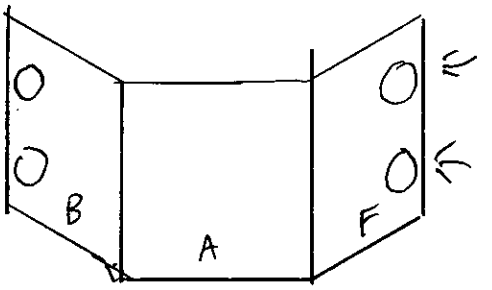
Note the stretcher arrangement - stretchers on center side.



Glue and screw Outer Supports so top is even with Deck Stretchers.

Arrange the units in Base Hex Plate and Deck Hex Plate, do not screw down yet.

Attach Skirt pieces, being sure to align the access windows in segments F and B to allow access to the bolts connecting the Outer Supports of the doubled central unit.



The Skirt pieces should bring all the units into alignment.

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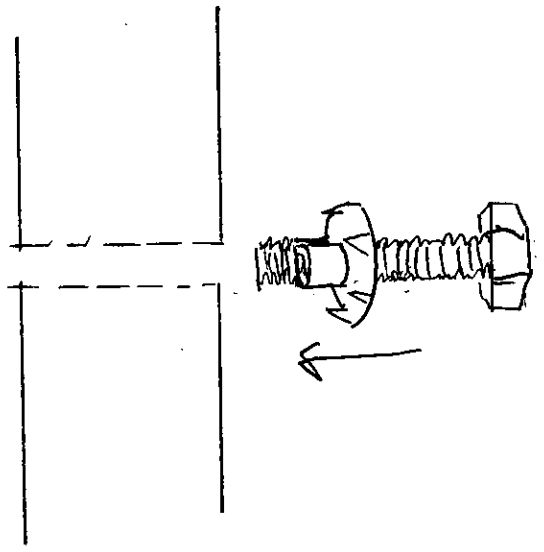
Now screw the Deck Hex Plate and the Base Hex Plate to the individual stretchers.

Bolt the Staircase to the Skirt at Segment D and the Dividers to Skirt at AB and EA, using T-Nuts on the inside of the Skirt.

Learn from my mistakes! It can be awkward to hammer a T-Nut into a board in a tight space. Thread the T-Nut onto a bolt, prongs out, hammer it into place, then unscrew the bolt.



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2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-32 Airship Deck Cover
2 | Sc 1 in = 1 ft | 3/4 Ply 48 x 96
Tools: Table Saw (Rip) Handheld Drill Router Jigsaw

Before making the deck cover, assemble the airship base and attach the skirts. Attach the stairs and dividers and make sure access holes are right.

Rather than lay this out with measurements, it's probably easiest to tape together scraps of carboard on the airship to make a deck cover to fit around all the notches.

Once everything is right, trace the cardboard shape onto 3/4 plywood and cut out with jigsaw.

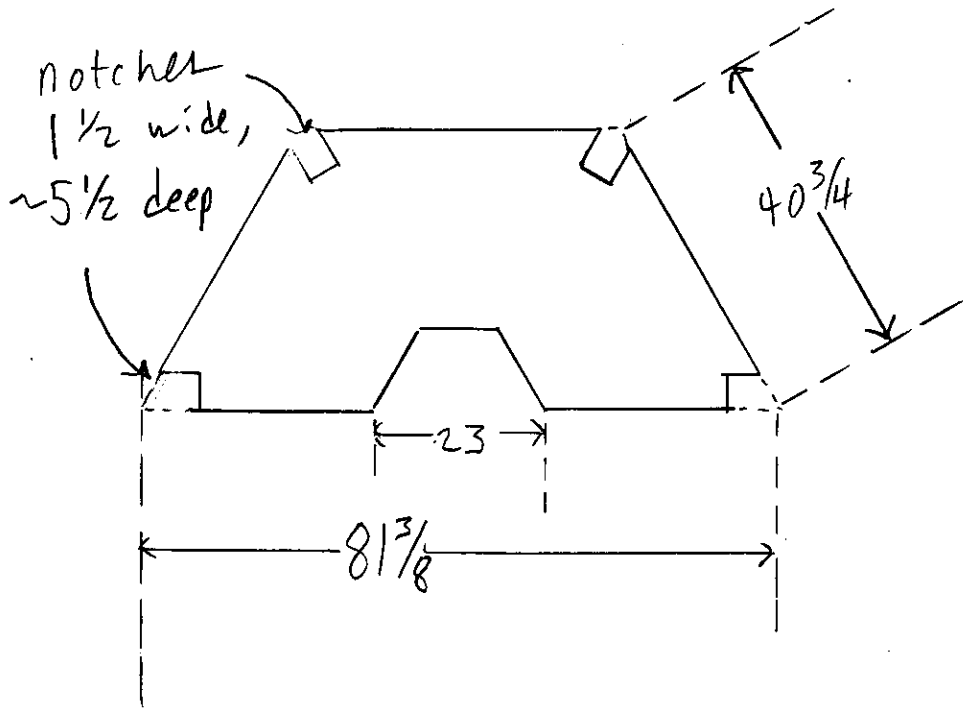
Fit tightly to the steam tank hexagon and the notches, but leave the outer edges a little oversized.

Screw the deck temporarily to the airship, then use a pattern bit on a router to trim the edges where they meet the skirt.

Unscrew from airship and finish the edges with a jigsaw into the corners where the router did not reach.

Attach glue blocks to the skirts, then screw the deck cover securely down to the glue blocks.

Use a chalk line to mark where to screw down to stretchers.



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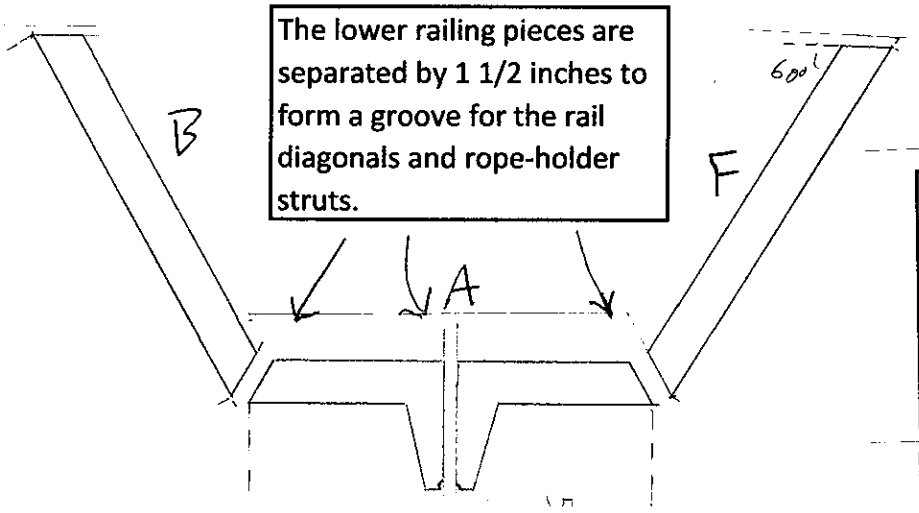
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Railing Overview, Segment A, B, F (Alliance Side)

Not to scale

Diagram shows how railing plates fit together. Lower rail plates are shown inside upper rail plates.

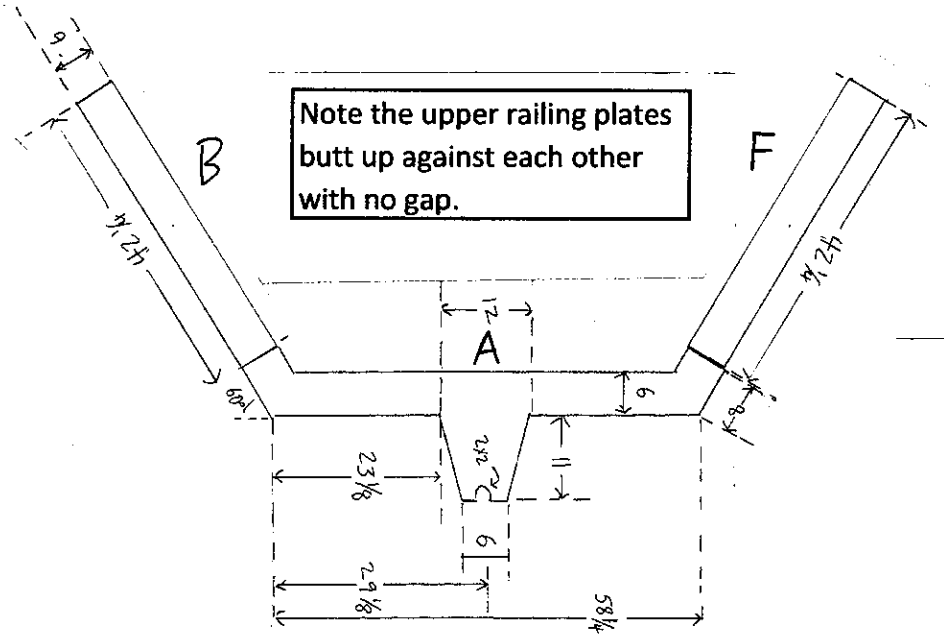
When ready to assemble rails, it is probably best to laminate the railing plates together in stages.



The lower railing pieces are separated by 1 1/2 inches to form a groove for the rail diagonals and rope-holder struts.

If the grooves do not come out right, they can be widened with a router, or narrowed by attaching glue blocks on either side of the groove.

The groove is 3 inches wide where the two halves of the airship meet - between segments B and C and between E and F.



Note the upper railing plates butt up against each other with no gap.

Note that the lower rail plates on the alliance side extend out to articulate with the extended upper rail plates on the non-alliance side.

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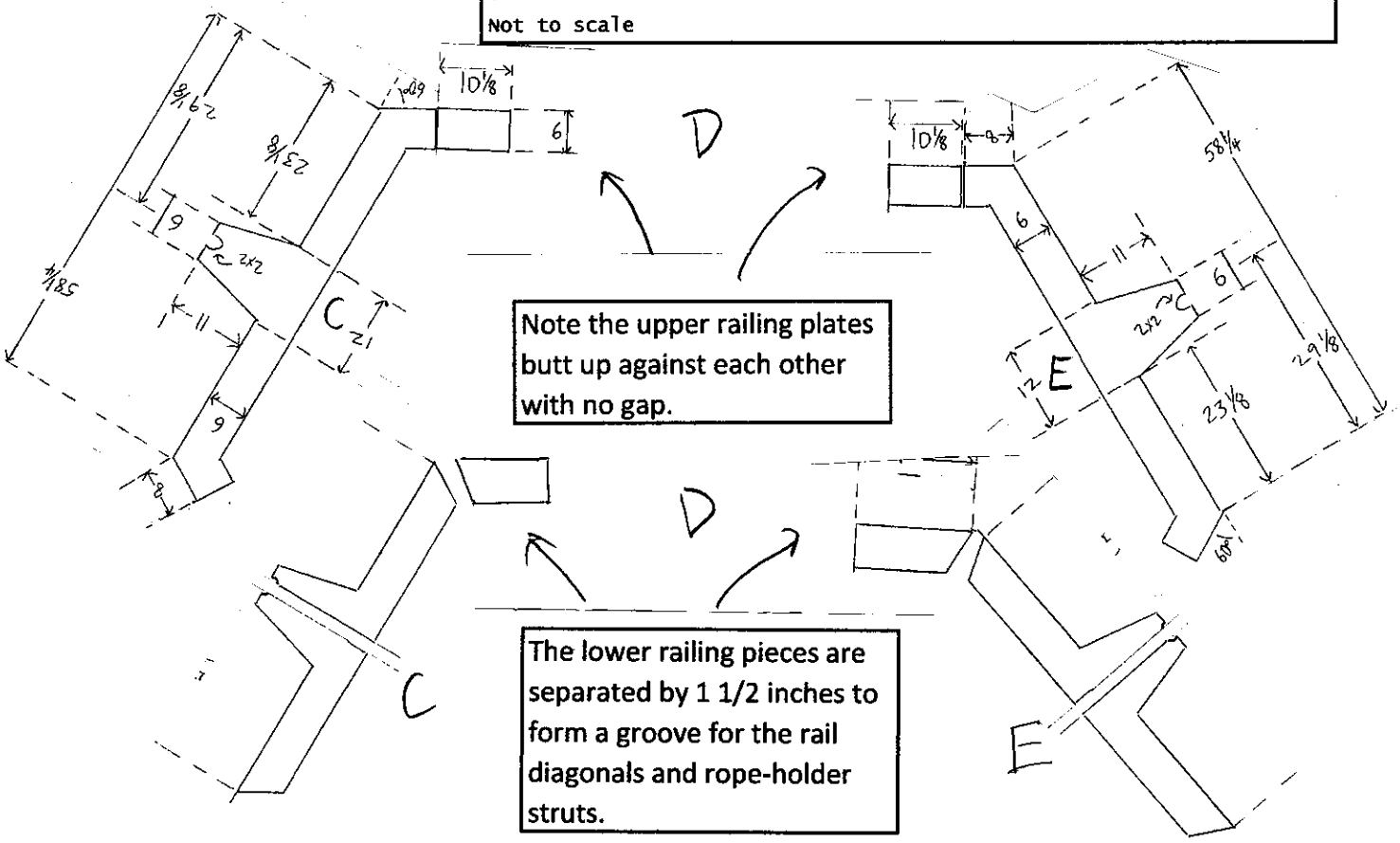
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Railing Overview, Segment C, D, E (Non- Alliance Side)

Not to scale



Note the upper railing plates butt up against each other with no gap.

