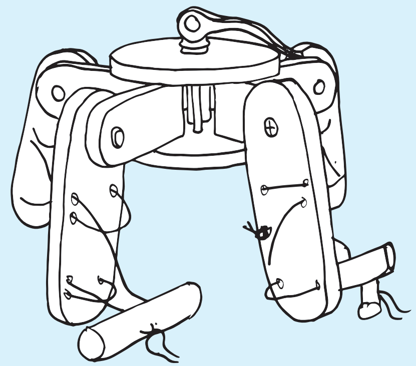
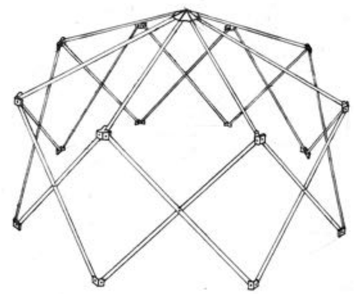
Investigations and experiments into



Expandable shapes and structures



By Joseph T.L. Potter

Overview

First watch the my 'Final display video' in my exhibition space or memorystick provided with the PDF to gain an overall summary of both my projects.

My investigations into expandable shapes and structures have focused on 2 main projects throughout the year.

The first project looks into how to utlise branches from trees or cheap length materials so they can be easily built and adapted into transformable frames and other geodesic type structures.

- The project allows the user to explore construction of the articles at full scale where they could afterwards cover their shelter with a chosen covering i.e. canvas, tarpaulin, bed sheets, bracken etc. It is an interactive and informative design that engages people with building structures, the outdoors and working as a team.

- Research methods throughout this project have been a series of structral visual reseach, followed by resourcing materials, protoyping and testing to improve and experiment with the designs through each stage.

Contents

PART 1
High-Tech Den Building

Making a set of joins that can be used to create foldable frames and geodesic spaces.

To view a summarized version of my overall project, please watch my ‘FInal Display Video’ in my exhbition space or on the memory stick provided. This will give you an overall summary of my project outcome and ethos.

Aims

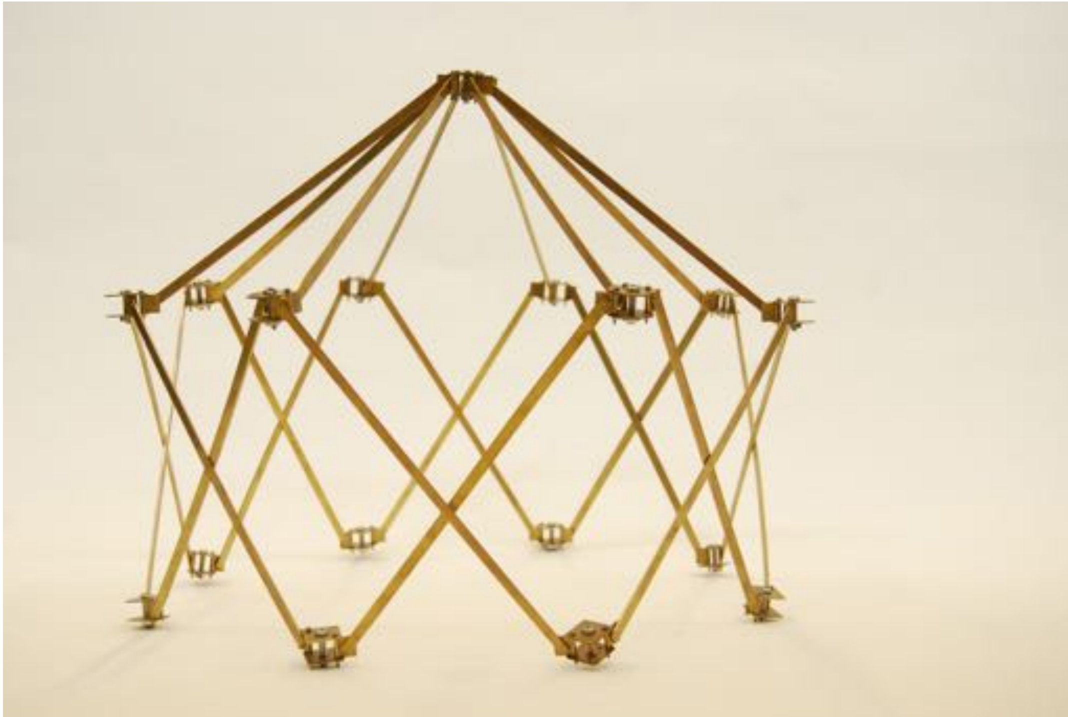
The main aim of this project was to develop a tool/joint that can be used to enable interactive learning and play with foldable and non-foldable structures. This follows on from my second year project where i created a tent frame inspired by a mongolian yurts structure.

- The platform encourages people to get outside and play with making their own DIY framework space.

- Incorporates existing manufactured parts and materials.

Initial Output

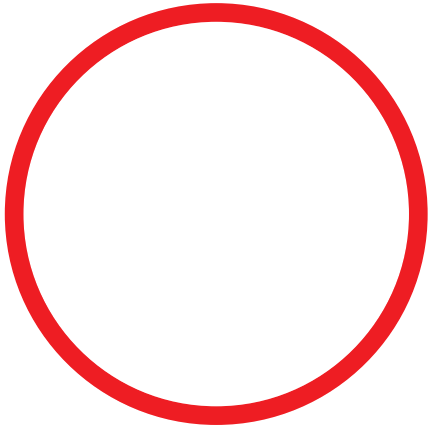
First foldable frame design : Fixed joints

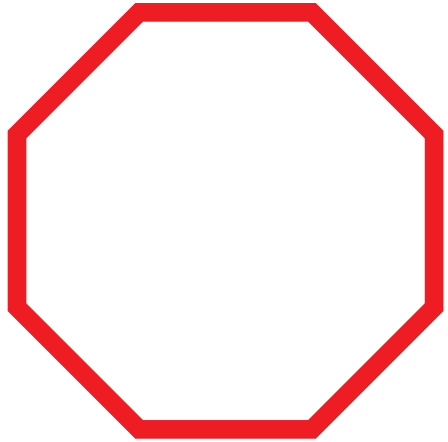


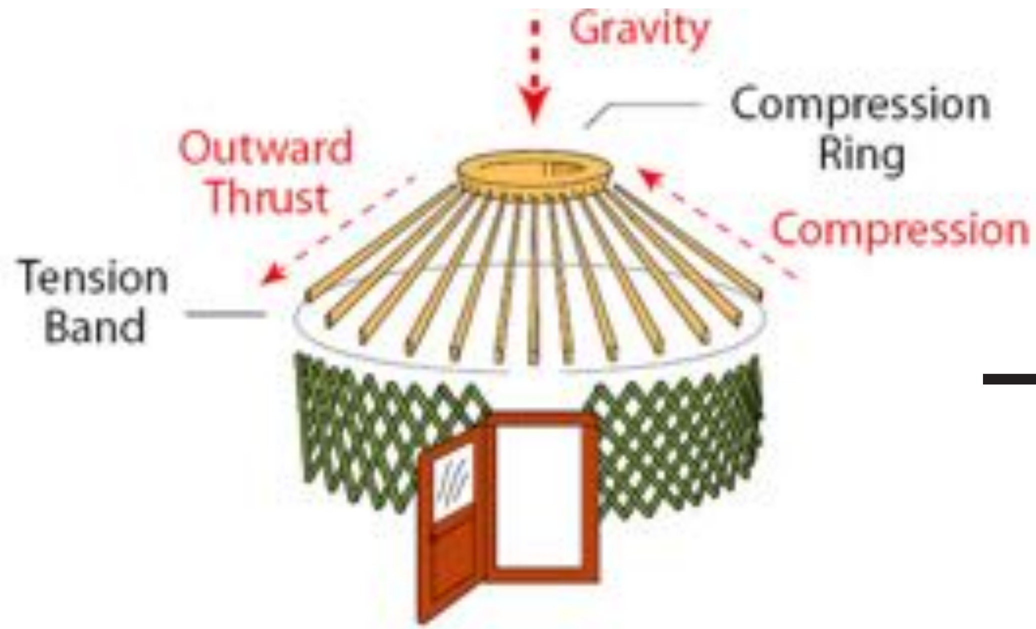
Brass proposition model: Testing the initial idea of a transformable frame with adjustable joints

Background of the Idea

Through simplifying a yurts structure down to an octagonal folding frame, I created a small-scale folding yurt frame that was intended as a childs folding play tent. The design comprised of joins that allowed the straight struts to pivot at fixed angles. I realized this angle could be adjustable, seeing the potential to create a universal join that would allow for open-ended play with creating these structures.







Yurt Diagram

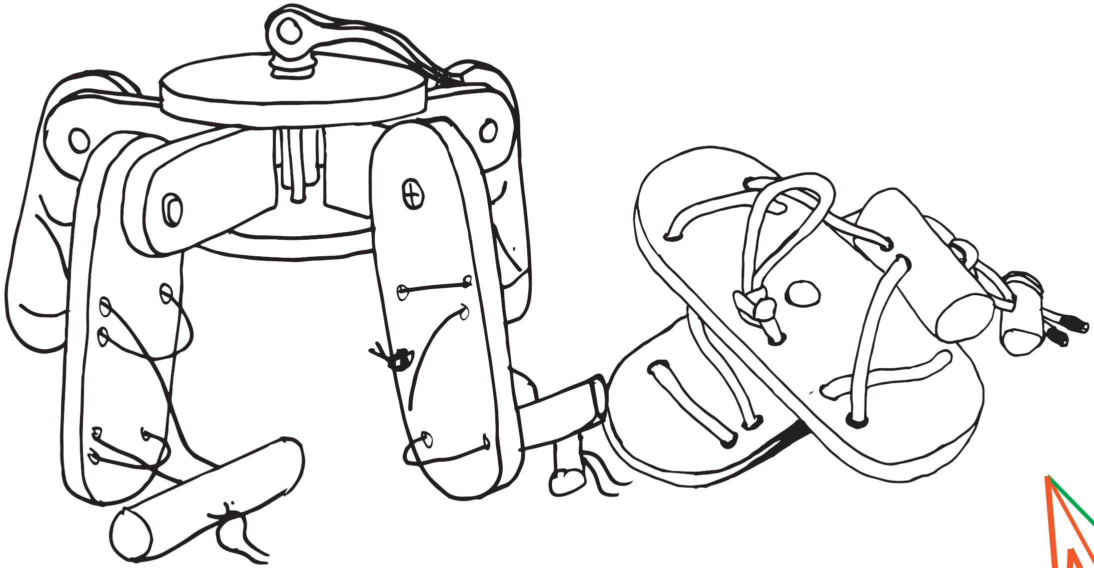
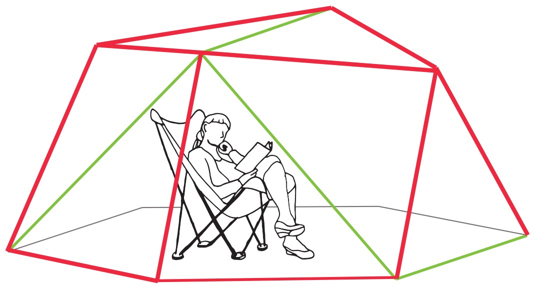
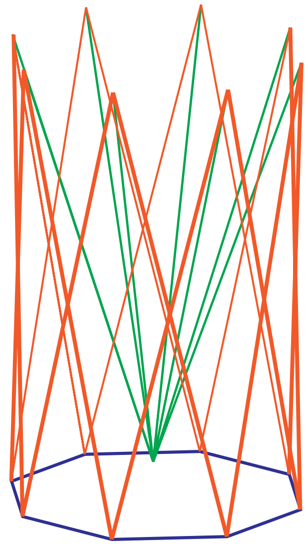
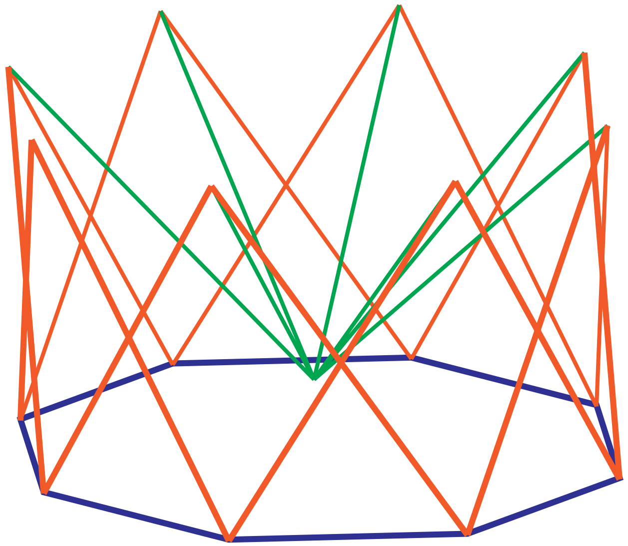
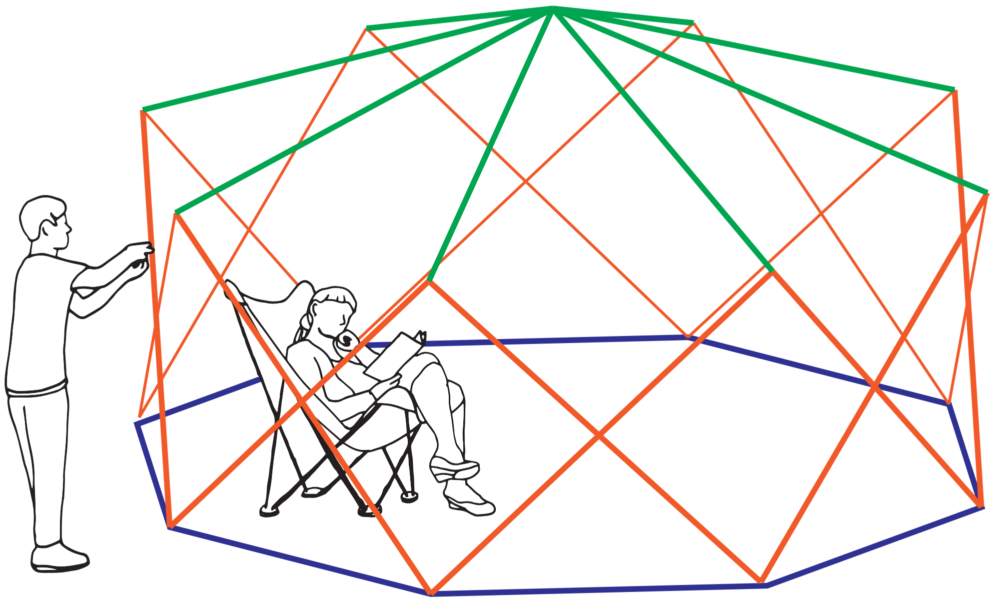
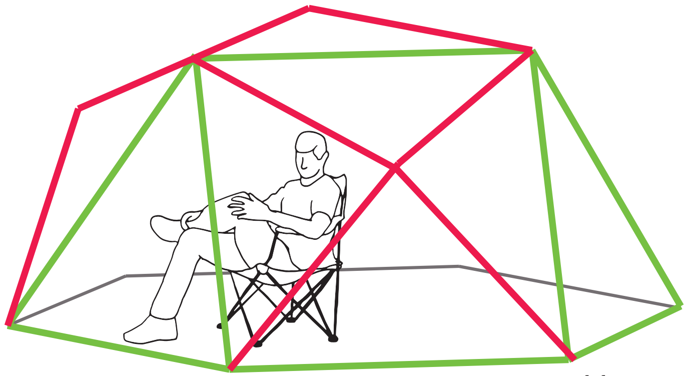
Octagon yurt with fixed joins

Image: Google image search 'Yurt Diagrams'

Geo-Hubs

High tech den building

A universal joint that can be used as a building block for dens and geodesic domes.

Use low grade materials

- Branches from the woods
- PVC Pipes
- Bamboo canes
- Carboard tubes
- Found aluminium tubes

To create High Tech Structures...

‘Geo-Hubs’ are designed to explore constructing high-tech foldable frames, as well as non-folding geodesic domes and irregular imagined structures. Presenting the freedom to use tree branches or other found length materials, spaces can be built, deconstructed, reused and reconstructed into other forms. The outdoor tool enables interaction and aims to engage people of all ages.

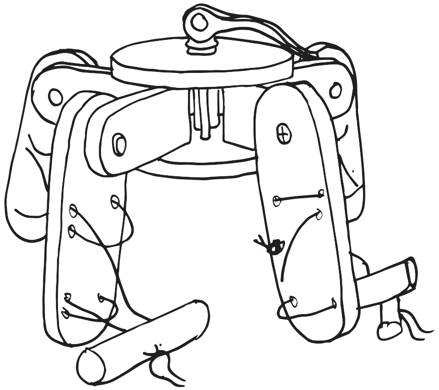
*Geo-Hub building is intended as a group activity. At most stages of building you will need two or more people involved to help support the frame throughout construction.

* The Geo-hub

-Consisting of a top and bottom plate with rubber surfaces, a quick release skewer, and adjustable arm components.

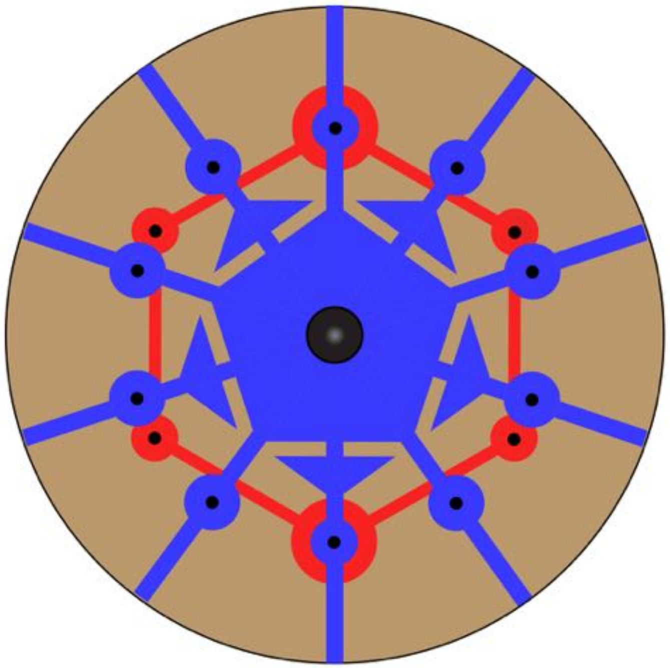
* The X-Hub

A pre-assembled component that holds 2 poles at a midway point, allowing them to hinge in a scissor motion.



The Geo-hub: Parts

Below: Plate Decal



Using a PZ1 drill bit, and the PZ1 screws, you drill your pivot screws into the holes on the top and bottom plates accordingly to how many fixing points you want on your hub for the arm components to attach.

The plate decal is explained in the following pages.

Top and bottom plate with quick release skewer.

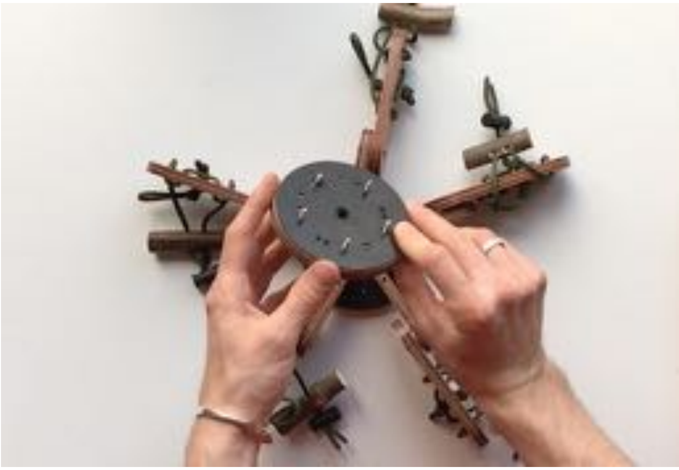
Arm components
- layout with philips screwdriver

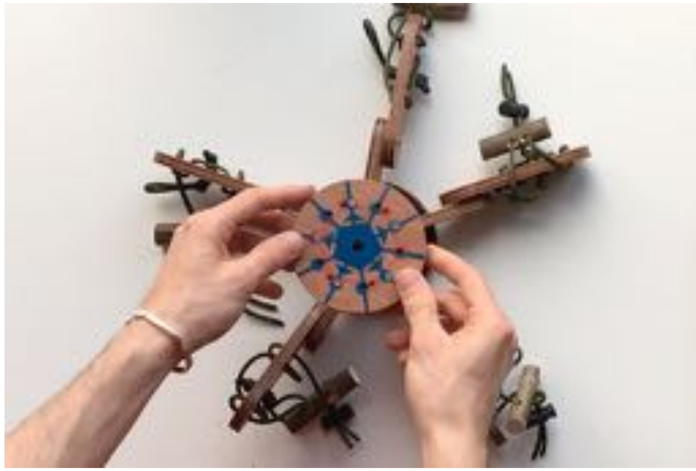
Hub Assembly

Step 1: Twist the screws in loosley by hand in the location holes. Use a roll of tape to elevate the plate for the next stage.

Step 2: Using the PZ1 drill bit, and a hand screwdriver or electric drill, drill the screws all the way through the location holes (do not over-tighten the screws).

Step 3: Locate your preassembled arm components to the pivot screws.



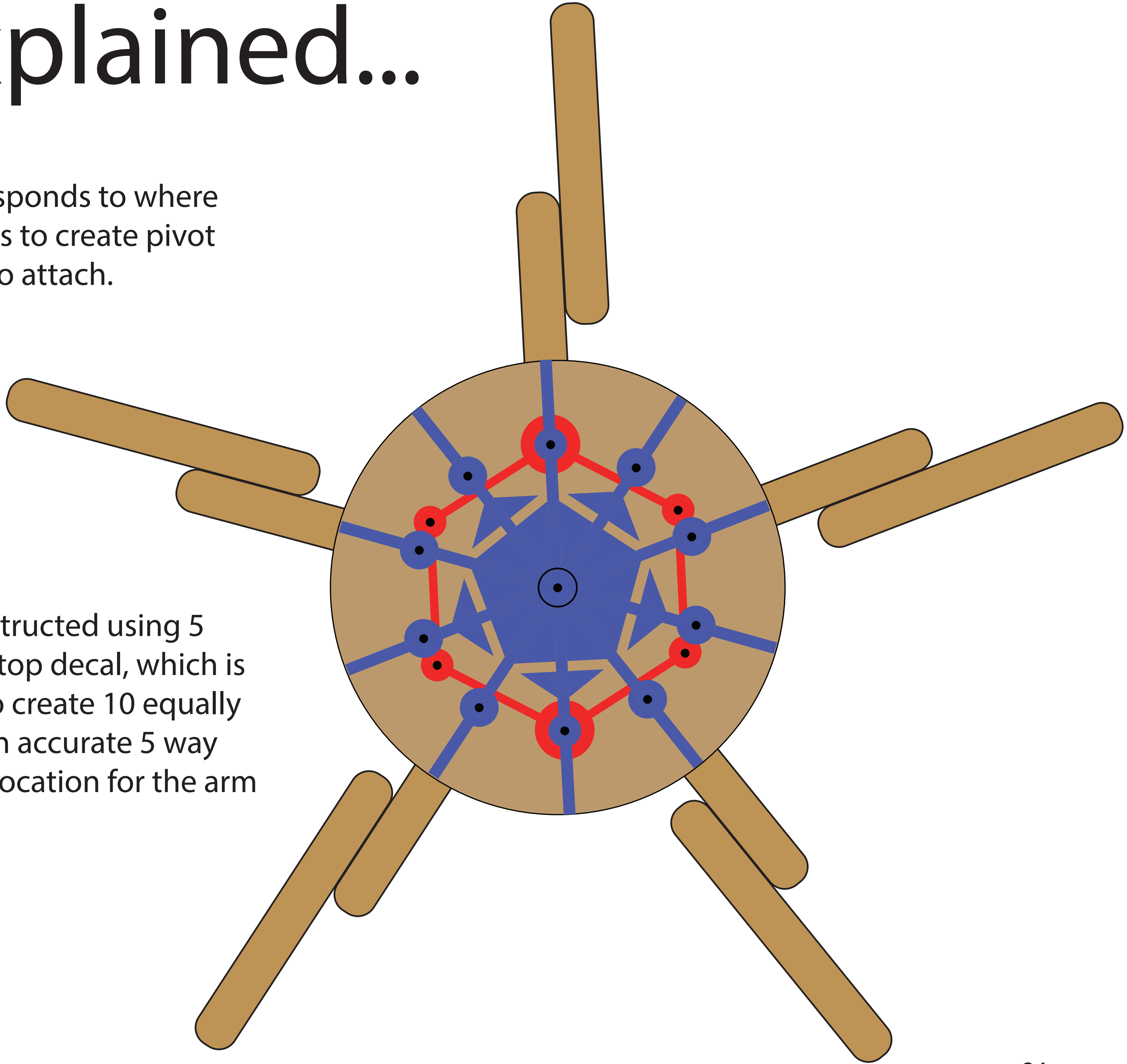


Step 4: Add the top plate to the assembly making sure that each screw locates properlly in the arm holes.

Step 5: Finally, add the quick release scewer to the assembly. Close the quick release when loose and wind clockwise to a tighten enough.
* Avoid overtightening the quick release.

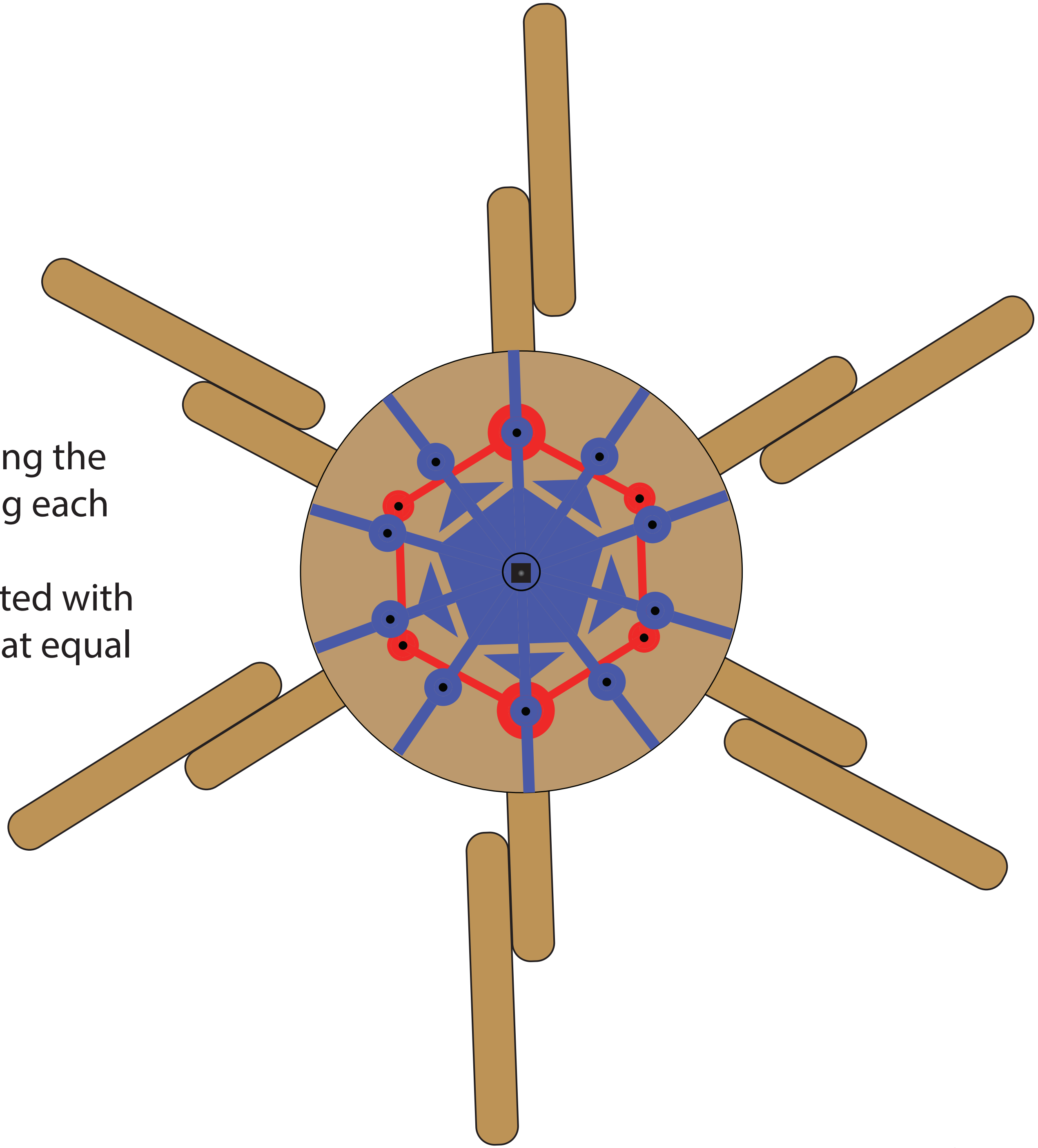
Decals explained...

