

**Bird Sculpture
for
The Randall Museum**

**Ben Trautman
Trautman & Associates
April 20th, 2016**

Full Scale Mockup

A full scale cardboard mockup was presented in the lobby of The Randall Museum on October 15th, 2015. A final placement was agreed upon, shown in the series of photos below. Some of the issues discussed included:

- 1) clearances from the walls to allow the piece to swing in a seismic event
- 2) height from floor to avoid people reaching up, @ 9' to 9'-6" was discussed as a reasonable height. (We are now thinking that 10'-6" is will be the minimum height of the sculpture.)
- 3) keeping the piece from encroaching on the exhibit areas
- 4) the direction the piece is facing and the narrative that suggests

In this view, the tail feathers dipped below the level of the clearstory. A major concern for the engineer was that the clearances would not be sufficient to allow any swing.

For this reason, I have adjusted the overall dimensions. I have shortened the tail feathers and reduced the wingspan, changing the dimensions from $20' \times 8'$ to $19' \times 6'$.



Another change I anticipate from what is shown here is that the mockup had a significant slope to how it hung so that the depth was too much.

I will flatten out the angle at which it hangs to keep the depth to a minimum.



I think that the sculpture can be hung slightly closer to the ceiling, maybe 12" higher than we had in the mockup. Again, this will give us the tolerances to maintain a safe height out of reach even as the piece moves.



A result of these changes
is that you will not see
the tail feathers hanging
down below the line of
the clearstory.



Plan view of 50% scale model

As stated previously, the overall dimensions have been adjusted to ensure proper clearances from walls and floors.

Original dimensions in mockup: 20' x 8'

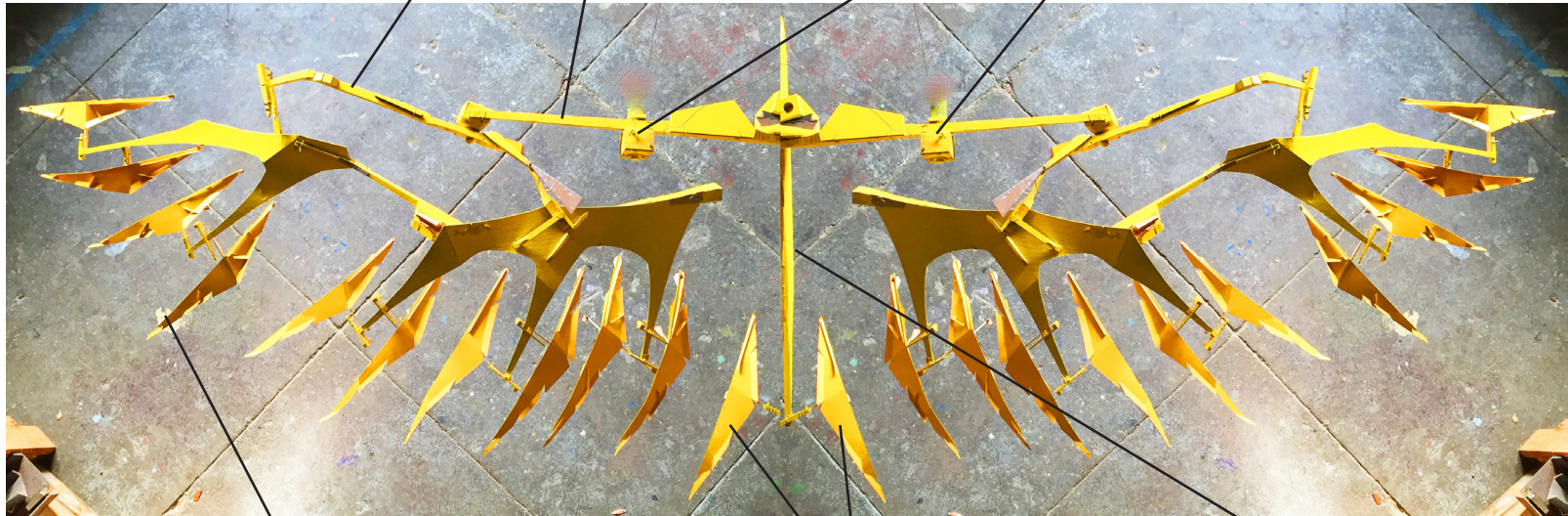
New dimensions: 19' x 6'



I built one half of the bird form in this model and then mirrored it in Photoshop.

I will add visual weight to these main structural arms on each side. They are too thin in this model.

Main hanging points, 1 cable each side, 2 total 1/8" stainless cable



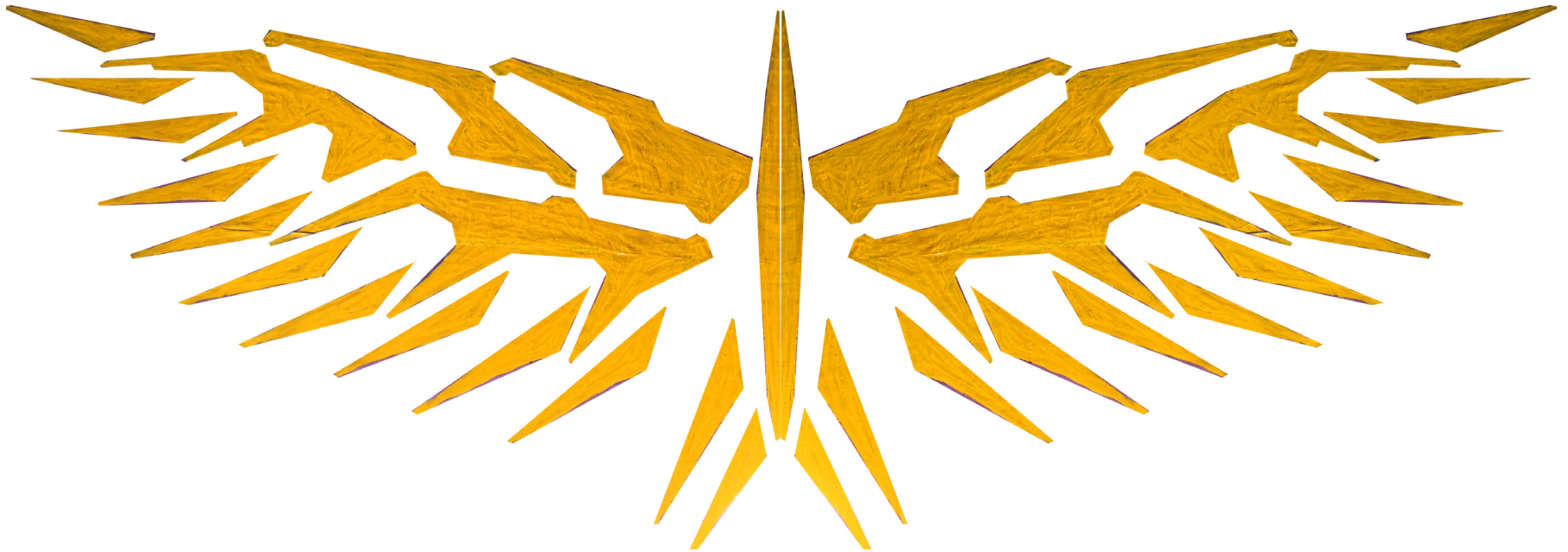
feathers

I will add one more tail feather on each side for a total of 4

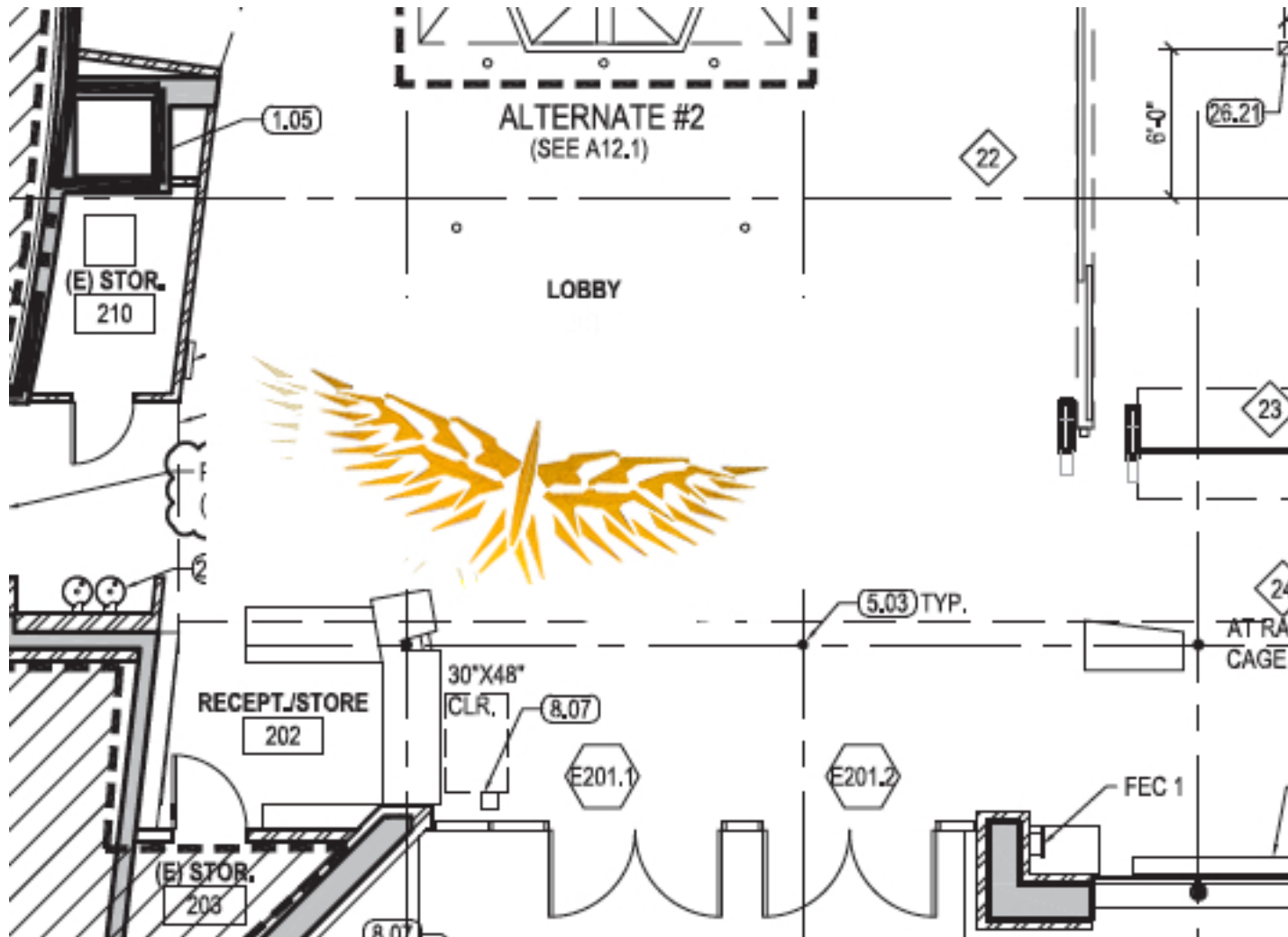
The central body piece will be an abstractly carved piece of cherry wood with Tung Oil finish

Full Scale Plan Drawing

After building the 50% scale model shown above, I used that information to draw a full scale plan of the piece. There will be changes and distortions as these parts are bent and formed, hinged, attached etc.



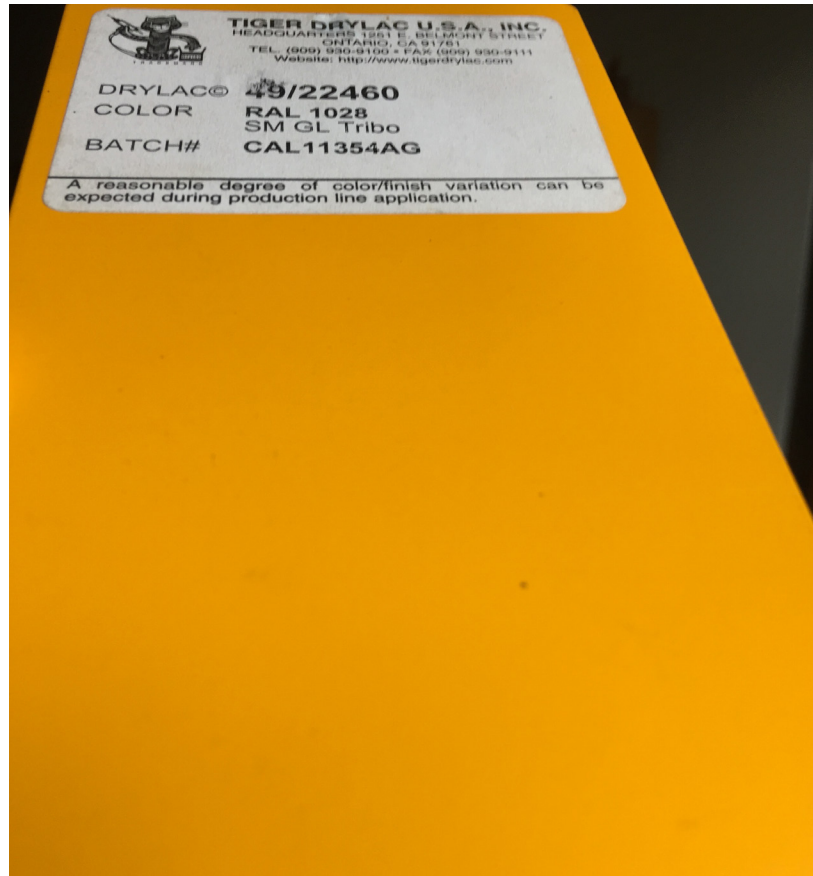
Drawing placed in Lobby plan



On March 3, I brought the full scale drawing to the Randall with a laser level to locate the hanging points up from the floor to check the placement relative to the exposed ceiling beams

On April 7th, I returned to verify clearances and, with approval from Randall Staff, I adjusted the placement, moving it to the right by about 1 foot. The ghost image of the left wing tips represents the previous location.