The lower railing pieces are separated by 1 1/2 inches to form a groove for the rail diagonals and rope-holder struts.

If the grooves do not come out right, they can be widened with a router, or narrowed by attaching glue blocks on either side of the groove.

Note that the lower rail plates on the alliance side extend out to articulate with the extended upper rail plates on the non-alliance side.

The groove is 3 inches wide where the two halves of the airship meet - between segments B and C and between E and F.

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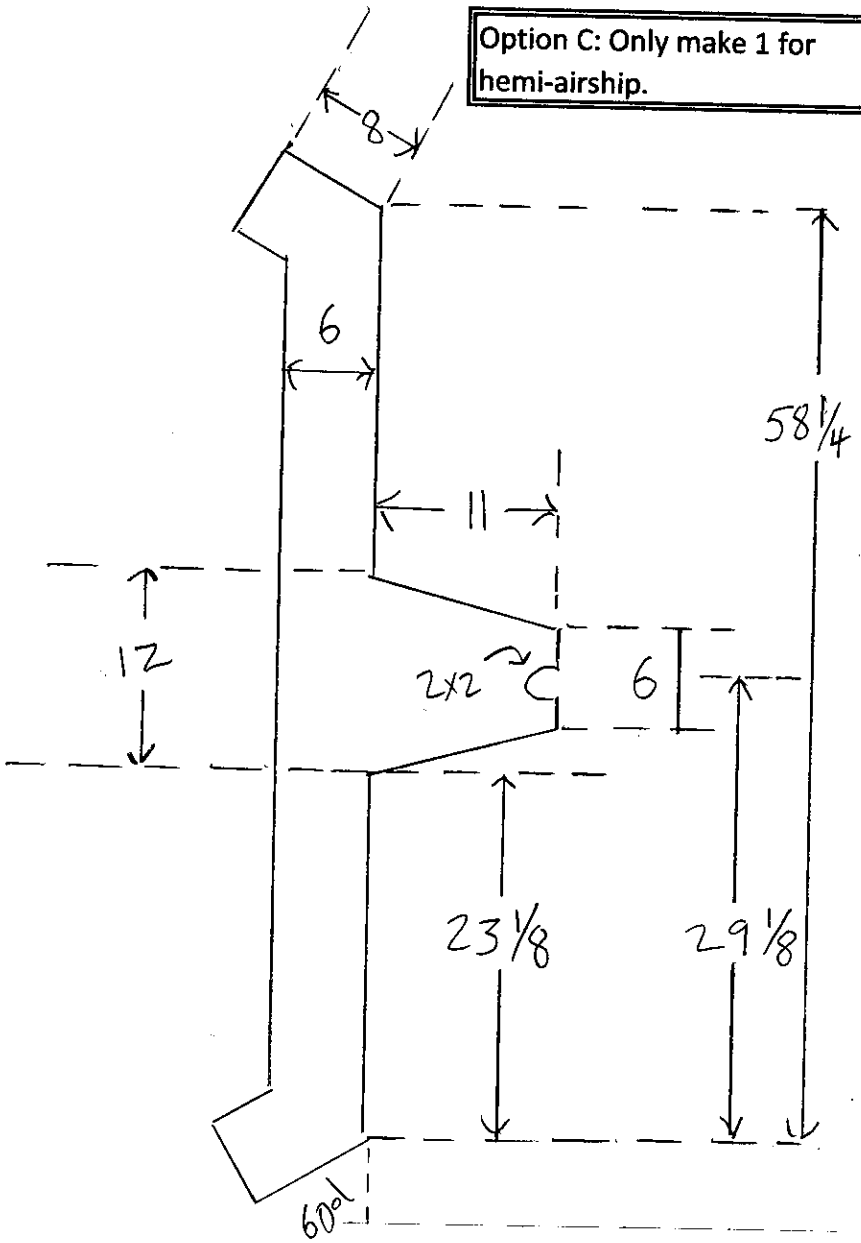
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-34 Airship Upper Rail Davit Plate
3 | Sc 1 in = 1 ft | 3/4 Ply 21 x 66
Tools: Table Saw (Rip) Bandsaw Nailer Router

Option D: No need to "bump out" railing if not implementing davits.

Option C: Only make 1 for hemi-airship.



These plates form the railing, support the rope lifts and help hold the rail diagonals in place. They attach to the rail diagonals and are laminated with the lower rail plates.

The upper rail plates for the segments with ropes extend 8 inches past the corners for strength.

Lay out and cut one plate carefully, then use it as a pattern for the rest - can use router to reproduce precisely.

Start by making a template of the Rail holder "bump".

Cut a strip 6 inches wide, miter both corners to outer edge of 58 1/4 inches.

Cut 2 strips 6 inches wide, 8 inches long with one end mitered.

Tack the four pieces to a sheet of 3/4 plywood as shown. Cut out roughly with bandsaw, skilsaw or jigsaw, then use router to complete shape.

Use the first finished upper rail plate as a template for two more pieces.

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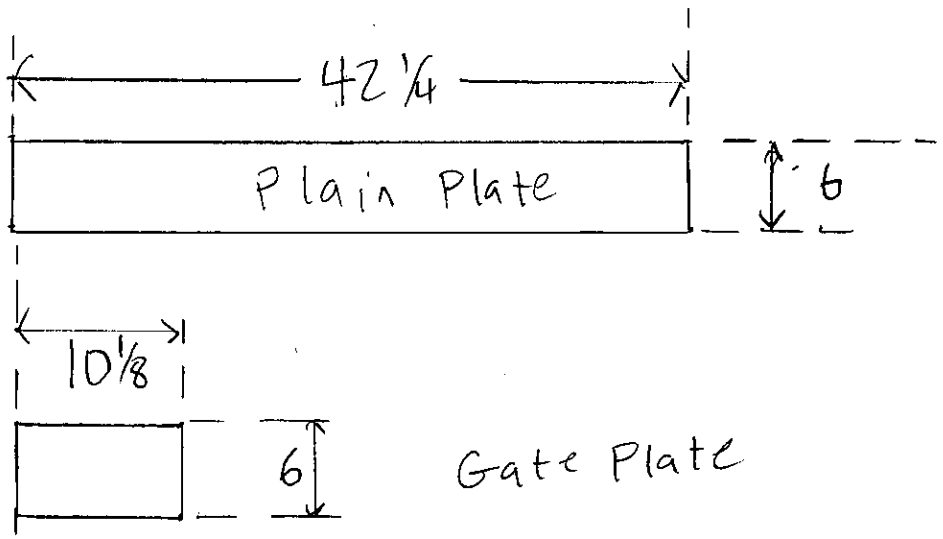
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-35 Airship Upper Rail Plain Plate
2 | Sc 1 in = 1 ft | 3/4 Ply 6 x 42 1/4
Tools: Table Saw (Rip) Bandsaw Nailer Router

Option C: Omit this part if making hemi-airship.

Part Sparta-997-36 Airship Upper Rail Gate Plate
2 | Sc 1 in = 1 ft | 3/4 Ply 6 x 10 1/8
Tools: Table Saw (Rip) Bandsaw Nailer Router

Upper Rail Plain Plates laminate with the lower plates on the sides which do not include ropes (B, F)

Upper rail Gate Plates adjoin the gate. (D)



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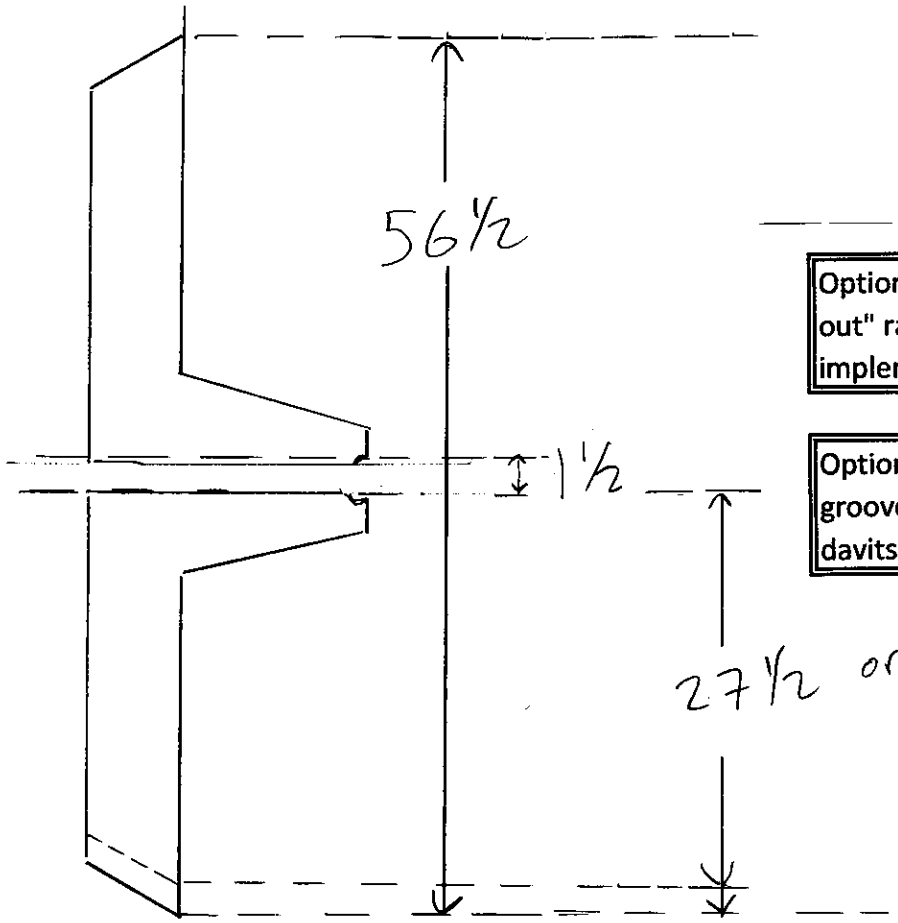
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-37 Airship Lower Rail Davit Plate
3 | Sc 1 in = 1 ft | 3/4 Ply 17 x 56 1/2
Tools: Table Saw (Rip) Bandsaw Nailer Router

Option C: Only make 2 for hemi-airship.

These plates are laminated with the upper plates, leaving a groove at the corners for the rail diagonals. They include the "bump out" for the rope lift.

Start by using one of the upper plates as a template, then shorten.



Option D: No need to "bump out" railing if not implementing davits.

Option D: No need to make groove if not implementing davits.

When the lower plates are laminated with the upper plates, they are not centered, since one end forms part of a 1 1/2 inch groove and the other end forms part of a 3 inch groove.

Make two of the plates shorter, to make the wider grooves where the two halves of the airship meet.