The plate decals geometry corresponds to where you will need to locate the screws to create pivot points for the arm components to attach.



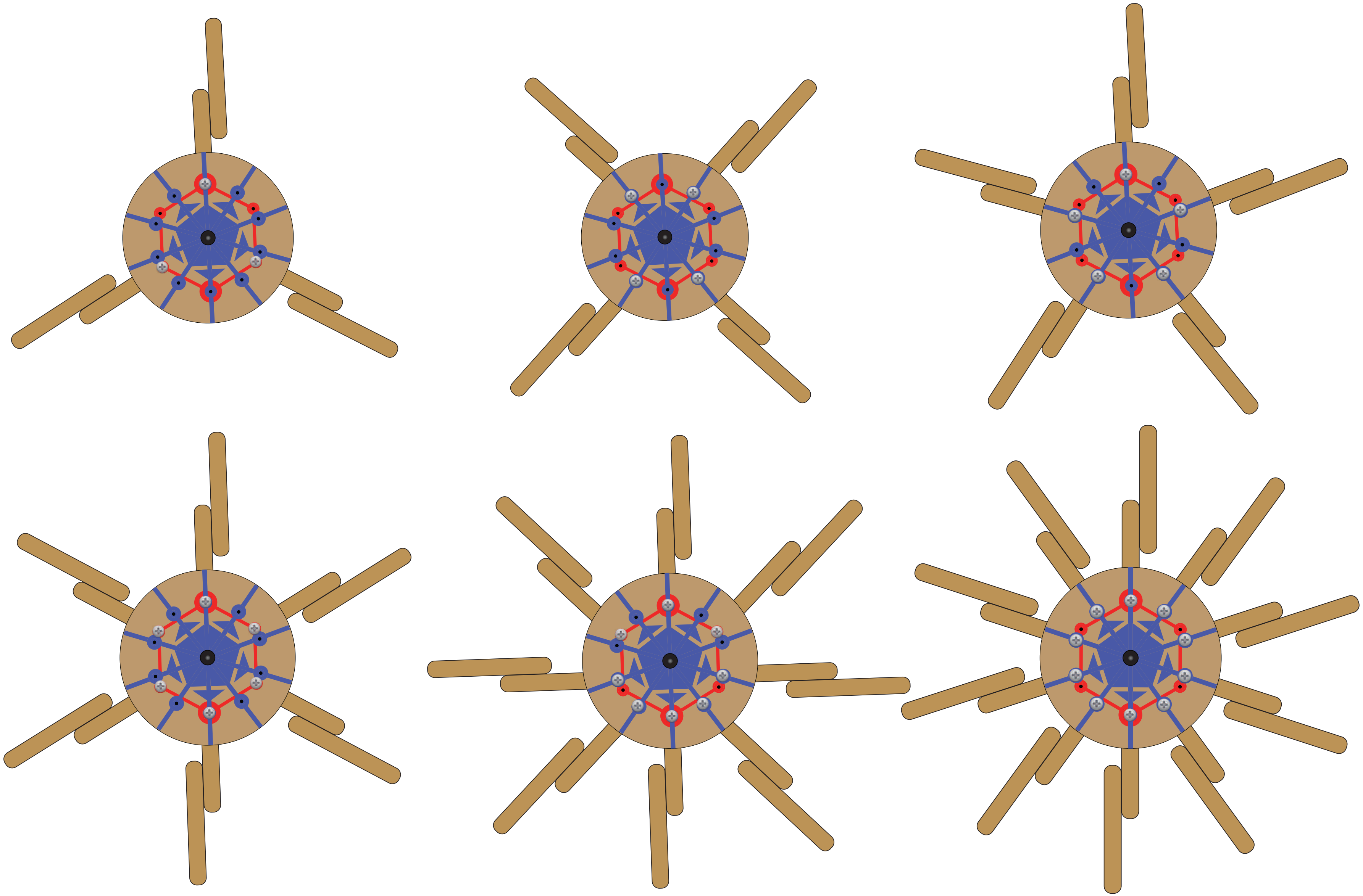
Geodesic domes are mainly constructed using 5 and 6-way hubs. Using the blue top decal, which is divided into 36 degree radians to create 10 equally space fix points, you can setup an accurate 5 way hub using each other point as a location for the arm fixings.

The same goes for a 6-way hub, following the locations of the bottom red decal. Using each other hole sets up a perfect 3 way hub. Other frequencies of setup can be located with holes that roughly seperate the points at equal distants.



*Refer to the following page to see the locations for the screws.

Screw Locations for the plates



* Make sure to refer to the diagrams when setting up your hub screws.

- It is important that you evenly space the locations of the arms around the cirumference of the plates to make sure the hub can clamp the arms solid.

Attaching Materials

Step 1:

Loosen the toggle and pull the loops open to allow enough room for your chosen material to slide into.

Step 2:

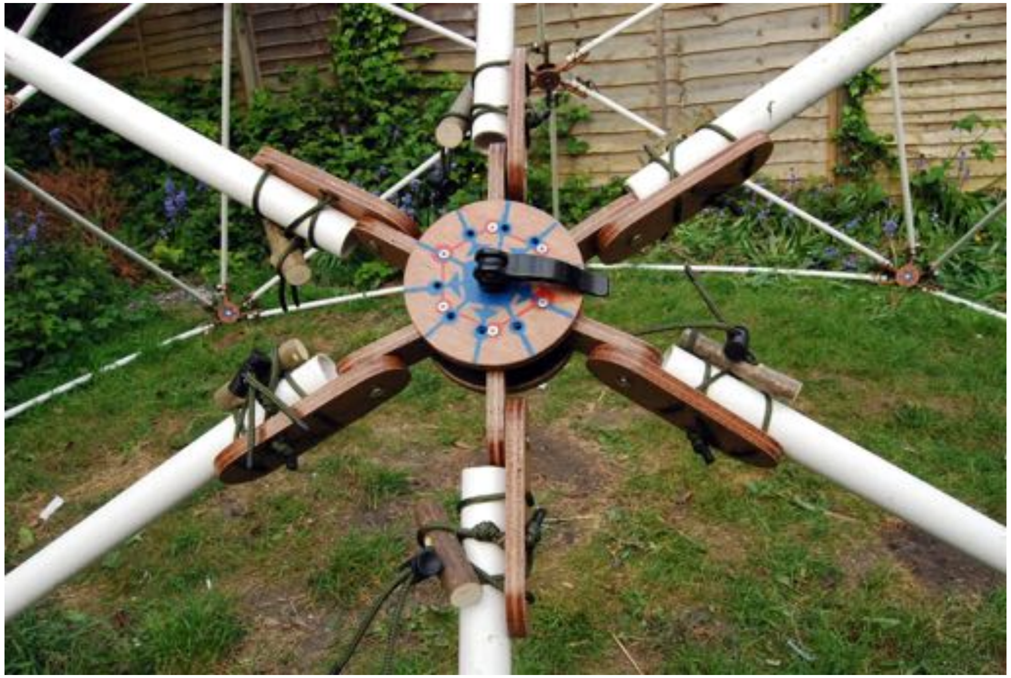
Add the pole/branch into the loop and pull the toggle to tighten and remove any slack.

Step 3:

Once there is as little slack as possible, tighten the knot after the wooden toggle. Tye it tight to the wooden toggle, twist and you should feel the knot lock as you twist.
Twist until the hold on the material is firm enough.

Step 4:

Finally once the hold on the material is firm, add the loop over the end of the toggle to ensure the tigh twist will not unravel.



Example of a 6-way hub in use.

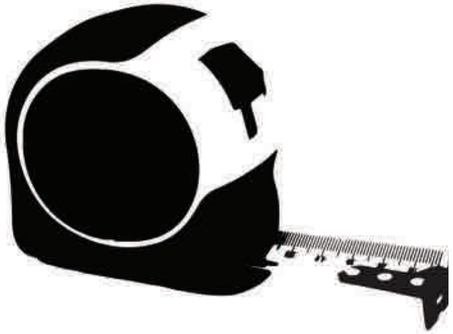
Example of an X-Hub in use.

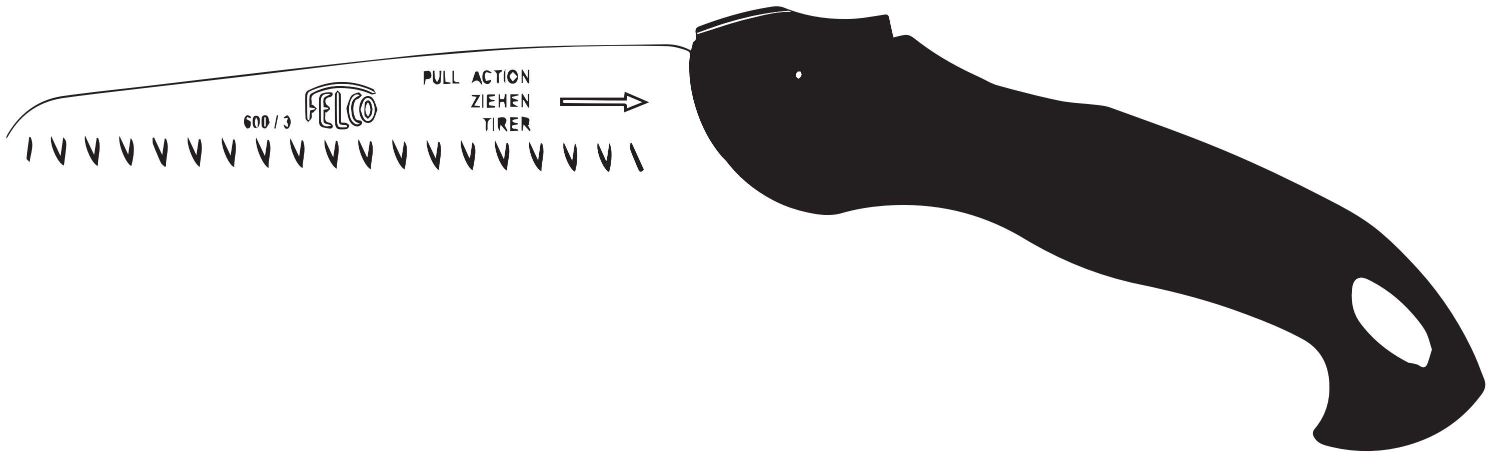
Example of assembling the X-Hub

Getting Prepared to Build

Harvesting sticks: You will need...

- A tape measure.
- A pocket saw.
- Some rope to tie your bundle together.

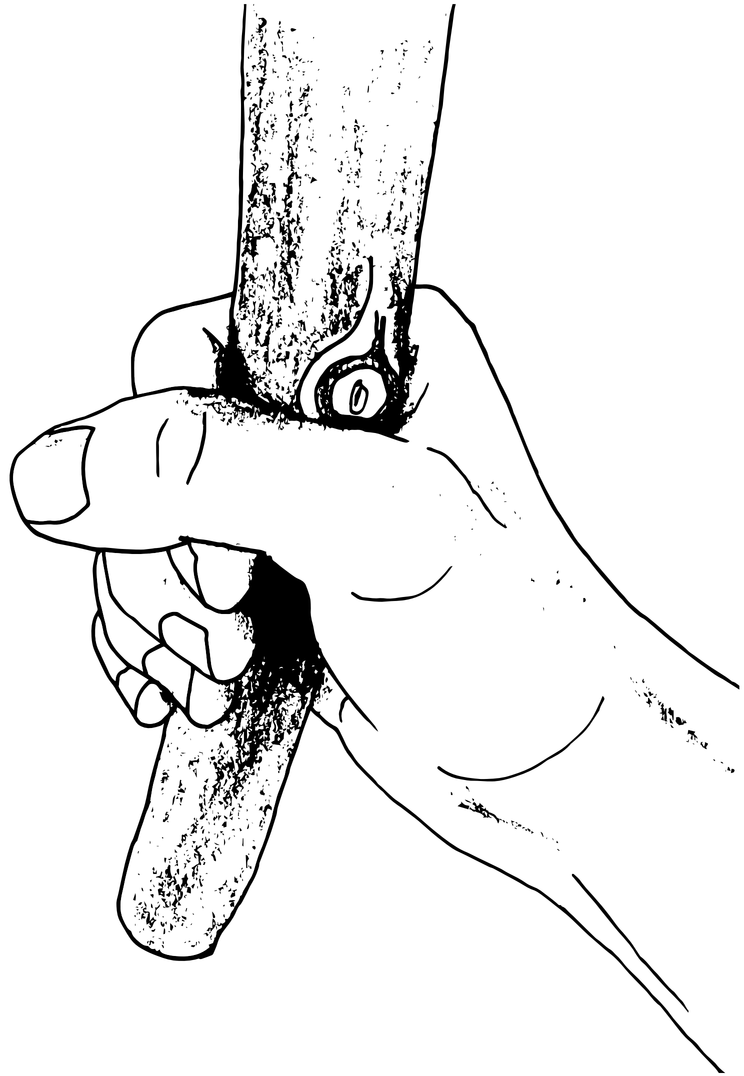




Sourcing material for Geo-Hubs

The branches you want to use should be between 25-40mm, to ensure they are strong enough and the right size to fix to the arms.

- Your hand is a good gauge of the right size branch to use. If it holds snug in the hand then it is generally the right size.



Where to find your Materials

Material tips

* Make sure you source your branches responsibly from places you know you are allowed to take them from i.e. When you prune hedges or trees in the garden, from woodland with permission, or fallen trees.

* At a reasonable price for a fair quantity, bamboo is an ideal material due to its strength, weight and attainability. It is also easy and fast to grow!

- 1 inch PVC pipe is also a low cost material that is easy to get hold of from builders and plumbers merchants in large lengths.

- Scrap aluminium tube is also a great to use if you can attain it as a waste material.

ALWAYS use wood that is strong. Test the strength of the wood that are thinking of using before building.

*You can experiment building with cardboard tubes, but be save building more complex structures that you want to cover as they are more likely to fold.

*Do not remove branches in areas you are not allowed to take them from

Other suggestions

- Using a tarpaulin or two, you can cover almost any shaped structure well enough to provide shelter.

- Use spring clamps to fix the tarpaulin at points around the structure.

- If you are out in the woods and there are ferns around, you can use layers of ferns to cover the frame if the structure is small enough to do so.

Getting to Grips

First have a go at setting up a 5-way hub and attach some equal length poles.

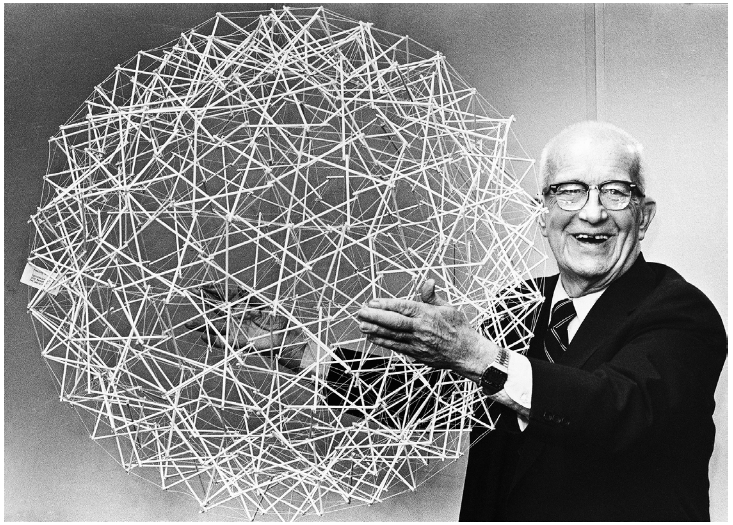
- Make sure it is sturdy, using this first go with the hubs to get to grips with attaching the poles correctly.

Use a tarpaulin and the spring clips to play around with covering your shelter...maybe add a groundsheet too.

An Introduction to Geodesics

Geodesic Domes were largely popularized during the 1950's by a man named Buckminster Fuller. Fuller patented his ideas in America, and went on to build the first large commercial dome for Ford Motor Company's HQ in Michigan.

In the modern day there are over 300,000 geodesic domes built across the globe. They have been a popular structure to build, down to their efficient use of materials, whilst providing strength with evenly distributed weight across the wholes structure, and open space inside without obtrusive supporting columns.

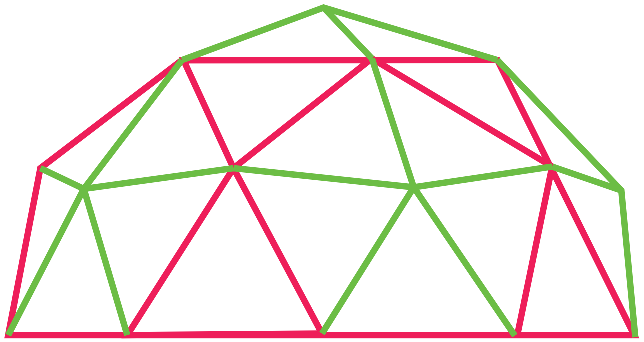


Richard Buckminster Fuller holding a geodesic model.

Image coutesy of: https://www-tc.pbs.org/wnet/americanmasters/files/2001/12/BuckminsterFuller.jpg
Information courtesy of: https://www.bfi.org/about-fuller/biography

Chord Factors and Strut lengths

To work out how to build a geodesic structure in your own space using Geo-Hubs, you need to know how to calculate each struts length in relation to the size of the dome that you want to build. This is actually simple



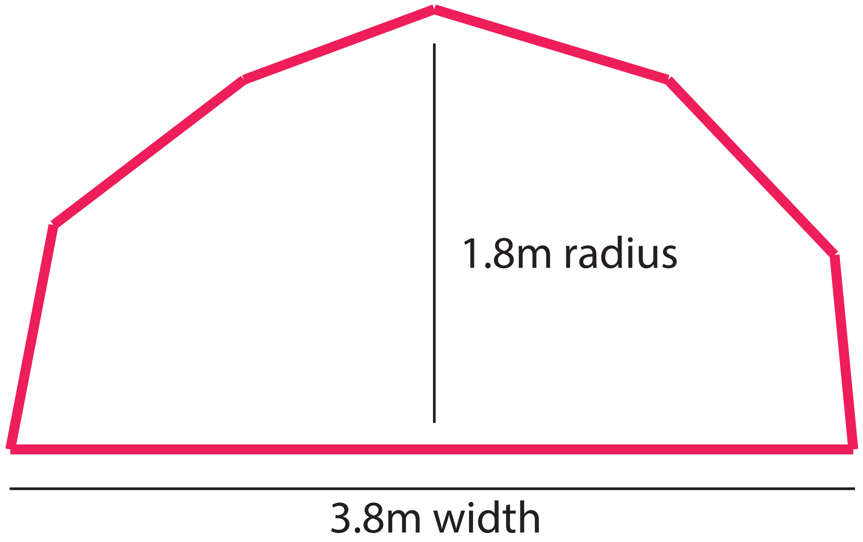
You first need to know the radius of the dome you want to build. The width of the dome will be roughly double the radius depending on how the geometry of the build is segmented.

You will need to know the chord factors (decimal calculations of the strut lengths) for your build.

- Multiply the radius by the chord factor.

The output of each calculation will provide you with the exact length you need to cut your poles to for each strut.

The following instructions provide you with some already calculated strut lengths for a certain size structure, but you can also calculate your own to change the sizes.



Example Calculation

Chord Factors:
- A = 0.54653
- B = 0.61803

The build needs 30 x lengths of 'A' strut and 35x B struts.

Use the radius of 1.8metres x by the 'A' strut chord factor

1.8 x 0.54653 = 0.983754 rounded to 0.98m = 98cm A strut

1.8 x 0.61803 = 1.112454 rounded to 1.11m = 111cm B struts

Building Strategy

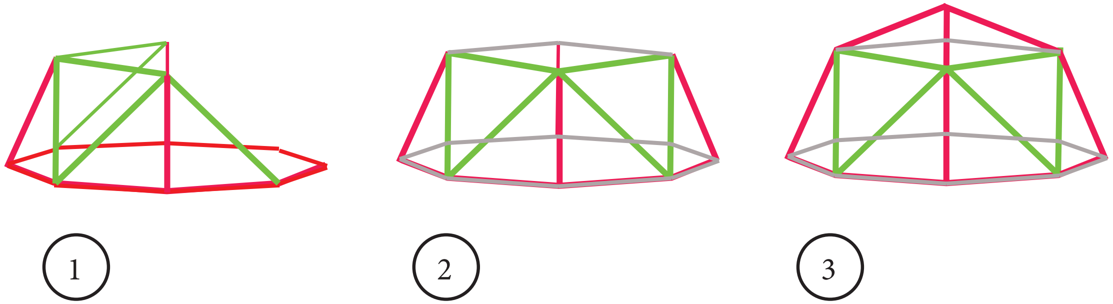
Build Tips and Rules

* Always build from the ground upwards. Assemble the bottom struts and then build the first layer.

- Prepare the central roof hub with the struts attached, fixing the central hub as the last stage of every build.

- Ensure you always tighten the toggles thoroughly and re-check their grip as you continue to build.

- Always make sure you have somebody supporting the frame or something to prop the frame against as you build. You risk breaking the joins if there is too much flex and weight on the structure as you build it.



* To make sure you place hubs in the correct location whilst building a dome, always refer to the diagrams provided in the instructions, carefully observing how many struts form each intersection.

Sequence example

1

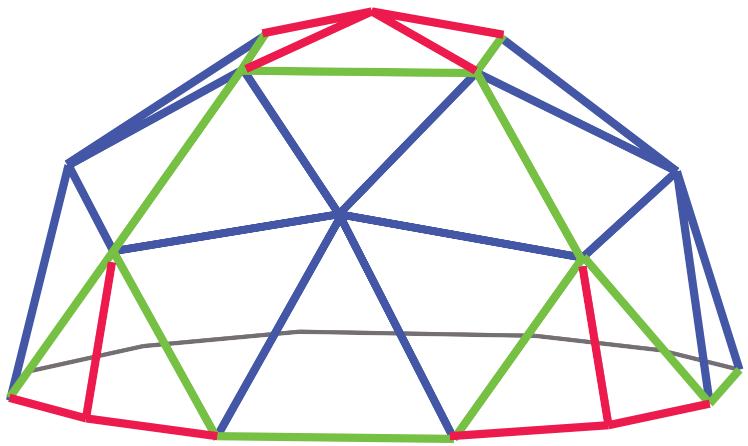
2

3

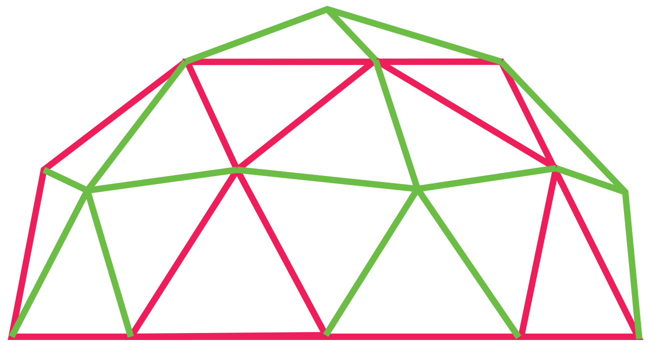
4

*Follow this sequence of floor to roof building for all of your geodesic builds

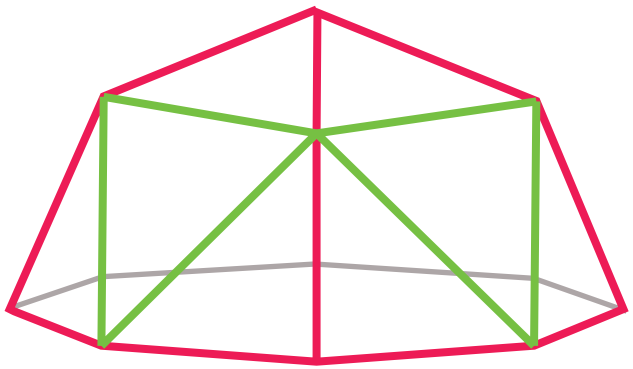
Acheivable Geodesic Builds



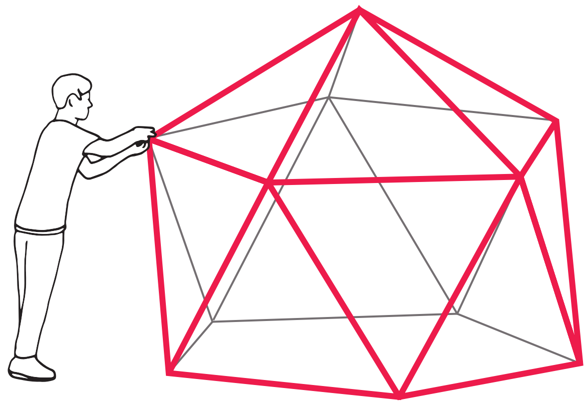
Truncated Octahedral Dome



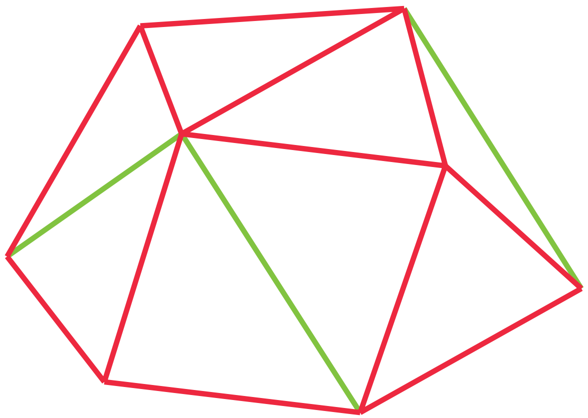
2v Iscosahedral Dome



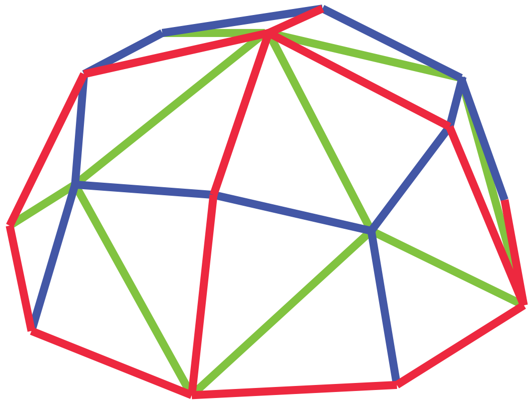
Octahedral based dome



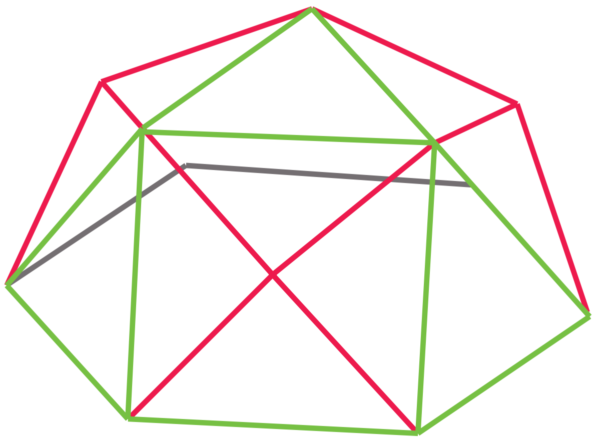
Iscosahedral Dome



Cube Based Dome



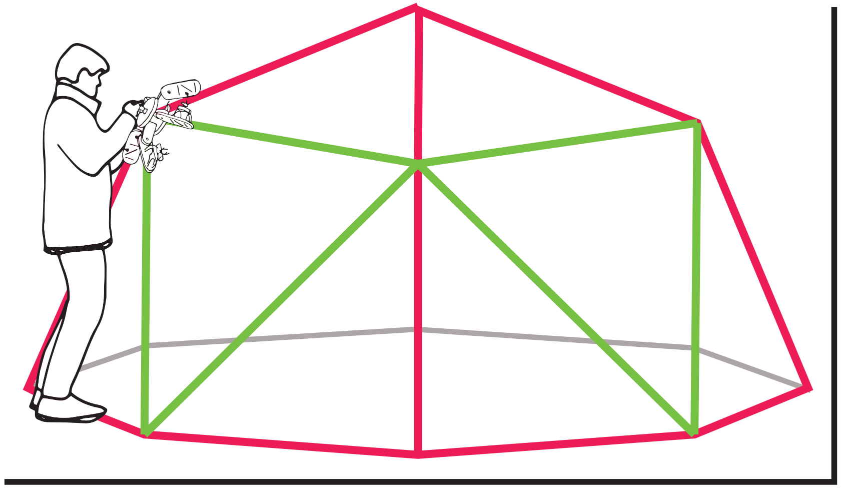
Type 2 Octahedral based dome

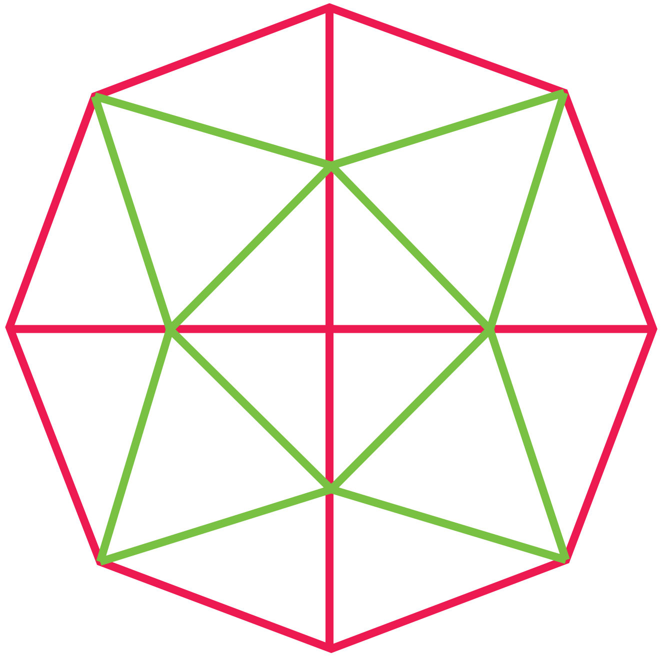


Cuboctahedron Dome

These are the most achievable builds with Geo-Hubs. With other geodesic domes there are larger amounts of intersections that would require a hub for each point. Larger builds would be a lot more strategic and too complex to build safely with Geo-Hubs, whilst requiring an amount of hubs that you are unlikely to ever have.