Sample of the powdercoating color
for steel frame and aluminum forms

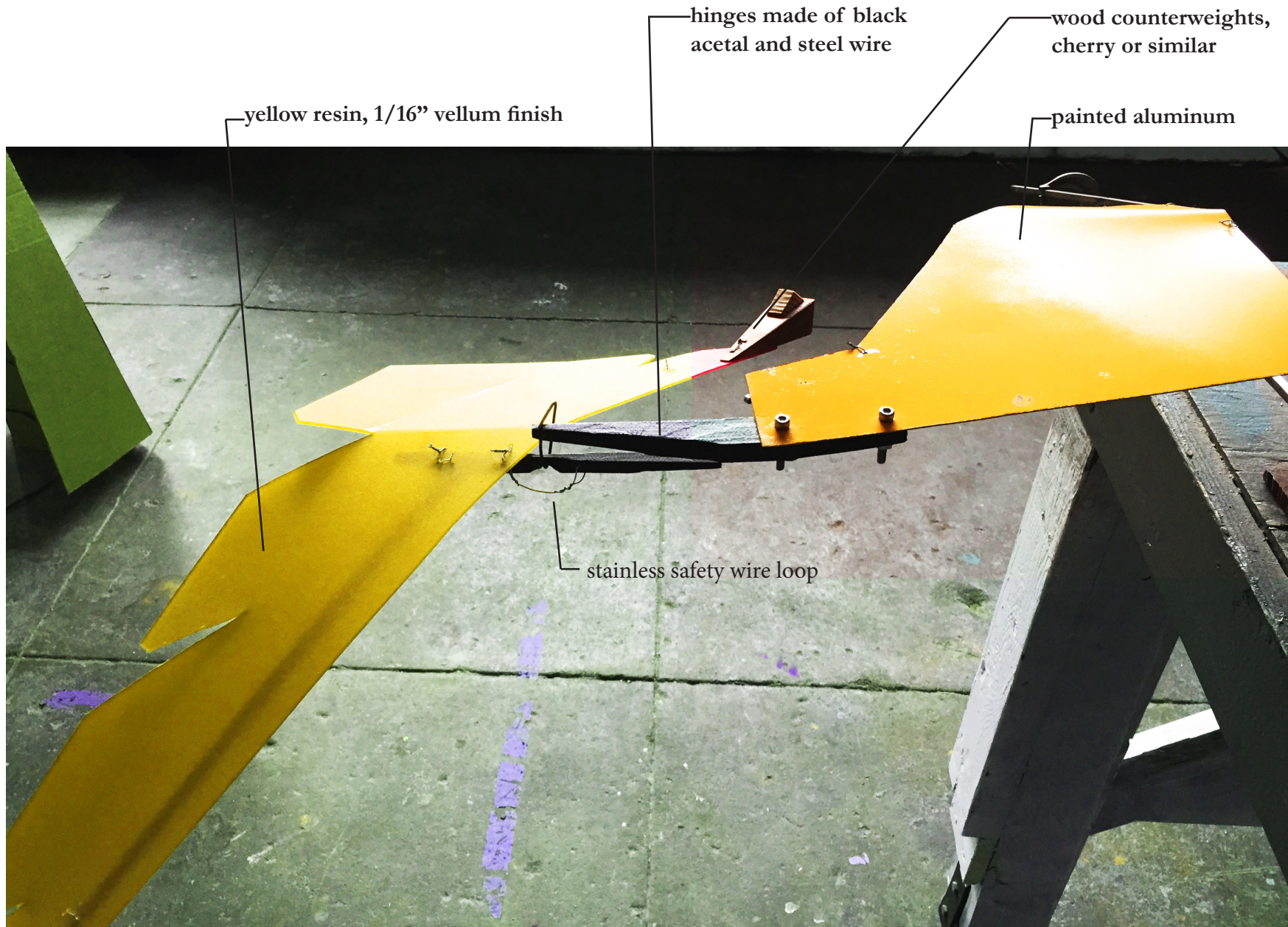


The feathers will be made from yellow
resin, with UV protective layer added at the
factory

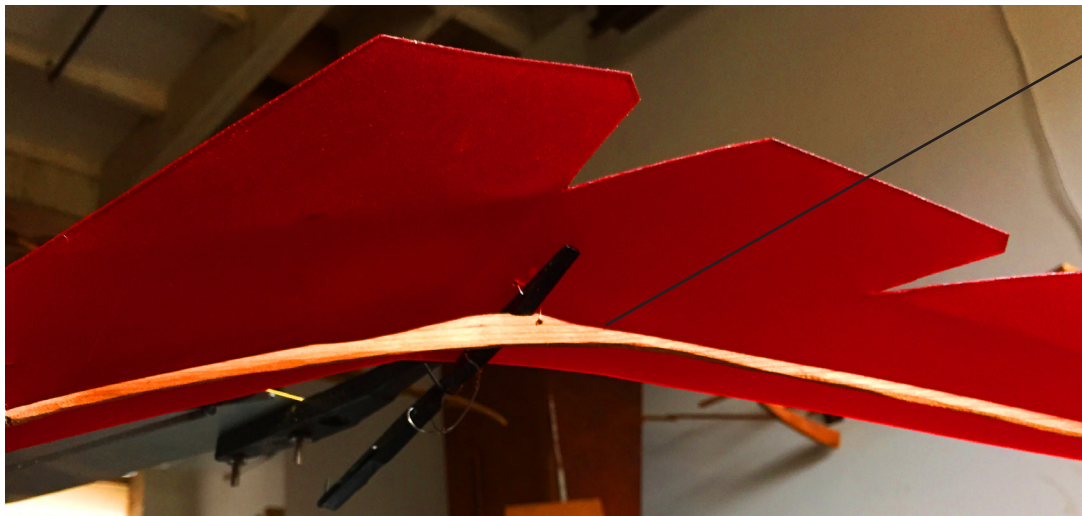
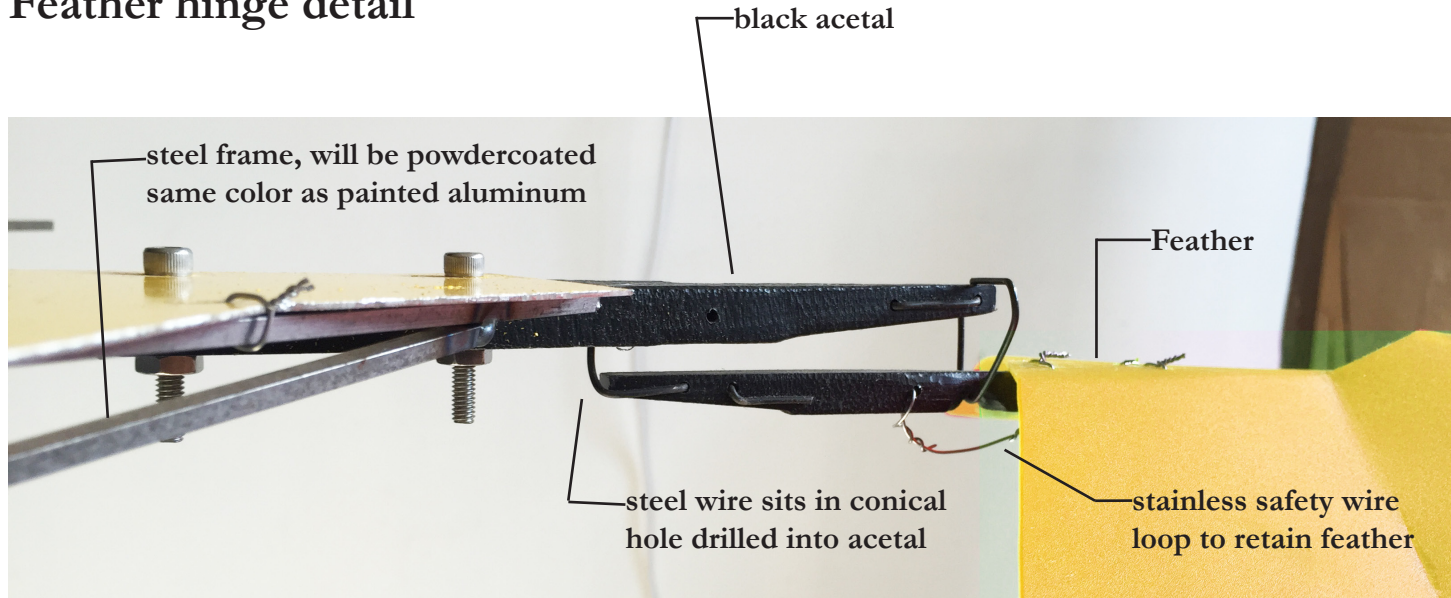


Prototype

This is a full scale prototype of the connection of the resin feather to the supporting section. The feathers will be made of 1/16" yellow resin, cut and bent into the faceted forms as shown below. Each feather will have a faceted wood counterweight, cherry or similar treated with Tung Oil. The black acetal, a high strength, low friction material will complement the bold color of the rest of mobile.

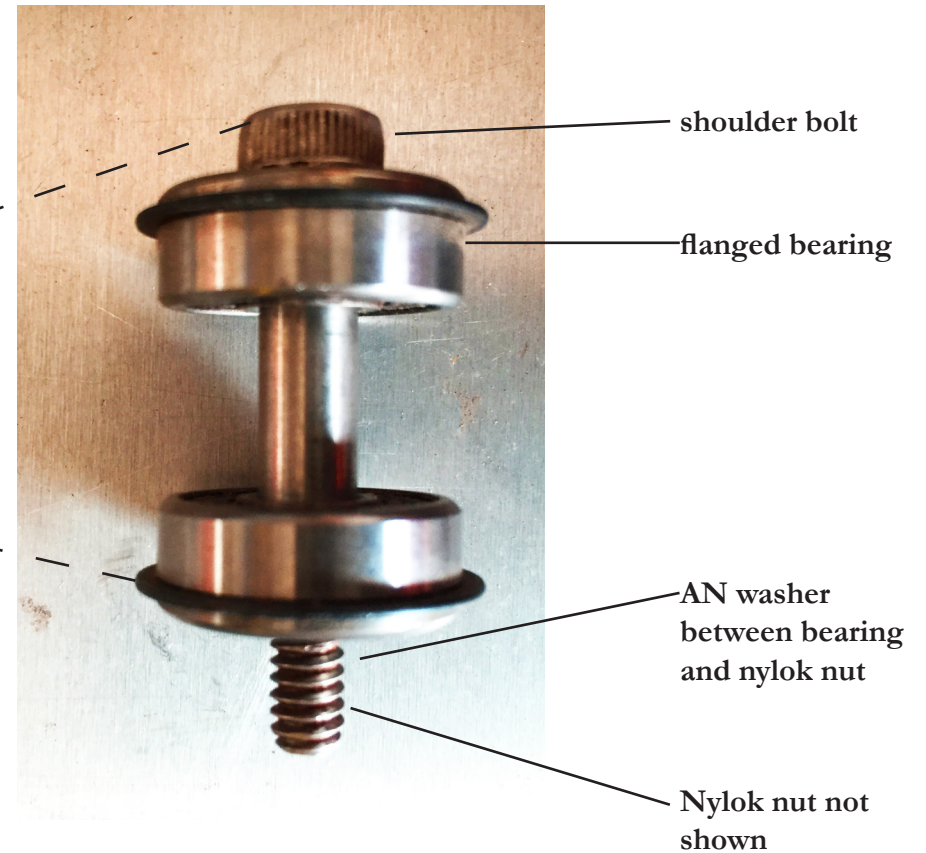
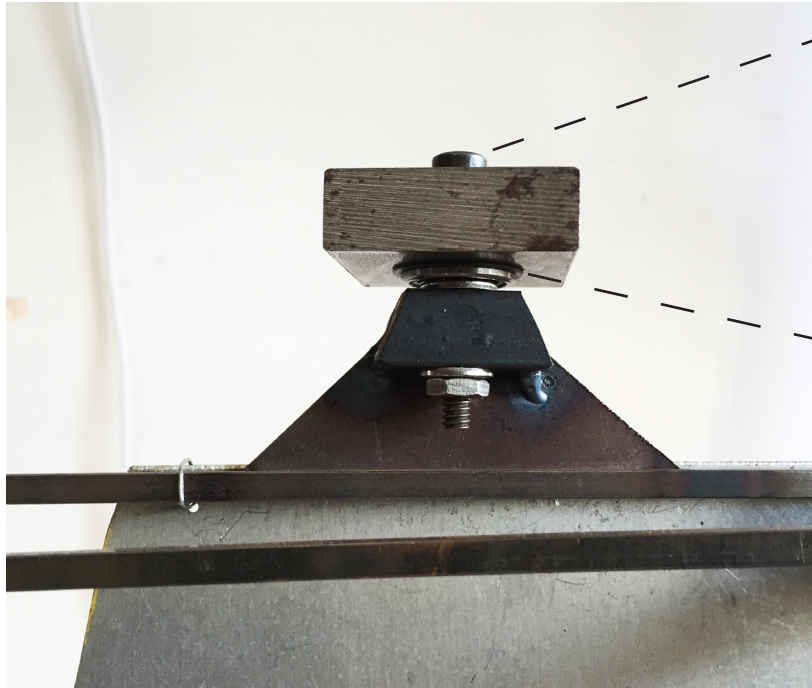


Feather hinge detail



Consistent with the added wood elements in the piece, I decided to stiffen the resin feathers with carved cherry wood strut wired to the resin.

Main hinge details



For hinges other than the feathers, all the other linkages in the sculpture, I will use a variation on this detail. A block of steel drilled out to accept flanged steel bearings sandwiched around it, a steel shoulder bolt, AN washers and a nylok nut. For the lightest hinges, I anticipate using 1/4" shoulder bolts and bearings, stepping up to 5/16" for the next hinges, and 3/8" for the hinges taking the greatest forces. All connections to be reviewed and approved by structural engineer.

Center wood piece

The central body of the bird will be carved cherry wood, with a simple Tung Oil finish. The piece below is the start of that center carved form.



“Bird in Flight” by Brancusi is the level of abstraction I will have in mind as I complete the central body piece.