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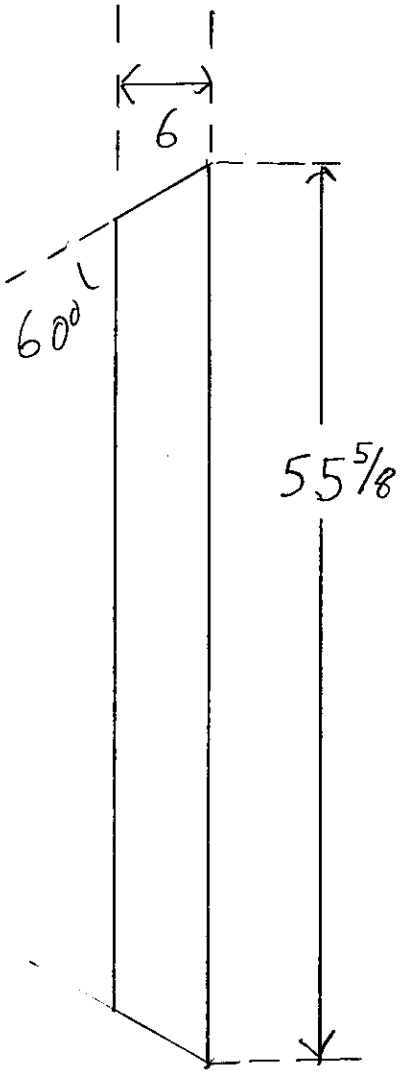
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-38 Airship Lower Rail Plain Plate
2 | Sc 1 in = 1 ft | 3/4 Ply 6 x 55 5/8
Tools: Table Saw (Rip) Bandsaw Nailer Router

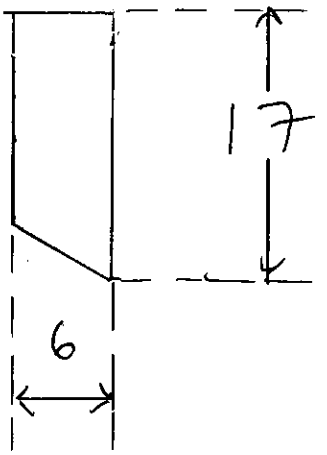
Part Sparta-997-39 Airship Lower Rail Gate Plate
2 | Sc 1 in = 1 ft | 3/4 Ply 6 x 17
Tools: Table Saw (Rip) Bandsaw Nailer Router

Option C: Omit this part if making hemi-airship.



These plates are laminated with the upper plates, leaving a groove at the corners for the rail diagonals. (B, F)

Corners are shortened, leaving room at the corners for the rail diagonals. (D)



When the lower plates are laminated with the upper plates, they are not centered, since one end forms part of a 1 1/2 inch groove and the other end forms part of a 3 inch groove.

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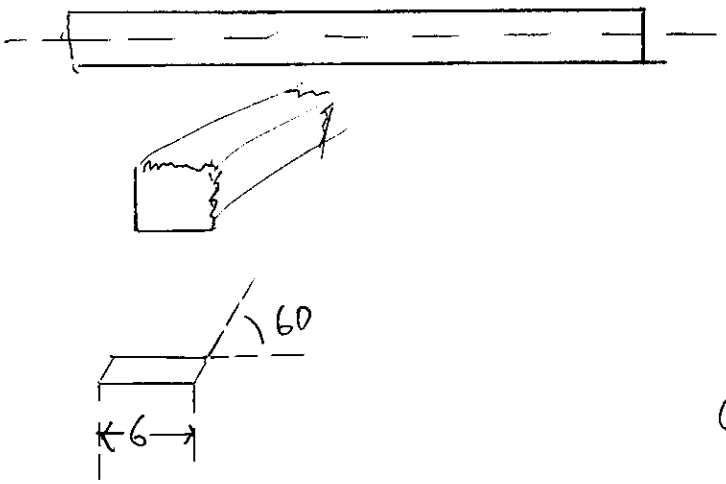
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-40 Airship Railing Glue Block
12 | Sc 1 in = 1 ft | 2x4 board 36 long
Tools: Table Saw (Rip)

Option C: Only make 6 for hemi-airship.



Rip 2 x 4

Re-Rip to get 2 smooth faces

Cut into six inch lengths

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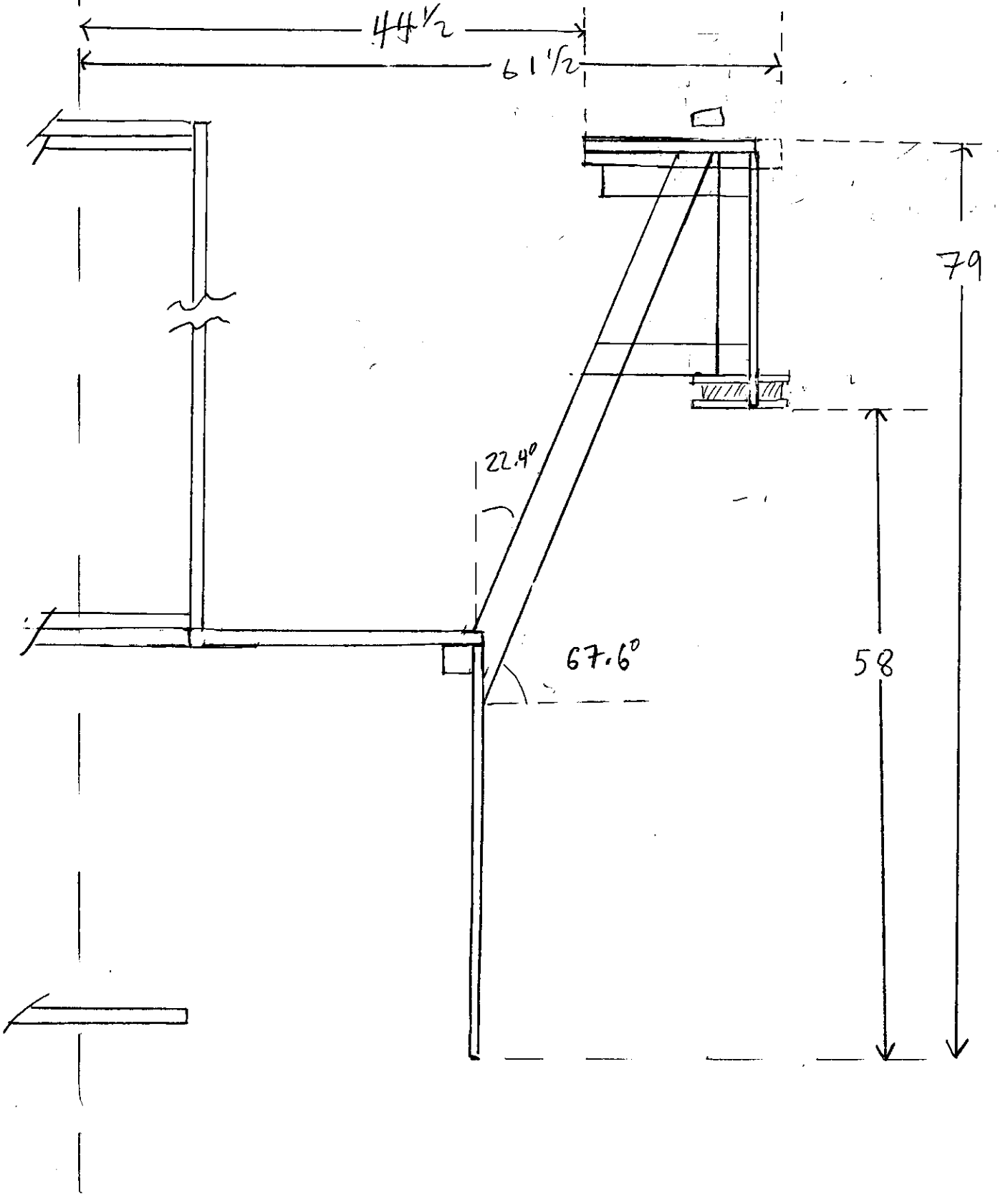
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Davit Cross Section
Scale: 1 inch = 1 foot



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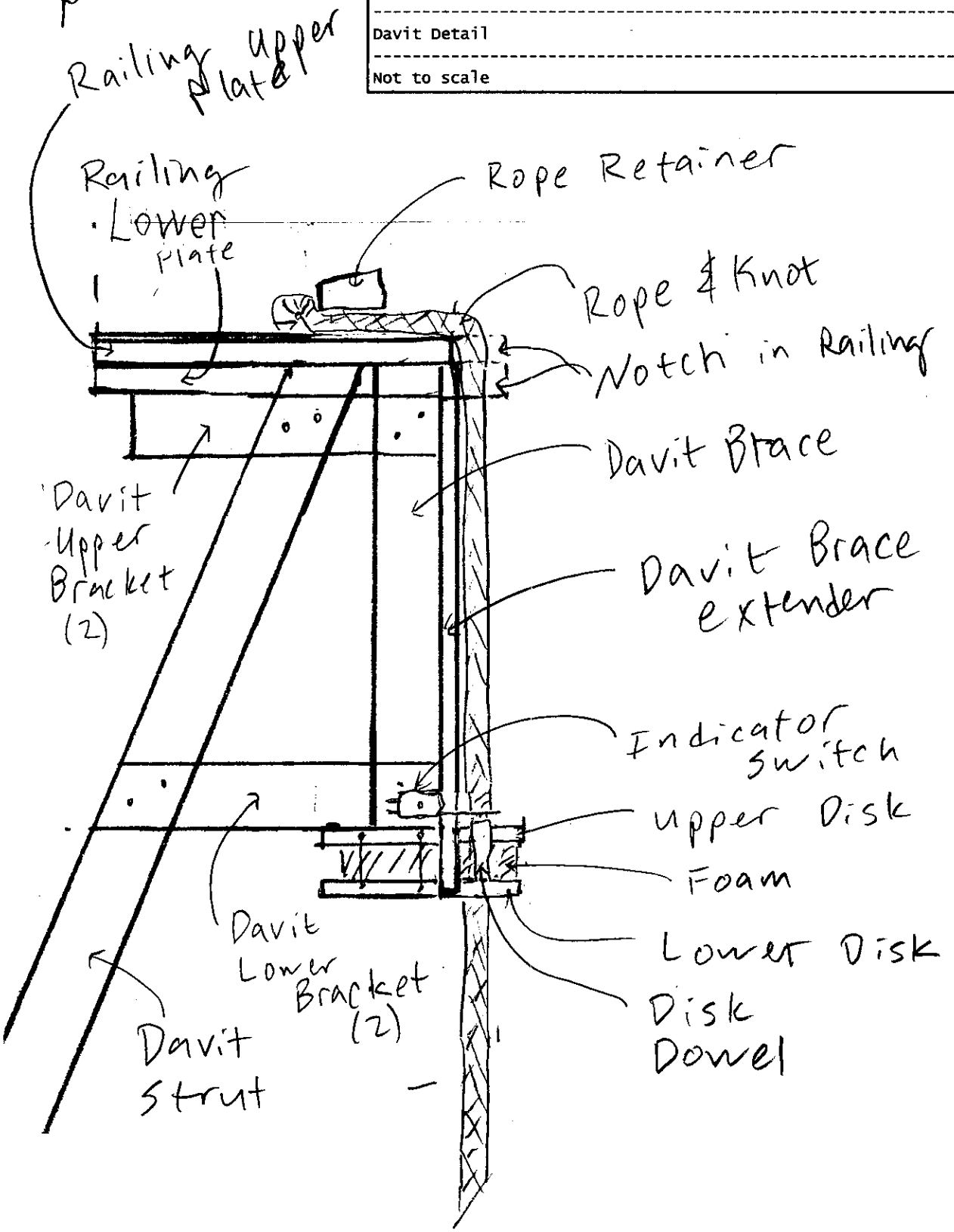
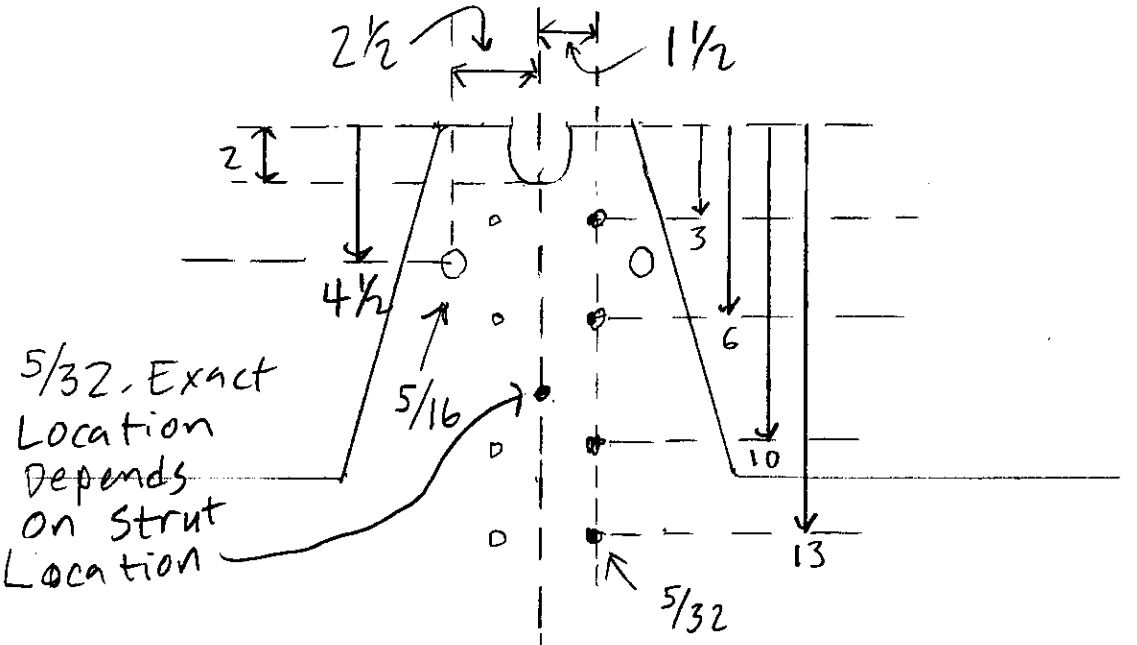
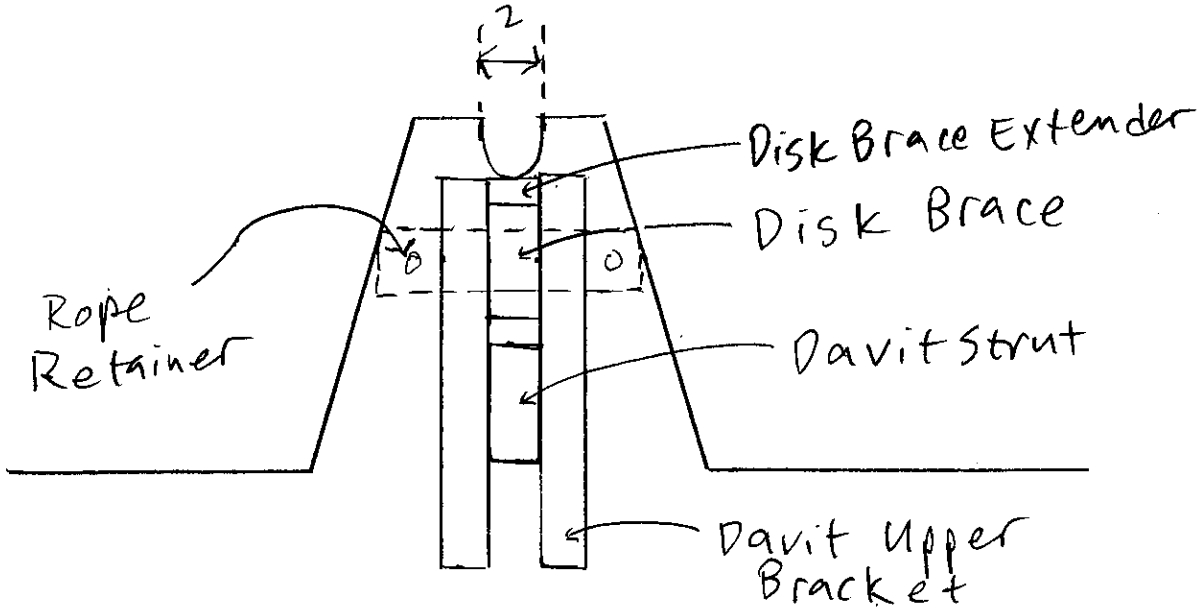
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Davit Detail
Not to scale