Ocatahedral Based Dome





13 Hubs - 28 poles

1.8metres high

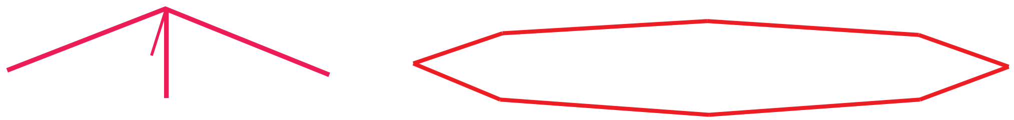
- 12 lengths of strut 'A' cut to 180cm
- 16 lengths of strut 'B' cut to 139cm

- 4 x 3-way hubs
- 4 x 6-way hubs
- 5 x 4-way hubs

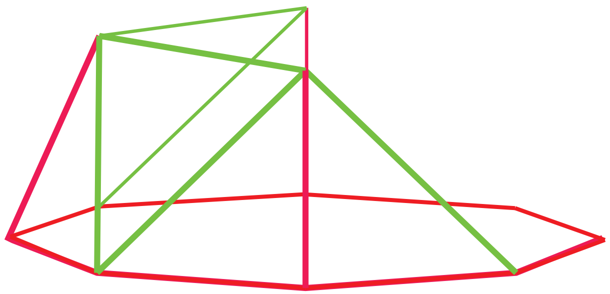
Chord Factors:

- A = 1.00000
- B = 0.76537

Build sequence

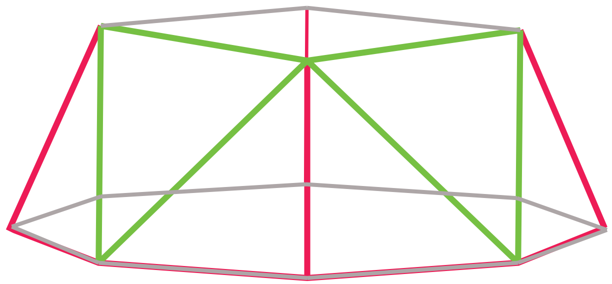


1 Assemble both the 4-way roof hub with B struts, and the floor struts with 3-way and 4-way hubs.



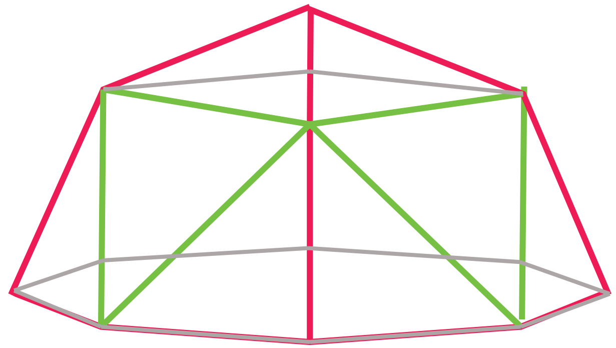
2

Start to build the first layer, whilst supporting each pole correctly with people holding it as you construct the layer.



3

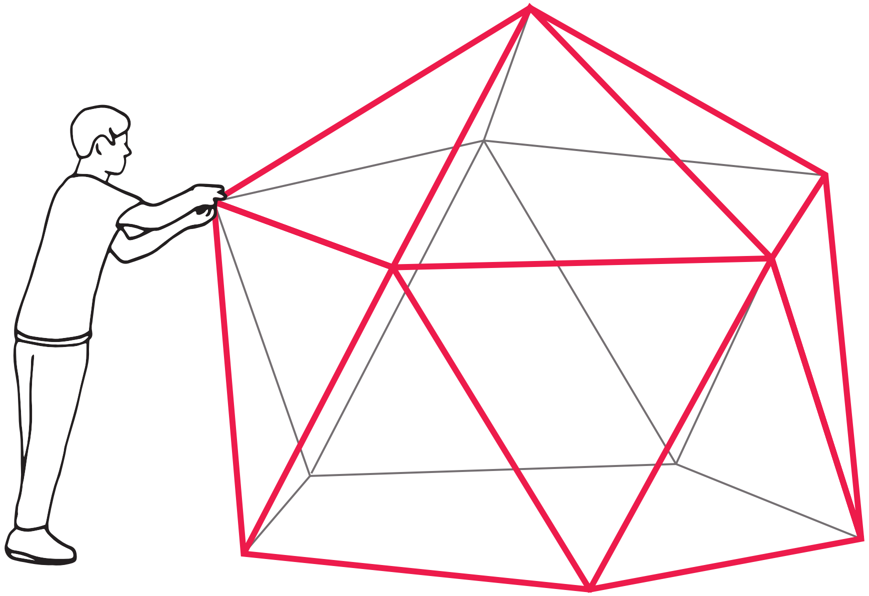
Complete the first layer and keep the frame supported.

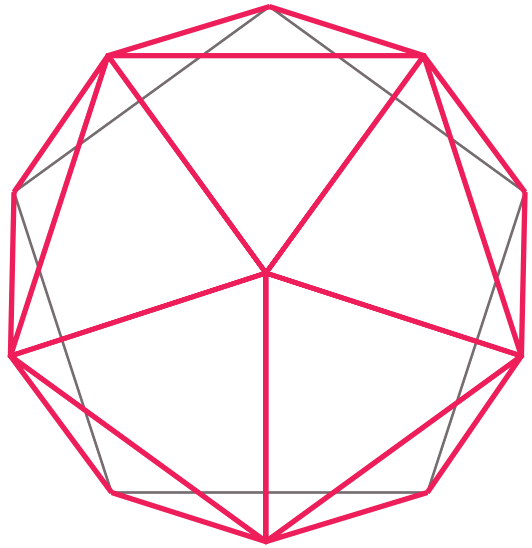


4

Finally add the central hub and roof struts.

Iscosahedron Dome





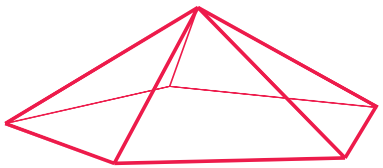
11 Hubs - 25 poles

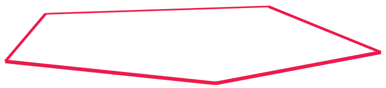
- 25 struts of equal length

- 6 x 5-way hubs
- 5 x 4-way hubs

Chord Factors:
- There are no chord factors for the iscosahedron, simply cut all poles to equal lengths

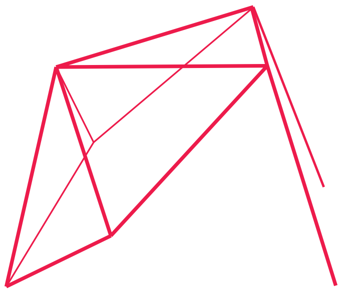
Build sequence





1

Assemble both the 5-way roof hub, and the floor struts 4-way hubs.



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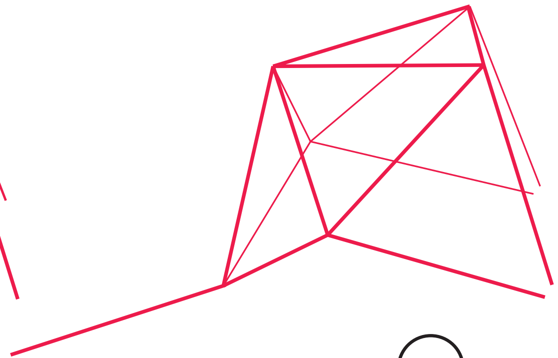

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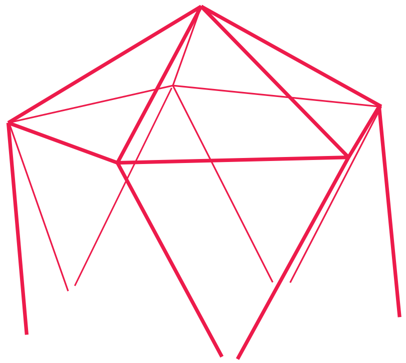
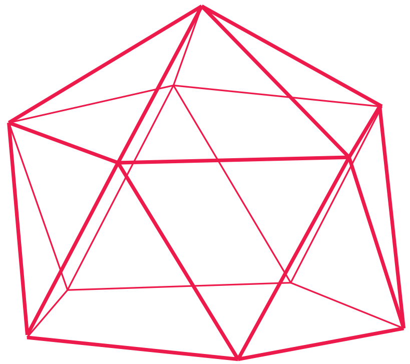
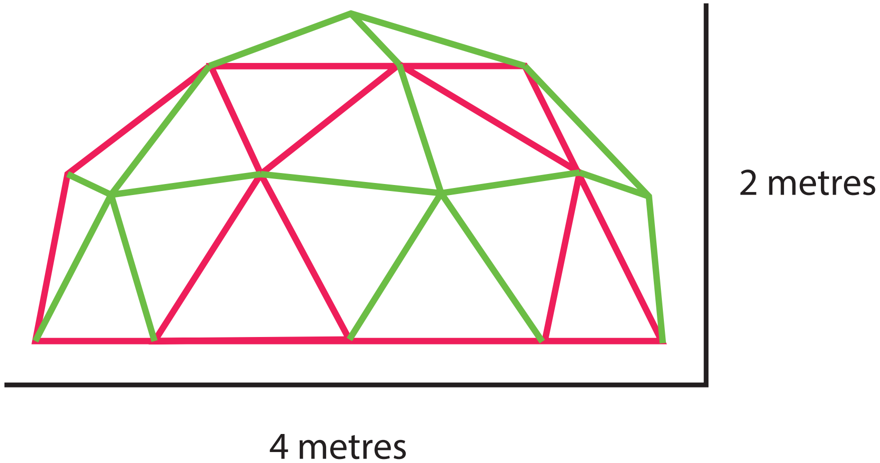


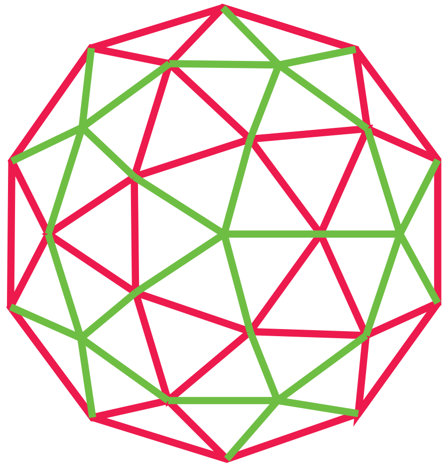


4

The icosahedron can be built by this sequence or using a floor to roof method. Continue to use the floor to roof method for all other builds.

2v Icosahedral Dome





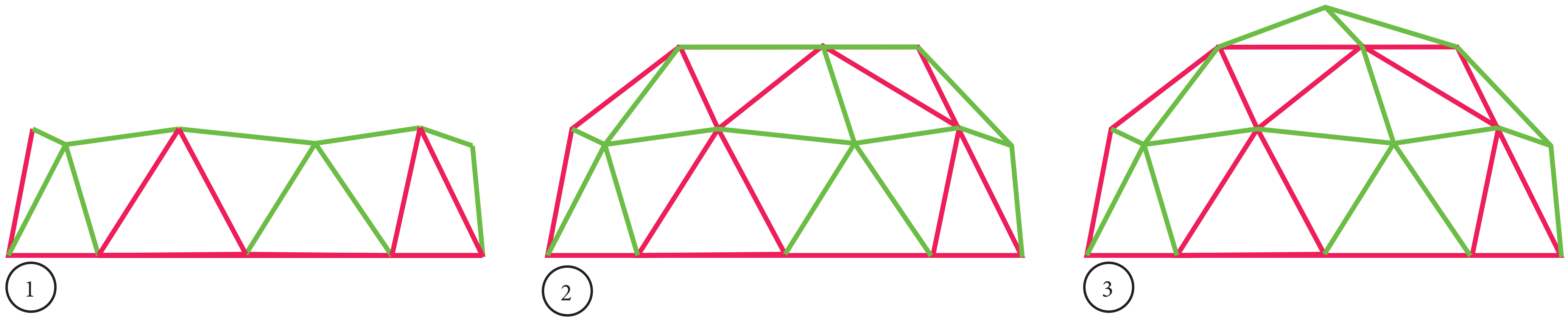
26 Hubs - 75 poles

2 metres high

- 30 lengths of strut 'A' cut to 110cm
- 35 lengths of strut 'B' cut to 125cm

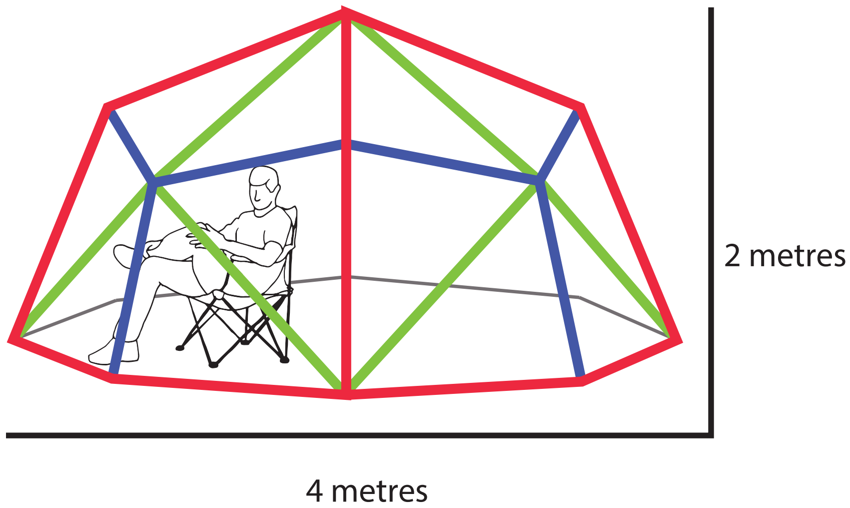
- 10 x 6-way hubs
- 6 x 5-way hubs
- 10 x 4-way hubs (for the base)

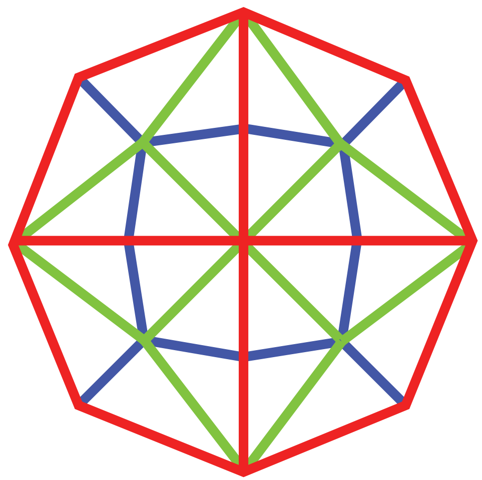
Chord Factors:
- A = 0.54653
- B = 0.61803



Form the dome from the base upwards whilst supporting the frame at each step of the way.

Type 2 Octahedron Dome





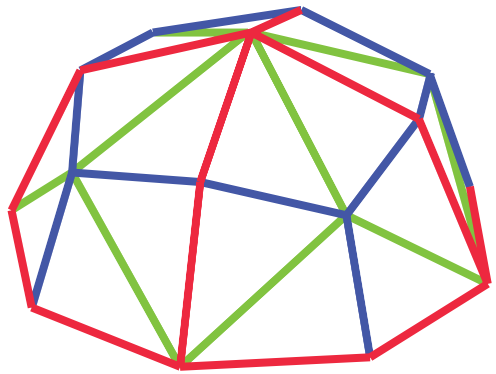
17 Hubs - 40 poles

1.8metres

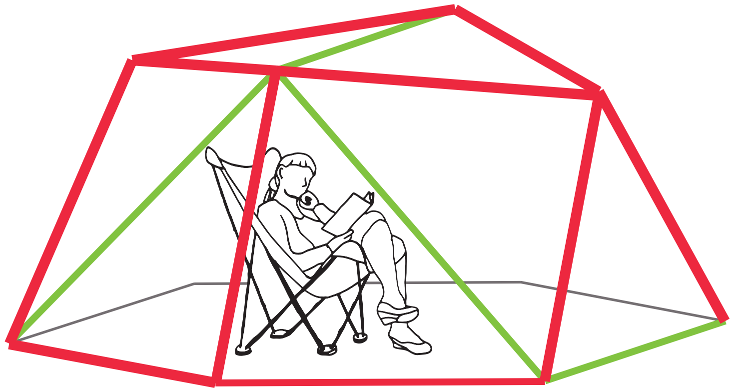
- 12 lengths of strut 'A' cut to 101cm
- 16 lengths of strut 'B' cut to 138cm
- 12 lengths of strut 'C' cut to 162cm

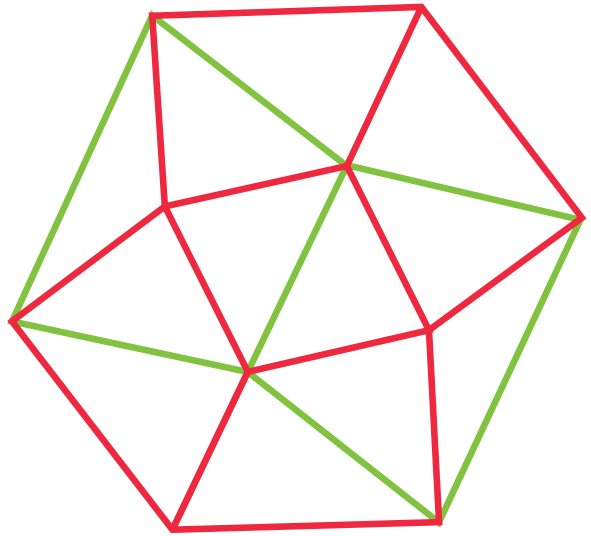
- 1 x 8-way hub
- 4 x 3-way hubs
- 4 x 6-way hubs
- 4 x 4-way hubs
- 4 x 5-way hubs

Chord Factors:
- A = 0.60581
- B = 0.76537
- C = 0.91940



Cube Based Dome





10 Hubs - 21 poles

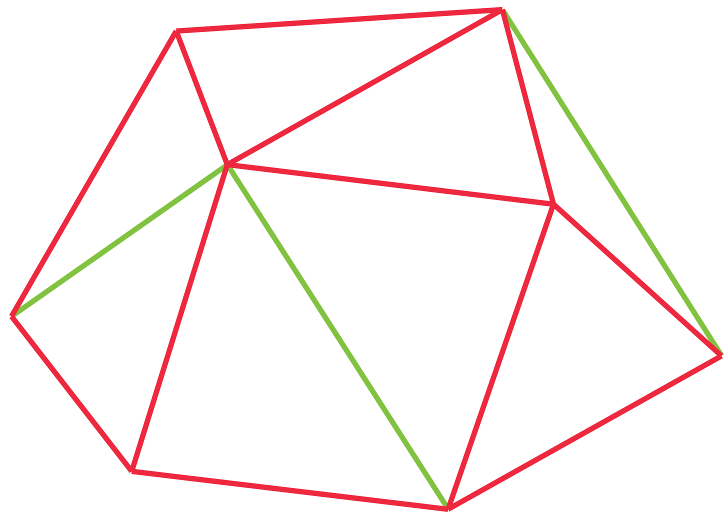
1.8metres

- 7 lengths of strut 'A' cut to 207cm
- 14 lengths of strut 'B' cut to 164cm

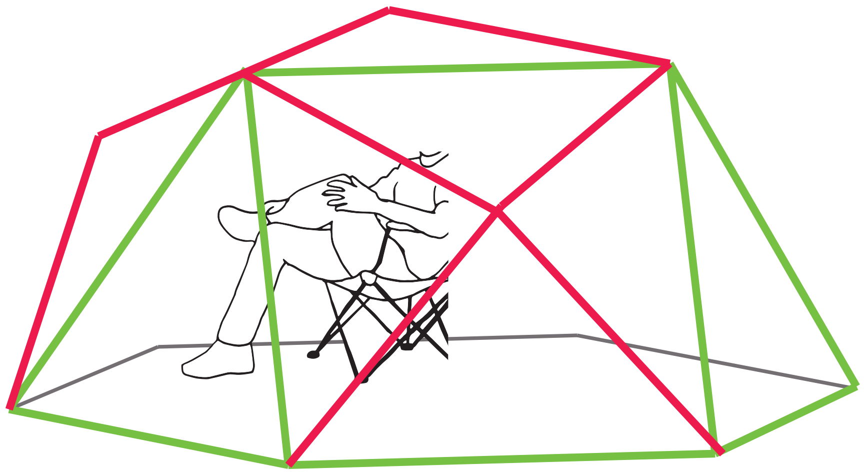
- 2 x 3-way hubs
- 2 x 6-way hubs
- 6 x 4-way hubs

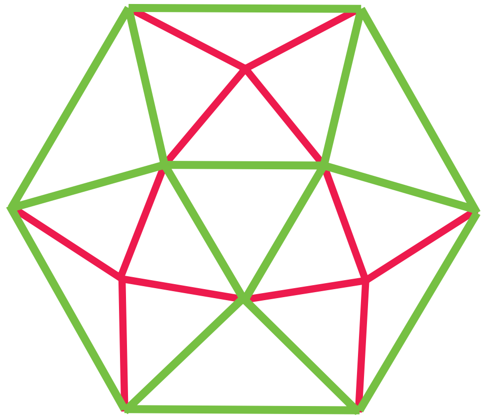
Chord Factors:

- A = 0.9194
- B = 1.1547



Cuboctahedron Dome





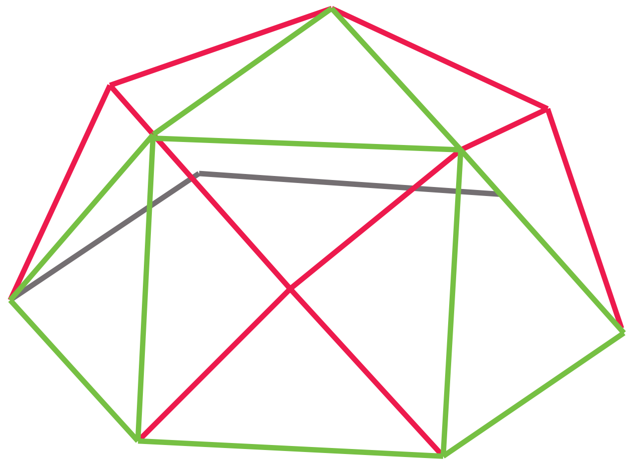
12 Hubs - 27 poles

1.8metres

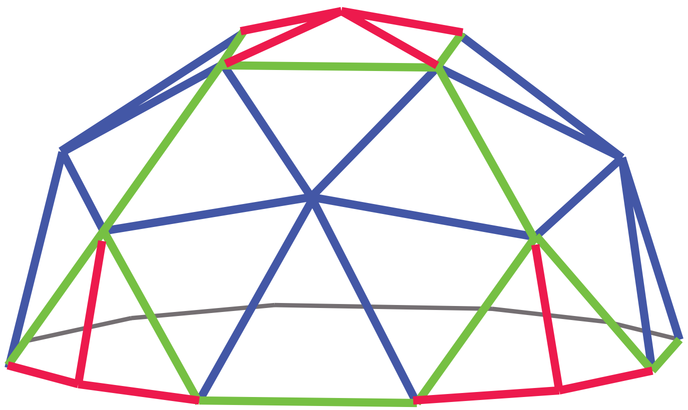
- 15 lengths of strut 'A' cut to 180cm
- 12 lengths of strut 'B' cut to 139cm

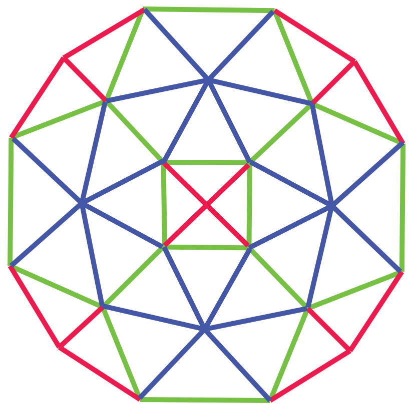
- 3 x 6-way hubs
- 9 x 4-way hubs

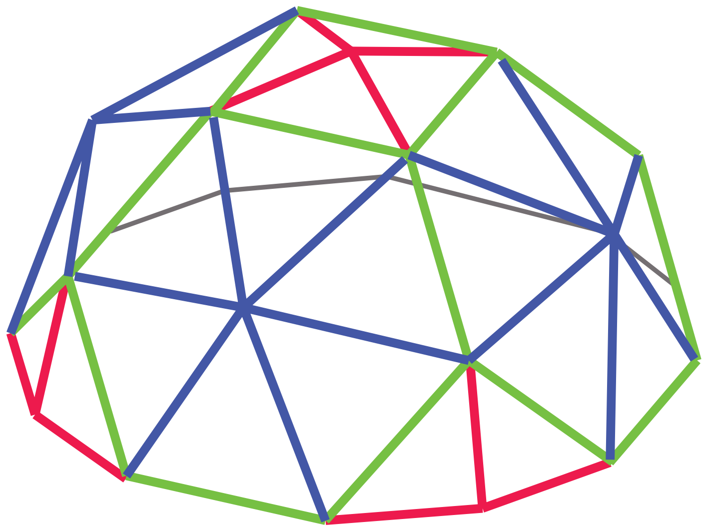
Chord Factors:
- A = 1.00000
- B = 0.76537



Truncated Octahedron Dome







25 Hubs - 60 poles

2 metres

- 20 lengths of strut 'A' cut to 126cm
- 16 lengths of strut 'B' cut to 92cm
- 24 lengths of strut 'C' cut to 120cm

- 4 x 3-way hubs
- 12 x 6-way hubs
- 9 x 4-way hubs

Chord Factors:

- A = 0.63246
- B = 0.45951
- C = 0.67142

Adaptive Scissor Frames

Using Geo-Hubs, a lattice wall can be constructed from multiple scissor mechanisms made with the X-Hubs.
A lattice wall is an adaptable structure that can be manipulated into a wide range of spatial shapes.