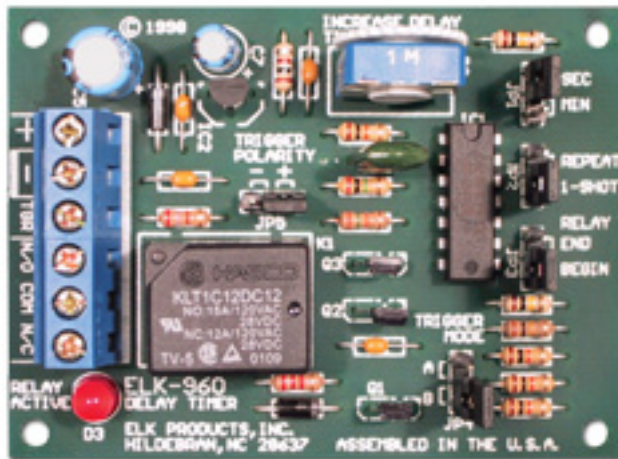
This is the central piece that will be carved wood, not painted as shown here.

Motion

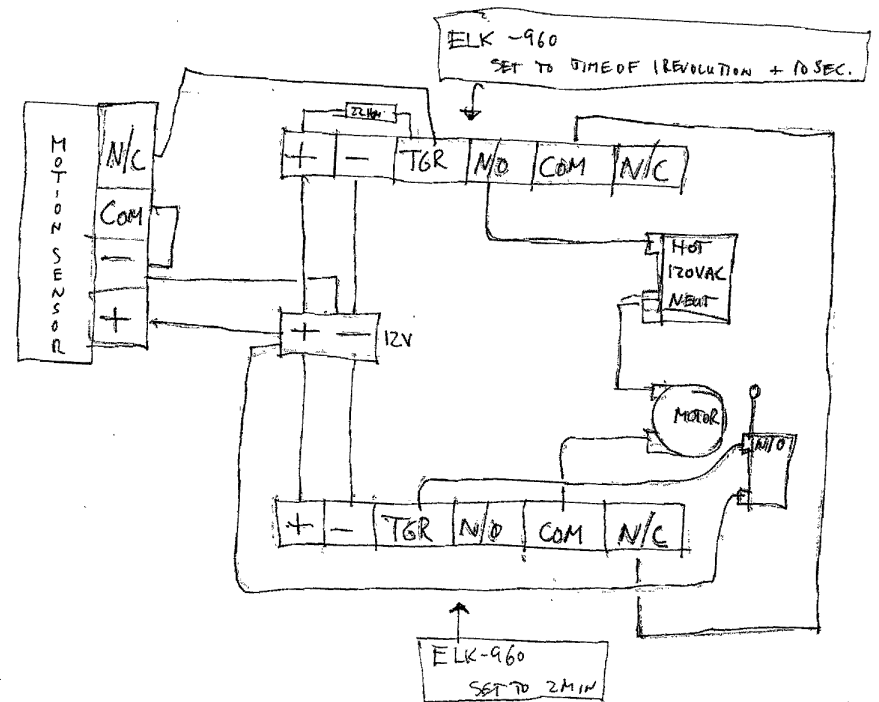


Visitors activate the sculpture by triggering a motion detector that will turn on a motor setting the wings in motion. The motor will be installed above the ceiling level so that it is out of view. A slot in the ceiling will allow a cable from the motor to pull up on the central body of the sculpture.

ELK - 960 Delay Timer



This is the delay timer. I will use two of these, one to have the motion detector trigger the motor, and a second to stop the motor after one full revolution with a 2 minute shutdown afterwards to allow the sculpture to come to rest.



Wiring diagram for motion sensor with timing circuits

Bodine Motor



I have picked this motor for its durability. While a smaller motor might function well enough and be significantly cheaper, this motor is built to last. It has the right speed and will be a quiet motor. I have used Bodine before and have had it recommended to me by staff at The Exploratorium.

34R-Z Series Parallel Shaft AC Gearmotor Model 0449

Standard Features

Totally enclosed IP-20 rating.

Fan cooled for high output power.

Class “B” insulation system operated within Class “A” limits to prolong winding and lubricant life.

Aluminum center ring and end shields for high thermal efficiency and light weight.

Unvented gearhousing.

Industrial lip type seals on motor and output shafts.

Needle bearings throughout for increased radial load capacity and long life.

Permanently lubricated gearing utilizing semi-fluid grease for long life.

Wide reinforced thermoplastic helical primary gear for quietness and hardened steel spur gearing on subsequent stages for high output torque and long life.

Helical pinion accurately cut on motor shaft for maximum strength and minimum noise.

(0449) 1/15 Hp, 9.4 Rpm, 180:1,
100 Lb-in.,34R4BFCI-Z4,115
Vac.

Specifications Model Number
0449 Category Permanent Split
Capacitor, High Slip, Non-
Synchronous Speed (rpm) 9.4
Rated Torque (lb-in) 100 Motor
HP 1/15 Volts 115 Hz 60 Phases
1 Amps 1 Gear Ratio 180
Radial Load (lbs) 125 Length
XH (inch) 8.54 Weight (lbs)
9.3 Connection Diagram 074
10296 Capacitor Part Number
49401054 Required equipment.
Model 0449 will not work
properly without a capacitor.
Product Type 34R4BFCI-Z4



San Francisco

CONSULTING STRUCTURAL ENGINEERS



STRUCTURAL NARRATIVE
FOR RANDALL MUSEUM INSTALL
BY BEN TRAUTMAN
SAN FRANCISCO, CA
APRIL 8, 2016
JOB No. 15229.10





April 8, 2016

15229.10

Ben Trautman
Trautman and Associates, Inc
874 41st Street
Oakland, CA, 94608

San Francisco

Telephone

RANDALL MUSEUM INSTALLATION – BEN TRAUTMAN

415 693 1600

Dear Ben,

Facsimile

At your request, we have examined the structural issues related to your Bird Sculpture planned for installation at the Randall Museum in San Francisco, CA. Please see below for a summary of our review and recommendations.

415 693 1760

Scope of Review

Internet Address

Our review has been limited to the following scope:

www.holmesculley.com

- Determine the gravity, wind, and seismic demands on the installation at its proposed location based on the 2013 San Francisco Building Code.
- Validate the proposed sculpture members and connections' structural capacity based on above demands.
- Make recommendations for modifications if necessary to sculpture members or connections
- Design connection of sculpture to existing steel roof framing

130 Sutter Street

Suite 400

San Francisco

Structural Criteria

CA 94104

Seismic Design Criteria (2013 San Francisco Building Code)

USA

$S_s = 1.501g$

$S_1 = 0.656g$

$S_{ds} = 1.000g$

$S_{d1} = .656 g$

Offices in

New Zealand

Australia

$A_p = 2.5$ (Appendages/Ornamentations, Arch Components, ASCE 7-10 Table 13.5-1)

$R_p = 2.5$ (Appendages/Ornamentations, Arch Components, ASCE 7-10 Table 13.5-1)

$h_x/hr = 1.0$

$I = 1.0$

$C_s = 1.2 \times W$

$C_s \sim 180\#$

Wind Design Criteria (2013 San Francisco Building Code)

Interior installation, so no Wind Loads per Chapter 26

Designed to minimum 5psf pressure for Chapter 1.4 General Structural Integrity standards

Structure Description

This is a permanent installation and will be designed to meet the structural criteria of the 2013 San Francisco Building Code (SFBC).

The proposed Bird Sculpture installation has approximately 20 ft wingspan by 8 ft wide and 3 ft tall. It weight approximately 150 pounds including the counterweights and will be hung by two cables from unistrut that spans between the existing wide-flange steel beams above. The piece consists of cantilevered aluminum and resin “feathers” supported on 1/8” solid steel bars and balanced by counterweights. Each feather contains a safety wire loop to prevent the piece from unseating. The “body” of the sculpture is a solid carved piece of wood that weighs approximately 30 pounds. The piece contains an active kinetic system with one motor that actuates the central wood piece 2” to 3” up and down (total range of motion is 4” to 6”). The sculpture is supported from two 1/8” steel cables at hinge points located close to the central body. These cables are swaged to an eyelet that is coupled to a threaded rod hung from the unistrut supported by the existing wide-flange beams. The unistrut is connected to the bottom flange of the existing wide-flange beams with a unistrut beam clamp. The unistrut is also used to support the 10 pound motor.

Refer to Appendix A for drawings used as the basis of our design and structural sketches.

Design Assumptions

Our recommendations are based on the following assumptions:

- The sculpture is not intended to support live loads and no person will be permitted to hang on the structure. The Artist will develop a climbing deterrence program in conjunction with the Randall Museum.
- Holmes Culley is not responsible for the design of the existing supporting steel roof framing. A licensed professional engineer should be procured by the Randall Museum to validate the existing structure’s ability to support the sculpture based on the loading criteria described in this report.



- This is a permanent installation and will not become a traveling display. Please note that any future installation's site conditions will require re-evaluation by an engineer licensed in the local jurisdiction.

Conclusions

Based on the above criteria and assumptions, we have concluded that the sculpture and its anchorage outlined in Appendix A meets the life-safety structural design intent of the San Francisco Building Code.

We recommend that the sculpture maintain a 3'-0" clearance from the surrounding walls/partitions to allow for the anticipated sway during a design-level seismic event (10% chance in 50 years). However, even should the seismic motions exceed the calculated values, the feathers that impact the adjacent partitions would simply unseat and should not represent a life-safety hazard.

We appreciate the opportunity to be of service. Please contact us if have any questions or require additional information. Thank you.

Sincerely,

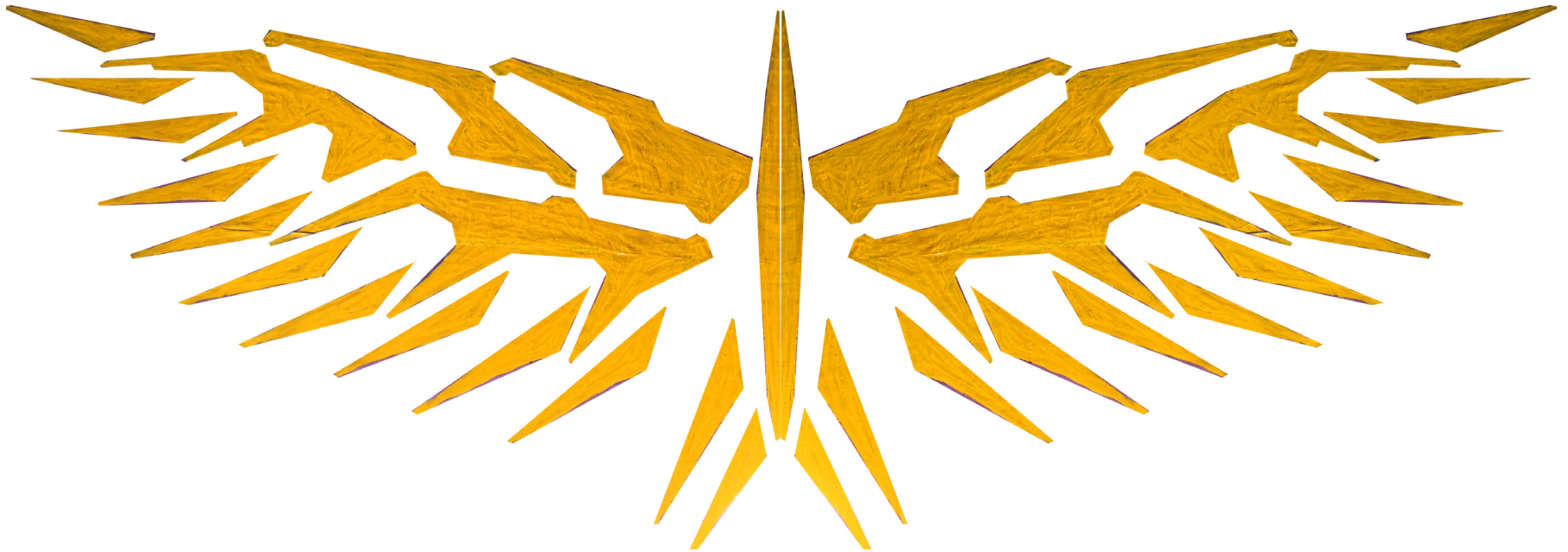
A handwritten signature in blue ink, appearing to read "Erik Kneer", with a stylized flourish at the end.

Erik Kneer, SE, LEED AP BD+C
ASSOCIATE PRINCIPAL

APPENDIX A: BASIS OF DESIGN AND STRUCTURAL SKETCHES

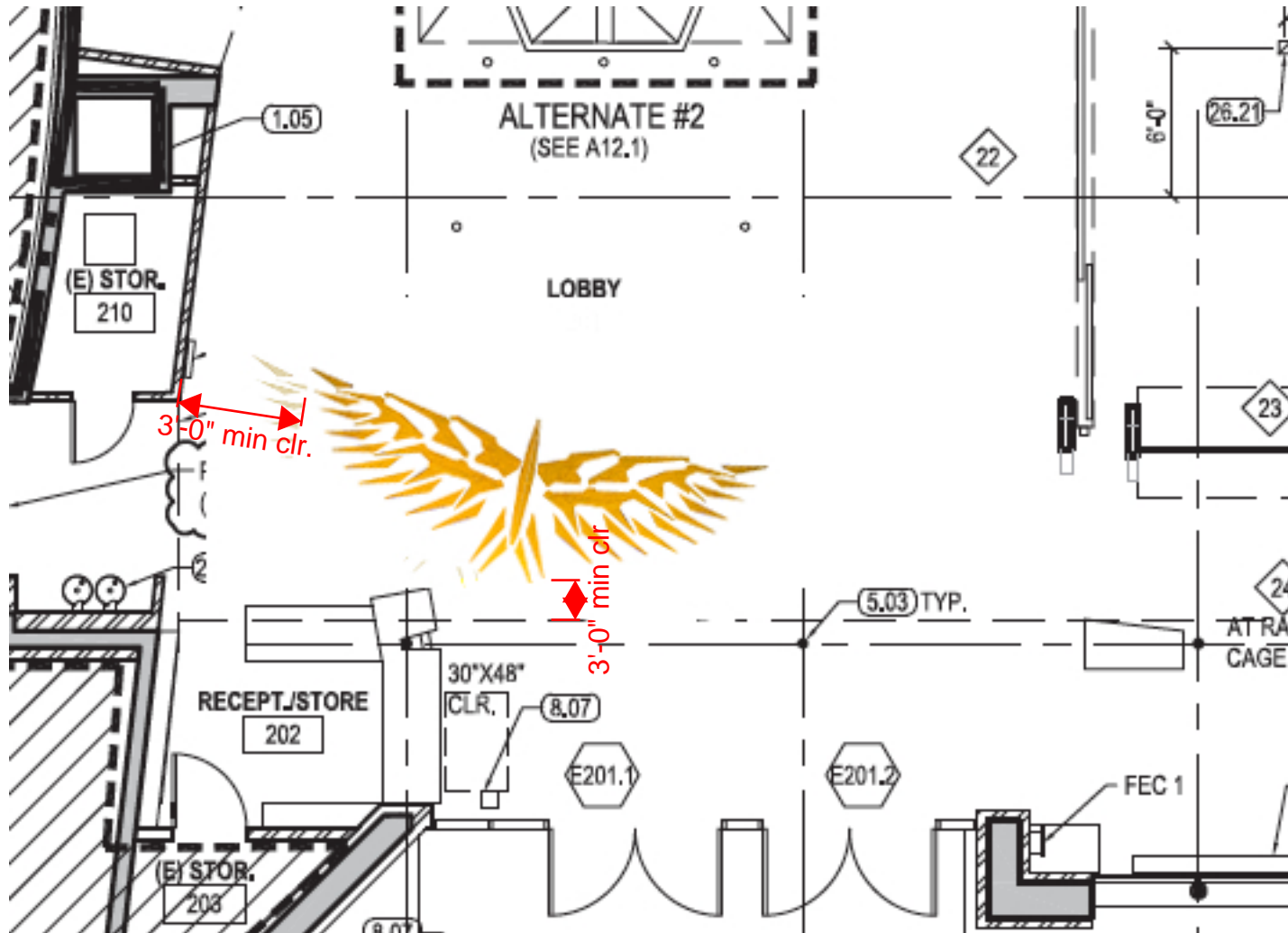
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Drawing placed in Lobby plan