2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Davit Railing Top View
Scale 1 inch = 1/2 foot





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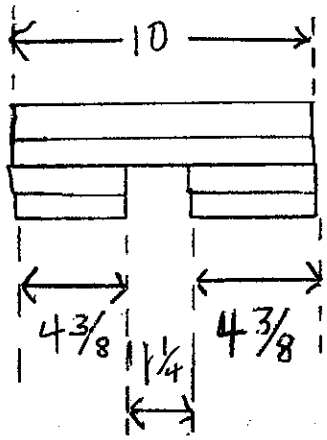
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-41 Airship Rope Retainer
3 | Sc 1 in = 1 ft | 3/4 Ply 11 x 12
Tools: Table Saw (Rip) Drill Press Nailer

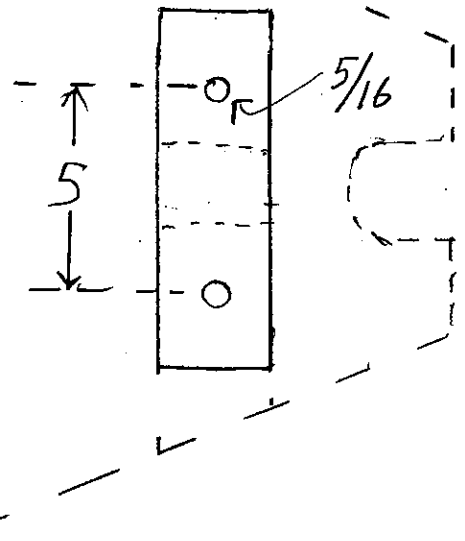
Attaches with Carriage bolts through upper and lower rail cover plates to hold rope.

Cut 3/4 Plywood into strips, 2 strips 10 x 8, 4 strips 4 1/4 x 8.



Glue and clamp strips as shown.

When dry(-ish), cut off 3 sections 2 inches wide.



Drill holes through Rope Retainer, upper plate and lower plate, affix with T-Nuts

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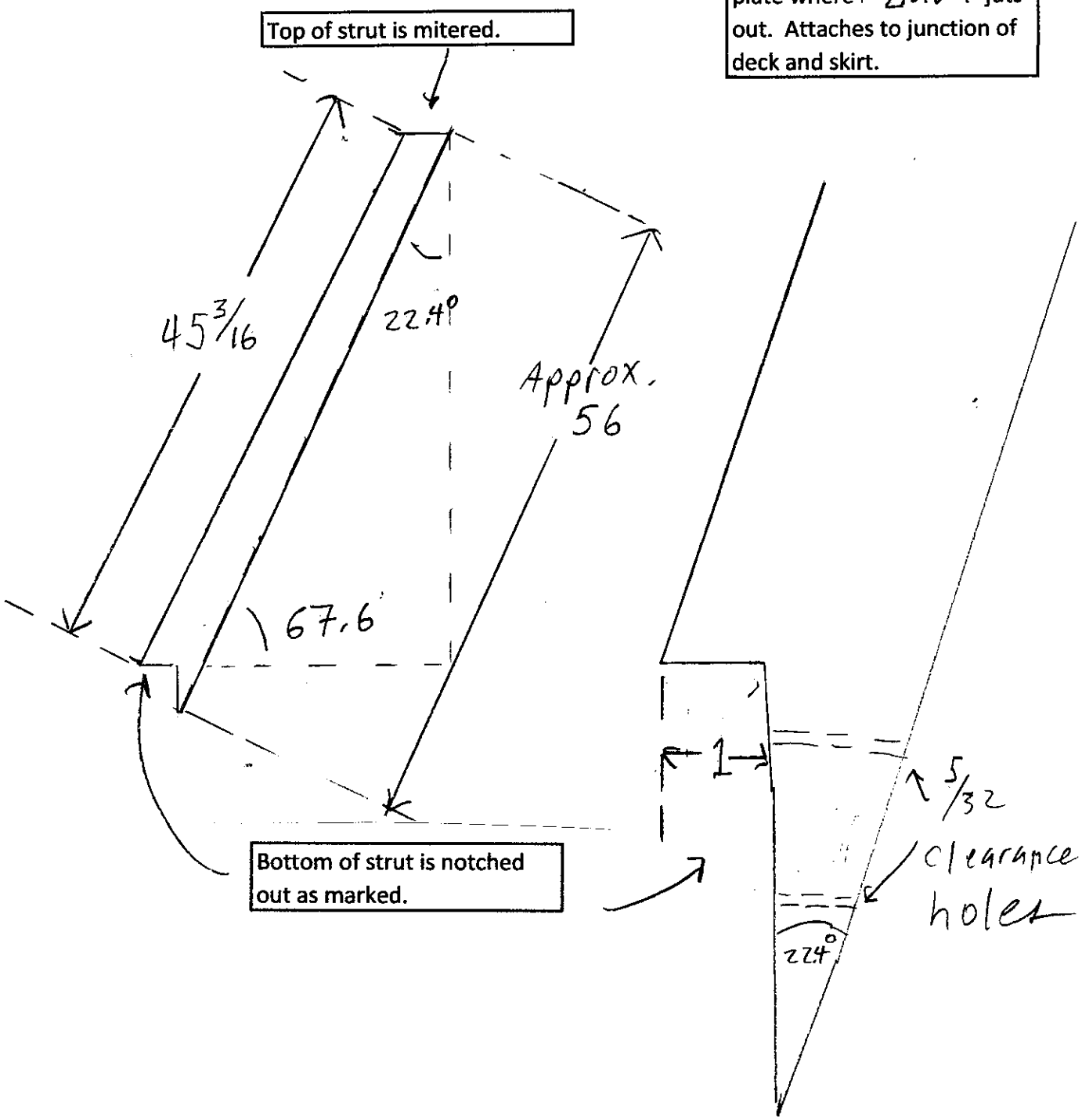
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-43 Airship Davit Strut
3 | Sc 1 in = 1 ft | 2x4 board ~~8~~ 56 long
Tools: Chopsaw Bandsaw

Fits into groove lower railing plate where davit juts out. Attaches to junction of deck and skirt.



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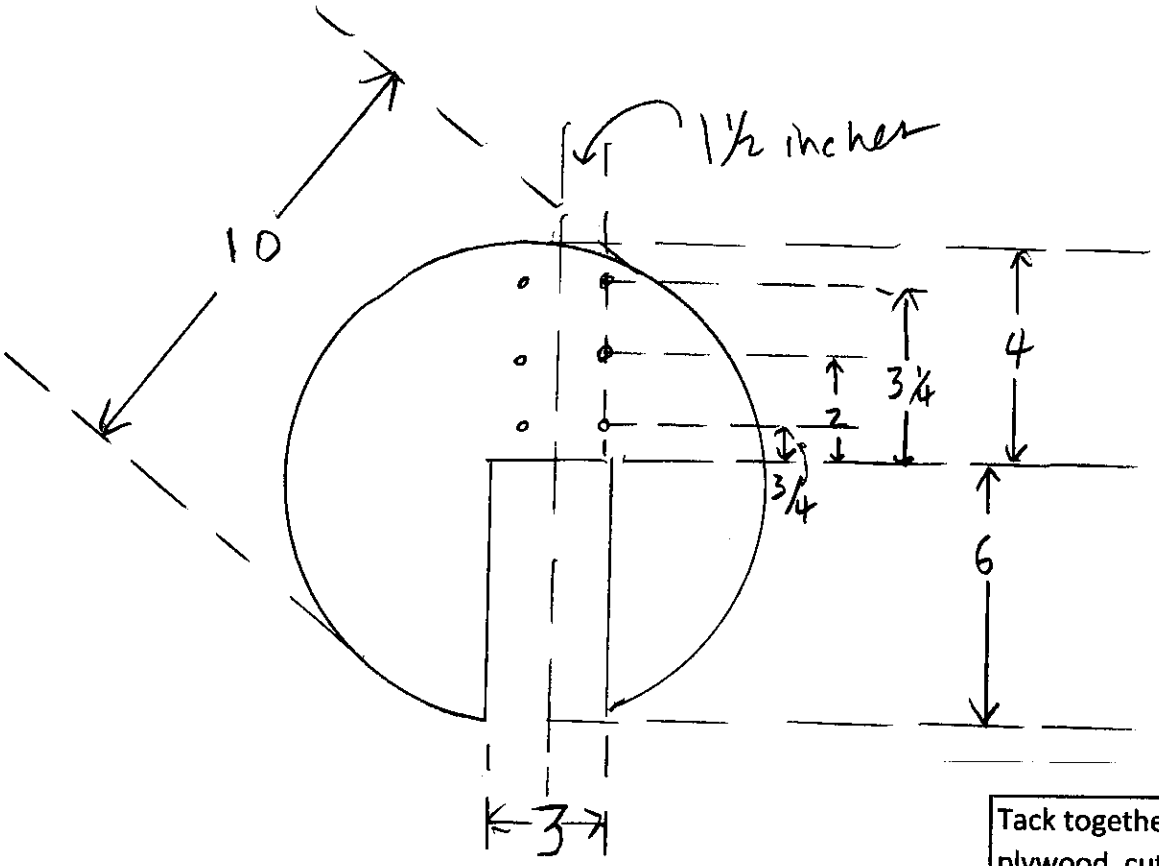
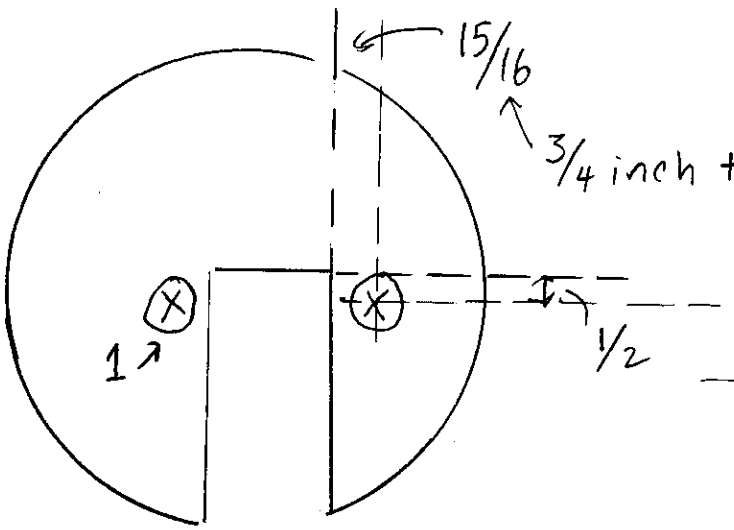
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-44 Airship Upper Disk
3 | Not to scale | 3/4 Ply 10 x 10
Tools: Bandsaw Drill Press Stapler



Tack together 6 layers of 3/4 plywood, cut out circle and notch on bandsaw.