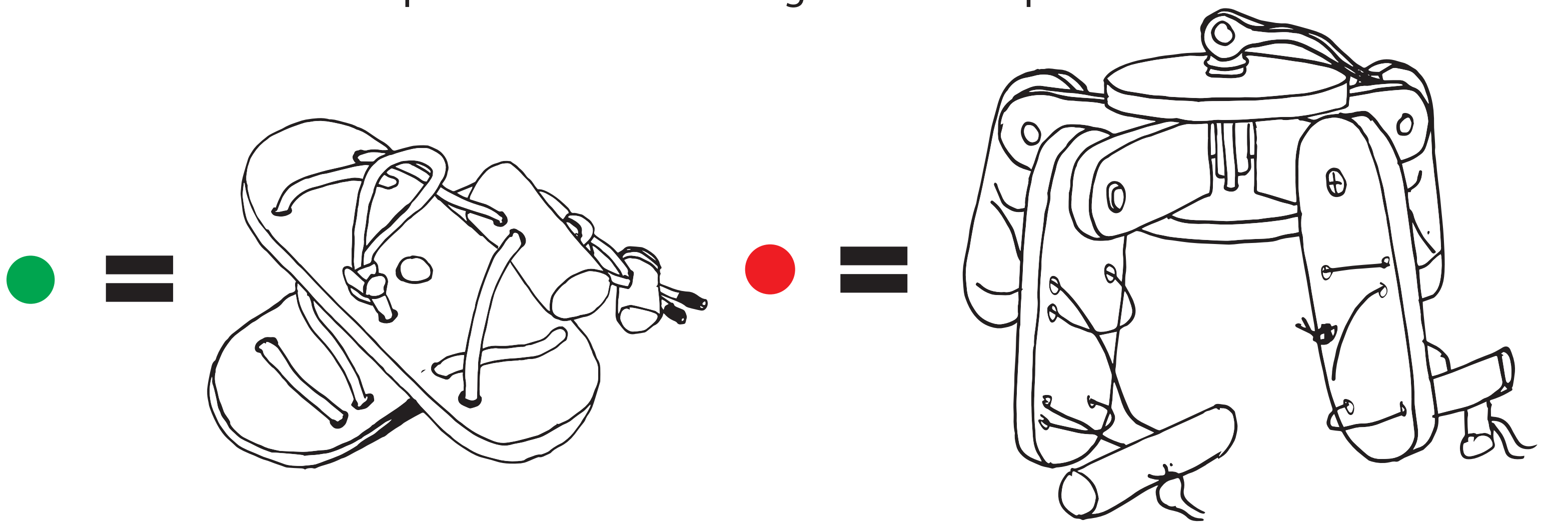
The following section shows you how to explore the adaptability of a lattice structure...

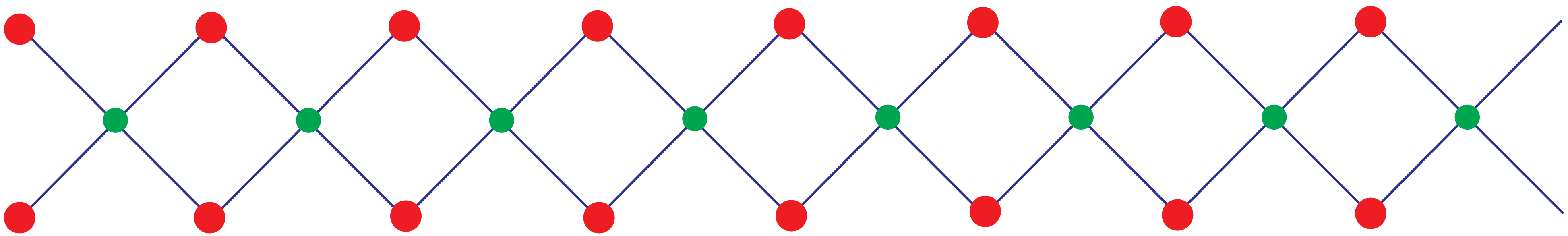
*Make sure you have some long lengths of rope to create a tension band and guy ropes to complete your build.

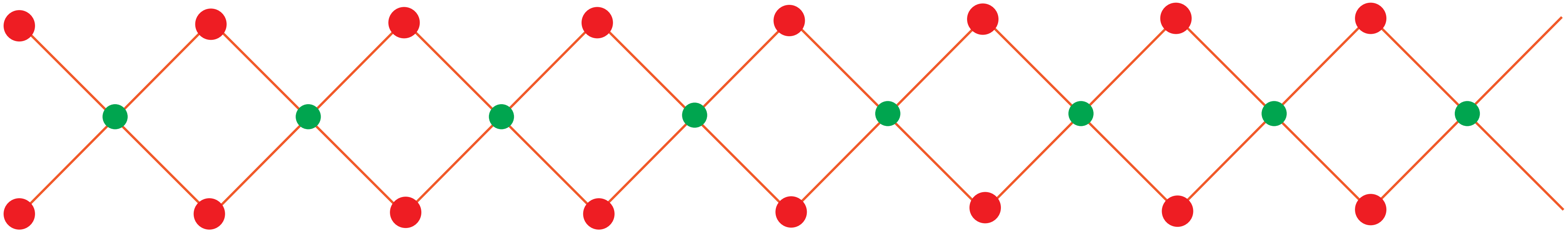
An 8 sided scissor frame wall (illustrated below) can be used as a constant component in a lattice build structure.

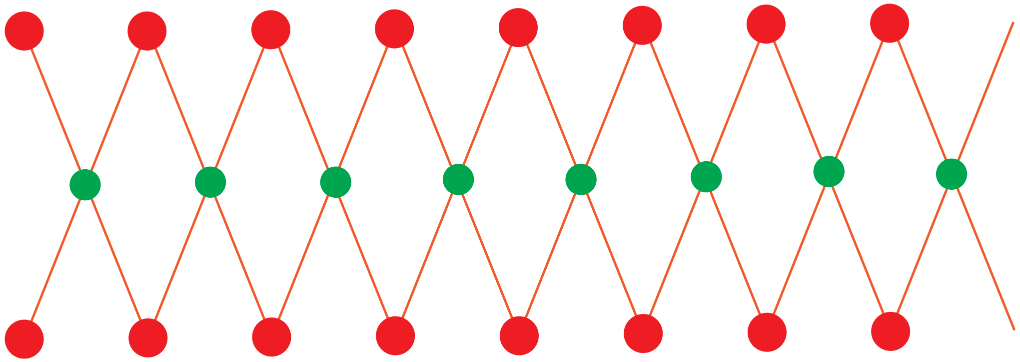
The 8 sided frame can be angled into a variety of configured spaces.

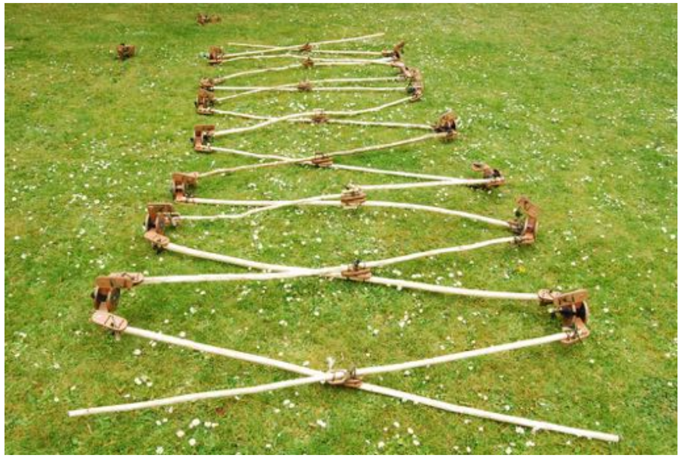
- The roof struts act as a variable component to these configurations of space.

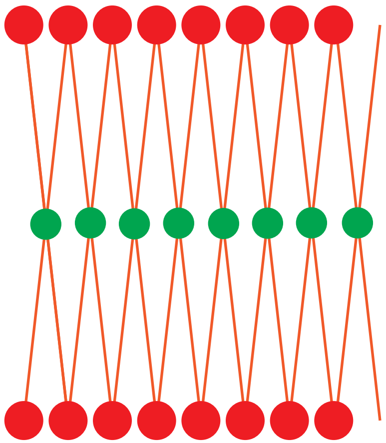






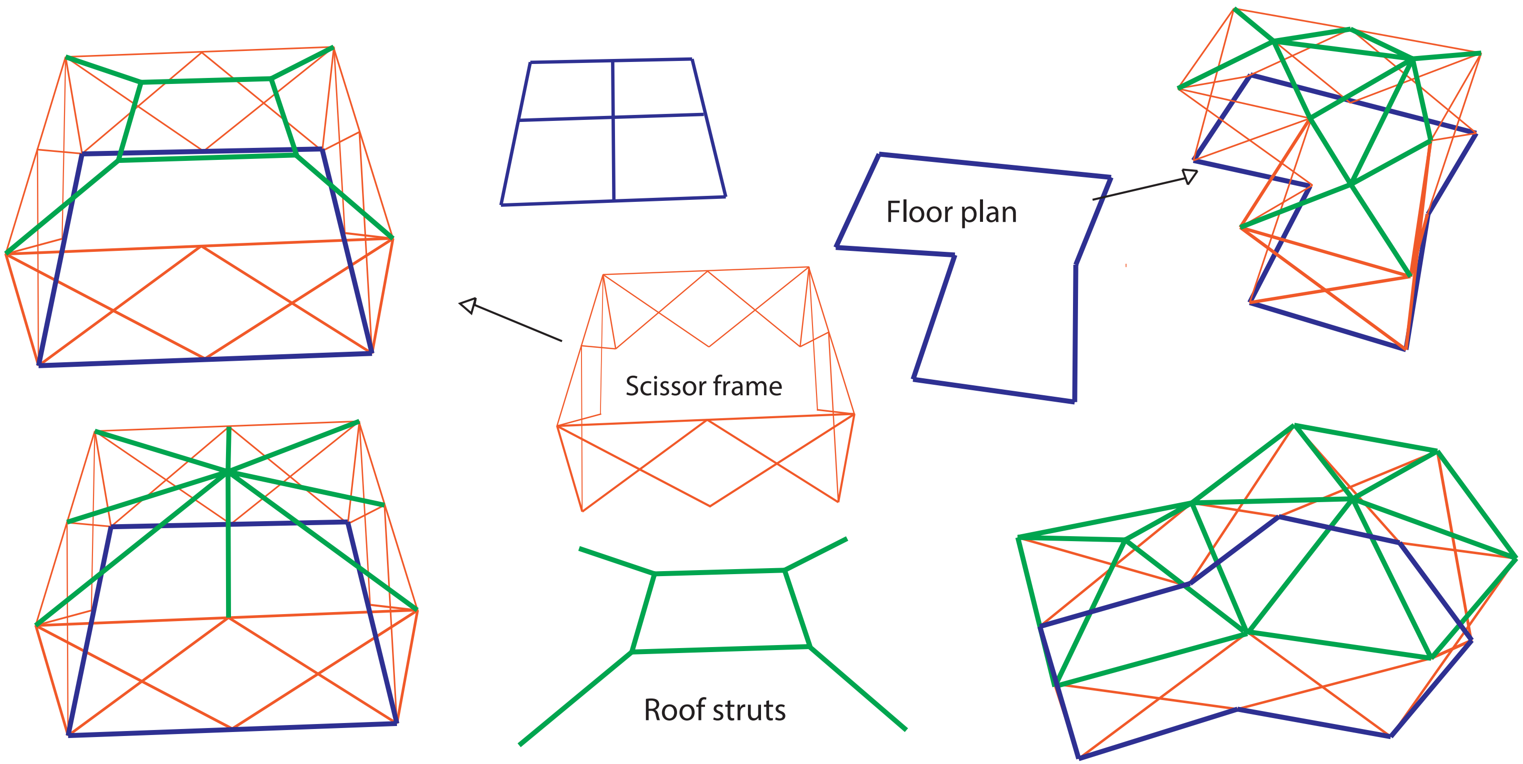


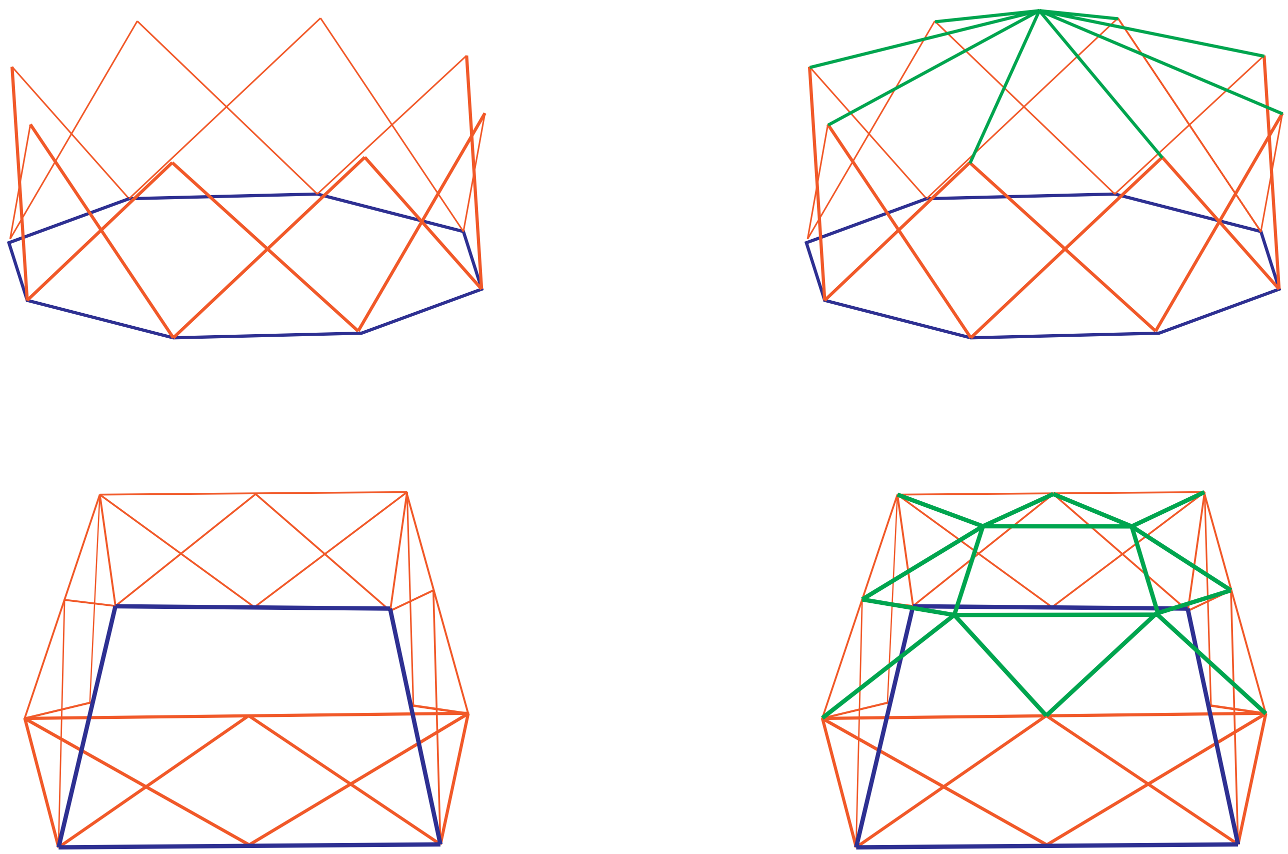




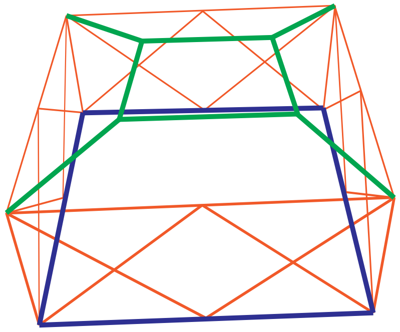
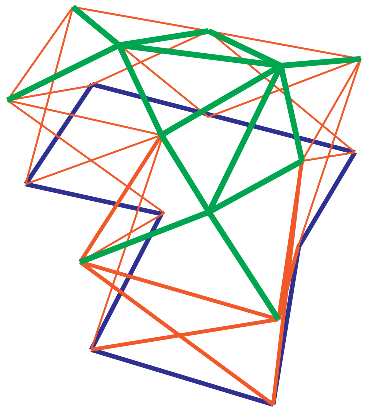
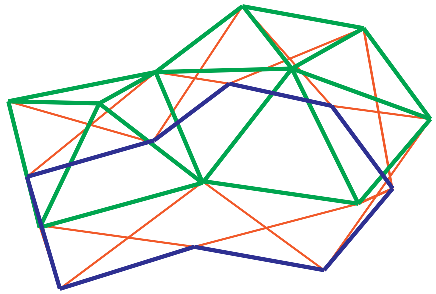
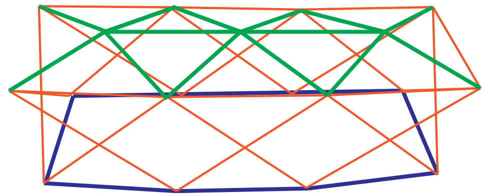
A lattice frame, comprised of multiple scissor mechanisms, like any single scissor mechanism, can hinge open and closed.

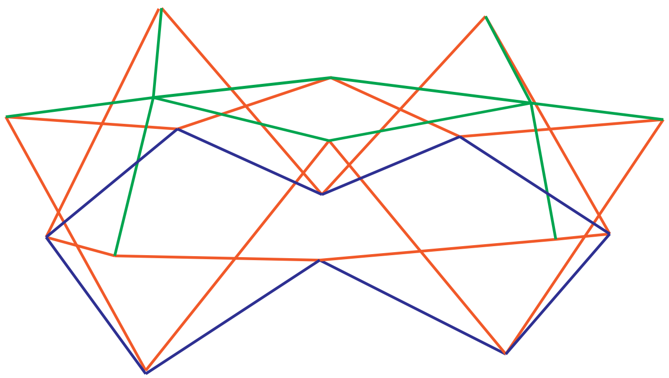
When multiple scissors are joined, using the Geo-Hub joins, as an upright wall, you can place the wall at any angle you like.
Making a closed lattice frame


Floor plan
Scissor frame
Roof struts



The 8 sided frame can be angled into a variety of configured spaces.
The roof struts act as a variable component to these configurations of space.



These are generally the best variety of ways to setup an adaptive 8 sided scissor structure.

*Observe how each diagram has and 8 sided wall with different roofs.

Create an 8 sided wall and have a go at some of these frames!

Frame Assembly

1

16 Hubs, 8 X-Hubs, 16 poles.

2

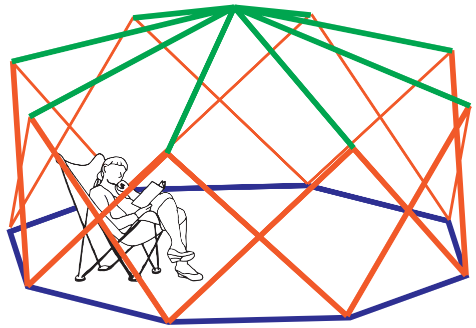
3

4

5

6

Adding the roof



With the lattice wall constructed you can adjust the frame into your desired shape.

Choose what roof you would like to add and setup the roof hubs with their struts.

The example to the right shows setting up a regular octagonal build.


*8-way hub with struts

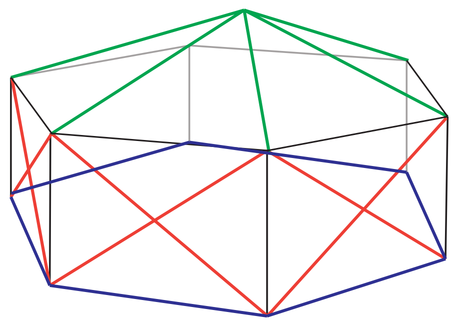
The Tension Band

Each folding scissor frame requires a tensioning band. The tensioning band runs around the outside of the upper joins of the lattice wall, countering the downward and outward force from the roof. You can use a long length of good quality cord or a strap if you have one, tyeing it firmly at the right length to form the sitting height of the structure.

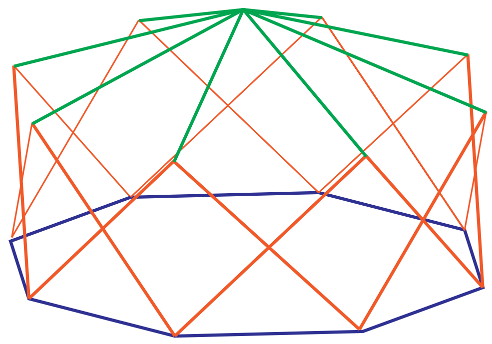
*You must always complete the structure with a tensioning band.

Octagonal Folding Frame

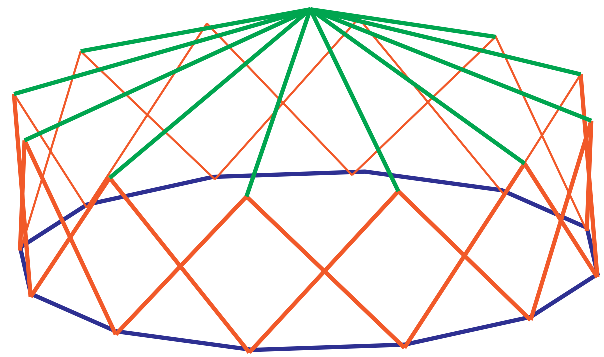
The octagonal folding frame is an example of forming a regular shape with an 8 sided lattice wall. Experiment with adding differnt roof configurations to explore the adaptability of folding frames!



Hexagonal frame

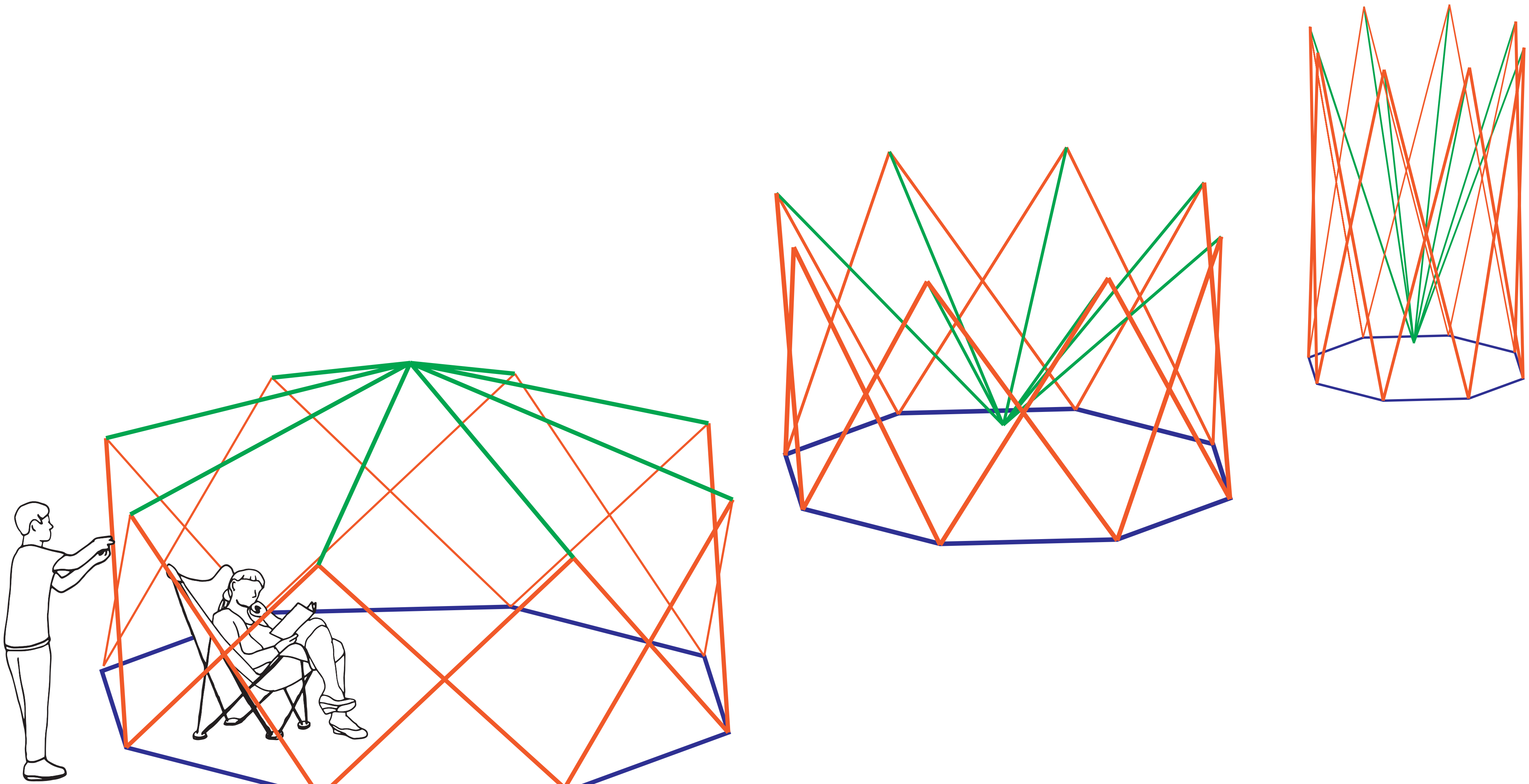


Octagonal frame



Dodecagon frame

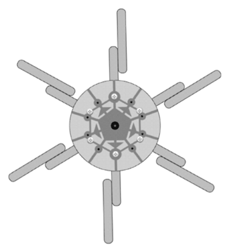
Folding frames can be created in every basic regular polygonal shape. Experiment with building different sided frames to explore folding structures more!

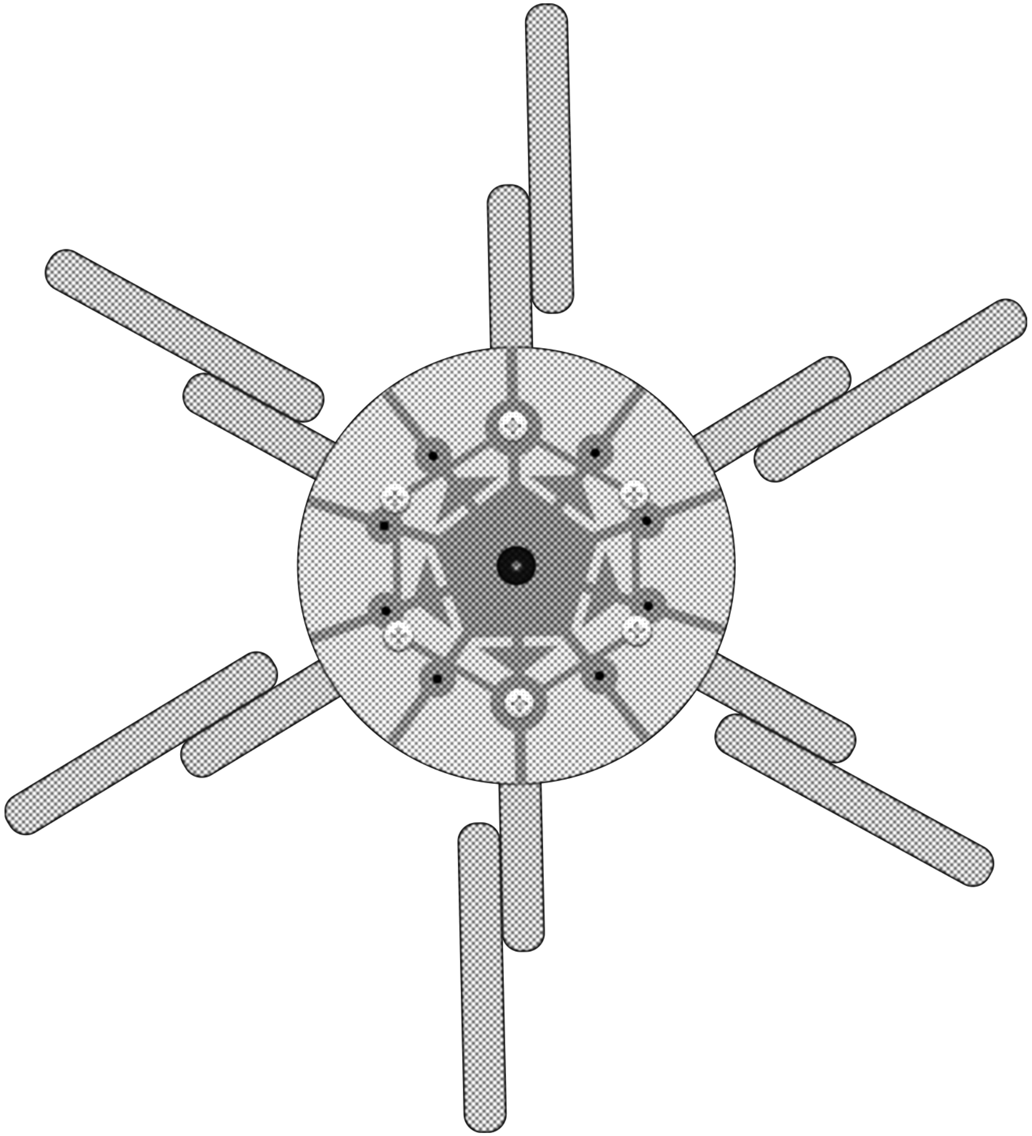


With your frame built, try and cover it with a tarpaulin using spring clips to fasten it to the poles.