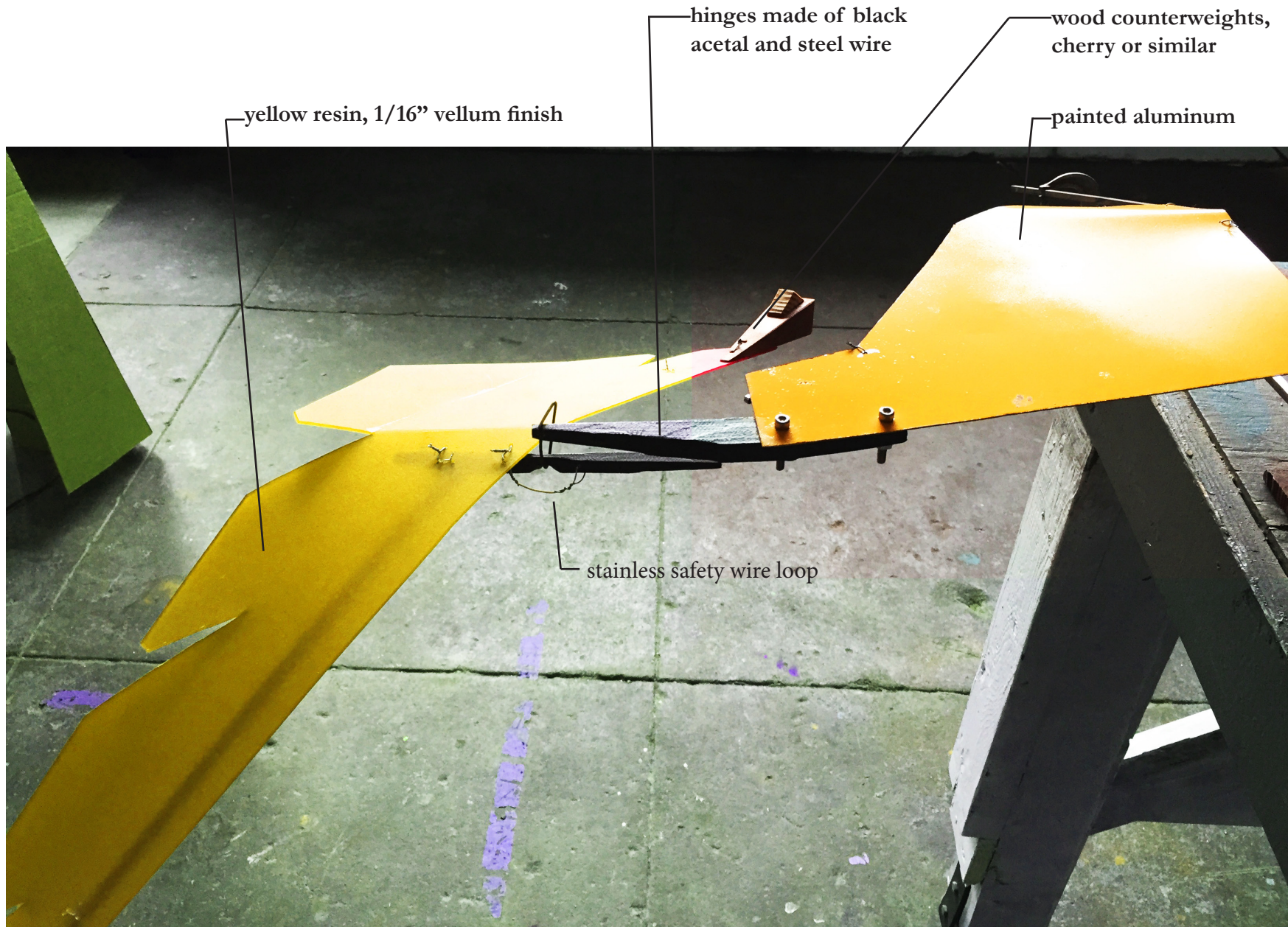
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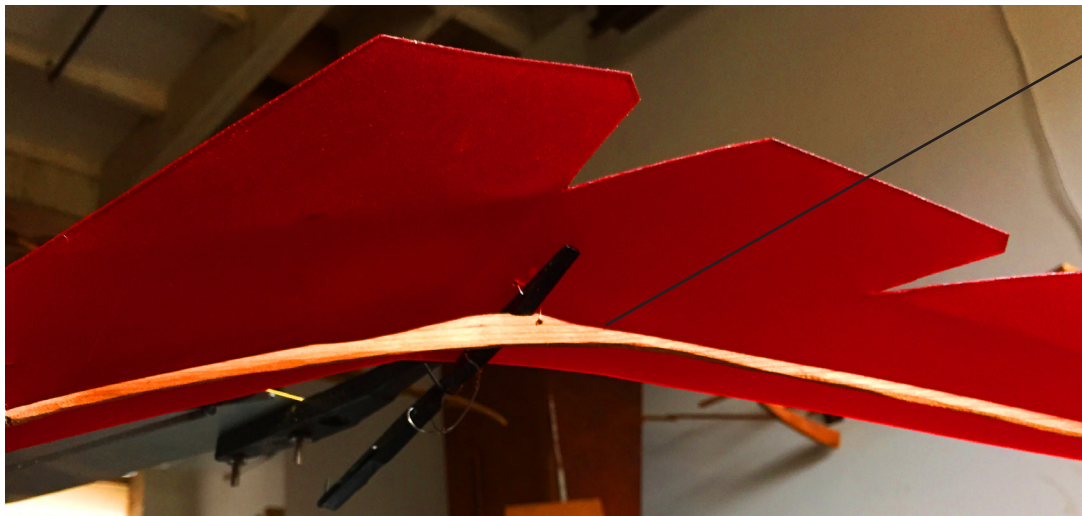
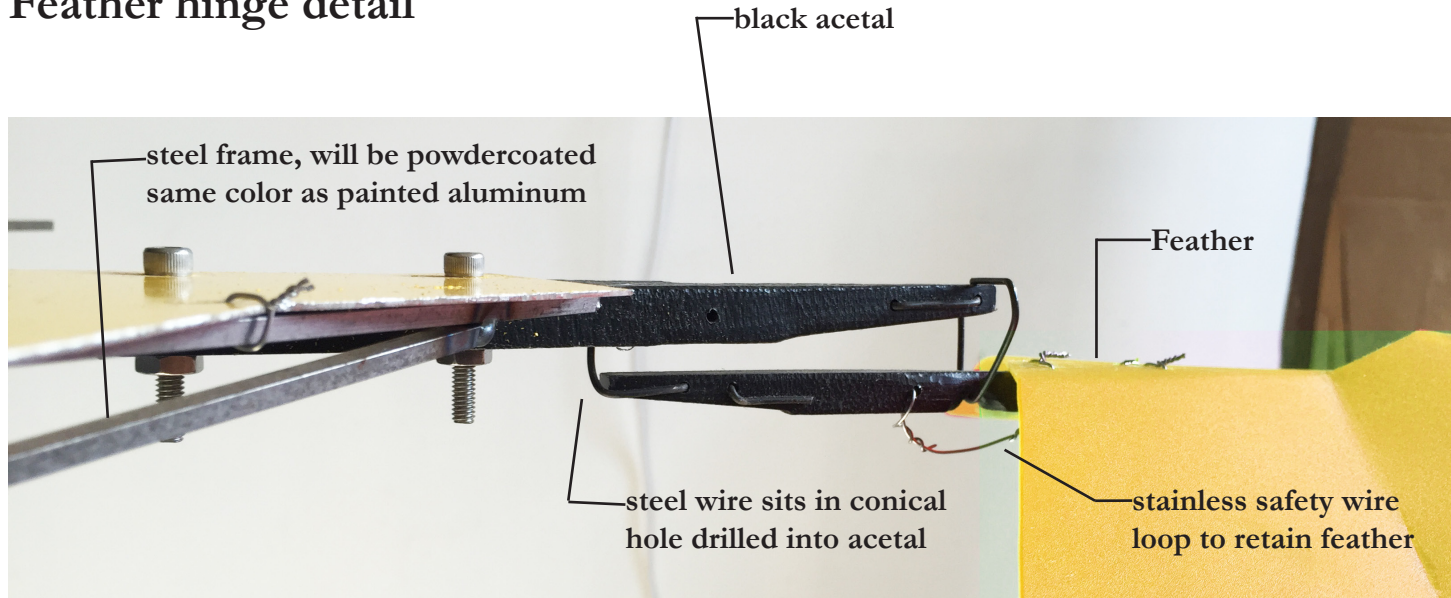
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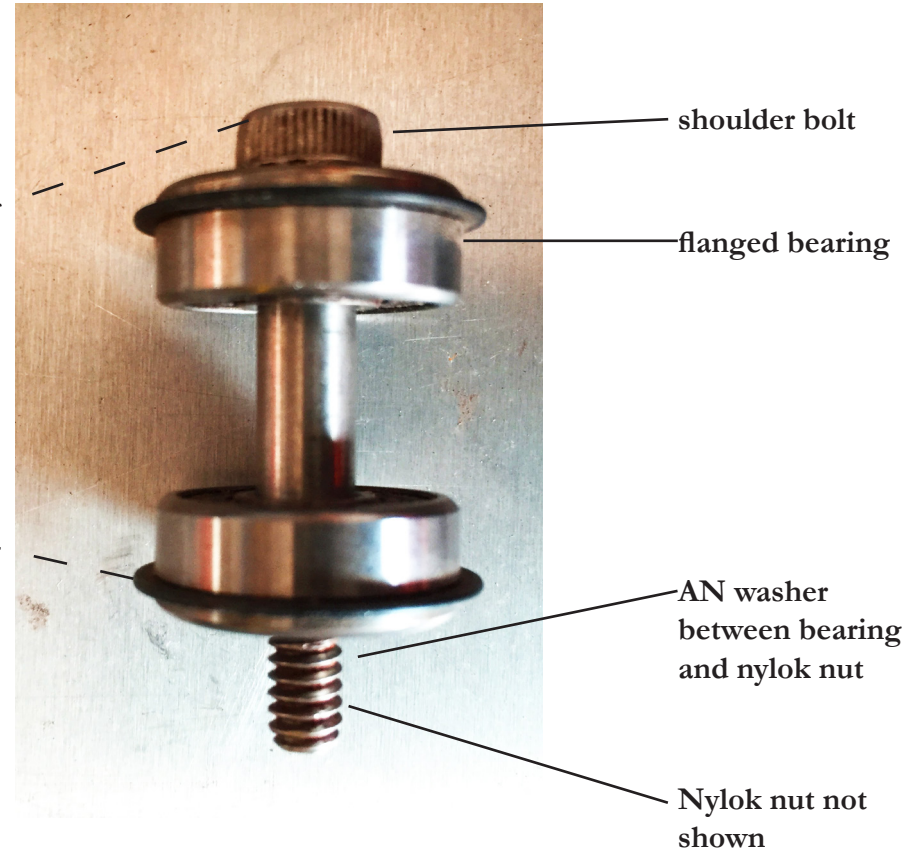
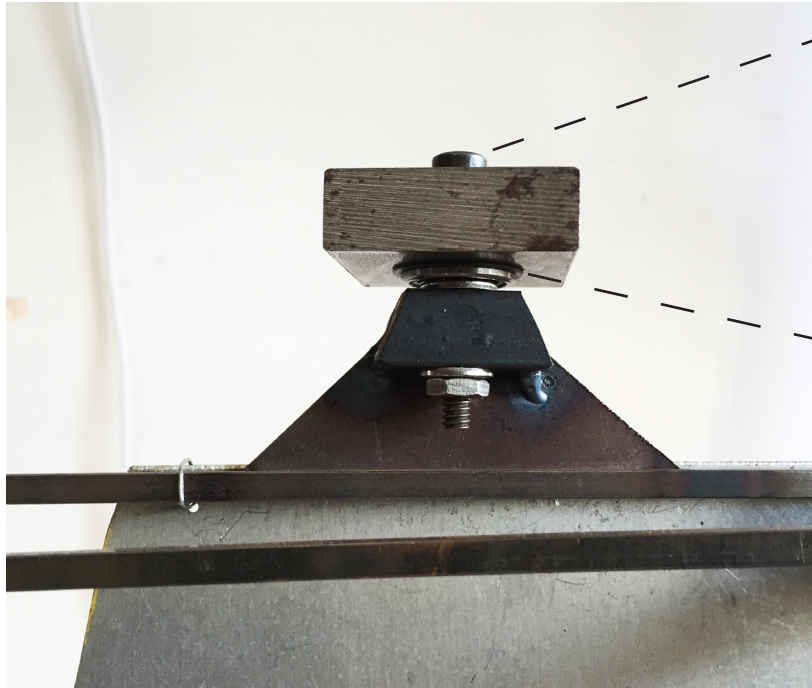