Separate into one set of three (upper) disks and three individual (lower) disks.

Drill clearance holes to attach Lower Davit Bracket in upper disks.



Carefully mark location of disk dowels, make oversized 1 inch holes in upper disks.

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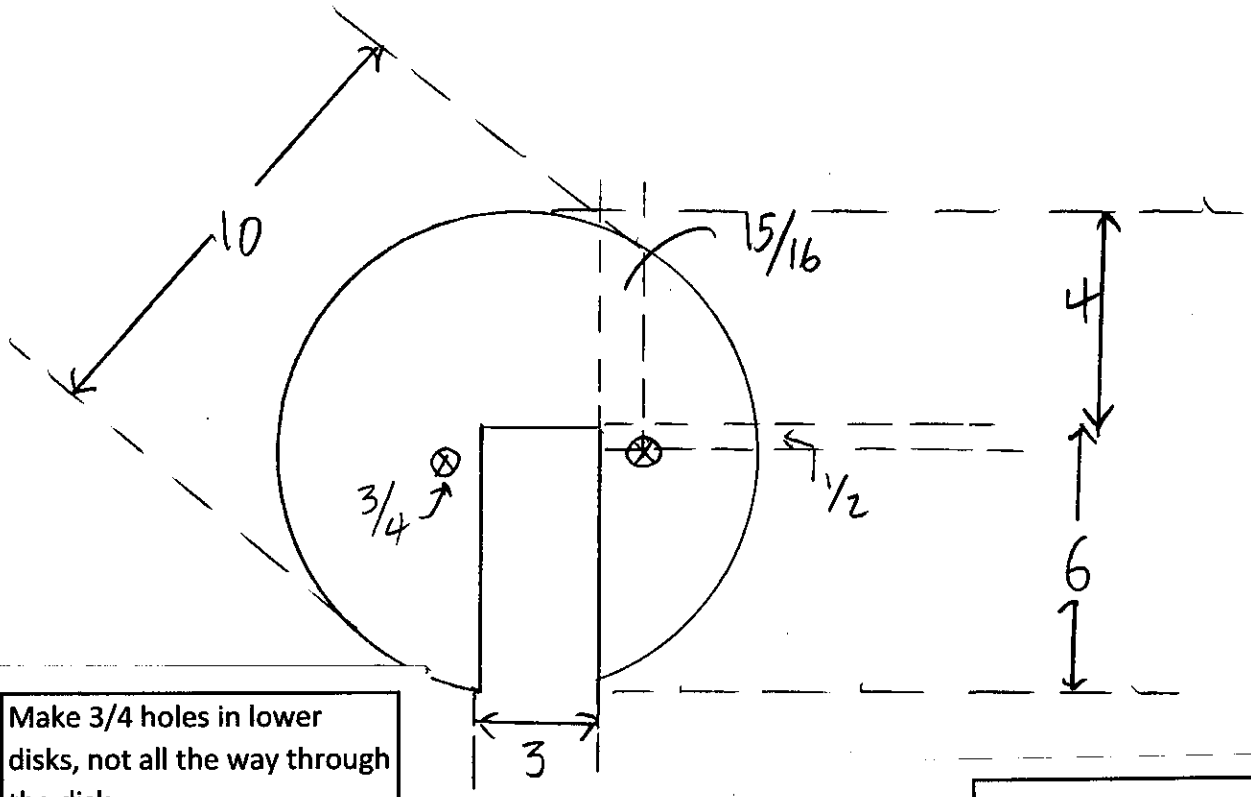
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-45 Airship Lower Disk
3 | Not to scale | 3/4 Ply 10 x 10
Tools: Bandsaw Drill Press Stapler

Option E: Omit this part for single static touch pad



Make 3/4 holes in lower disks, not all the way through the disk.

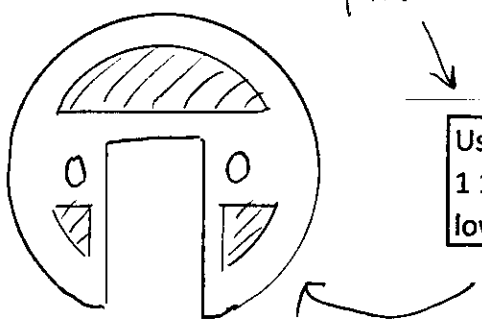
Glue dowels into holes, extending 2 1/4 inches above lower disk.

wait...

Attach foam first!

Attach the two disks together by stapling knotted string or bungee material to sides.

Space disks 1 1/2 inches apart.



Using spray adhesive, attach 1 1/2 inch layer of foam to lower disk as shown.

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Option E: Omit this part for single static touch pad

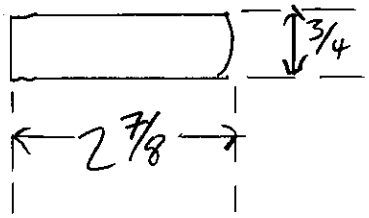
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

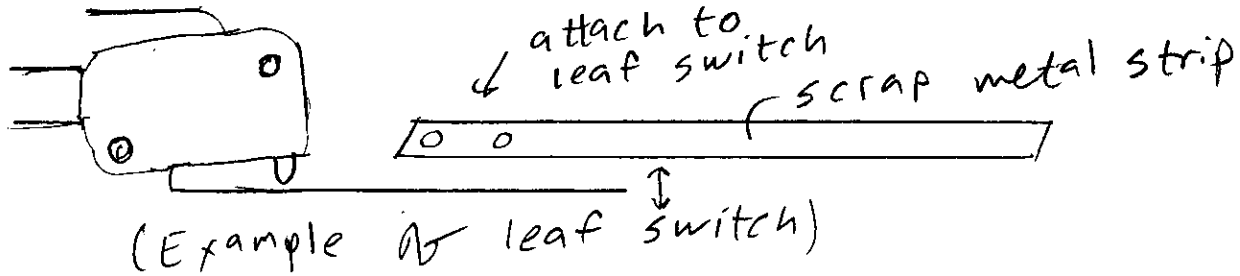
Part Sparta-997-46 Airship Disc Dowel

6 | Not to scale

Part Sparta-997-47 Airship Switches

3 | Not to scale





Attach the switches to the lower davit brackets so they are actuated by the disk dowel when the lower disk is elevated.

Extend the leaf switch with a piece of scrap metal strapping to avoid bending the leaf switch if the dowel is pushed all the way in.

Only need to implement switch on one side.

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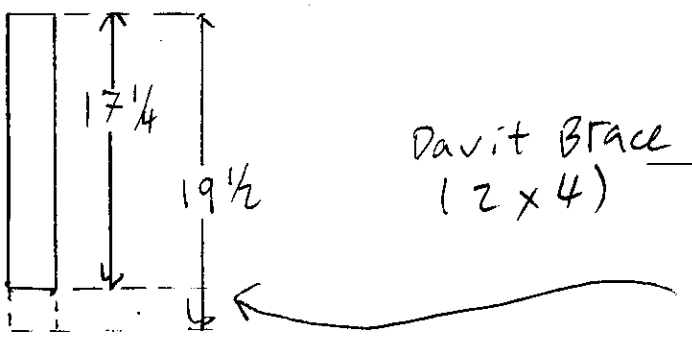
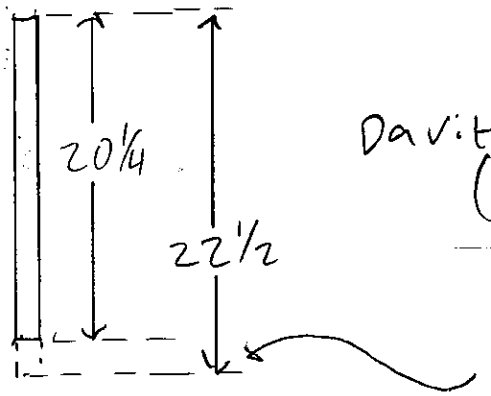
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-52 Airship Davit Brace
3 | Sc 1 in = 1 ft | 2x4 board 17 1/4 long
Tools: Chopsaw

Part Sparta-997-53 Airship Davit Brace Extender
3 | Sc 1 in = 1 ft | 3/4 Ply 1 1/2 x 20 1/8
Tools: Table Saw (Rip) Table Saw (Crosscut)



Davit Brace
(2 x 4)

Option E: (Static disk) If not making lower disk, make davit bracket longer so disk is still at correct height.



Davit Brace Extender
(3/4 plywood)

Option E: (Static disk) If not making lower disk, make davit bracket extender longer - will extend down from disk as per FIRST design.

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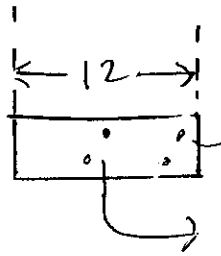
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-55 Airship Davit Upper Bracket
6 | Sc 1 in = 1 ft | 2x4 board 12 long
Tools: Chopsaw

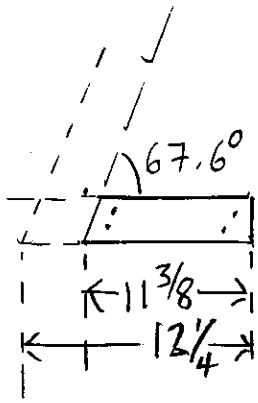
Part Sparta-997-56 Airship Davit Lower Bracket
6 | Sc 1 in = 1 ft | 2x4 board 11 3/8 long
Tools: Chopsaw



5/32 clearance hole

exact location depends on davit strut!

Davit Upper bracket



Davit Lower Bracket

Option E: Will be longer if implementing single touch pad.