You should have learned something through building structures, enjoyed being outdoors, and have been inspired by the structures you have made!

Geo-Hubs can be used to create many more structures than shown in the instruction guide. With enough hubs the possibilities are vast. Continue to create and discover more potentials of Geo-Hub made structures.





Section 2: Project Development + Research

Parts Development Timeline

At the start of the project i was initially aiming to use plywood as the making material with the initiative of developing cutting templates that were easy to cutout using simple making techniques and processes.

Through trial and error over different stages of prototyping i have managed to produce a large amount of completed functioning joins and have progressed to a stable stage with the idea, though i have came to the conclusion that a final product will need to be manufactured in a more stable and stronger material than plywood. I want to work towards the production of the parts by injection molding recycled plastic parts, maintaining a sustainable ethos with the product utilizing natural or recycled materials as should any design.

There are too many problems with plywood splintering and taking a very long time to cut and finish by hand or machine. The project requires high volumes of objects to be produced from prototype to final product, and the next stage of making has to be changing the manufacturing to molding parts.

Stage 1 Prototype
- Brass model

Stage 2 Prototype
- Testing the rubber plate concept

Stage 3 Prototype
- Rope threaded arms test

Stage 4 Prototype
- Better quality version with strong cord

Initially my aim was to use plywood to embrace an element of sustainability as wood is a natural renewable material. Over the 7 stages of prototyping plywood provided me with a lowcost method of prototyping and testing but towards the end i have begun to realise too many problems using the material with intent of it being a manufacturable product.

Stage 5 Prototype
- Screw pivots with paracord

Stage 6 Prototype
- Screw pivots with paracord, marine ply, sealed and laquered, with guide decal stencil.

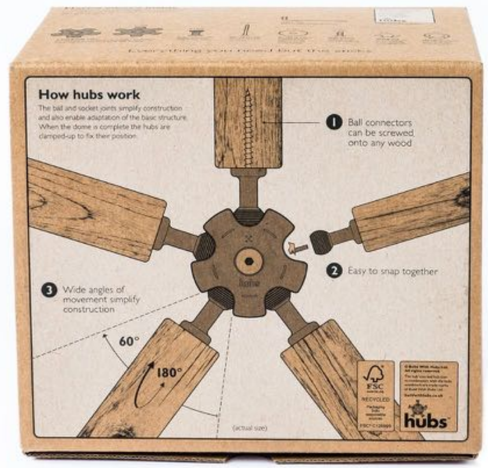
Stage 7 Prototype
- Rendered chunkier version with more strength, suggesting the appearance of injection moulded nylon parts

With a lot of time consumed sheerly by having to produce large volumes of parts to test the hubs at each stage of development it has become clear that producing the product in wood is not as viable as first thought. It requires too much time sealing and finishing to attain a result that still has a lot of weaknesses.

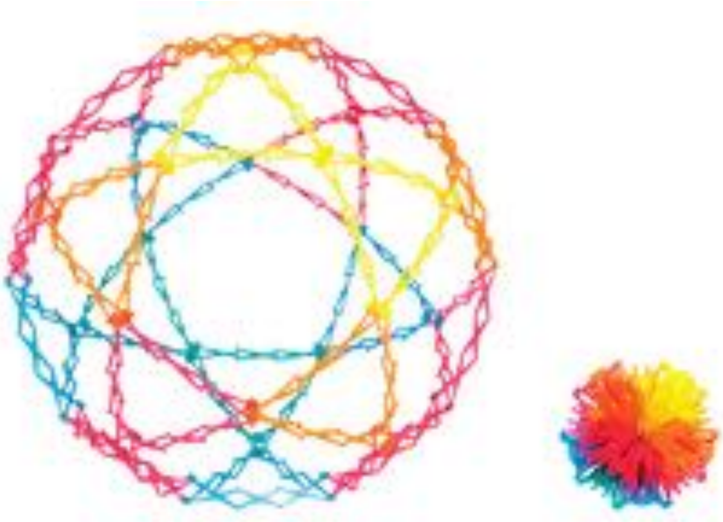
Product Research

Above and to the right: 'Macian' By James Fox

Below and to the right: 'Hubs' geodesic building funded from kickstarter

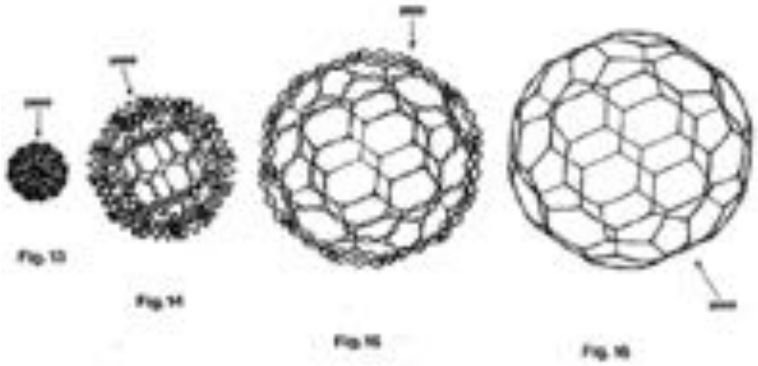


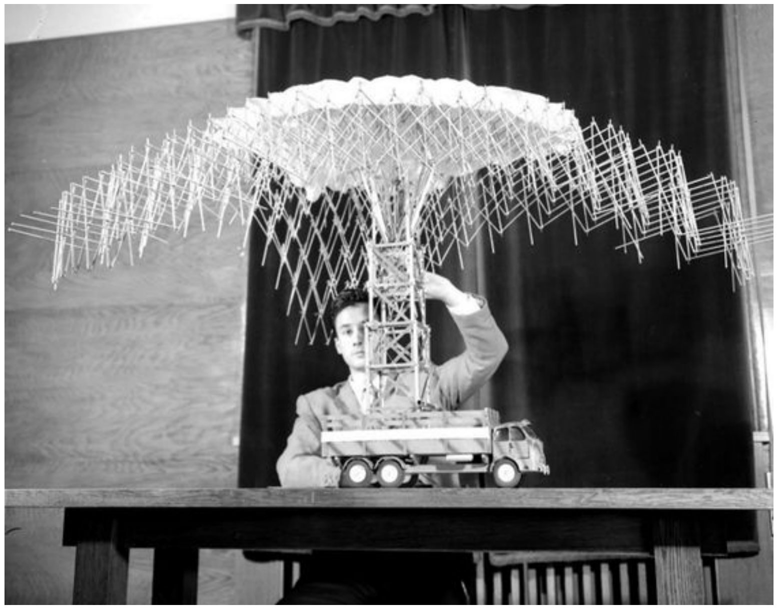
These are all toys that encourage creative investigation and learning about construction. I want to create a product that can acheive this level of play and interactive learning at a full scale in and outdoor environment.



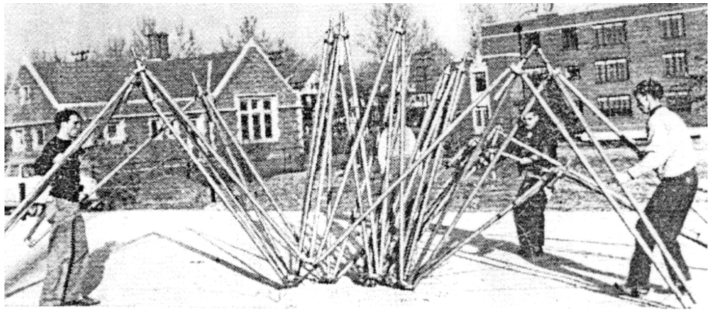
Hoberman Sphere Toy - Chuck Hoberman 1995

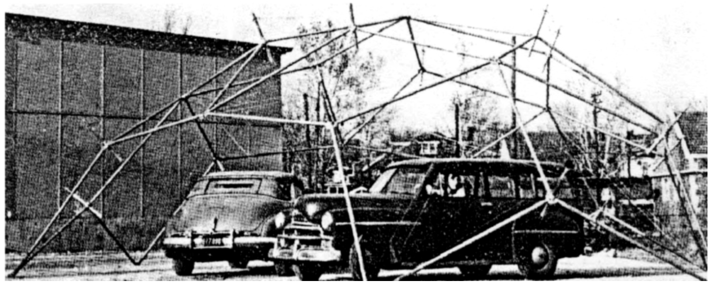
Structural Visual Research

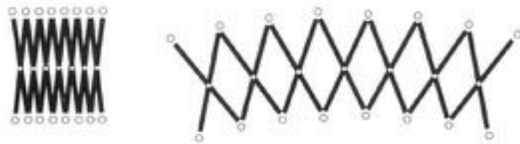


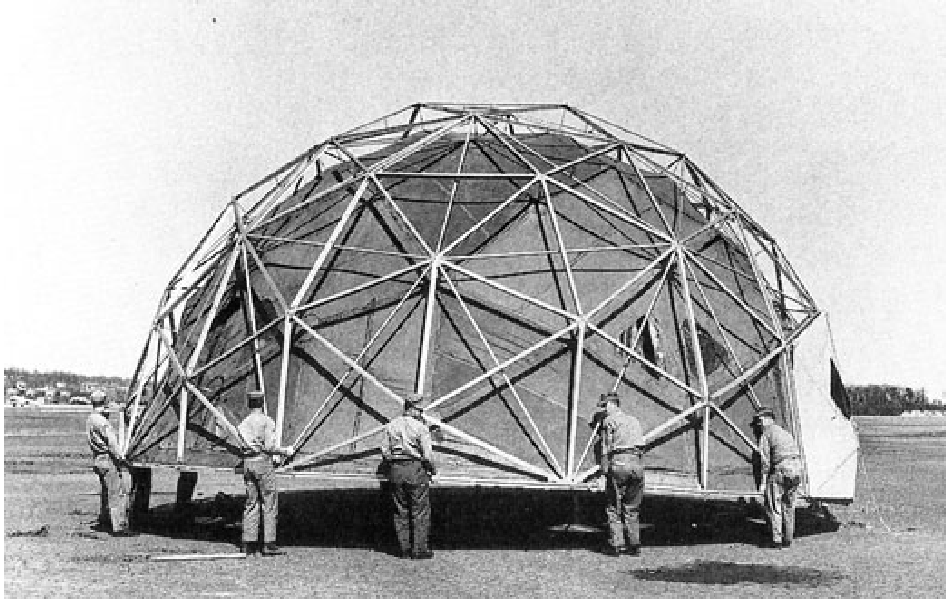


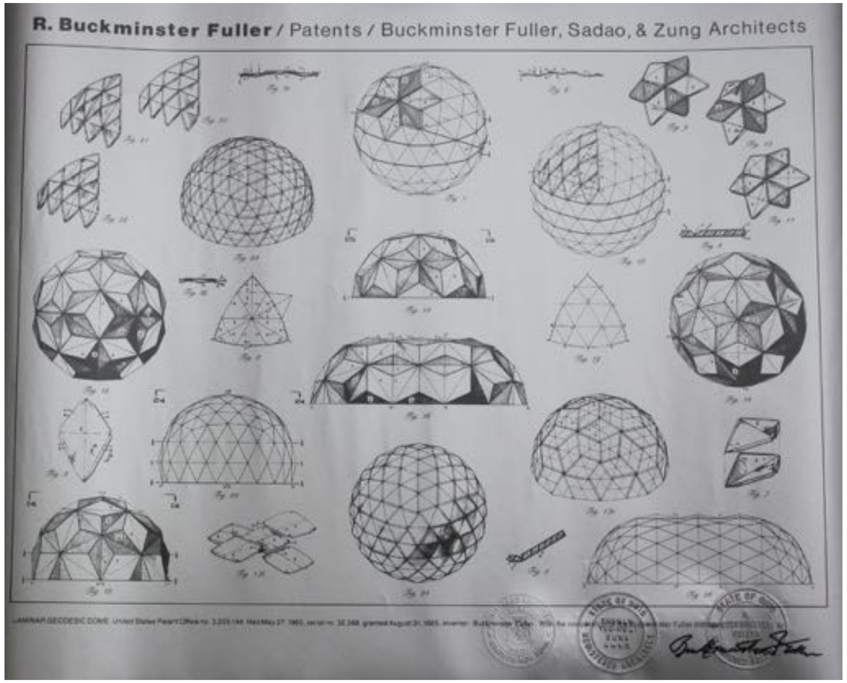
Emilio Pinero's Mobile Theatre Model

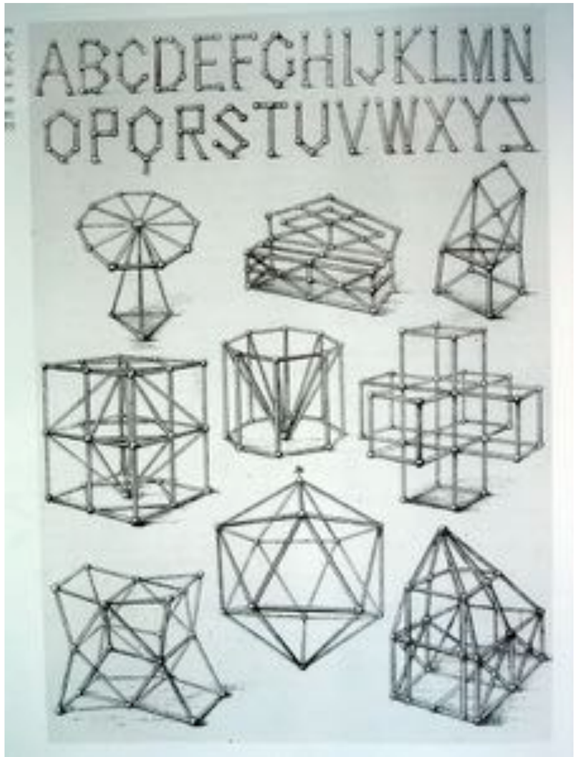









R. Buckminster Fuller / Patents / Buckminster Fuller, Sadao, & Zung Architects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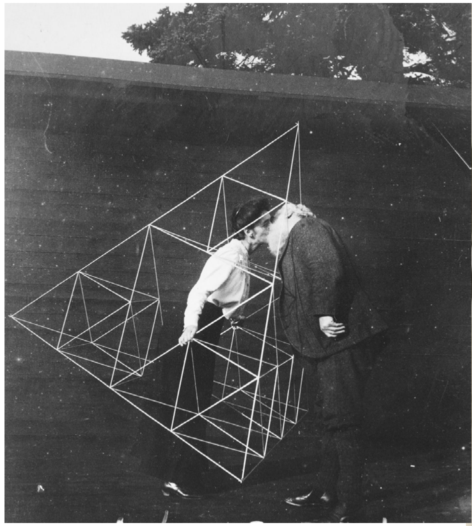
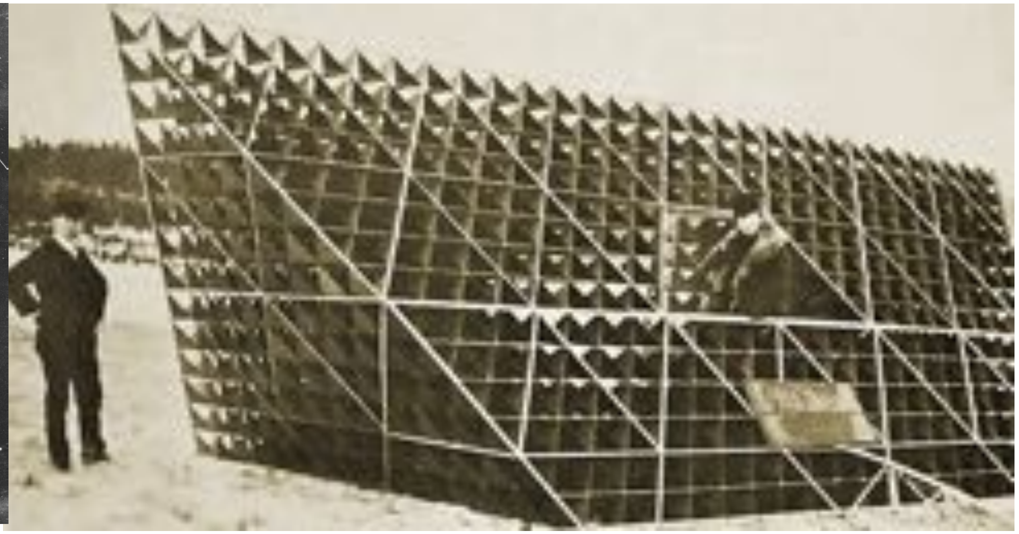
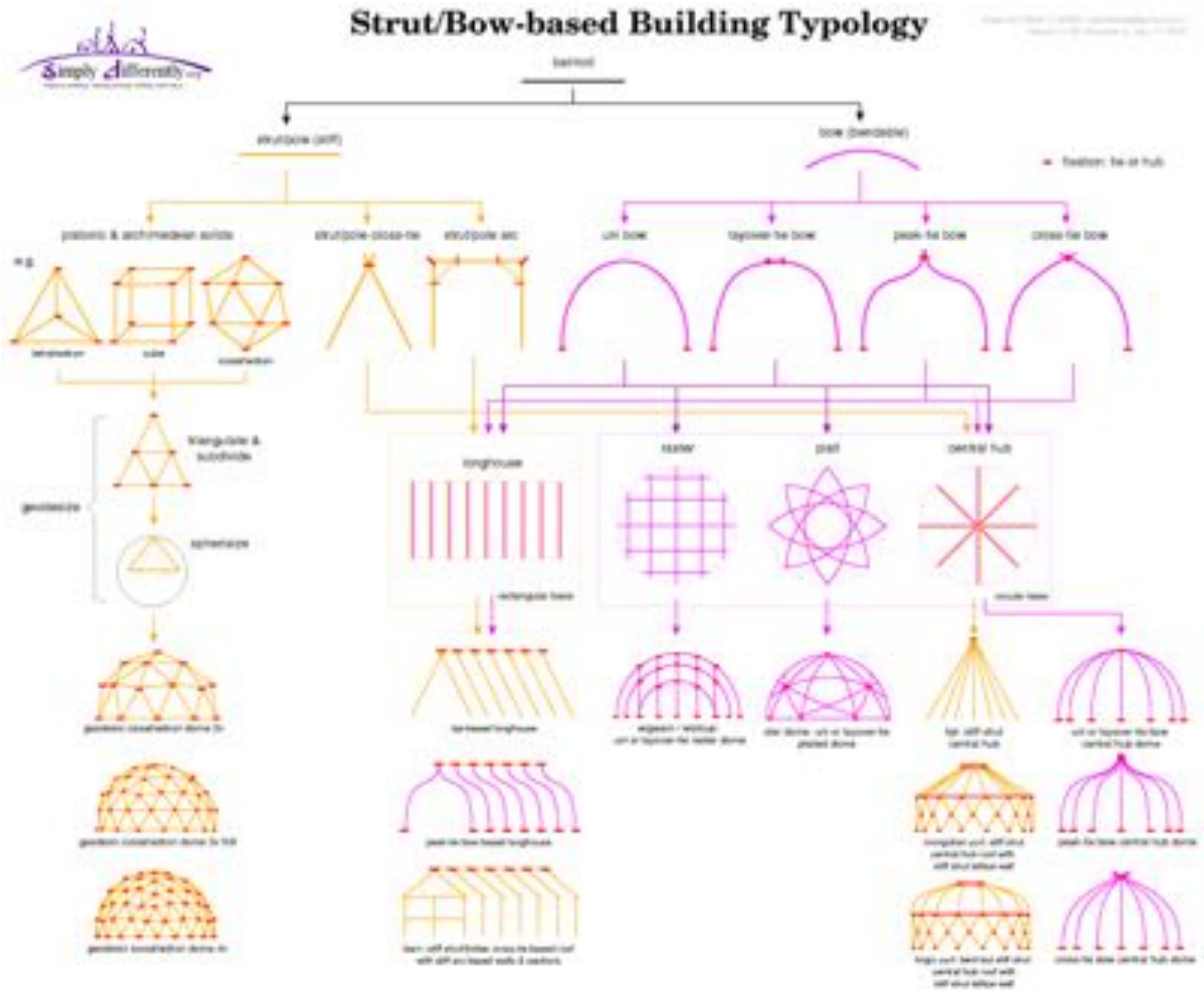
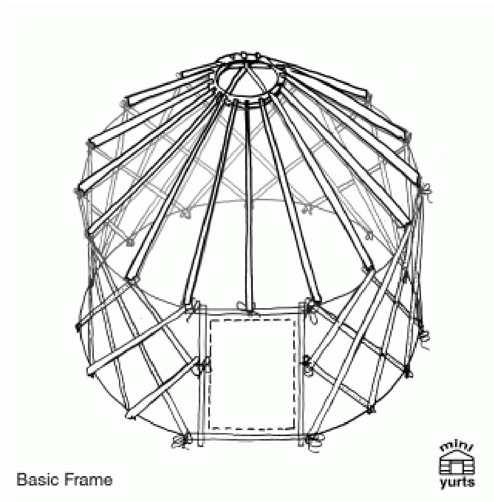


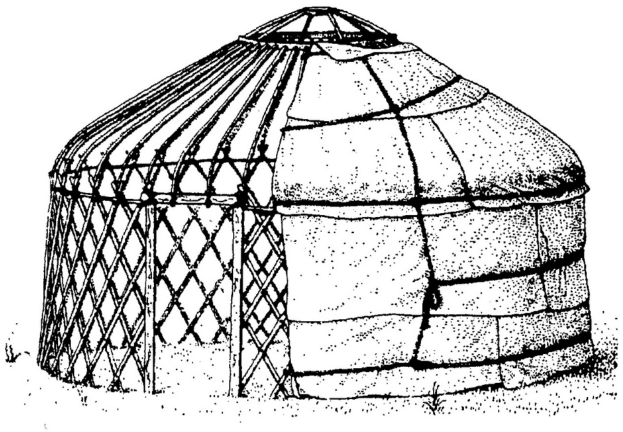




Left: All different structural styles of dome.

Image Sourced: https://simplydifferently.org



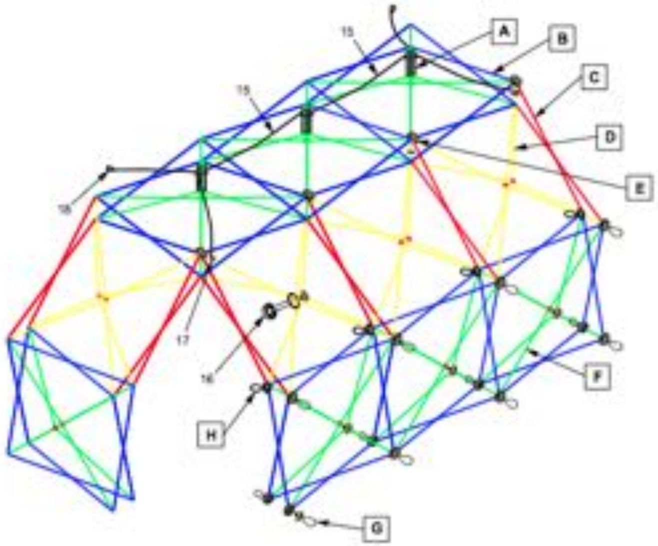


Traditional Mongolian Yurt drawings.

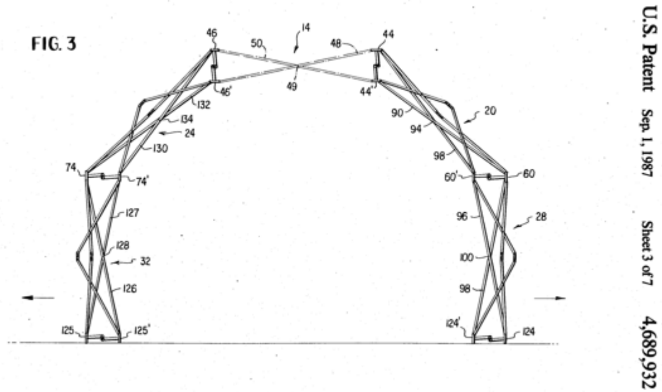
Multiplex Yurt

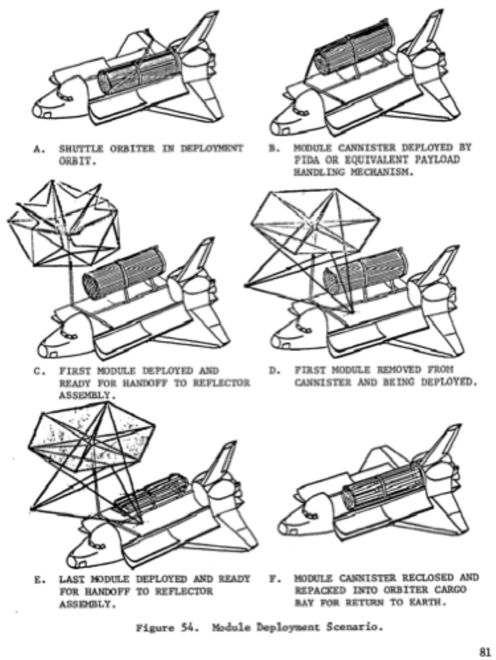
GRS Decontamination Shelters

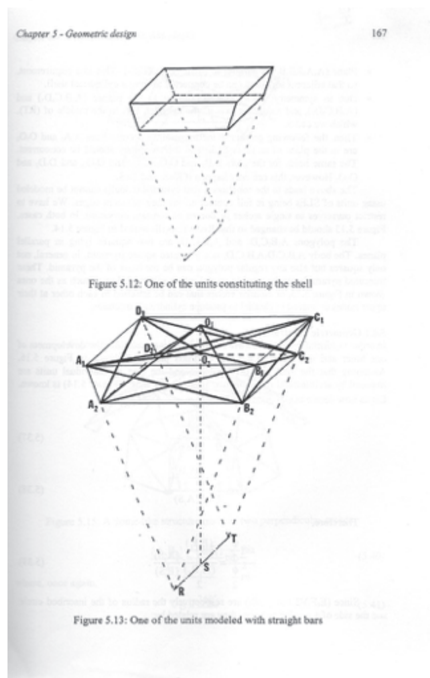
Revostage



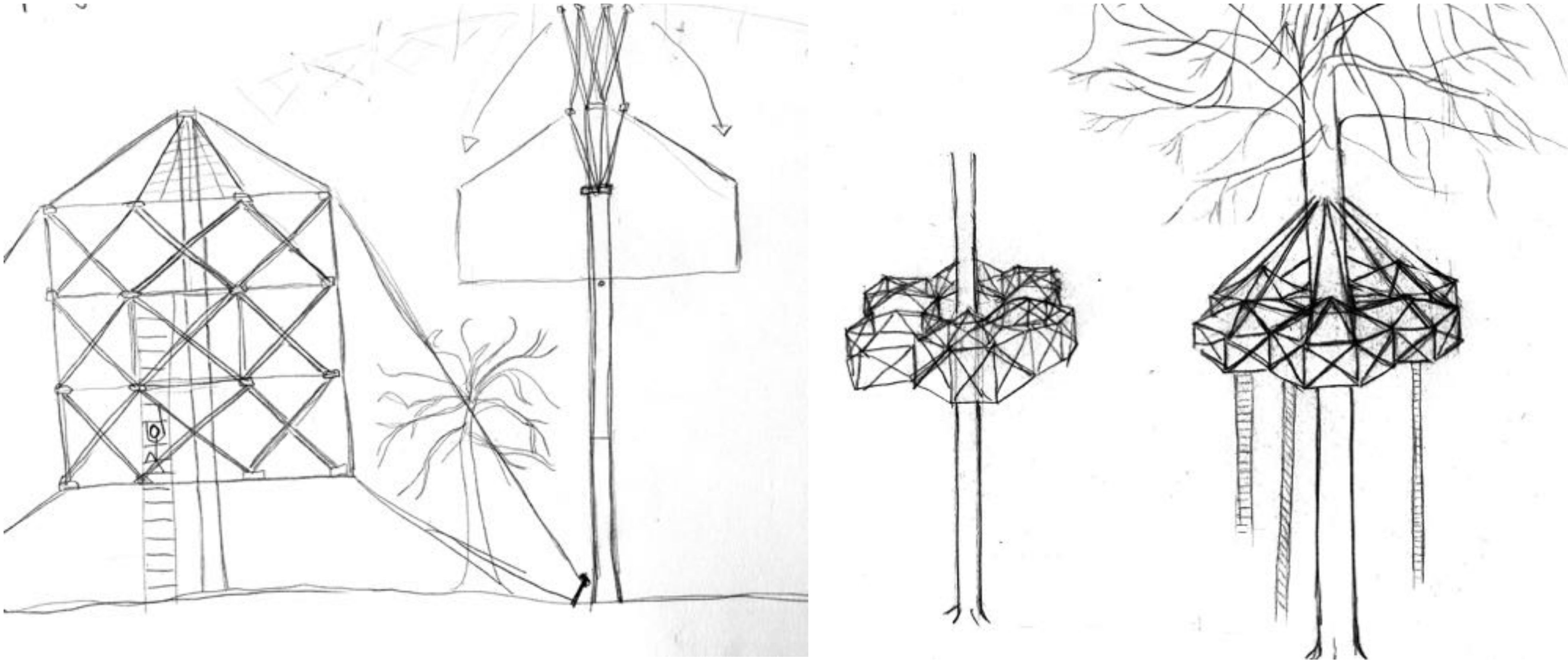
Above and Below: DRASH folding military shelters







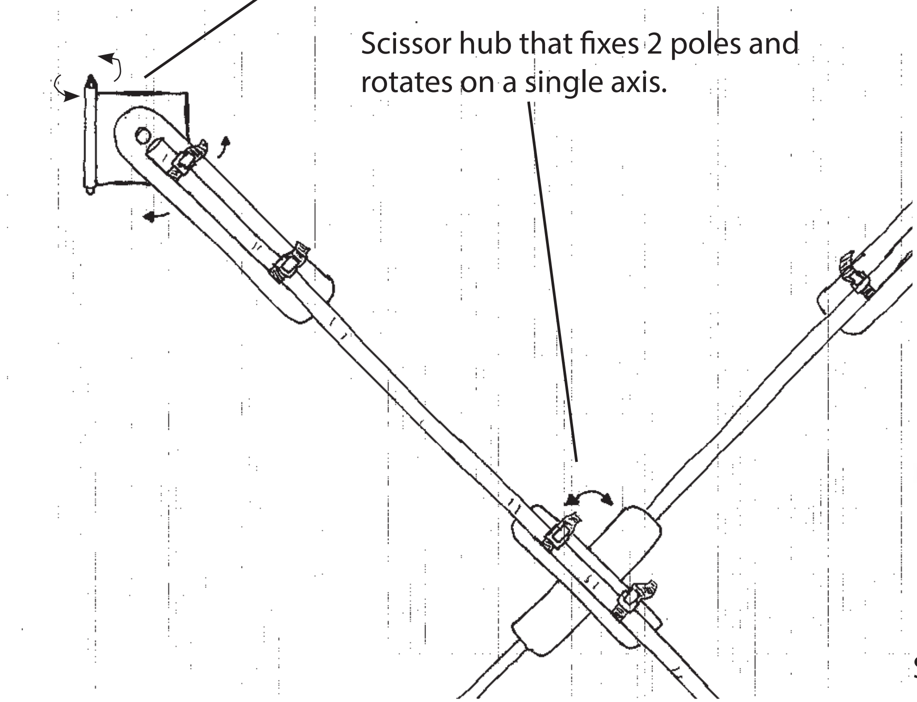
Informed by some visual research on structures and products, comprising of triangulated linear structures and scissor folding structures, the aim is to achieve creating a product that can build and experiment with these high-tech linear structures using low-tech materials like branches found in the woods, PVC pipes, cardboard tubes, 1x2" timber etc.