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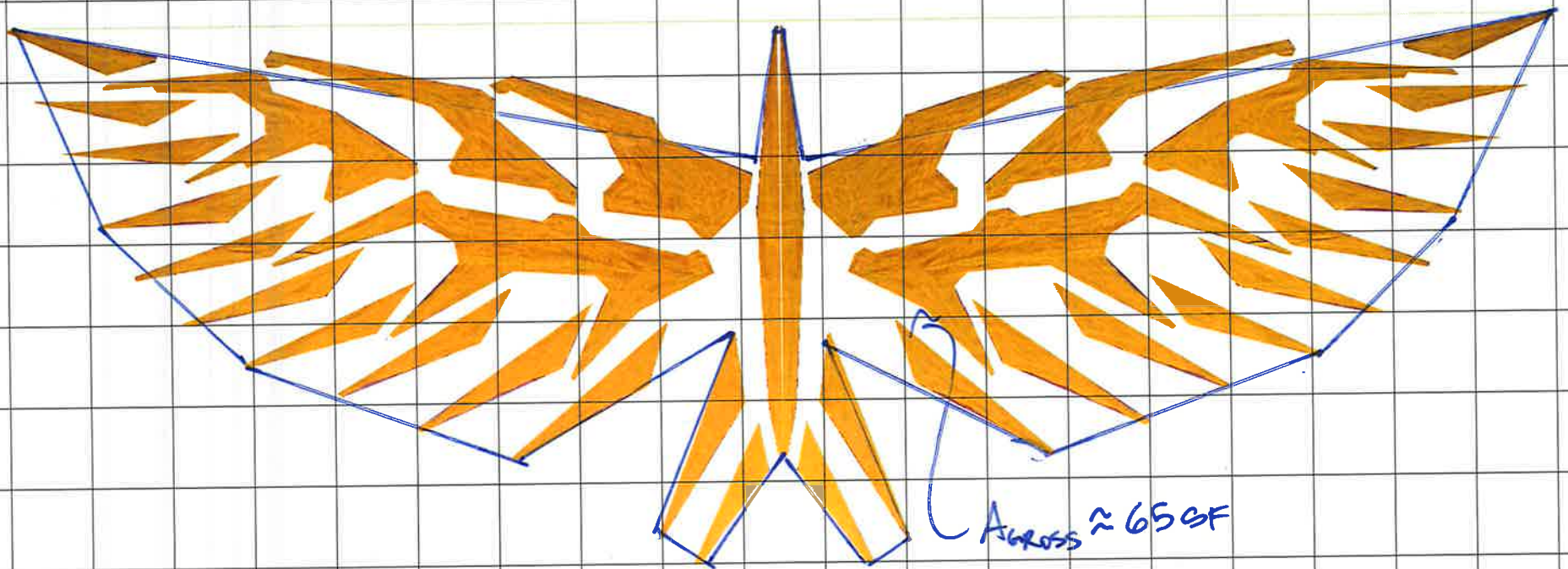
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9.3 Connection Diagram 074
10296 Capacitor Part Number
49401054 Required equipment.
Model 0449 will not work
properly without a capacitor.
Product Type 34R4BFCI-Z4

Scale: Grid is 1' x 1'



$$A_{\text{gross}} \approx 65 \text{ SF}$$

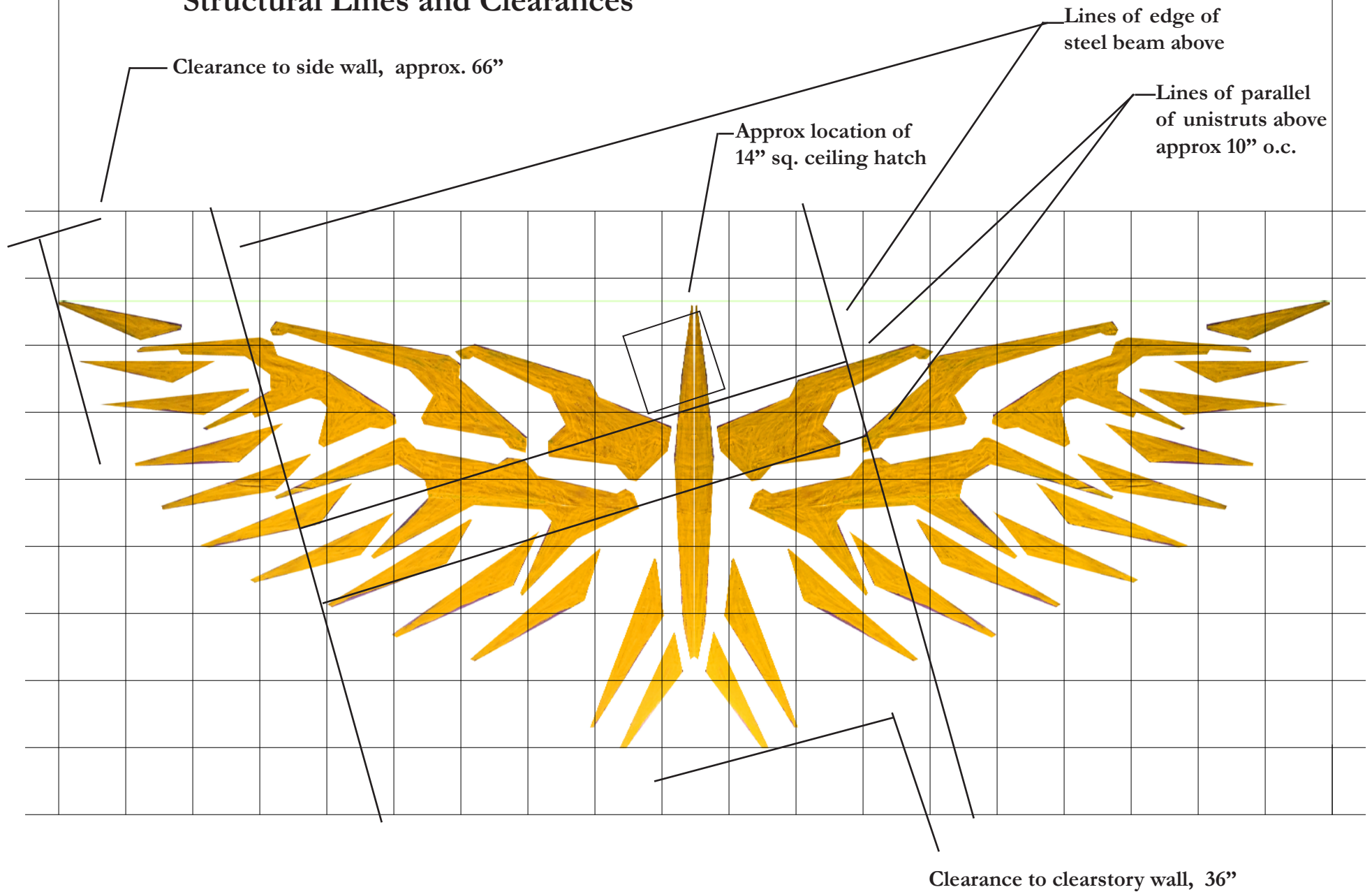
$$A_{\text{net}} \approx 40\% \times 65 \text{ SF} = 26 \text{ SF}$$

$$F_{\text{int, wind}} = 5 \text{ psf} \times 26 \text{ psf} = 130 \#$$

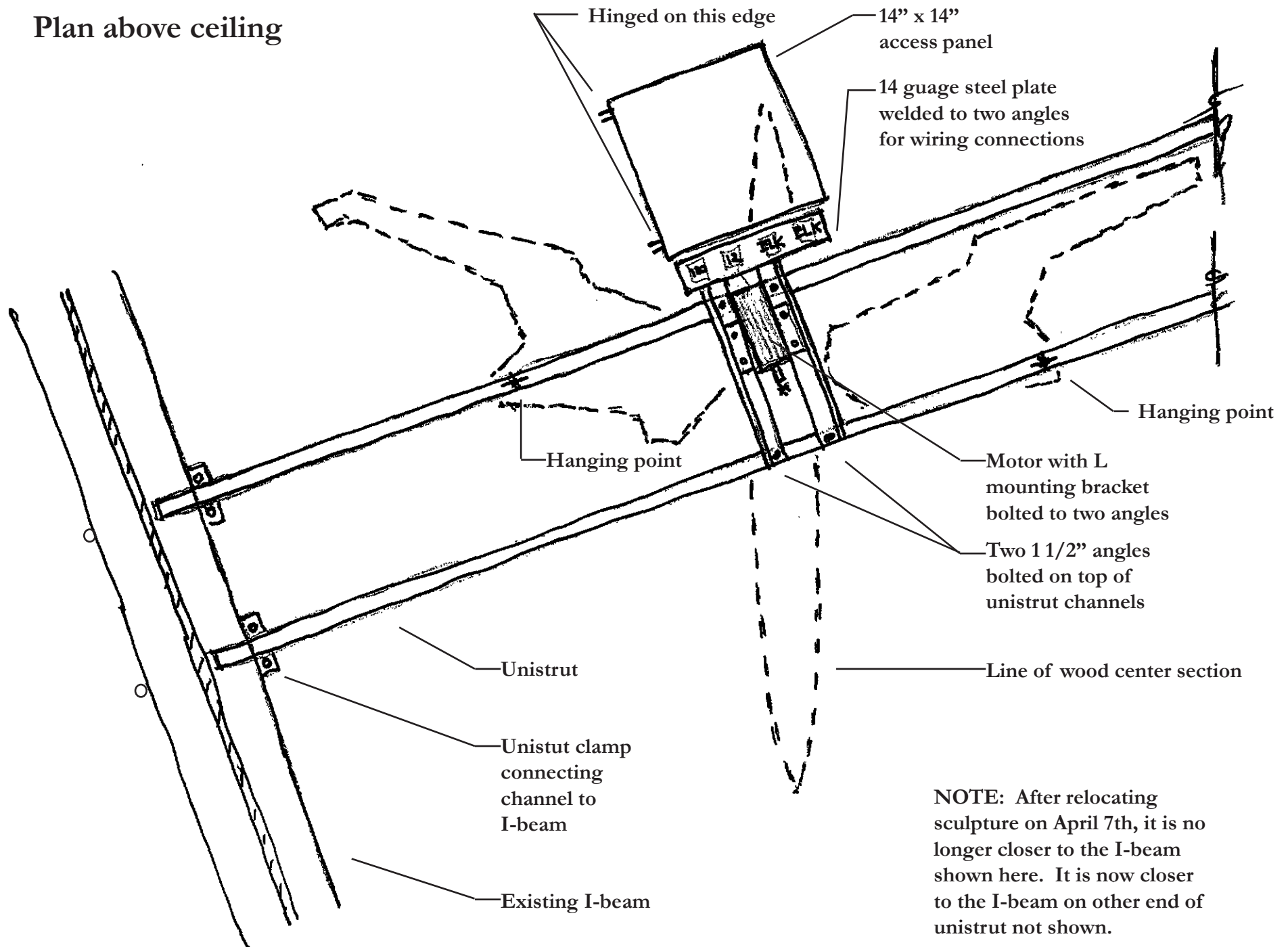
$$F_{\text{ex}} = 1.25 \times W = 1.2 \times 150 \# = 180 \#$$