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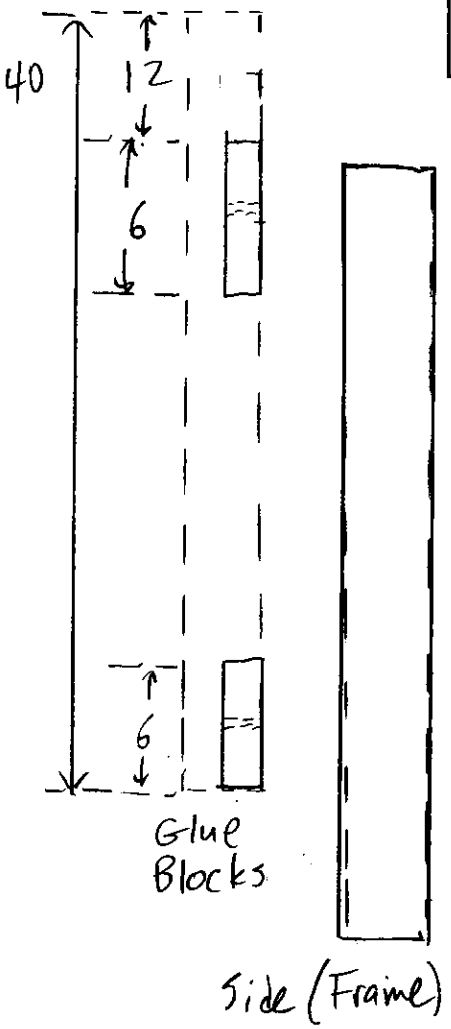
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

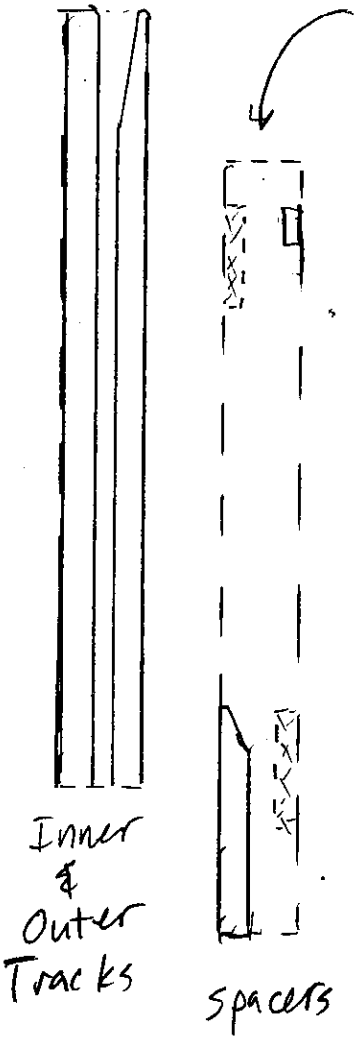
Gear Lifter Overview

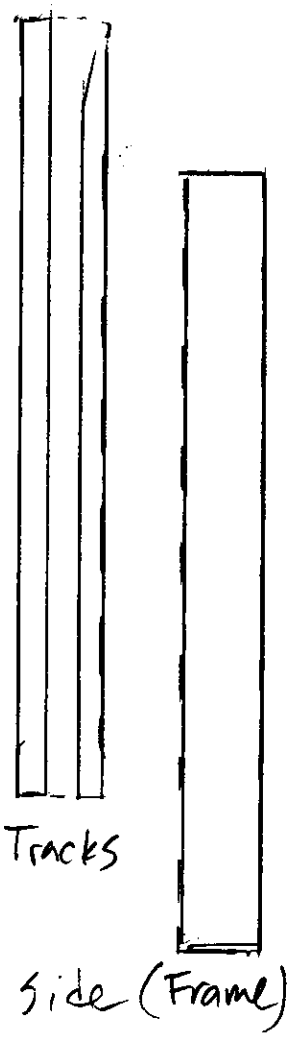
Not to scale

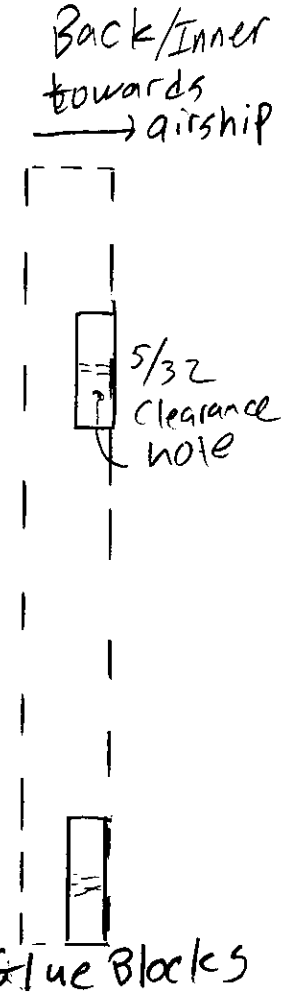


Gear lifter is open in front from 12 inches up to allow spring to pass.

Gear lifter is open in back to allow alignment notch to be lifted until it catches at top.







Glue up gear lifter in stages - start by gluing up the sides and long and short tracks. Long track in front, ~~short~~ tapered track in back.

Next, glue up with the spacers - tapered spacer front bottom WITH GLUE, catch spacer back top WITH GLUE. Include a couple more scrap spacers with no glue to maintain spacing.

Finally, glue blocks to gear lifters, in back, as marked.

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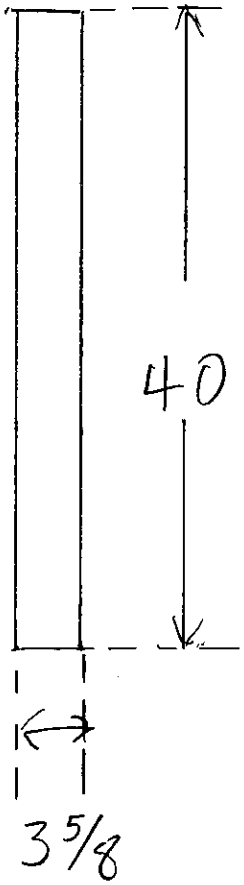
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-57 Airship Gear Lifter Frame
6 | Sc 1 in = 1 ft | 3/4 Ply 3 5/8 x 40
Tools: Table Saw (Rip)

frame holds the two tracks in place and connects via glue blocks to the airship skirt.



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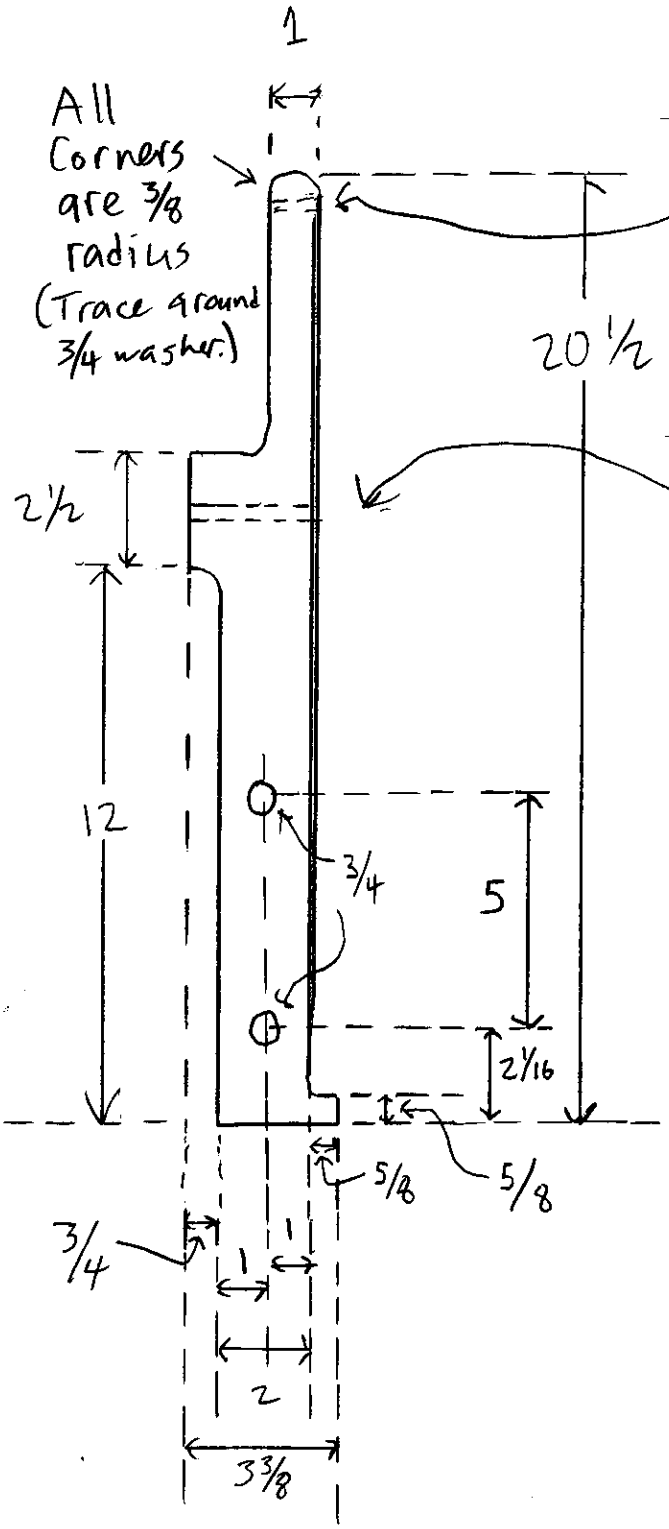
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-58 Airship Gear Lifter Body
3 | Not to Scale | 3/4 Ply 3 3/8 x 20 1/2
Tools: Table Saw (Rip) Bandsaw



Drill hole as marked, tie gear lifter to string and attach handle to string.

Drill hole for dowel to attach spring - size of hole and dowel depends on size of spring!

Wait to drill hole for peg/ spring until tested, to ensure precisely correct height from floor.

Consider making an extra in case a bot breaks off the dowel with the spring.

Attach alignment dowels to gear lifters. Be careful to drill hole to fit dowel - dowels are often undersized!

The dowels should protrude by 5/8 inch on each side.

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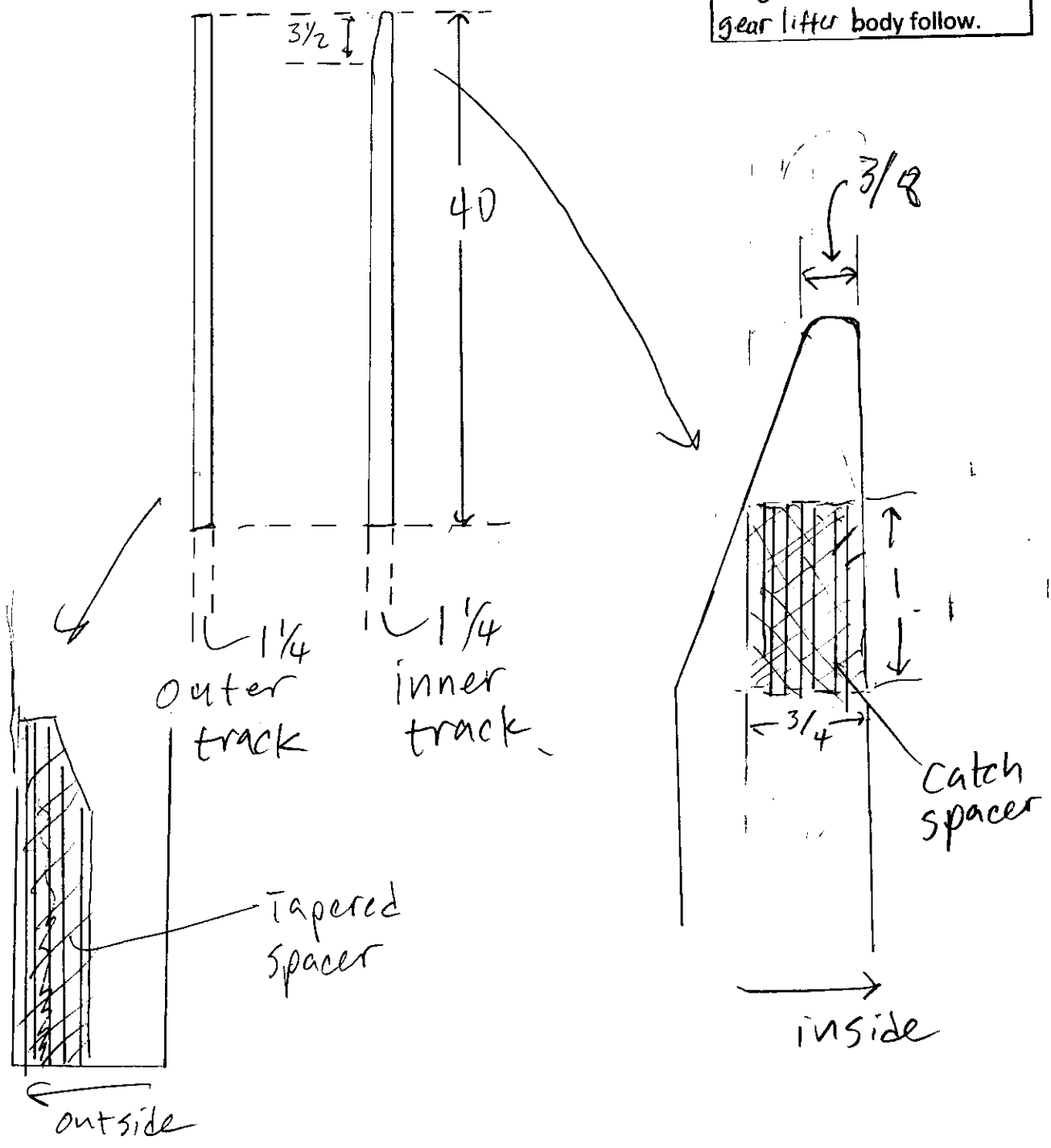
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-60 Airship Tapered Inner Track
6 | Sc 1 in = 1 ft | 3/4 Ply 1 1/4 x 40
Tools: Table Saw (Rip) Bandsaw
Part Sparta-997-61 Airship Straight Outer Track
6 | Sc 1 in = 1 ft | 3/4 Ply 1 1/4 x 40
Tools: Table Saw (Rip)

Tracks form the groove the dowels of the gear lifter body follow.