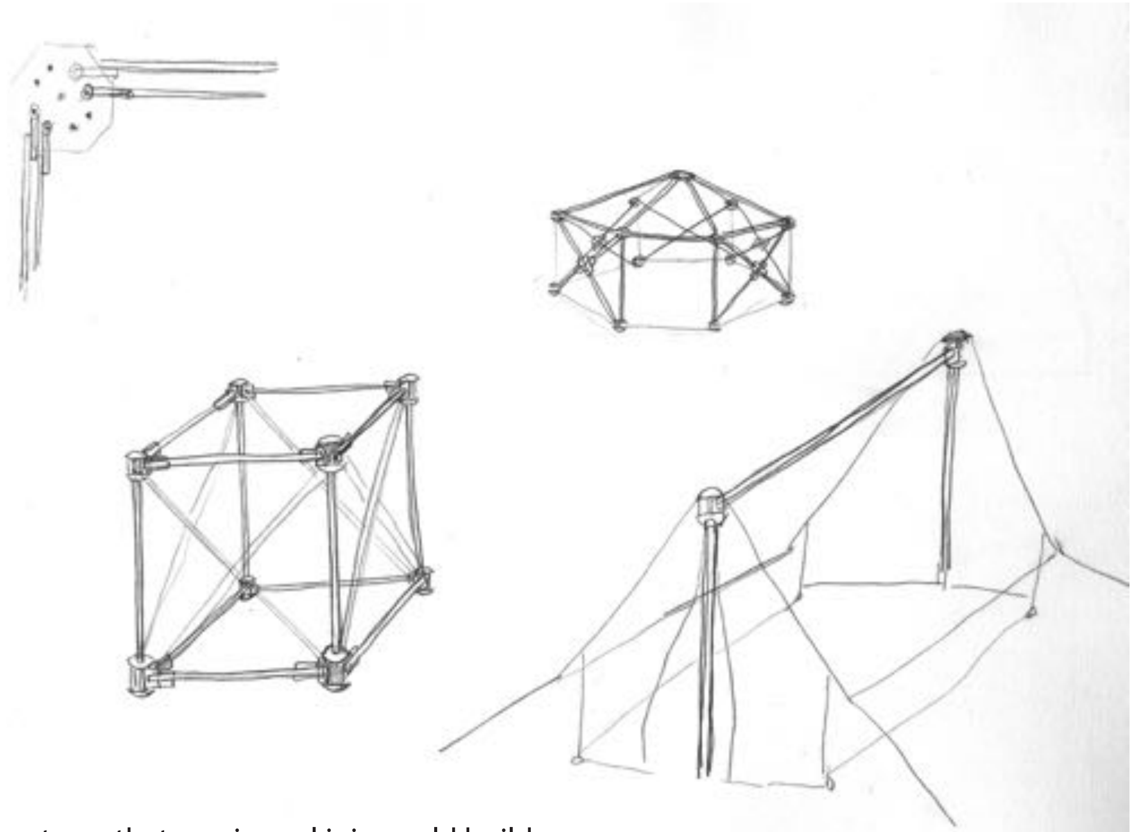


Above: Imagining tree tops structures

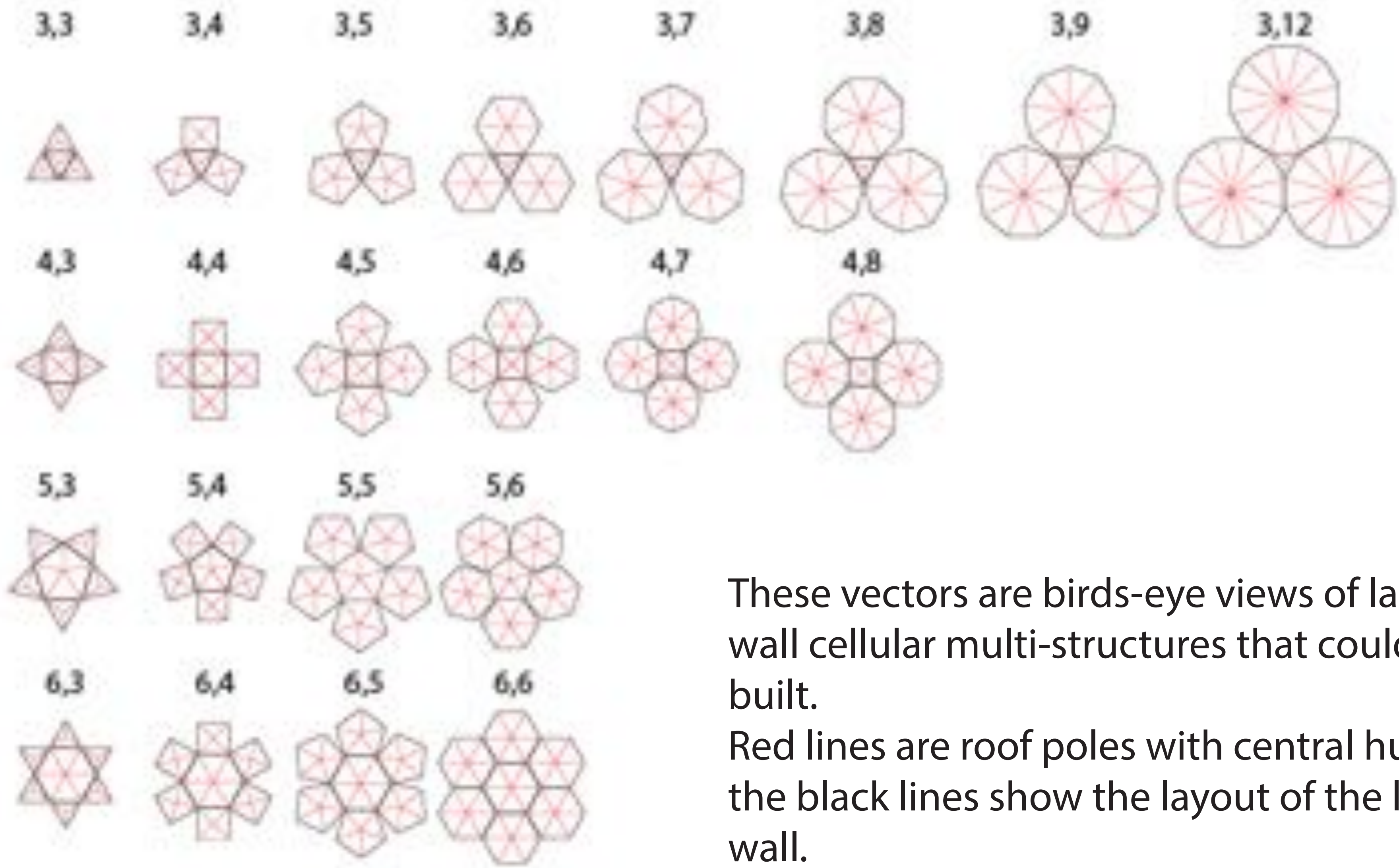
Ability to strap to a pivoting arm with 2 axis of motion.

Scissor hub that fixes 2 poles and rotates on a single axis.



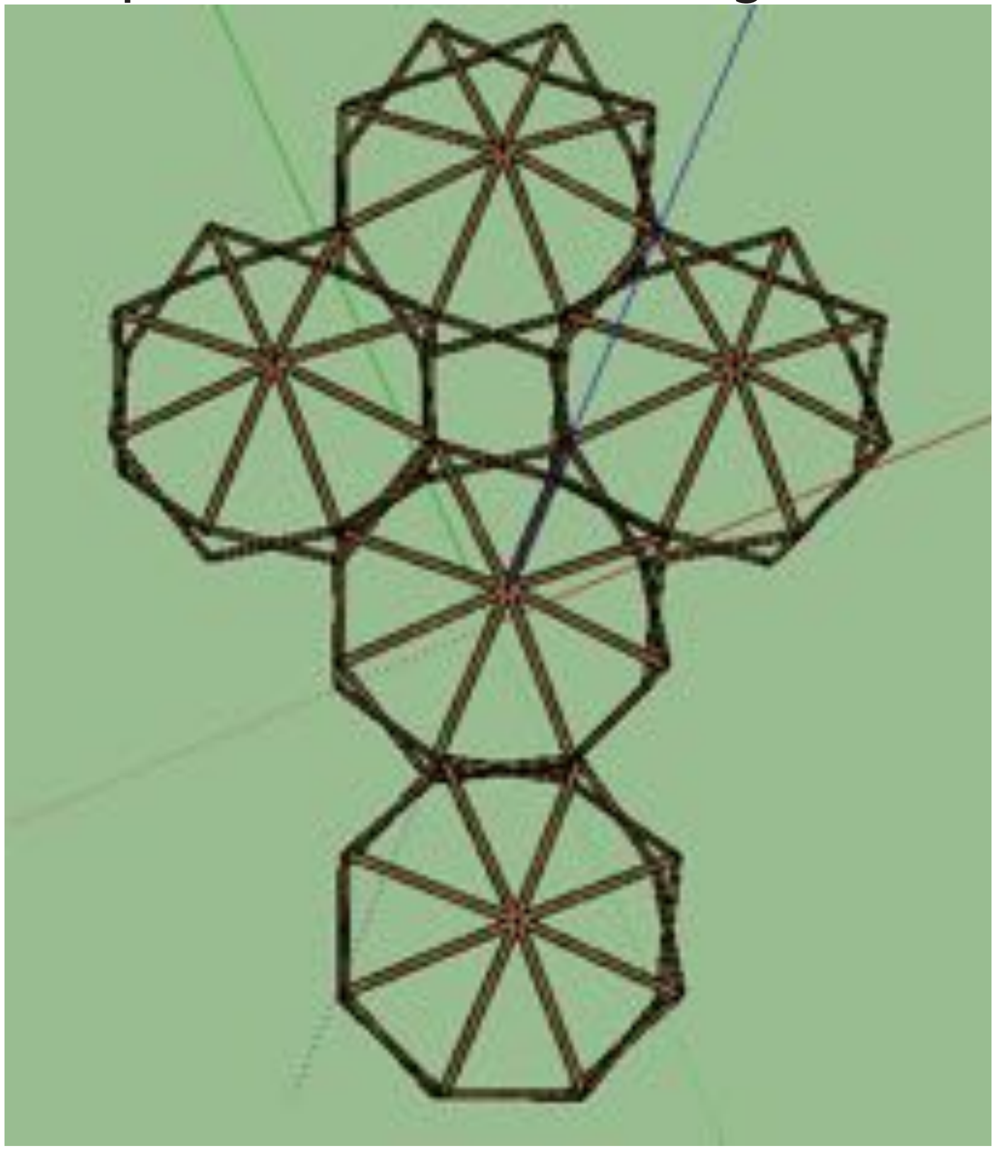


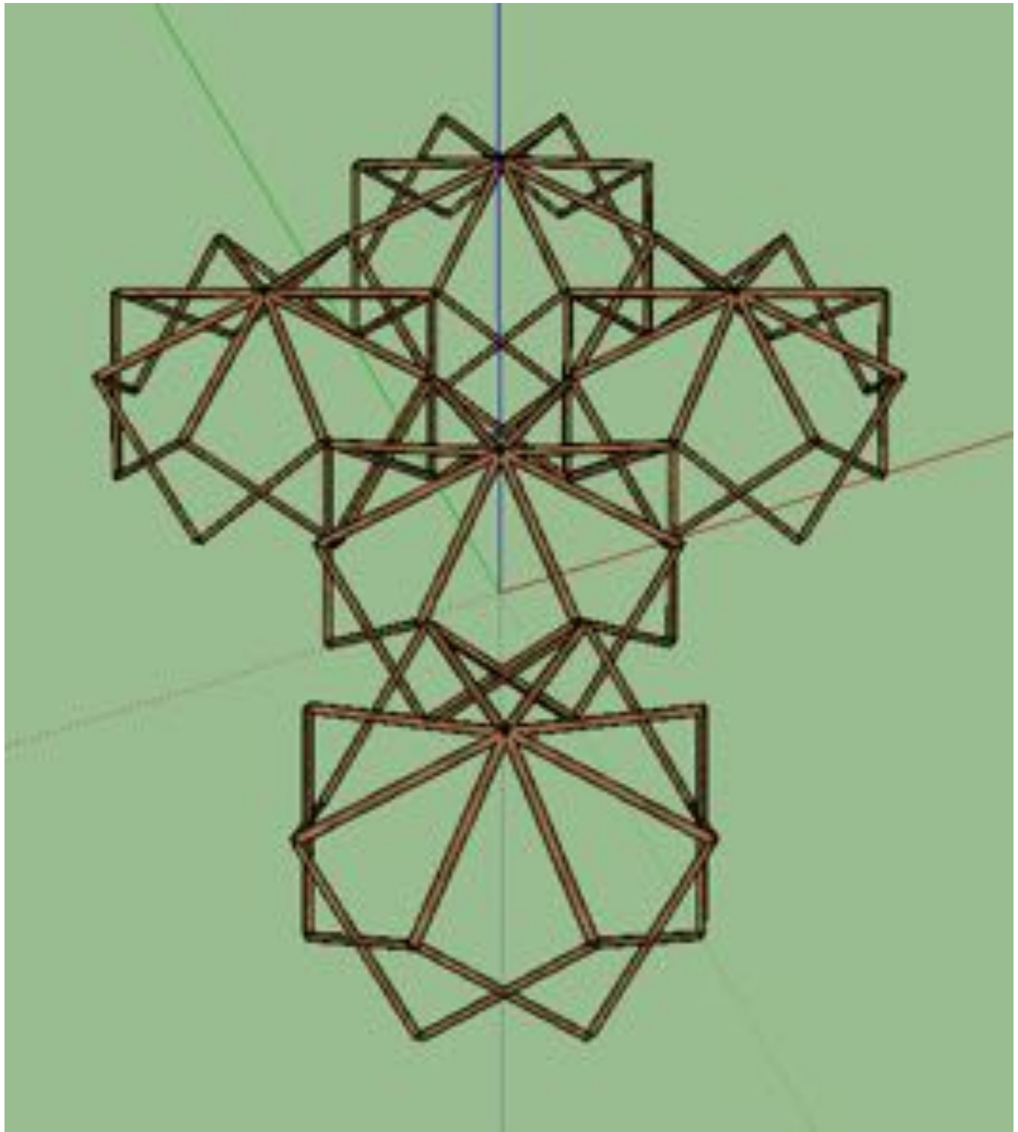
Structures that a universal join could build.



These vectors are birds-eye views of lattice wall cellular multi-structures that could be built.
Red lines are roof poles with central hubs, the black lines show the layout of the lattice wall.

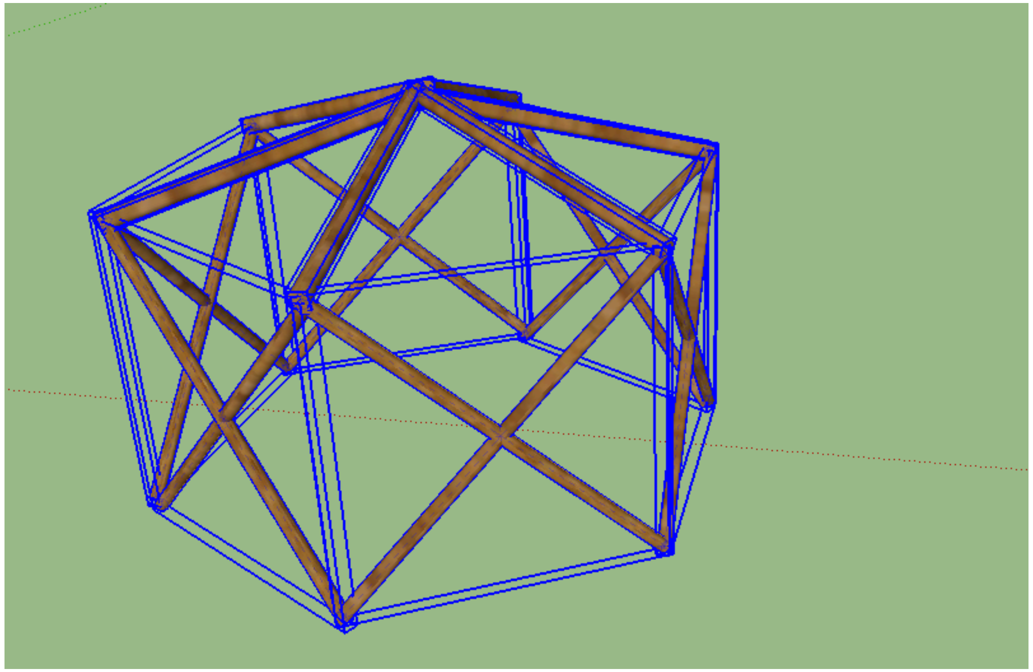
Some ideas of a multiplex frame that with enough universal hubs and poles would be potentially possible to construct. *The frame would be able to collapse into a smaller configuration.

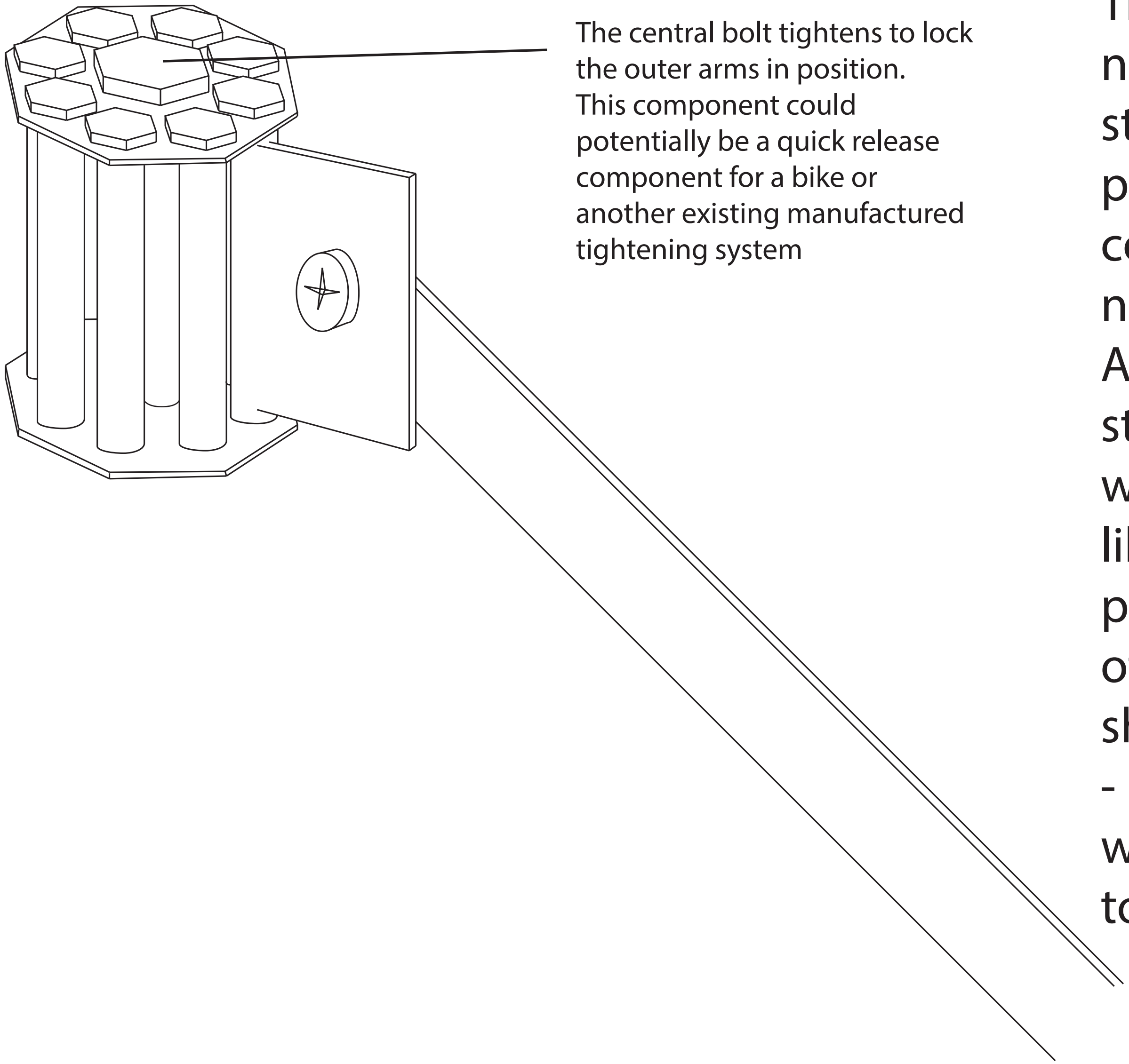




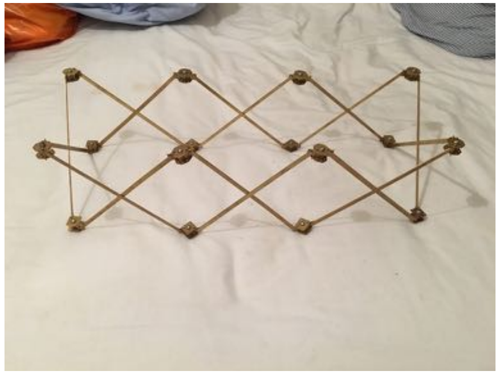
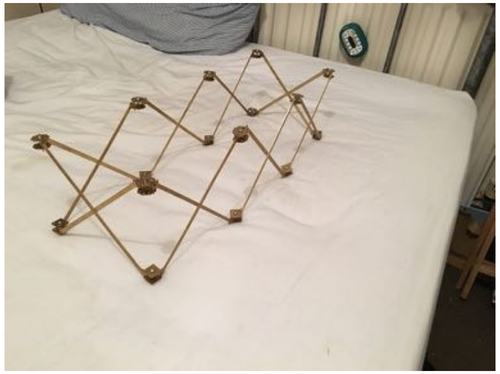
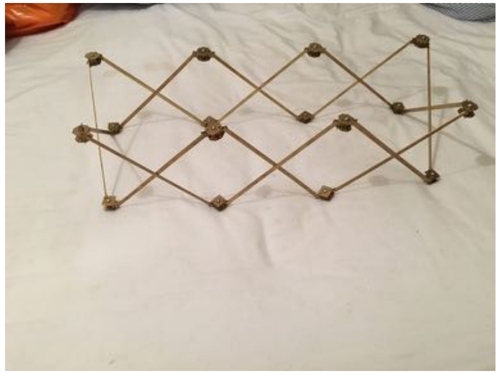
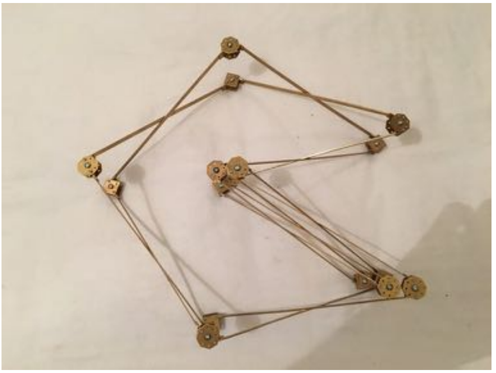
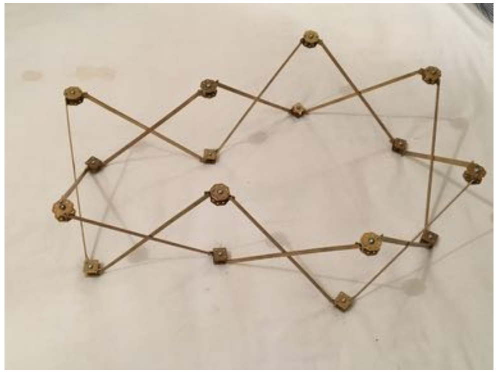
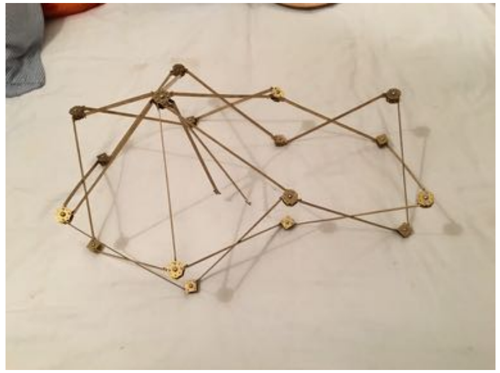
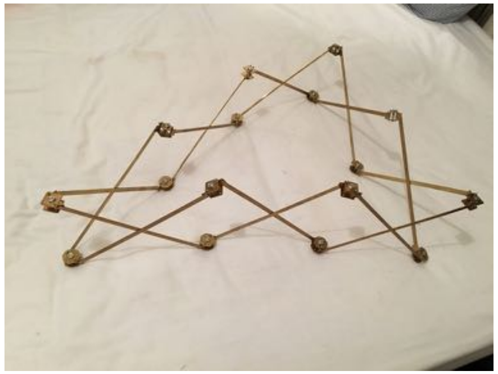
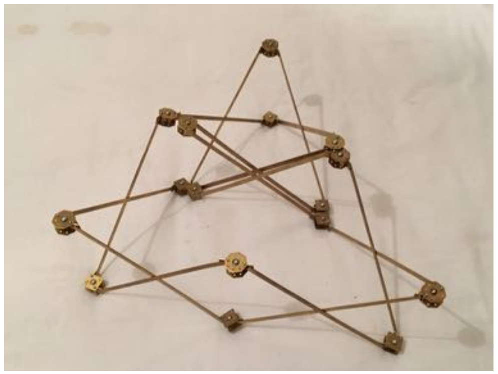
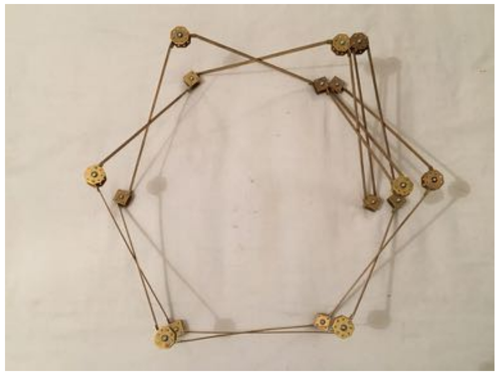
Stage 1 Protoyping

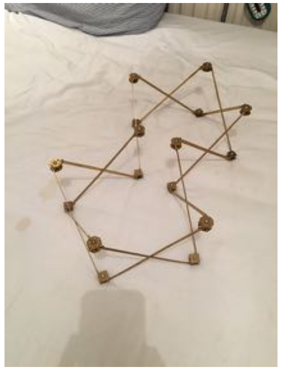
- Watch my model making process in '3D Proposition making video' on the memory stick provided with the PDF.