\therefore SEISMIC GOVERNS

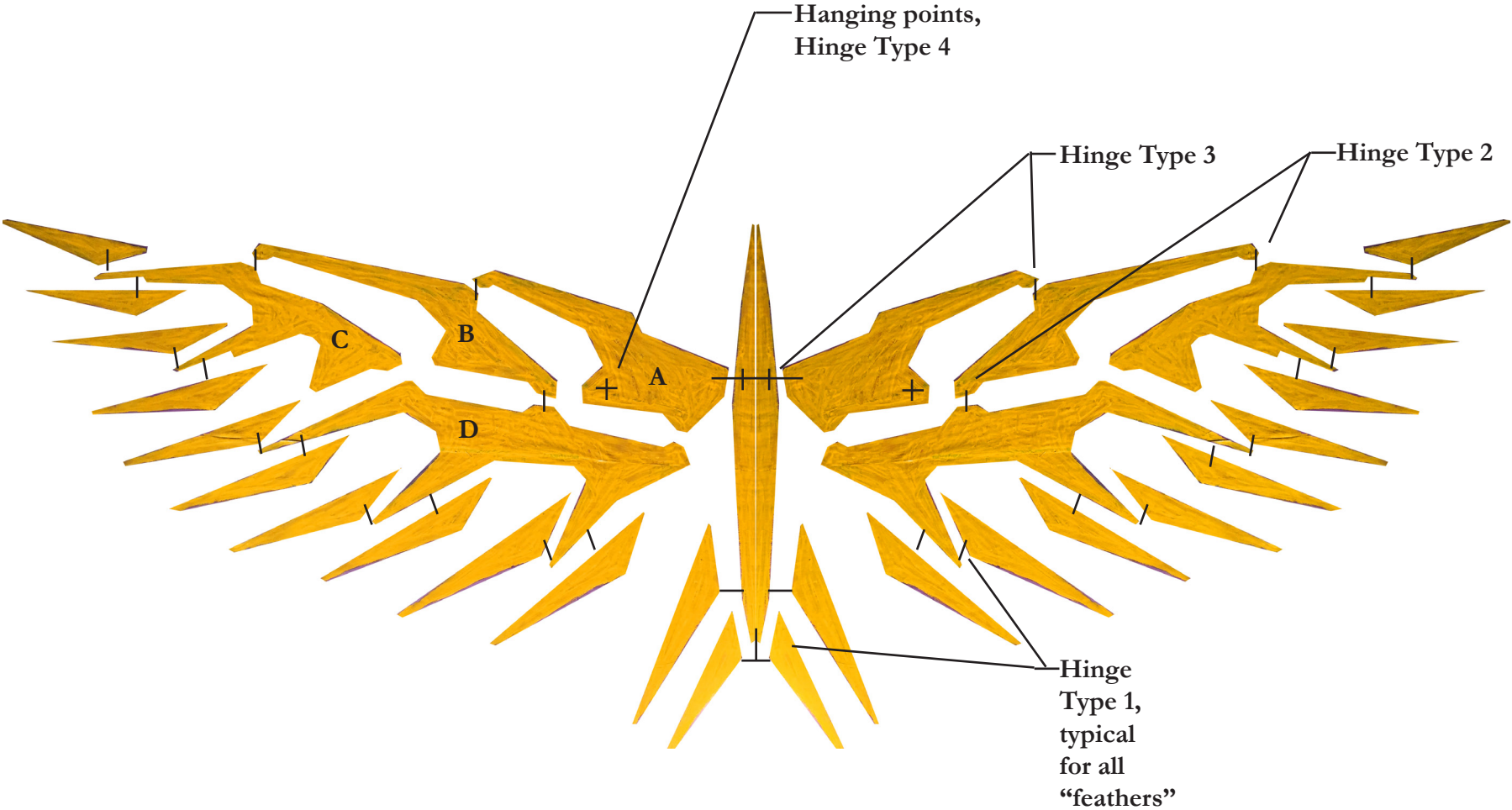
Structural Lines and Clearances



Plan above ceiling

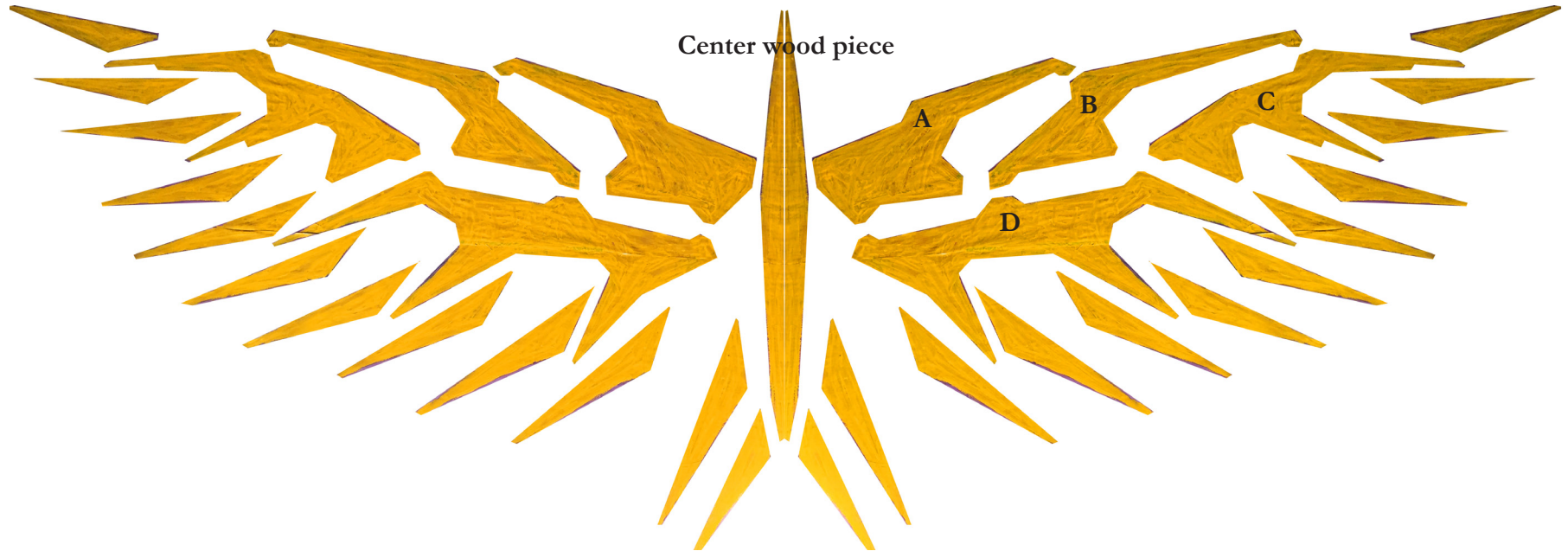


Hinge Layout and Types



Estimated Weights

Part C is the most accurate weight, since I have built one part. All the other weights are inflated estimates to allow for changes to occur for counterweighting.



Center wood piece, 30lbs This is allowing for 25 lbs of added ballast and steel hinging

Part A 25 lbs

Part B 15 lbs

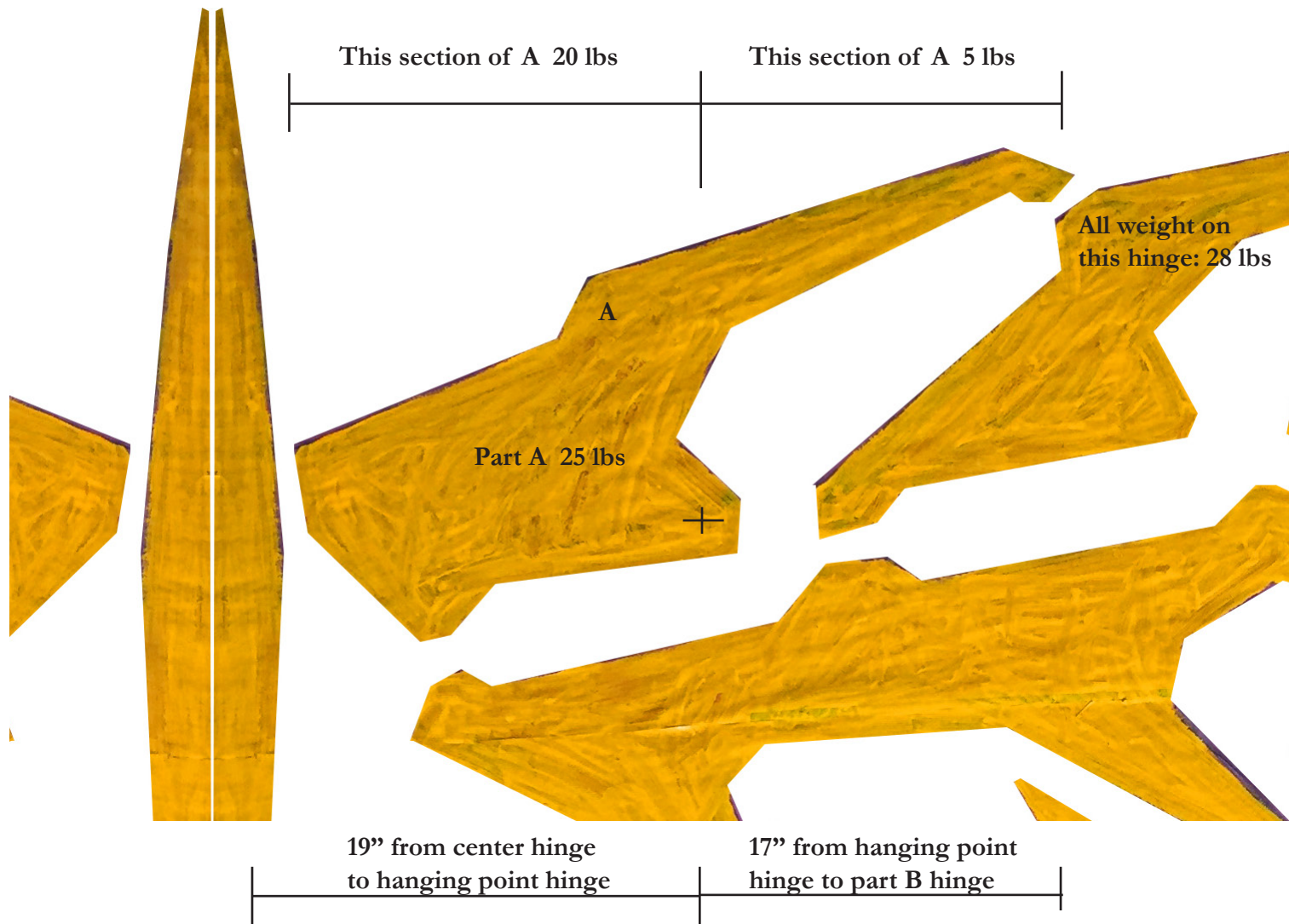
Part C 3.5 lbs, or 4.5 lbs with 4 feathers

Part D 7 lbs, or 8.5 lbs with 6 feathers

All feathers, including
acetal hinges, 4 ounces
each

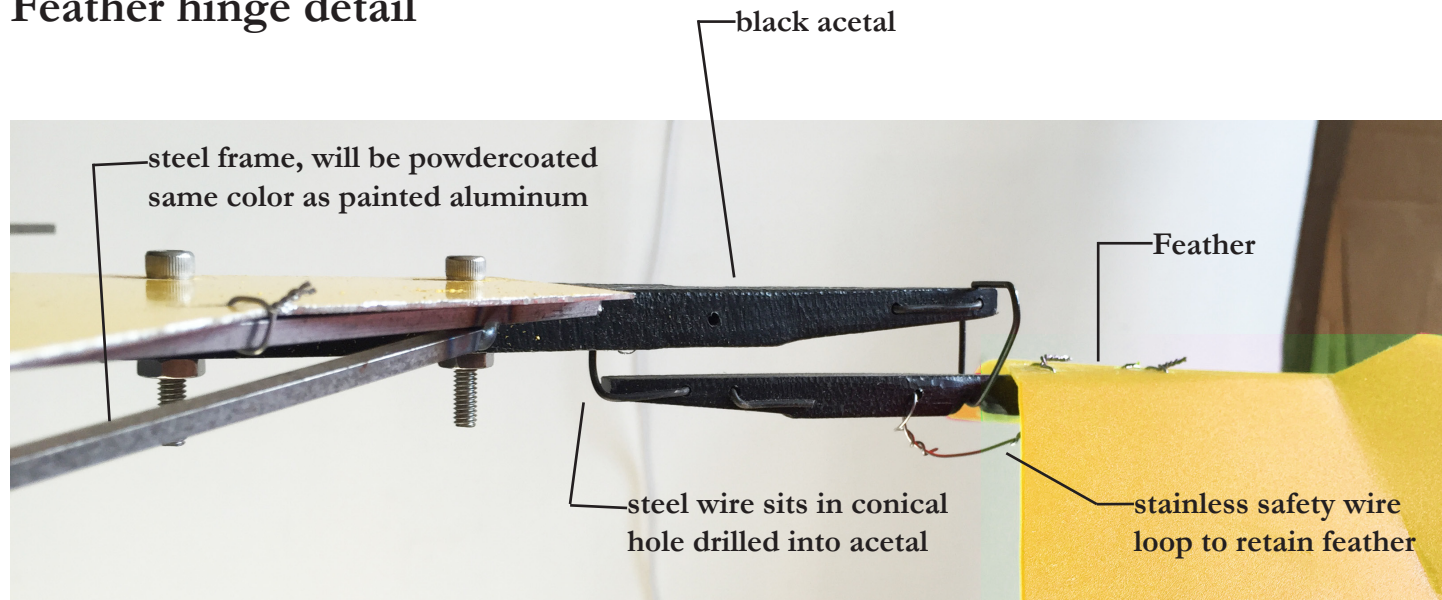
Estimated total weight:
136 lbs., so 150lbs.

Weight distribution around Part A

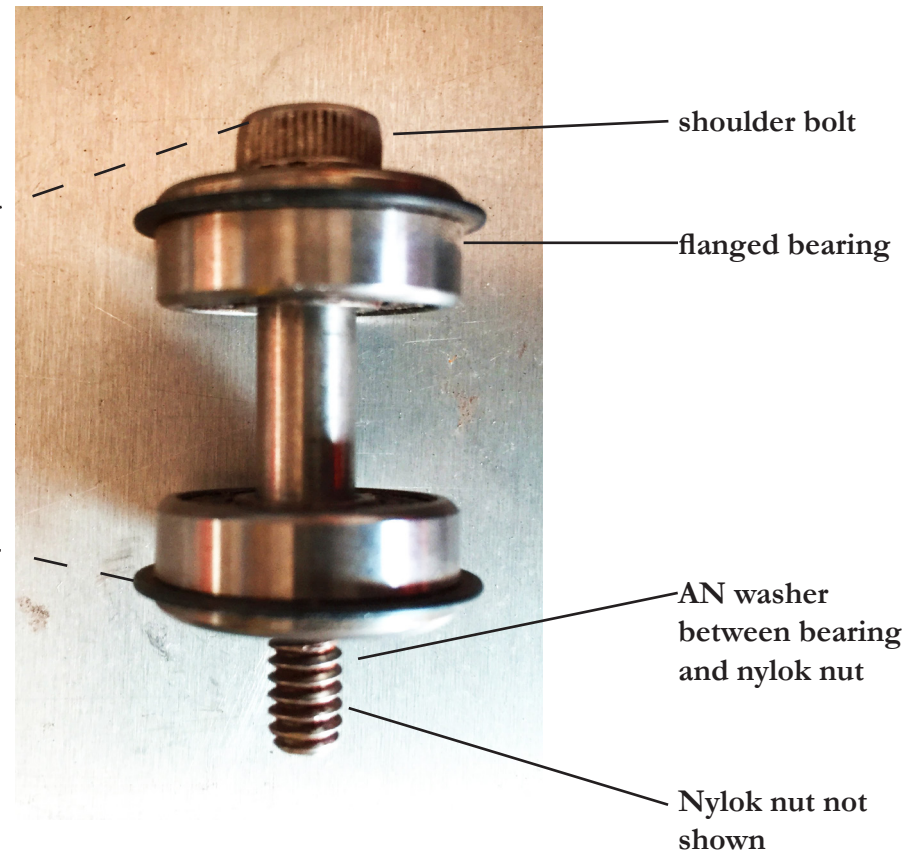
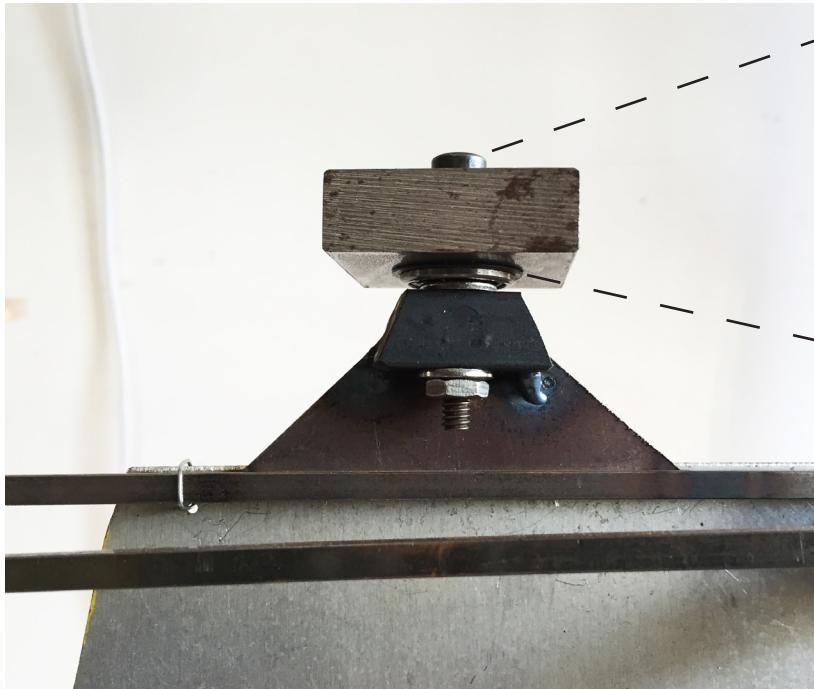