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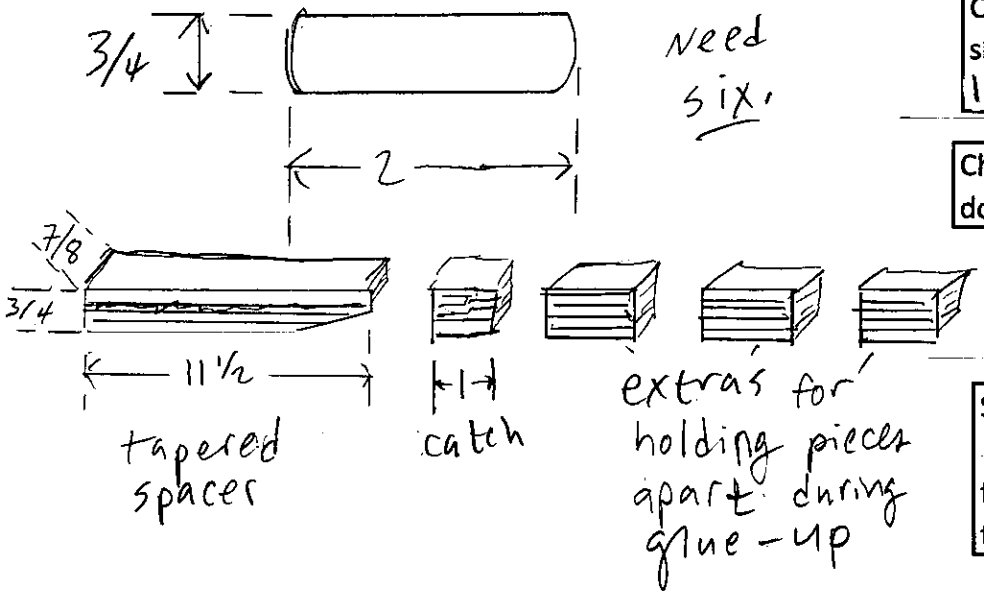
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-59 Airship Gear Lifter Alignment Dowels
6 | Not to Scale
Part Sparta-997-62 Airship Tapered Spacer Strip
3 | Not to Scale | 3/4 Ply 7/8 x 36
Part Sparta-997-63 Airship Catch Spacer Strip
3 | Not To Scale | 3/4 Ply 7/8 x 3
Part Sparta-997-64 Airship Extra Spacing Strips
12 | Not to Scale | 3/4 Ply 7/8 x 36
Part Sparta-997-65 Airship Gear Lifter Glue Block
12 | Not to Scale | 2x4 board 36 long
Tools: Table Saw (Rip)

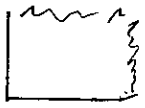


Cut to length, round ends slightly, attach to gear lifter body.

Check hole size carefully - dowels are often undersized!

Spacer strip allows the gear lifter body to move freely, also forms a stop for the gear lifter body.

Rip 2 x 4, then rip again to make smooth sufaces at 90 degrees.



Careful when positioning glue blocks to avoid the visual targets.

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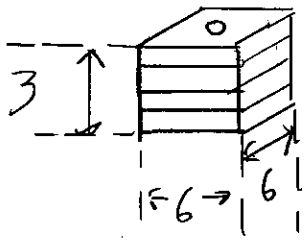
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997
Part Sparta-997-71 Airship Rotor Holder
Quantity 4 | Scale: 1 inch = 1 foot | Material: 3/4 plywood 6 x 24
Tools: Bandsaw

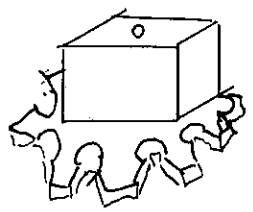


Rotor holder

Cut into 6 inch squares, laminate and glue.

Drill central hole for rotor pole. Consider drilling a pilot hole for a screw to hold pole in place, esp if using undersized dowel.

For extra fun, cut into pyramid shape, hexagon, cog or ??



Attach the three railing Rotor Holders to Gears.

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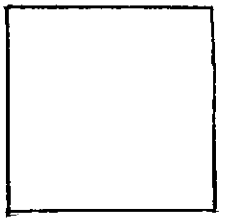
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Part Sparta-997-76 Airship Gears

20 | Sc 1 in = 1 ft | Tools:

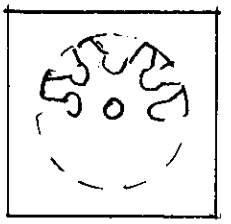
Table Saw (Rip) Bandsaw Drill Press Nailer

Gather up all your plywood scraps and cut them into 12 1/2 squares.

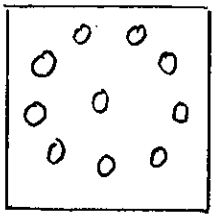


Tack pieces together into stacks about three inches high. Do not tack into center or edges.

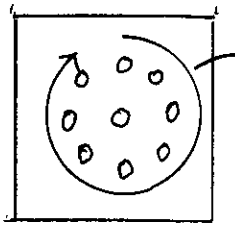
Trace plastic gear onto top of stack.

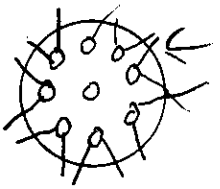


Use 1-inch Forstner bit to drill one hole in center and ten holes around edge, one between each tooth.



Use bandsaw to cut around entire gear, then use bandsaw to cut out individual teeth, turning blade around in the holes at the edge.





Optional: Spray-paint gears.

Learn from my mistakes! I had the bright idea of using spray adhesive to attach posterboard to the pieces before I drilled and cut them out. The spray adhesive didn't stick very well and the posterboard clogged up the Forstner bit so it wouldn't drill the holes! Just spray-paint the gears.

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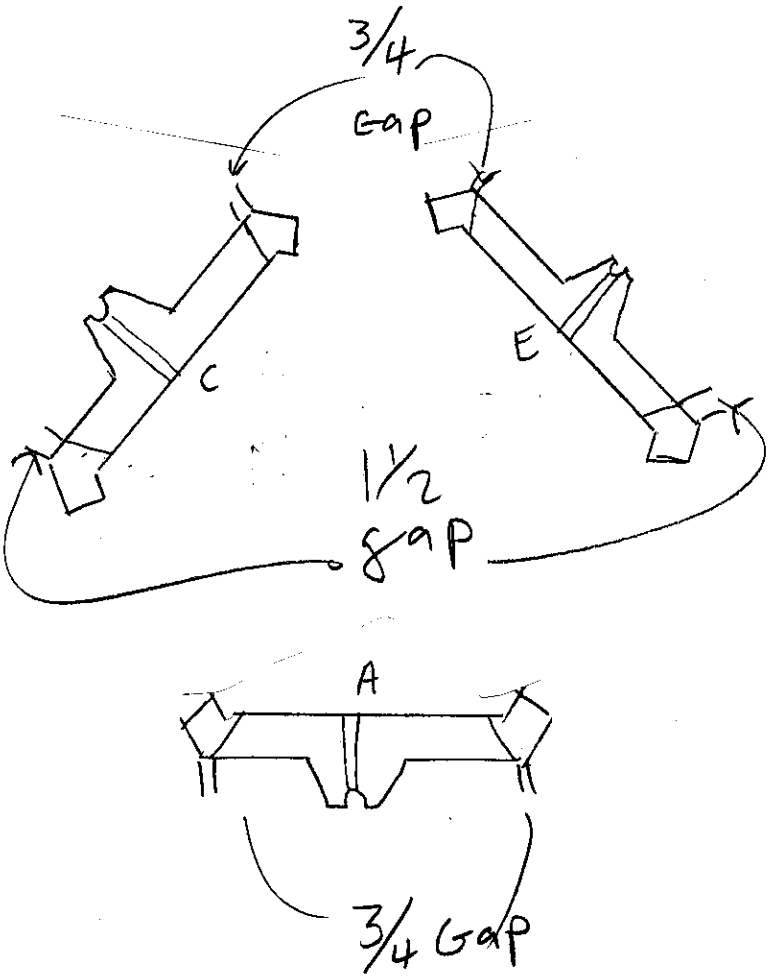
Assembly - Davits and Railings	2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997 Assembly Instructions Not to Scale

Laminate the railing pieces in stages, using glue and lots of clamps.

see also pp 46-51.

Laminate the three davit railings first - segments A, C, E. Glue each Upper Rail Davit Plate to two Lower Rail Davit Plates. Remember to allow for a 1 1/2 inch groove down the middle of the davit. Use the shorter Lower Rail Davit Plates for the junctions to allow a 3 inch groove where the two hemi-airships meet - at BC and EF.



Use the bumpout template to make a drilling template, then drill holes in the glued-up davit railing pieces for the Rope Retainers and clearance holes to attach the Upper Davit Brackets.

see p. 55 for hole placement

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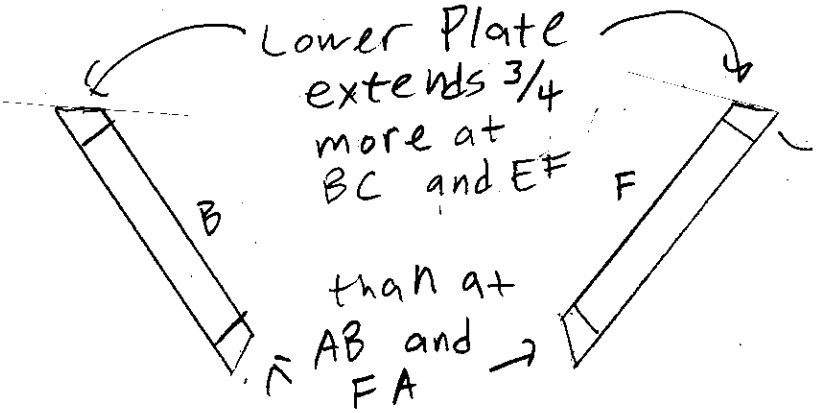
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Assembly Instructions

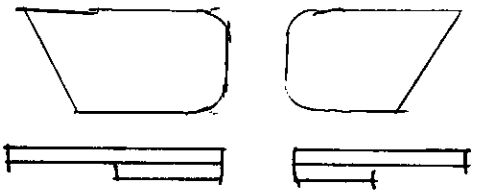
Not to Scale

Laminate the plain long railing pieces next - segments B and F. Glue up the Upper Rail Plain Plate with the Lower Rail Plain Plate. Offset the Lower Rail Plain Plate to allow a 3 inch groove where the two arishipsmeet - at BC and EF.

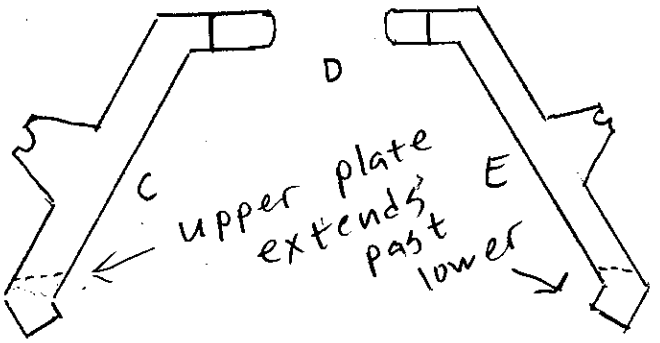


See also pp. 46-51.

Laminate the gateway railing pieces - segment D. Upper Rail Gate Plate to Lower Rail Gate Plate. Once they are laminated, round off the corners that form the gateway.

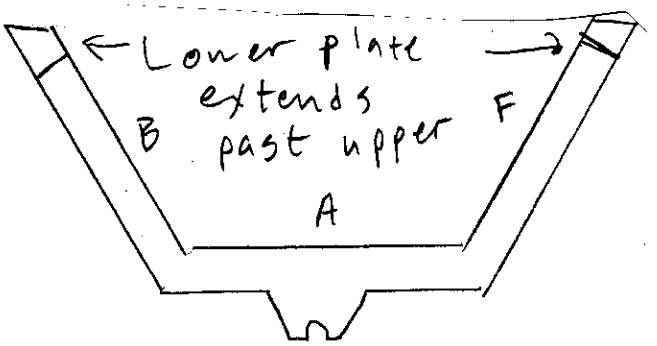


Learn from my mistakes! The gateway pieces are mirror images of each other, not identical!