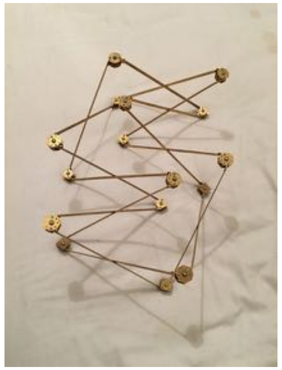


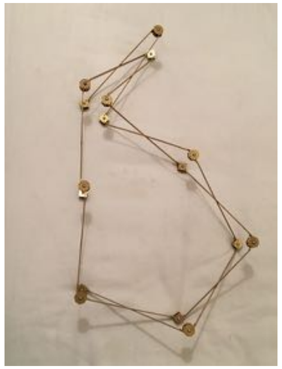


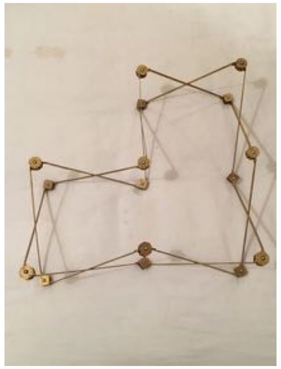
This illustration depicts a join/ node or hub, that can allow lattice struts to attach to adjustable fixing points, allowing the framework to be constructed from as many faces as needed by the user/builder.
Allowing somebody to create a structure with as many faces as desired would accommodate for situations like having a lack of materials and provide people with a greater feel of involvement when creating their shelter.
- If the join could fix any material then it would hold ultimate freedom for a user to create a structure.

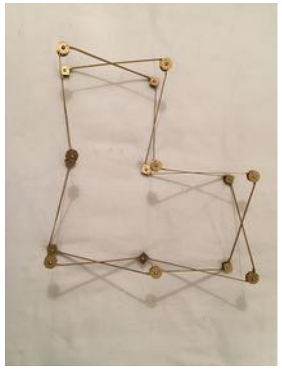










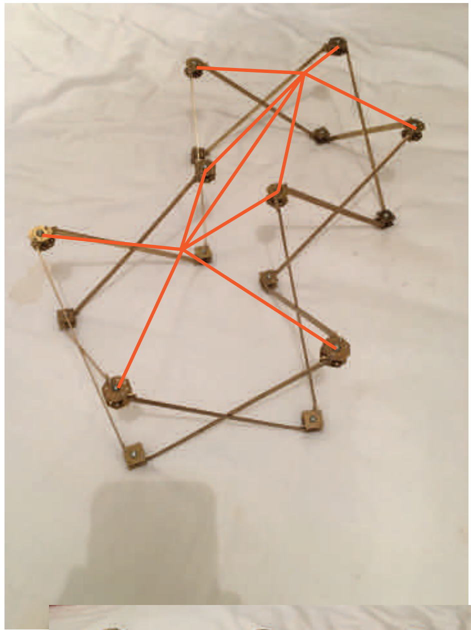


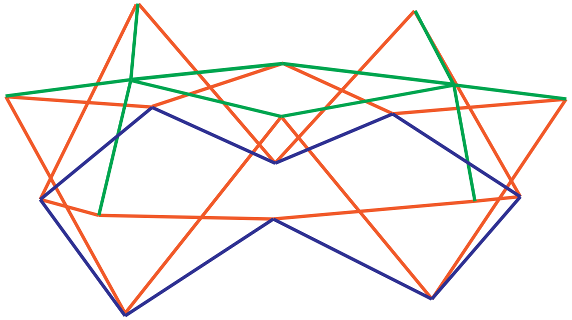


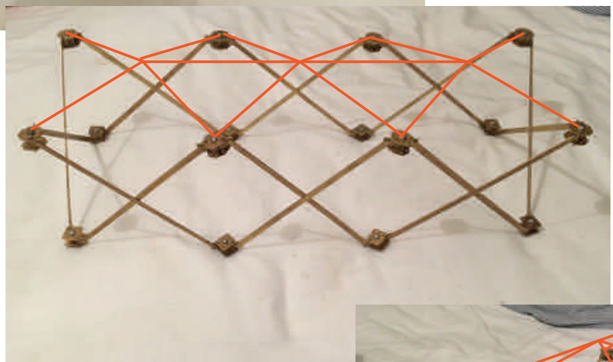


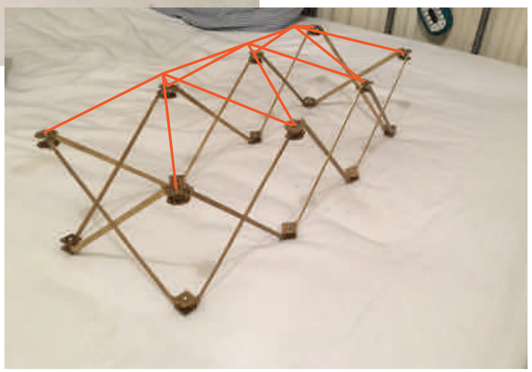


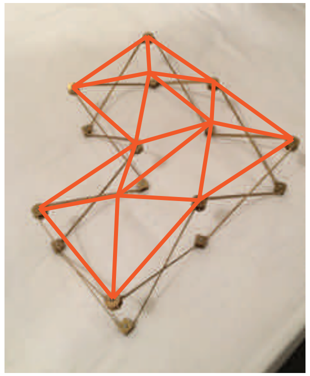


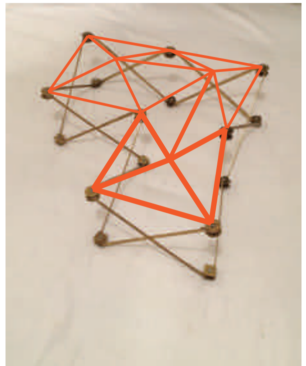


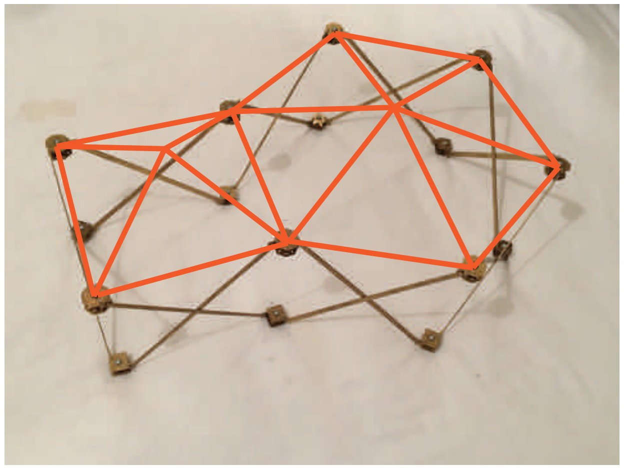




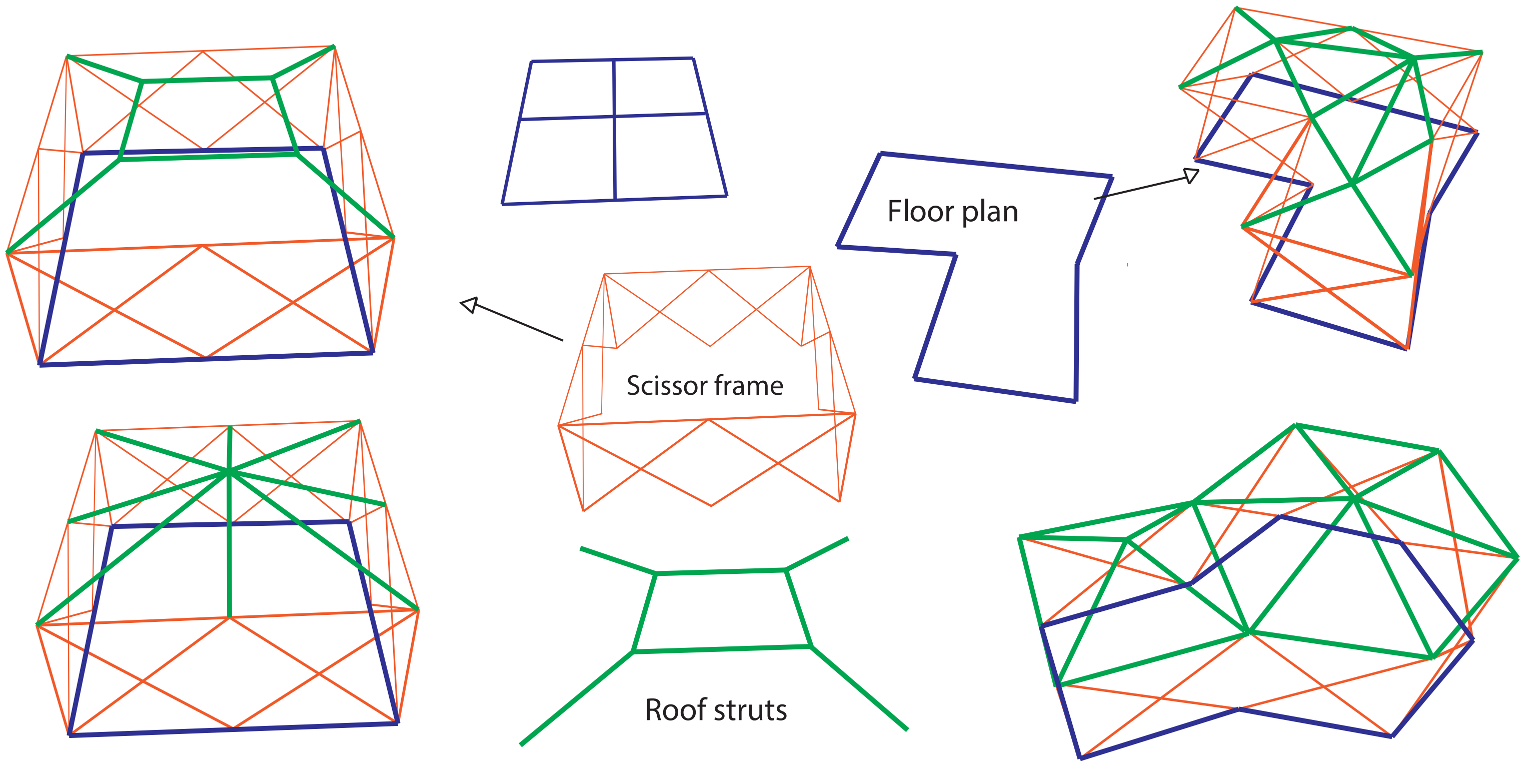


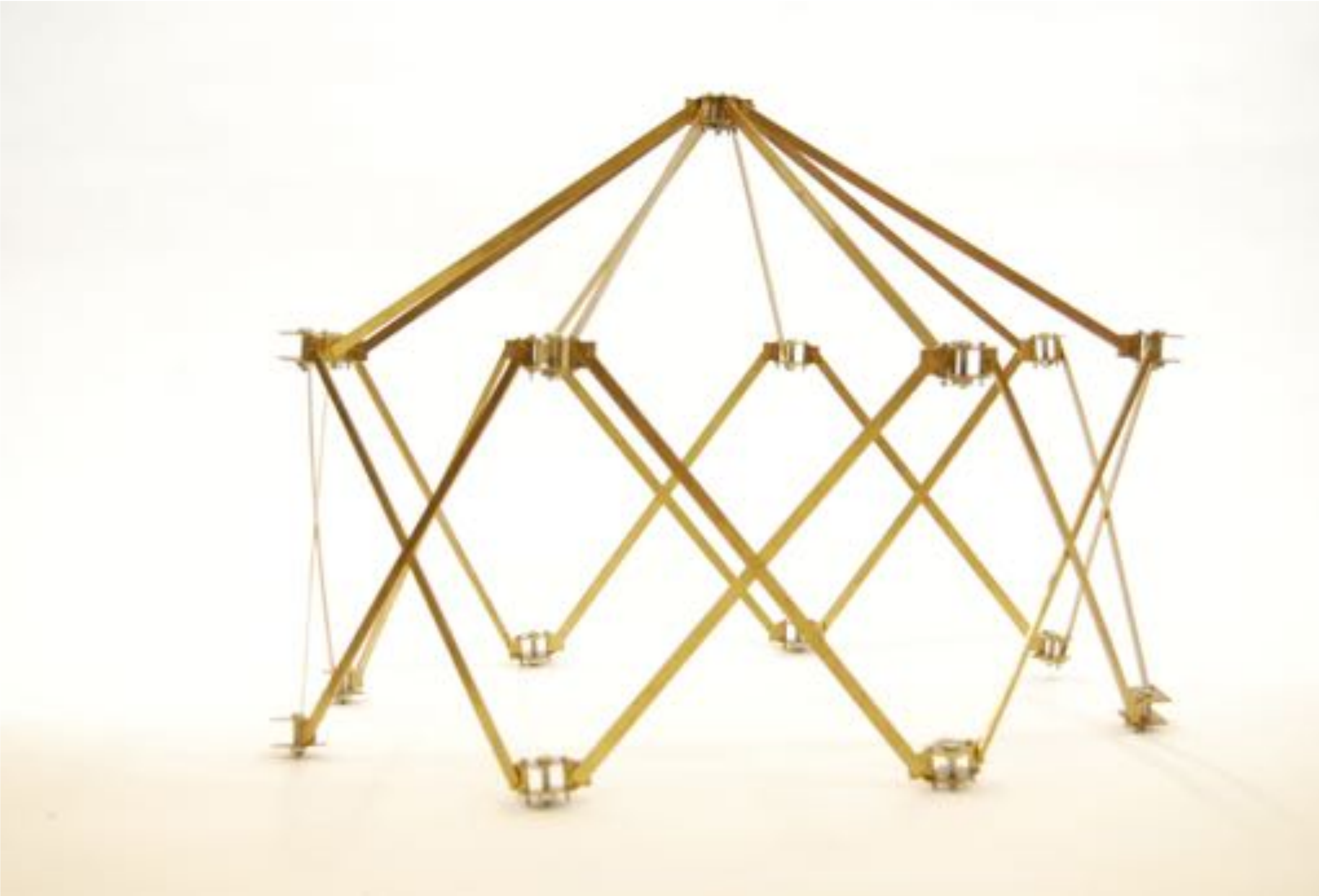






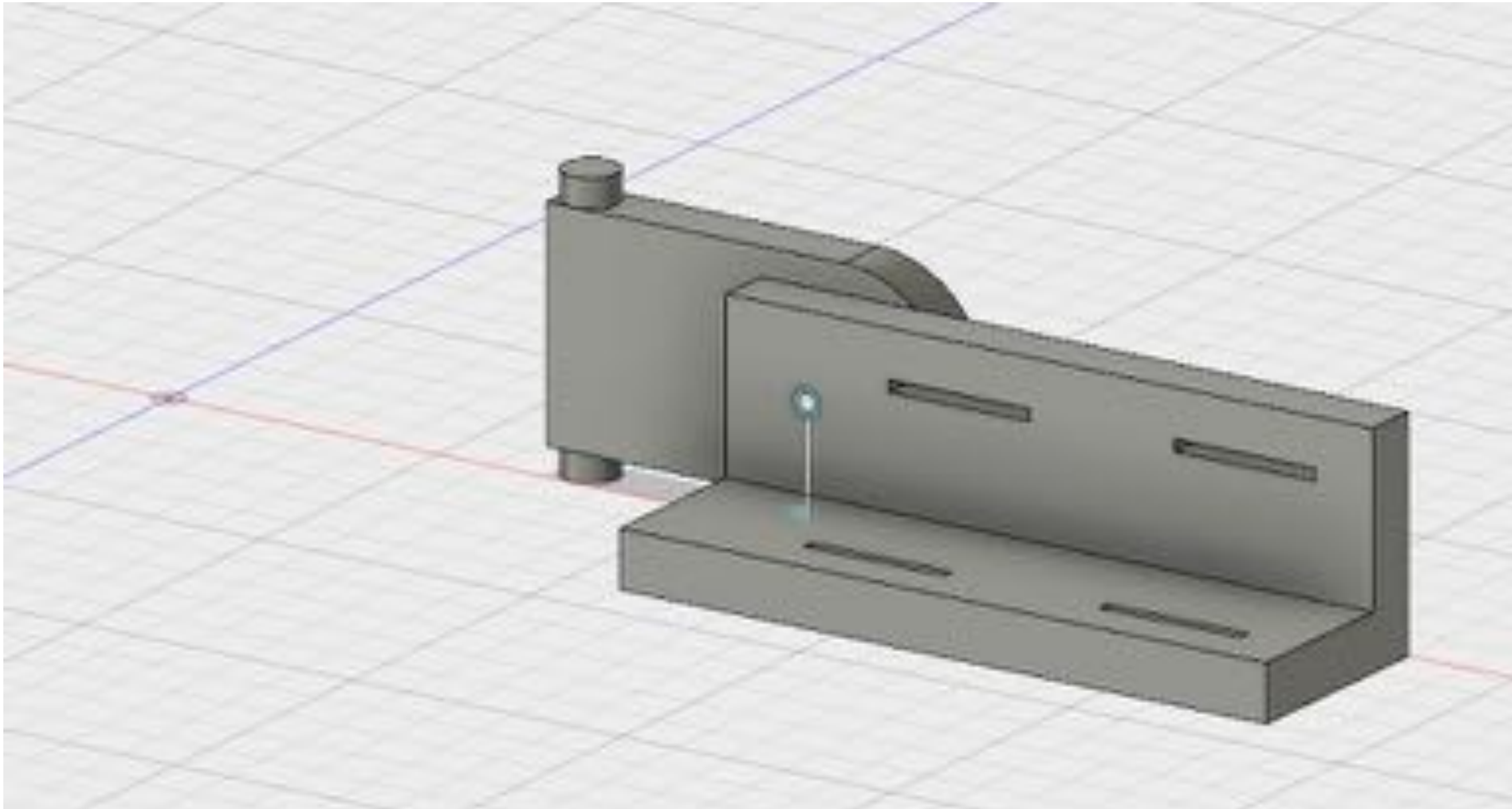
At this stage, playing around with the lattice wall model made me realize an 8-sided walls potential to adapt to a variety of configurations; something that could be acheived using hubs that accomodate full scale construction.





Stage 2 Prototyping

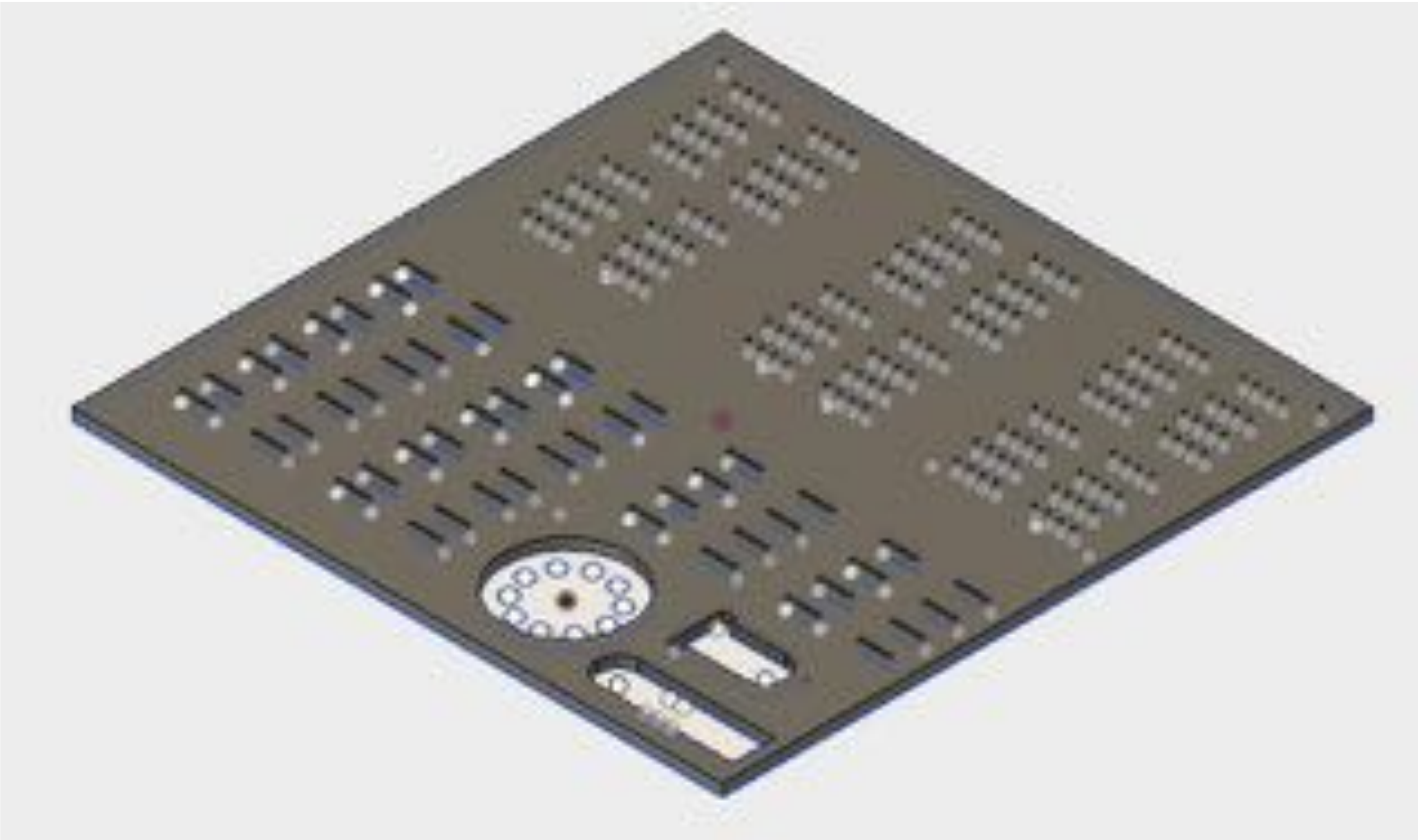
This prototype tests the potential to use rubber plates that will grip the arms in place when the quick release is tightened. The quick release component works perfectly, applying enough force on the arms to prevent them pivoting at all. The rubber acts as a cushioning layer that relieves stress on the wooden material and allows for small increments of movement if it were holding a structure.

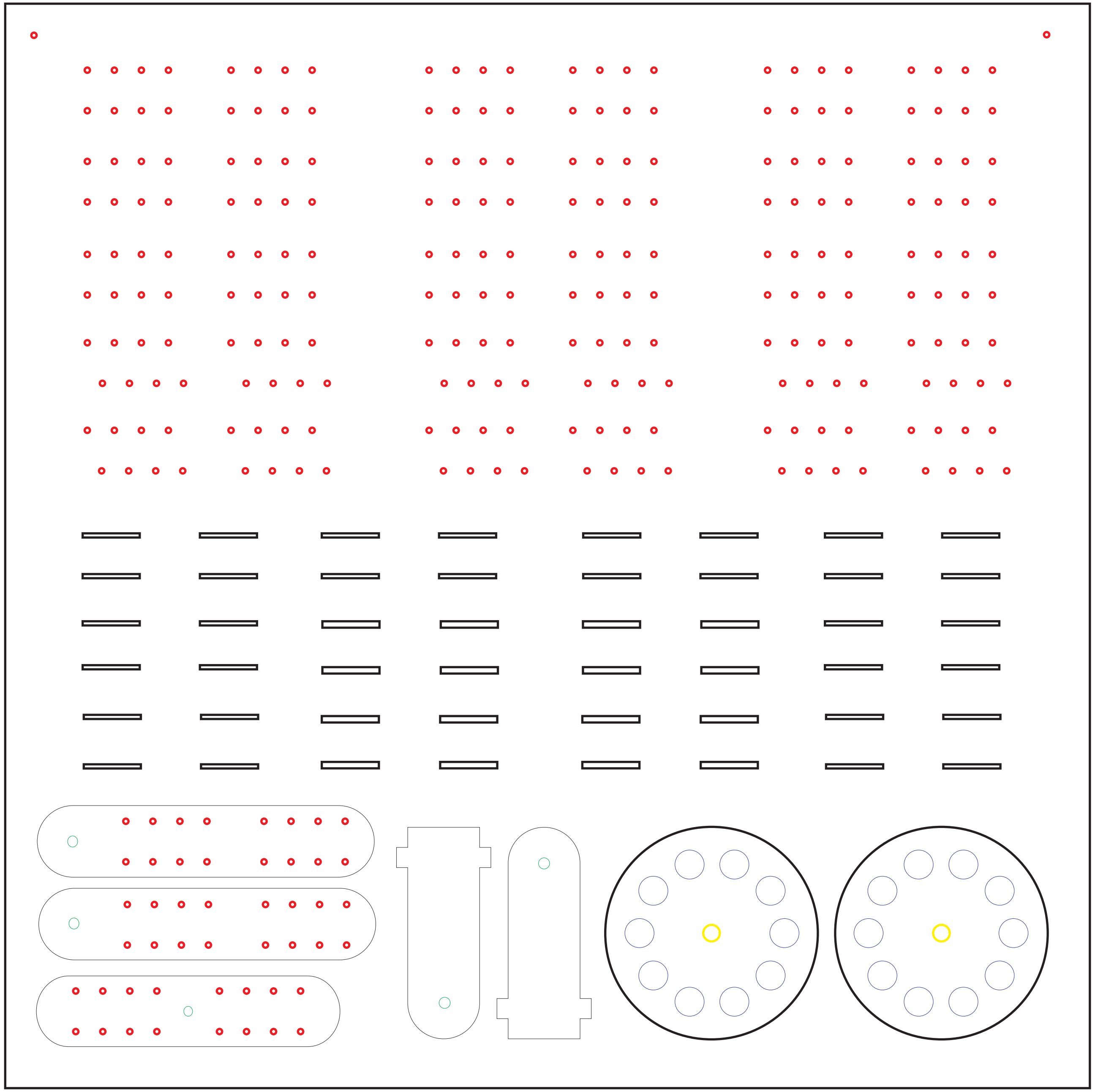


Render for a potenital arm component that would hold 2 straps to fix a length material to.

CNC Routing test

To investigate the potential of prototyping the joins using a machine through to a product, i decided to try out CNC routing. I chose to create a test board with routed grooves and a selection of holes to work out the best methods to attach materials (straps or rope/cord) , as well as some cutout components for the hubs.





This is the CNC layout i used to create the test board and a couple of test pieces. The results were:

- It took a long time and cost a lot of money to achieve something that could of been done by hand in the same amount of time.