Hinge Type 1

Feather hinge detail

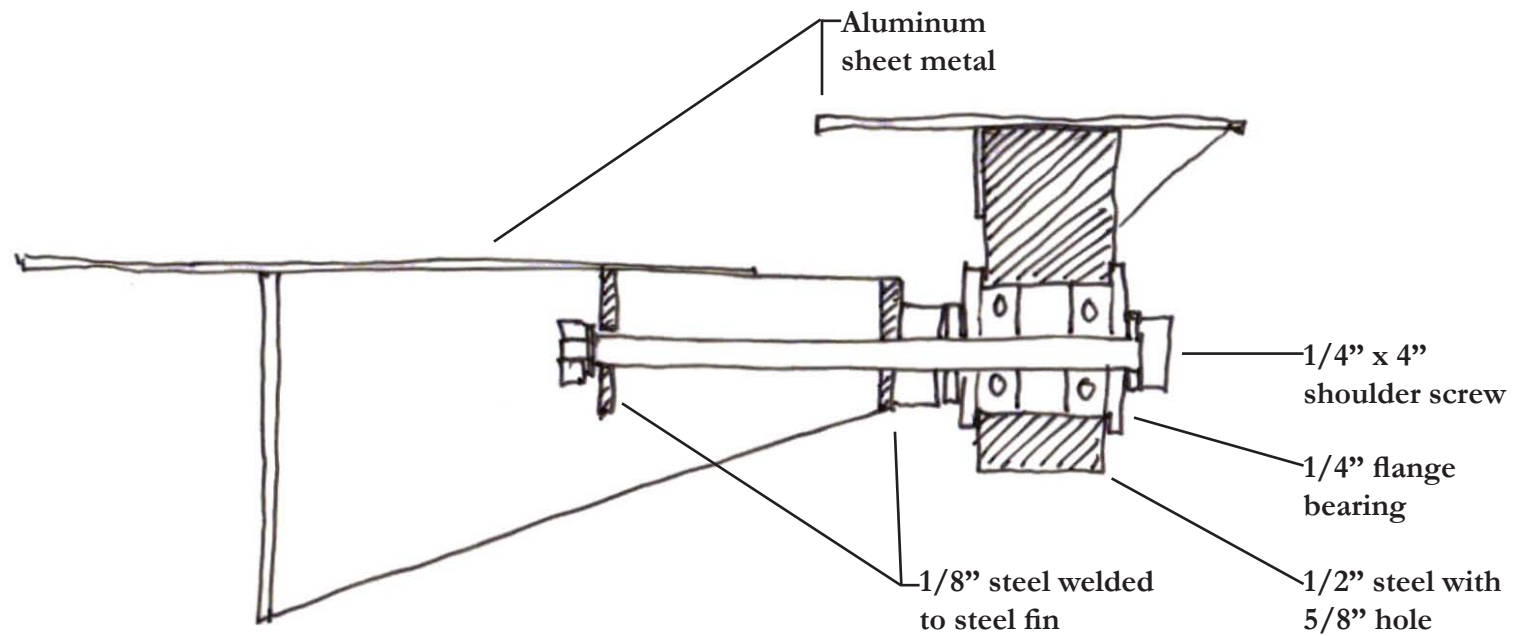


Main hinge detail, Types 2-4



Excluding the hinges for the feathers, all the other linkages in the sculpture will use a variation on this detail. A block of steel drilled out to accept flanged steel bearings sandwiched around it, a steel shoulder bolt, AN washers and a nylok nut. For the lightest hinges, Type 2, will use 1/4" shoulder bolts and bearings, stepping up to 3/8" for the rest of the hinges.

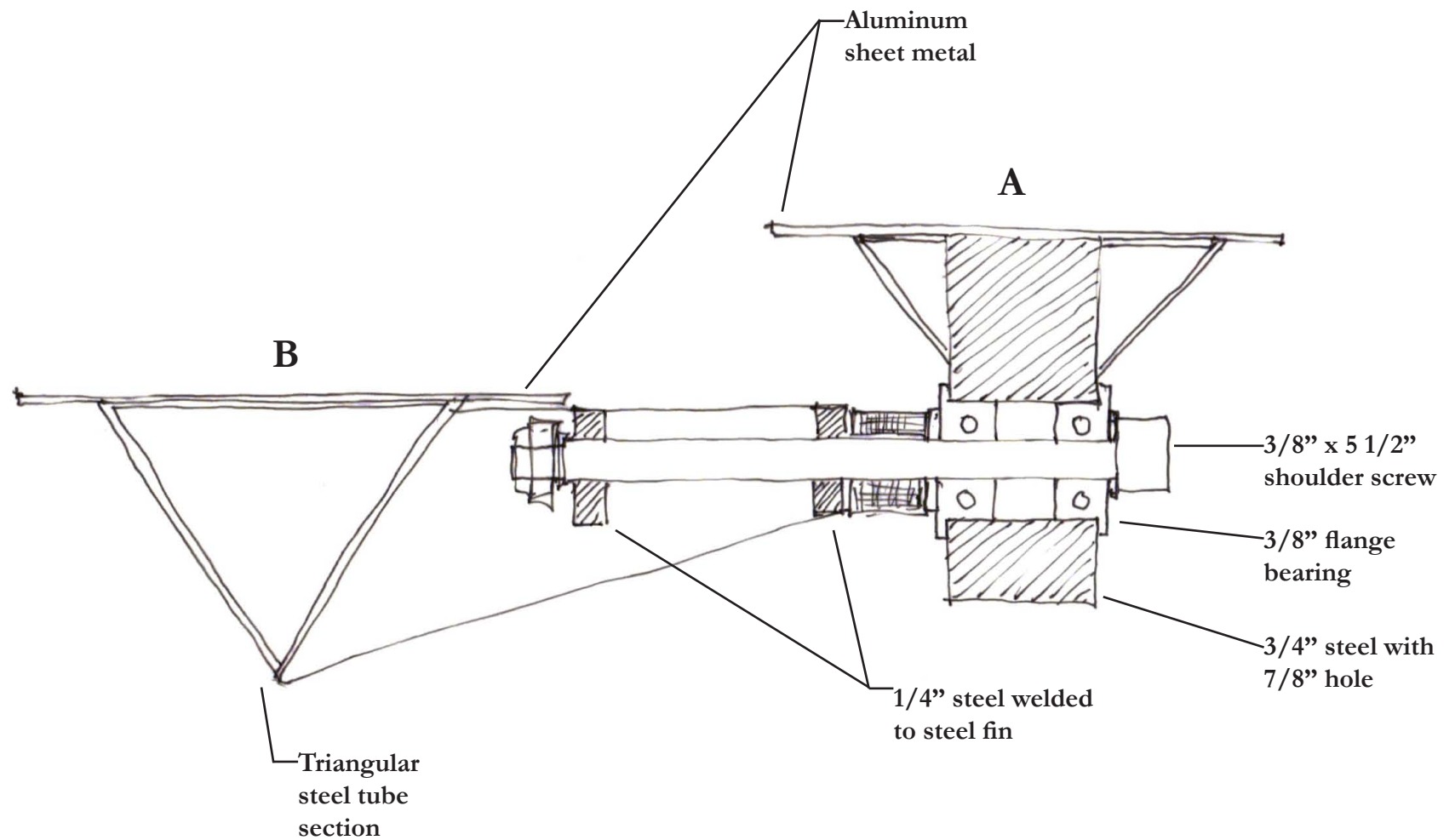
Type 2 Hinge, sketch detail, not to scale



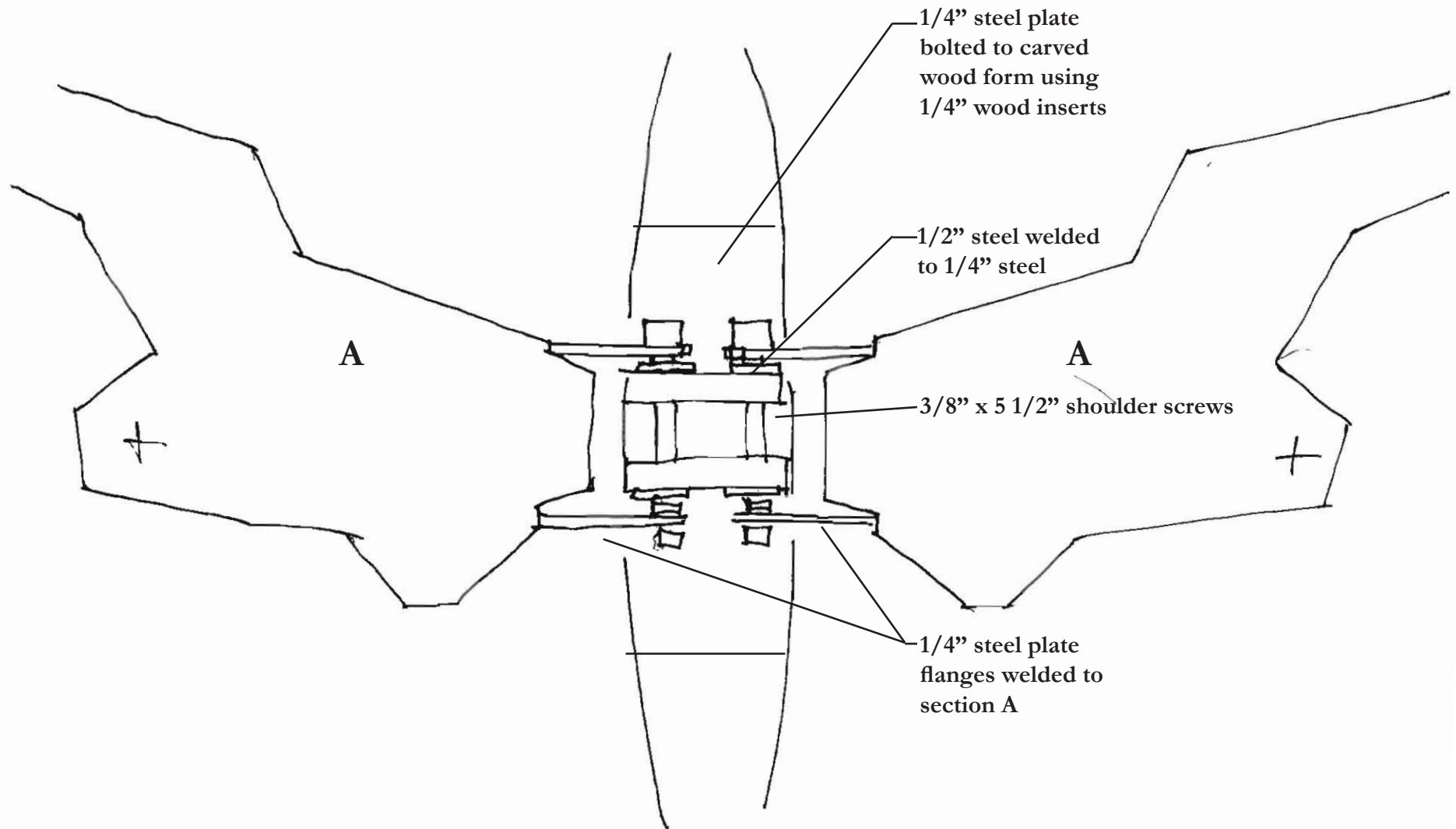
This section represents the lighter-weight pieces that hold the feathers, C and D shown in Hinge Layout