Glue and clamp together the three complete railing pieces - Segments EAB, Segment CD and Segment DE.

When gluing up, remember the grooves at AB, CD, DE and FA are 1 1/2 inches wide.



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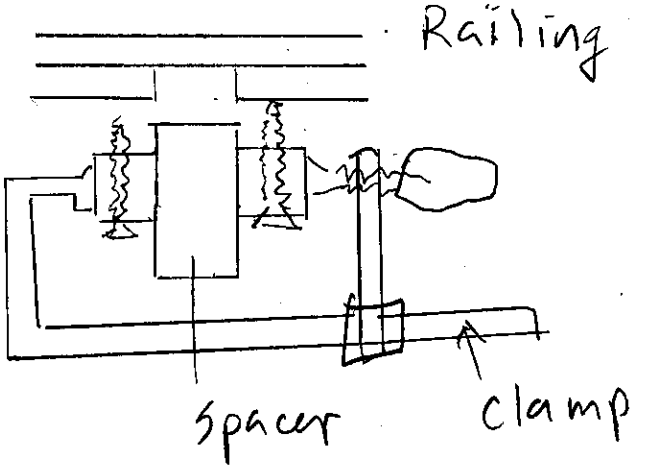
Use a belt sander to round off and soften all the edges, especially the upper inner edges.

Check all grooves for size. It too narrow, use router to widen to 1 1/2 inches - if too wide, can narrow the groove when attaching Rail Glue Blocks / Davit Brackets.

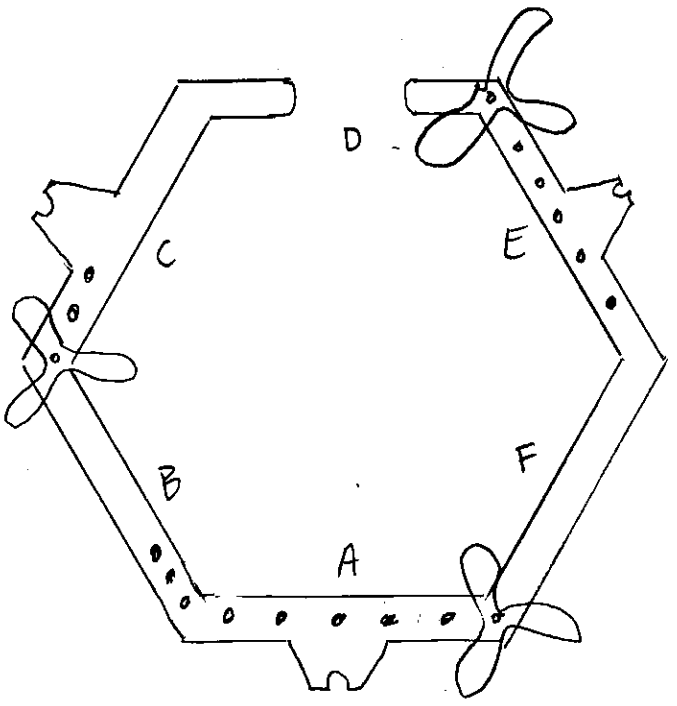
Attach

~~Screw~~ glue blocks to both sides of grooves at junctions AB, CD, DE and ED. Clamp together a spacer with the glue blocks to maintain spacing of 1 1/2 inches and to align them with groove while attaching them.



Drill 7/8 holes, 3/4 inch deep, separated by 10 inches center-to-center, glue in 7/8 dowels for Gears.

Glue in dowels for eight Gears plus the Rotor Holder in segment A, five Gears plus the Rotor Holder in segment E and two Gears plus the Rotor Holder on side C.



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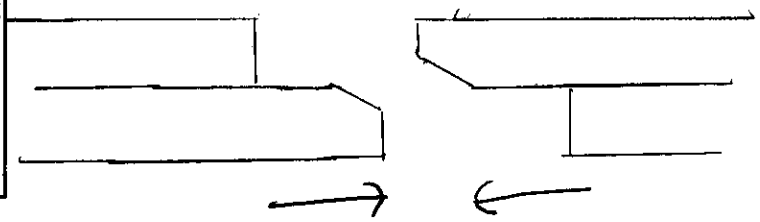
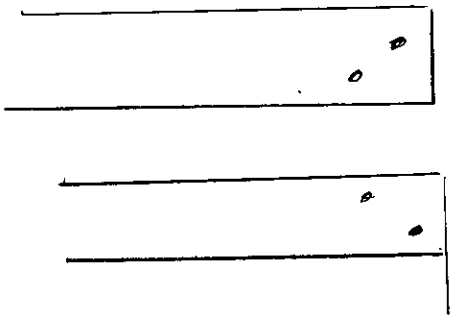
Assembly Instructions

Not to Scale

Use a handplane or sander to lightly bevel the ends of the upper and lower rail pieces at BC and EF (for later separating and re-attaching the two halves of the airship).

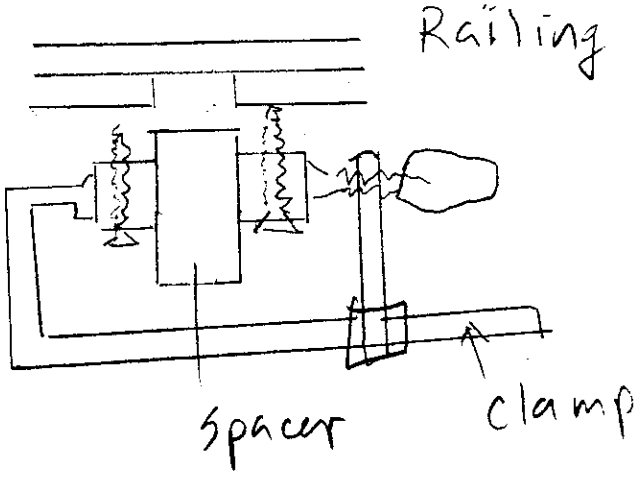


Pre-drill 5/32 clearance holes to connect Upper and Lower Davit Brackets to Davit Brace. Ideally, offset holes diagonally from one side to the other.



Attach

~~Screw~~ Davit Upper Brackets to davit railing pieces. Clamp together a spacer with the brackets to maintain spacing of 1 1/2 inches between them.



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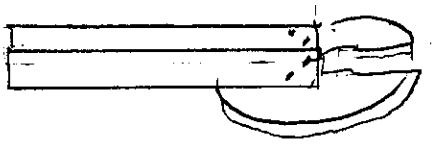
2017 FIRST Steamworks Airship | E. Frothingham, Spartan Robotics 997

Assembly Instructions

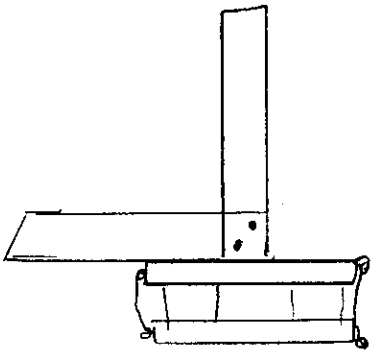
Not to Scale

Assemble Davit Brace / Davit Lower Bracket / Upper Disk / Lower Disk:

Screw Davit Lower Brackets to Upper Disks, with spacer as above.



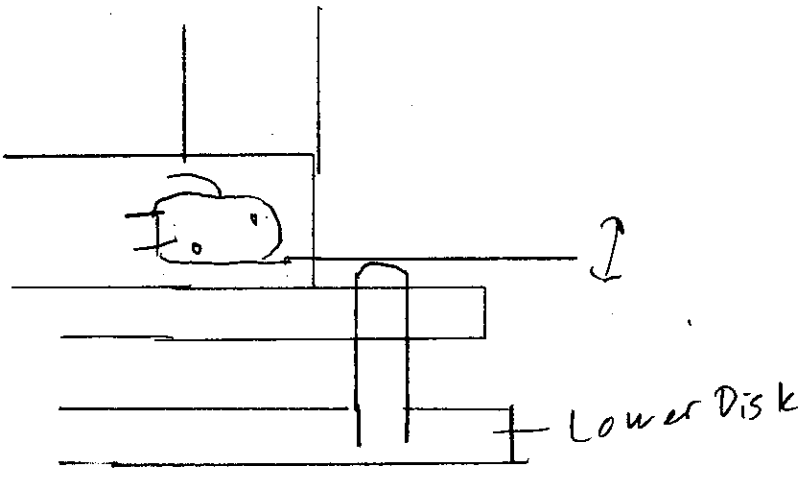
Screw Davit Brace to Davit Lower Bracket / Upper Disk.



Attach Lower Disk to Lower Disk with knotted string or knotted bungee cord.

Attach Switches.

Set aside assembly of Disk Bracket / Disk Brace / Upper Disk / Lower Disk / Switch.



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Don't install the railings until the deck is covered!

Lift the railings into place. Align with the Rail Diagonals as well as possible.

Temporarily clamp together at BC and EF while adjusting the railings on Rail Diagonals.

Drill 5/32 inch clearance holes and screw rails down to Rail Diagonals.

Drill 5/16 holes at BC and EF to bolt together upper and lower plates. Insert T-Nuts and bolt together.

Learn from my mistakes! It can be awkward to hammer a T-Nut into a board in a tight space. Thread the T-Nut onto a bolt, prongs out, hammer it into place, then unscrew the bolt.

Attach Railing Glue Blocks at BC and EF

Drill 5/32 clearance holes and screw all Glue Blocks to Rail Diagonals.

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Assembly Instructions

Not to Scale

Attach Davit Struts at midpoint of segments A, D and E. May need to hammer into groove at railing.

Screw Davit Strut to Skirt. Drill 5/32 clearance holes and screw to railing.

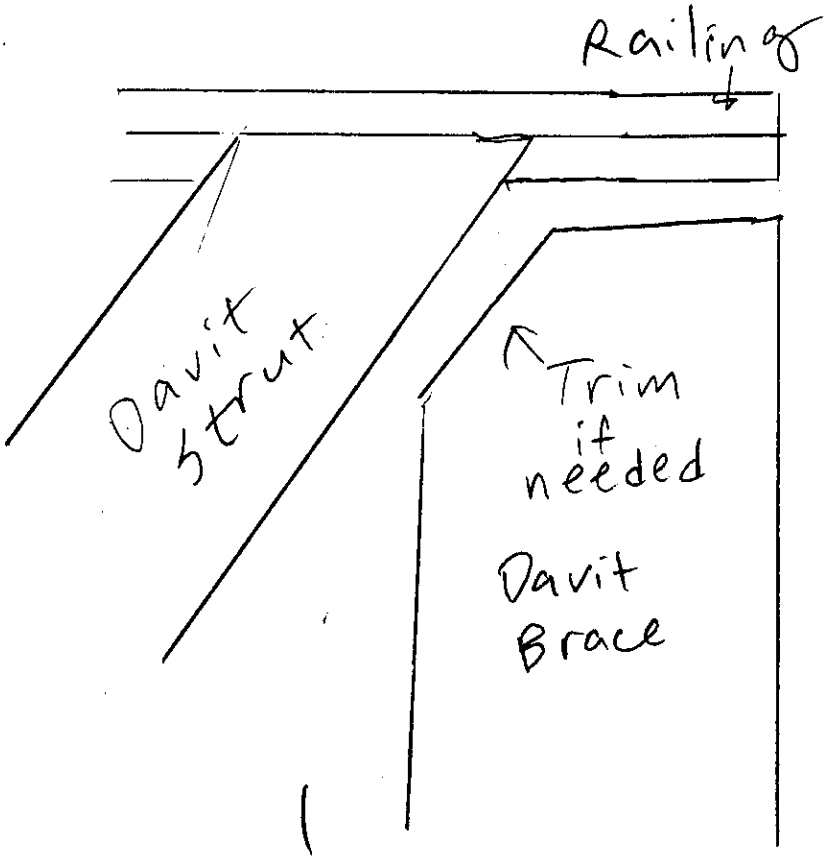
Make 5/32 clearance holes (offset front and back) and screw Davit Upper Brackets to Davit Strut.

Install Davit Brace / Davit Lower Bracket / Disks:

Check that the groove in the railing is clear for at least 4 1/4 inches past the davit strut. If not, trim off a corner of the Davit Brace to fit.

Insert the Davit Brace in the railing groove, right behind the notch in the railing. Screw to the Davit Brace to the Davit Upper Brackets, screw the Davit Lower Brackets to the Davit Strut.

Attach the gear lifters to the midpoint of segment B and F. Attach the gear lifter next to the Davit Strut of segment A.



Enjoy!

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