This is section B shown in Hinge Layout, holding sections C and D

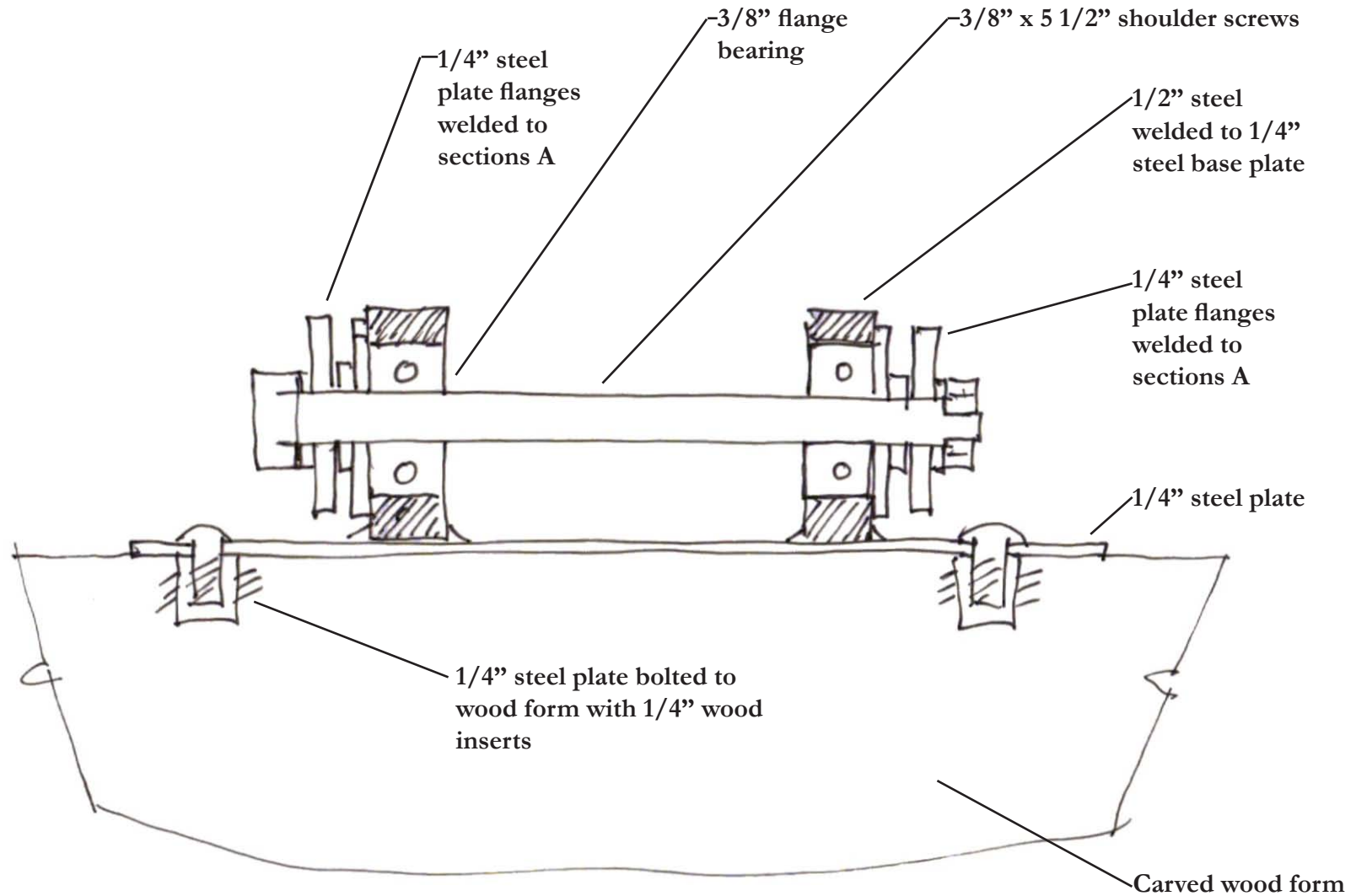
Type 3 Hinge, sketch detail, not to scale



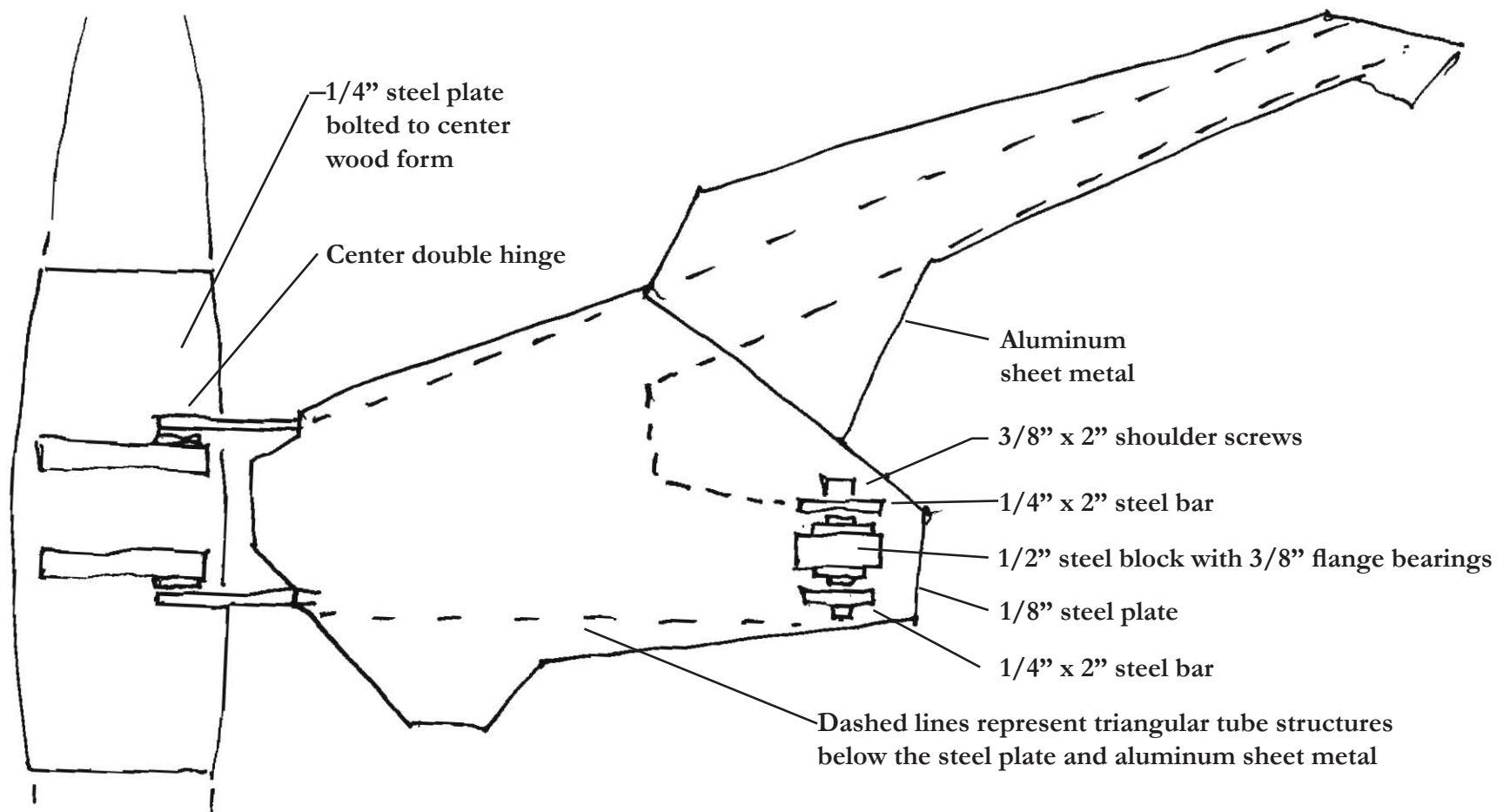
Double hinge at center section, sketch detail, not to scale

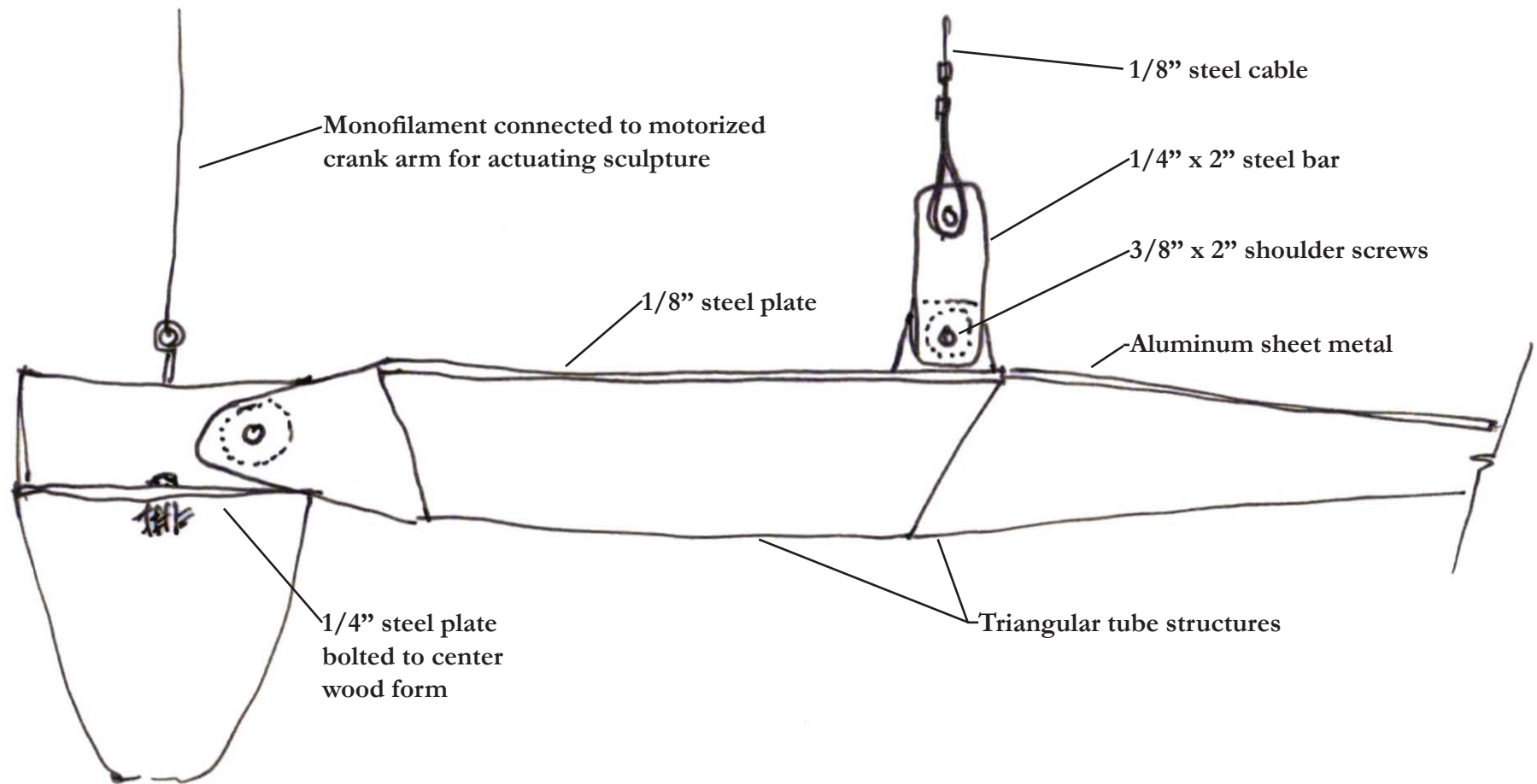


Double hinge at center section, sketch detail, not to scale

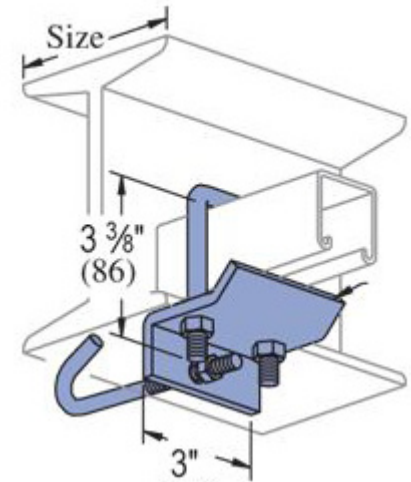
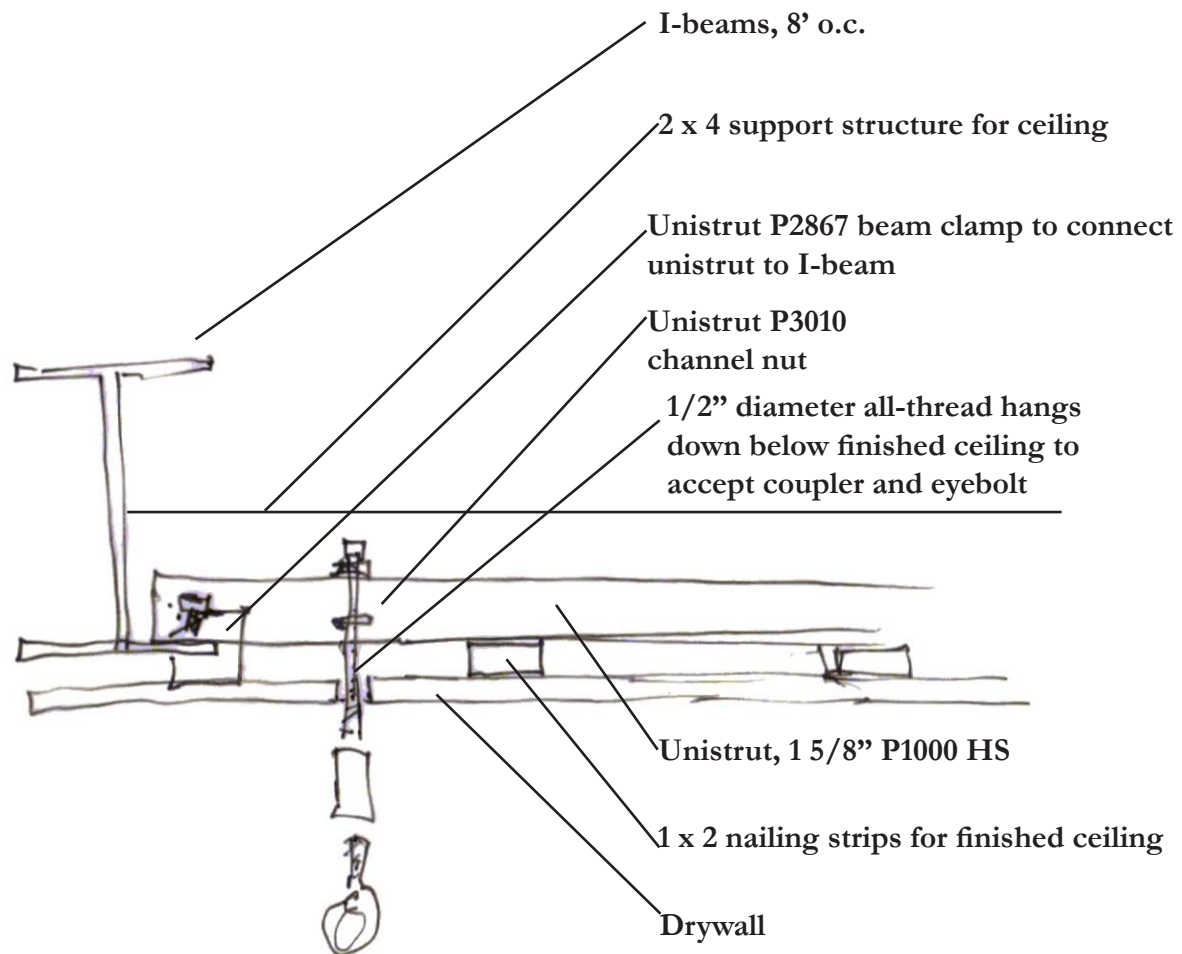


Hinge at hanging point, sketch detail, not to scale





Unistrut connection to I-beam, rough sketch detail, not to scale



Unistrut P2867 beam clamp

Unistrut connection to I-beam, rough sketch detail, not to scale