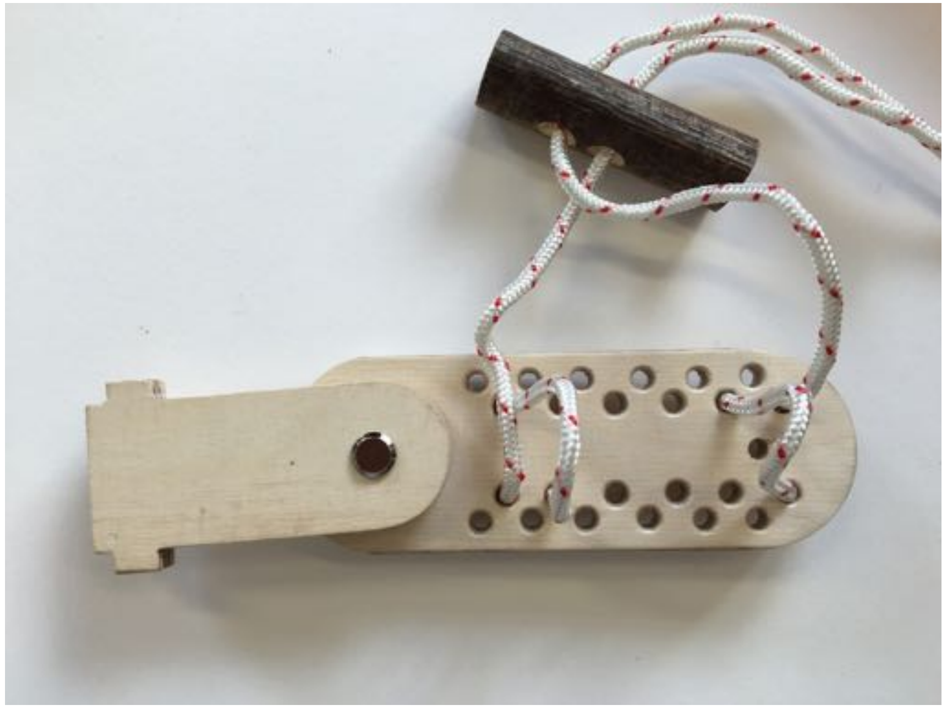
- The test pieces would still require a lot to time finishing the cut edges to make a safe non-splintering surface.

- My verdict was that any further CNC machining was not suitable to produce enough prototypes to research the performance of the designs, whilst at a cost and time effective rate. Hand making costs only time and i do not have the funds to afford machining.

Molding the parts is an option, but it would require work in another material area and detract from my sustainable focus of using wood which is a renewable resource - Unless using recycled plastic which is another large venture in itself (possible collaboration).

Testing a range of straps and buckles lead me to realize that straps were not the right component to use. They did not grip the branch tight enough and came loose quite easily compared to testing toggles and cord threaded through holes. The best decision was to use cord as it is strong and moldable to any shape when tightened.

Stage 4 Prototype



Woodland Test Build

The Kit.

The Location.

At this point with 2 poles at each end and a ridge pole, using 2x 3-way hubs, I wanted to add another branch to each end to let the structure stand freely. Whilst trying to add another arm component, I realized it was impossible to do so whilst the structure was up and when the joins were tight. This made me realize the need to design a method of adding more arms whilst the structure is up.

Folding Hexagonal Frame

- Watch the 'Hexagonal folding frame build' video to view the build in a sequenced time-lapse that displays the adaptability of the hubs as the build progresses.





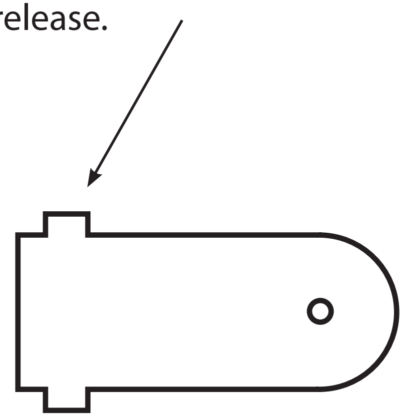

Test Build with 3m PVC pipes. The pipes were too flexible over a 3 meter length to complete the structure, but it was a successful build whilst the hubs worked successfully to hold the structure together.

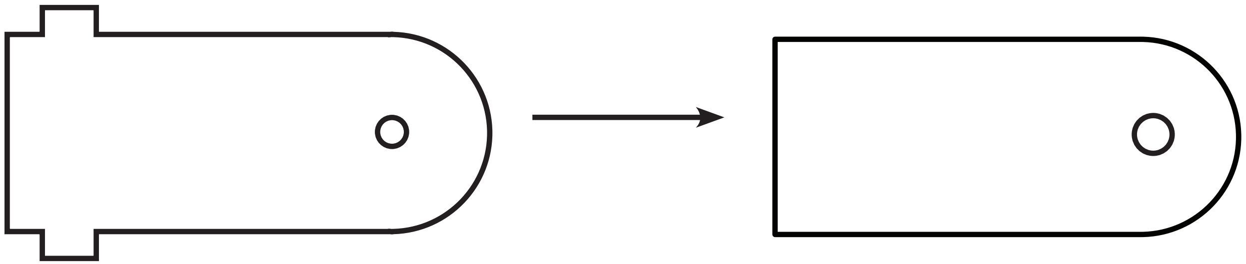
While i left the hexagonal structure outside for the first few day, moisture had penetrated the wood as i had used planed down solid oak topped ply laminate floor. The ply wasn't designed to prevent moisture as it is for interior use. I had to take the joins to a further stage of development a make a lot the next time round. The next material will be marine plywood which is bound with waterproof adhesive

Stage 5 Prototype

Adapting the last prototype, I added screws to the holes and sanded down the arms as displayed below in the diagram.

Removing the nobbles enables the arms to slide into a location on the hub when the structure is already up by releasing some tension of the quick release.



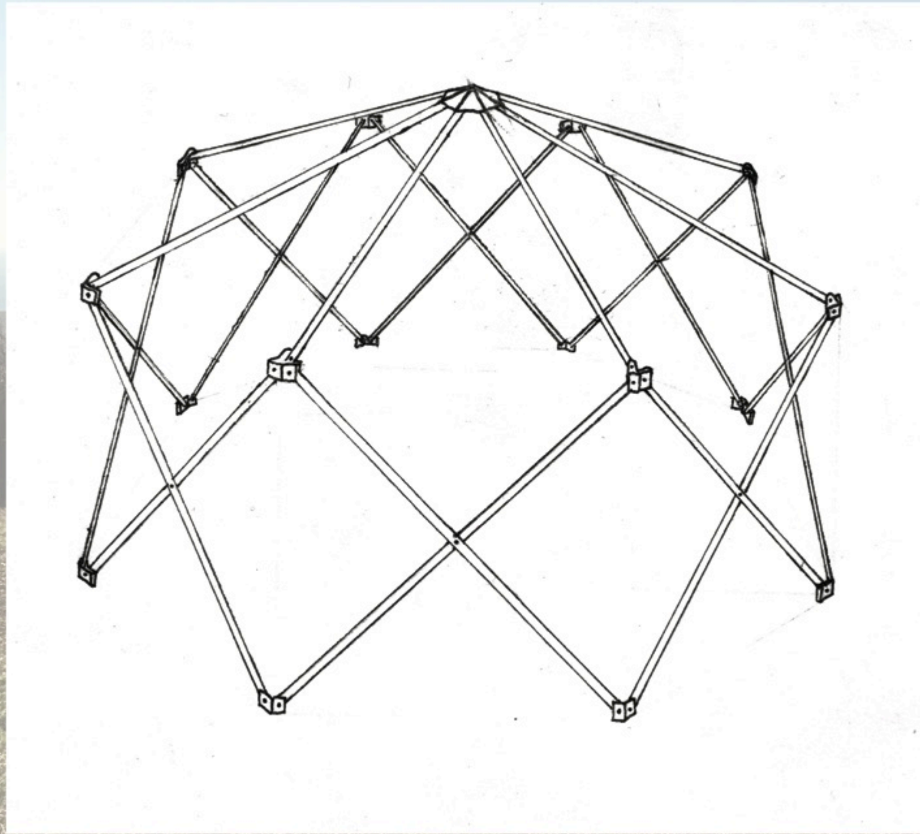


Woodland Survey

My trip revolves around gaining an understanding of how many suitable poles could be harvested to create struts for a geometric / geodesic structure. To do this I've chosen to select a random piece of woodland closest by to my house in Brighton to gain an understanding of its density of available trees.

5x5 meters of woodland = 18 usable branches

Dependant on the density of woodland i can estimate from this:100x100 meters of woodland could potentially have 360 usable branches.



With 24 branches, you wouldn’t need to search far to gather enough to build a structure this complex, even something twice as structural, or even three times.

This trip has provided me with an audit of random woodland, and represents the closeness of a useable piece of populated woodland, that maybe be used within my projects brief for most people who may go and search for woodland.

Woodland Trip - Harvesting poles

With permission to gather a few poles from the managers of the woodland at Cuckfield, East Sussex, i gathered a selection of hardwood poles (mostly ash and hazel), selecting the straighter poles to use for a future build.

With around 25 poles collected from the woods my plan was to keep hold of them to build something special that would enable me to display the freedom of the joins abilities to construct from unrefined materials.

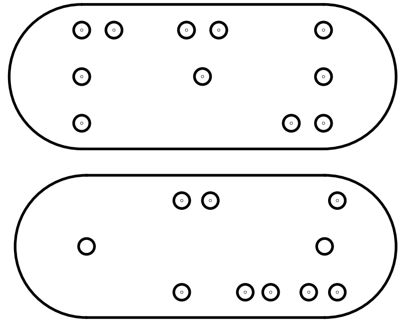
Prototype 6

At this stage of prototype i have used marine ply which is sealed and finished with lacquer to protect the hubs against moisture and warping.

You are now able to add arms into the hubs whilst a structure is up using screw location system.

A better choice of cord has been utilized enabling an improved grip on material.

*Watch 'Final Hub Making Process' to see the every stage of me making this prototype in the workshop.



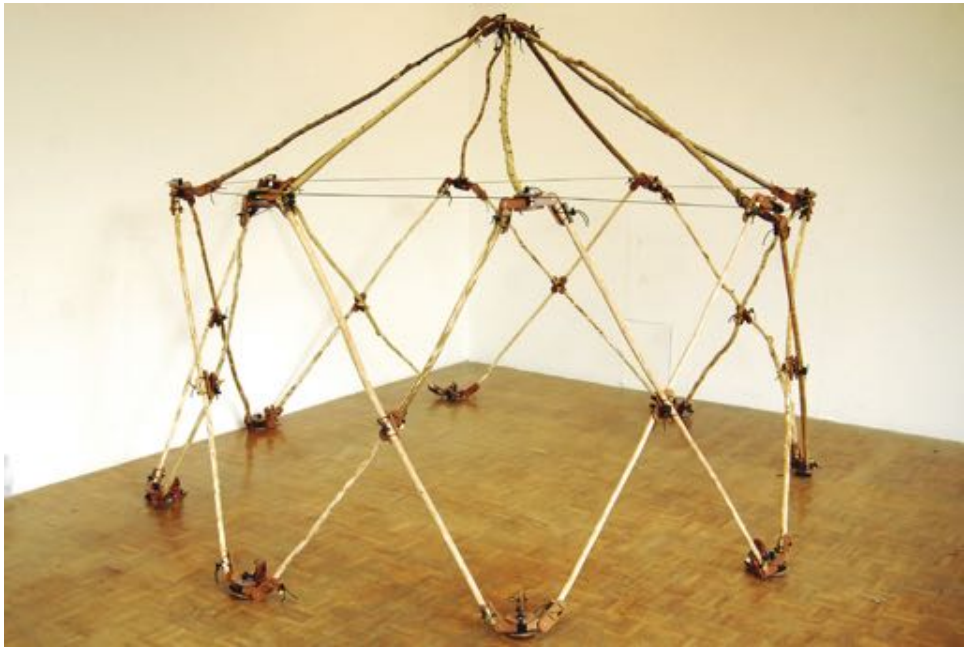
Tested Prototype 6 Builds

Type 2 Octahedral Dome

* Watch 'Iscosahedron Build Video'

Supporting my bodyweight using an 8 sided hub, and wooden poles, proves that the hubs can withstand a decent amount of evenly distributed downward force.



* Watch 'Wooden Folding Frame Build'

Prototype 7: A rendered representation of a final product that would be made using tough polymer.

Critical Review - 'Geo-Hubs'

In retrospect of the year, i have undertaken a project which would have been much more suitable for collaboration and not as an independent body of work and research.

The design has the potential to reach out to a wide audience, of which have not yet explored first hand as the product has not yet reached a totally safe stage to do so.

To take the idea to a further stage i need to produce a large volume of the 7th version of the hubs, using batch production molding. Technologies like 3d printing could be used to produce the final render but are not suitable for large amounts.

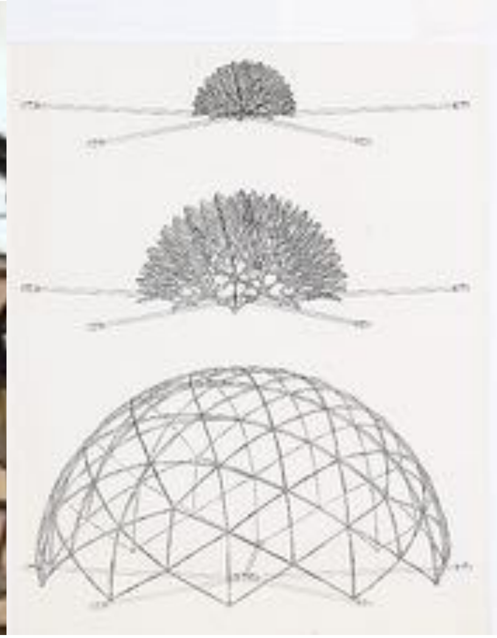
PART 2
THE SILVER PROJECT

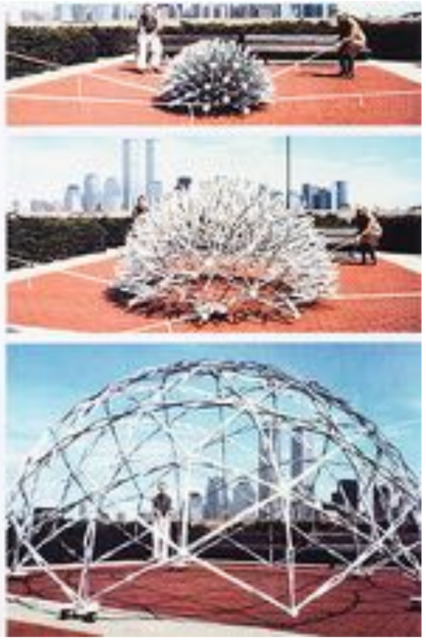
‘MOTION’ JEWELERY’

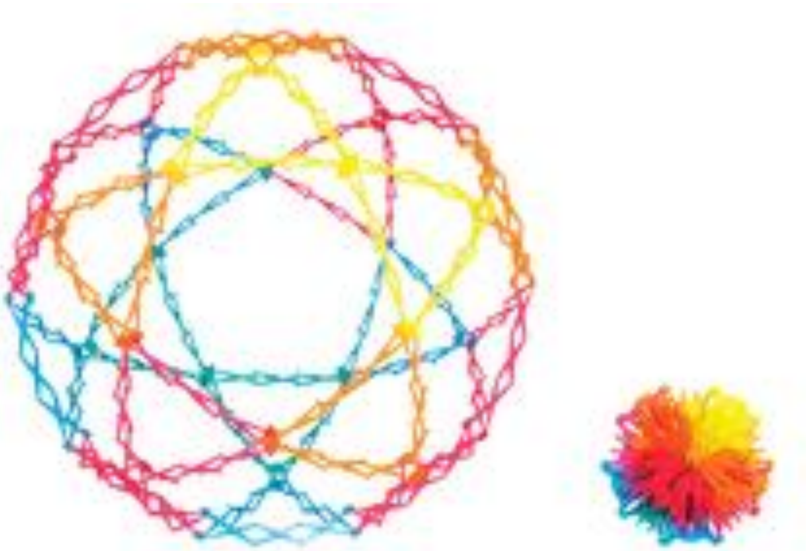
Furthering my studies into transformable shapes, i wanted to apply a contrasting scale to my investigations to produce some different outcomes.

With a large trend in ‘fidget’ items available on the market, i want to explore how jewelery can serve us as an item that can be used to relieve stress and transform with our change of emotion, creating pieces that adapt to our constant changes in life. Using transformable geometries to investigate this is an elegant use of a mechanism.

Hoberman Transformable Design





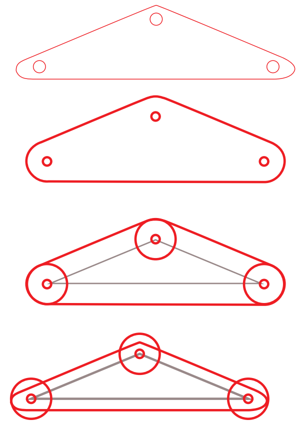


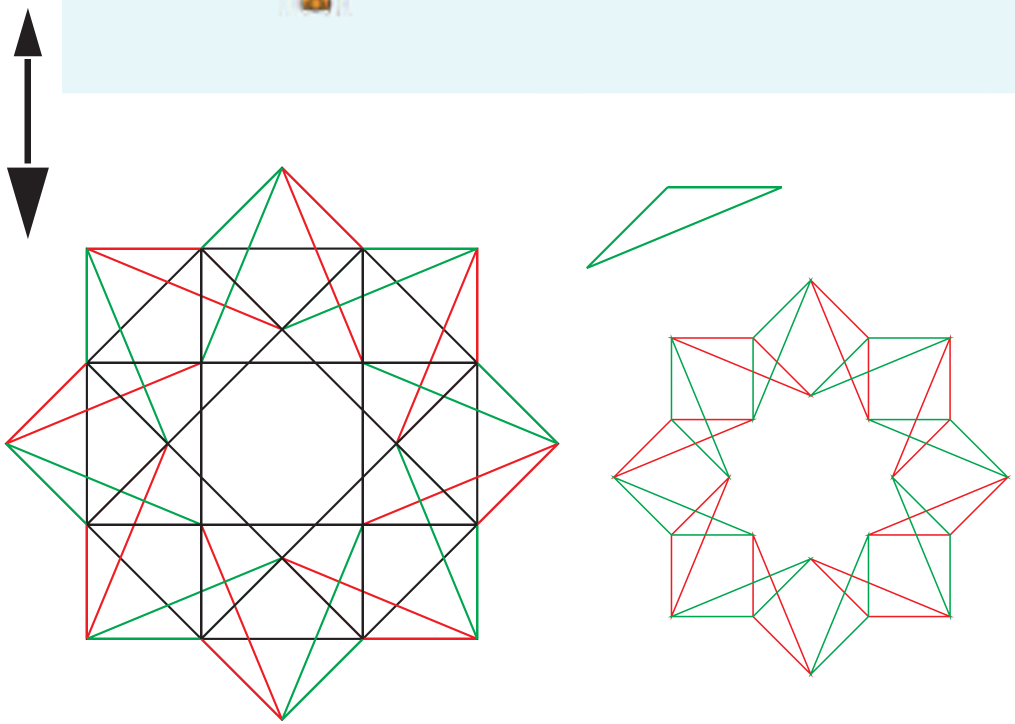
I find myself inspired by the work of Chuck Hoberman and Hoberman Inc. Transformable design holds fascinating qualities that would be accentuated at a small scale in a fine metal like silver and gold.

I want to harness some of the spectacular quality that the Hoberman Sphere toy holds and project this fascination toward an older audience in the form of jewelery aesthetic.

Fidget Toys Research

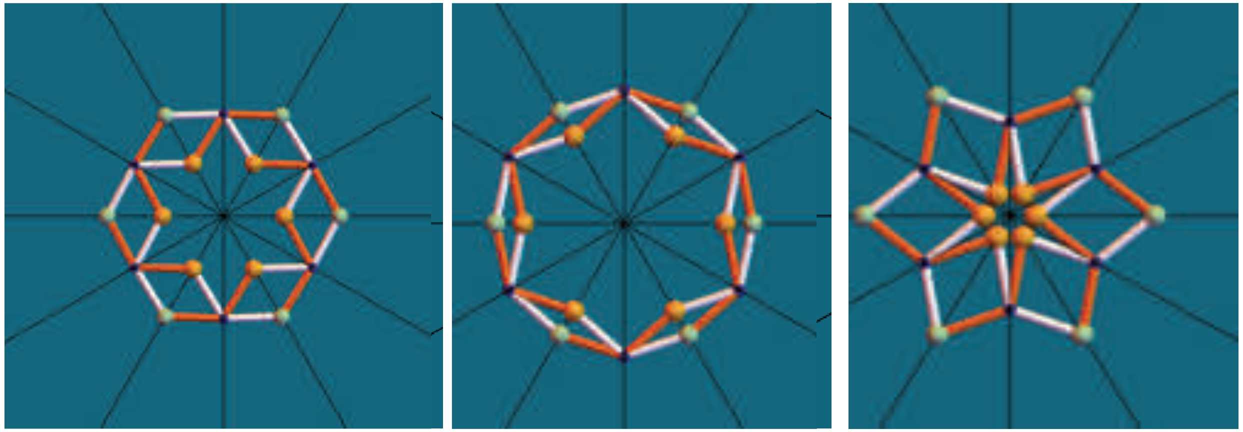
Kinetic Jewellery Research

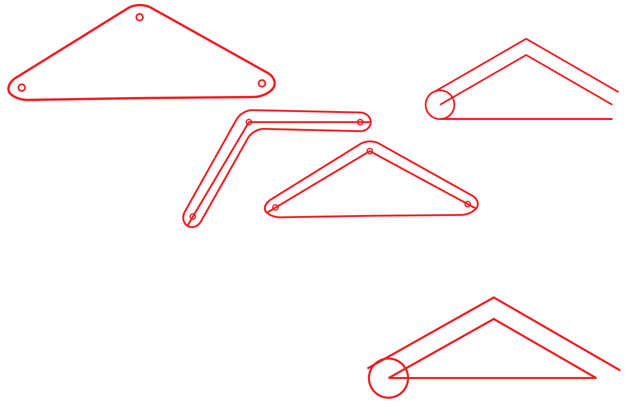


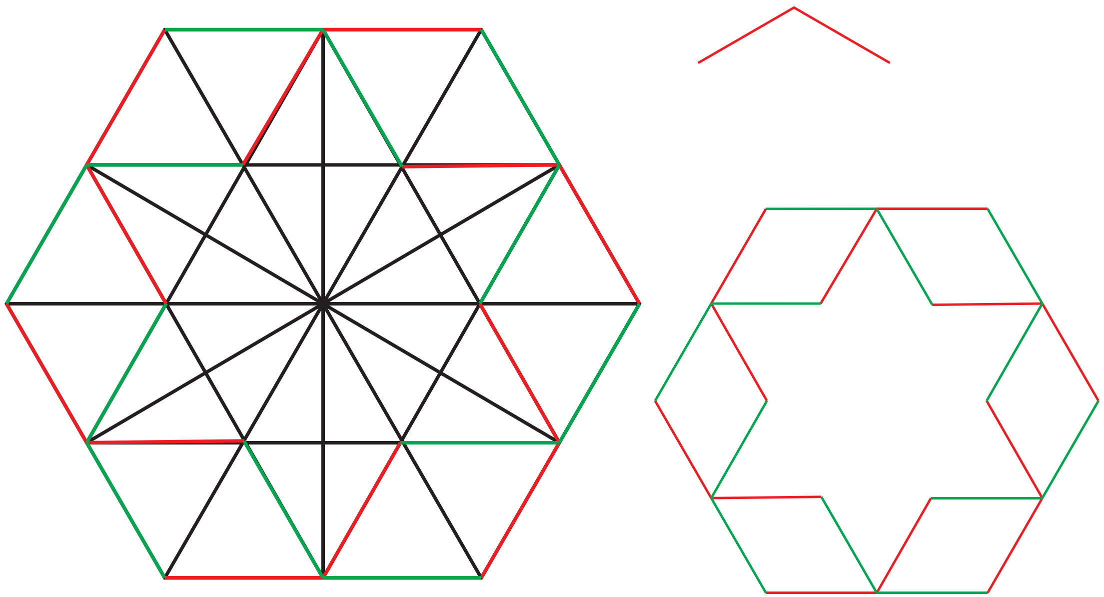


I have found a mathematic model of Hoberman rings on a site called Wolfram. Wolfram is an open source mathematical demonstration software for mathematical, geometric, and scientific models. I downloaded the software and ran the open source files of the Hoberman rings.

- From capturing screen-shots of the model actuating from its closed to open state, I could capture the geometry of the design and work out exactly where the nodes and pivots are placed within the objects frame. The octagonal piece above consists of 2 squares arranged on top of each other, with one rotated 45 degrees to layout the basic net of its geometry. By drawing lines from corner to corner within the net shape, I created the second stage of the net structure. By tracing parts of the lines as shown to the left, the triangular base shapes were outlined in red and green. This base triangle needs to be outlined with a margin, smoothed edges, and holes for rotation points at the corners.

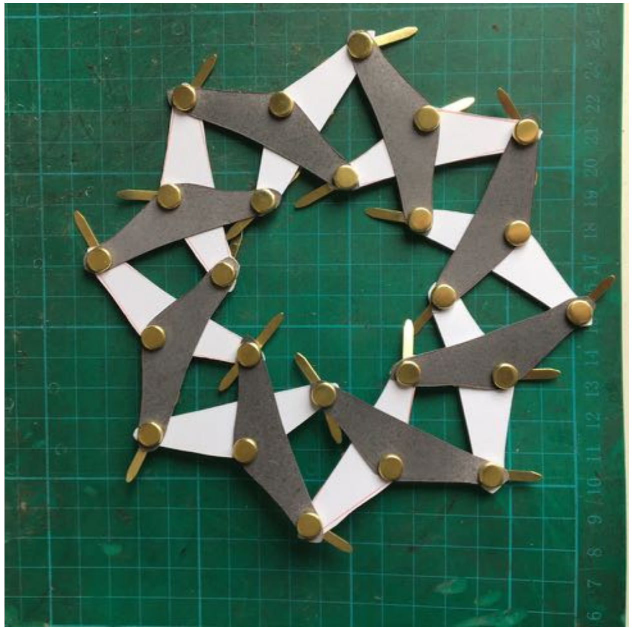


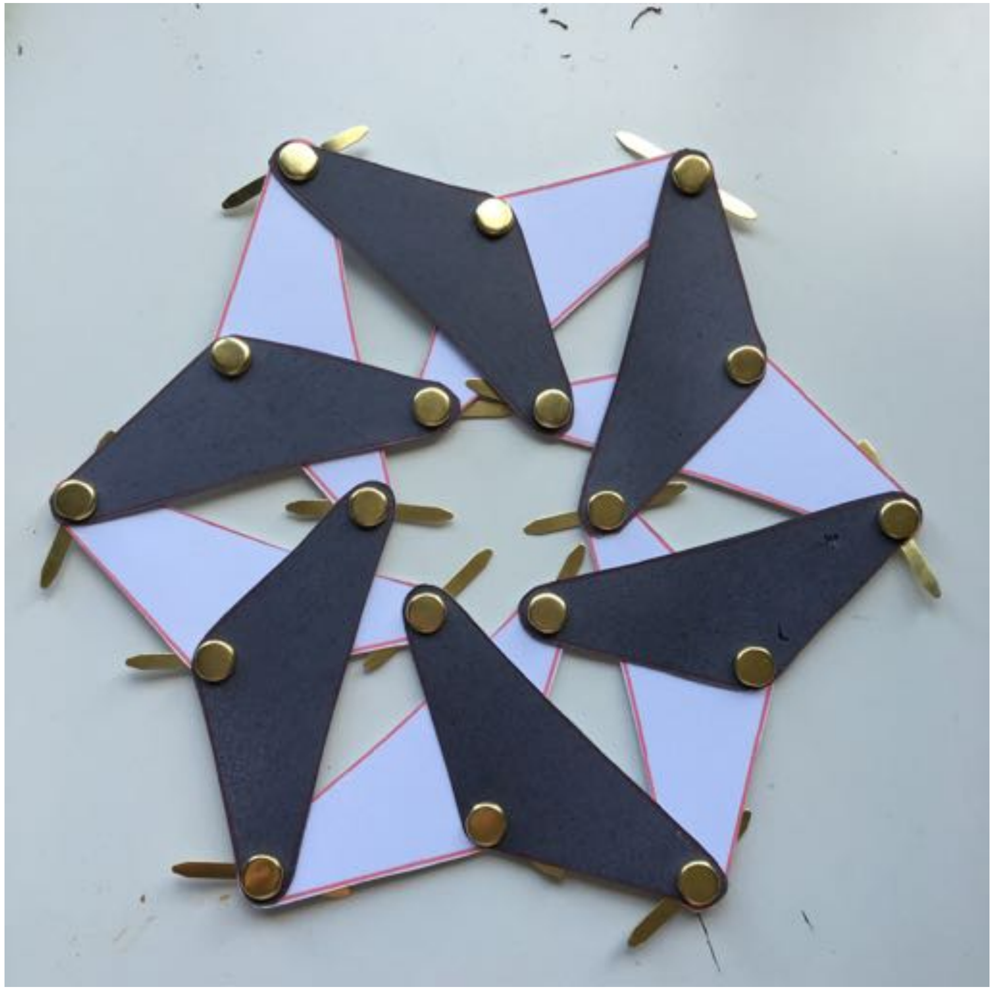


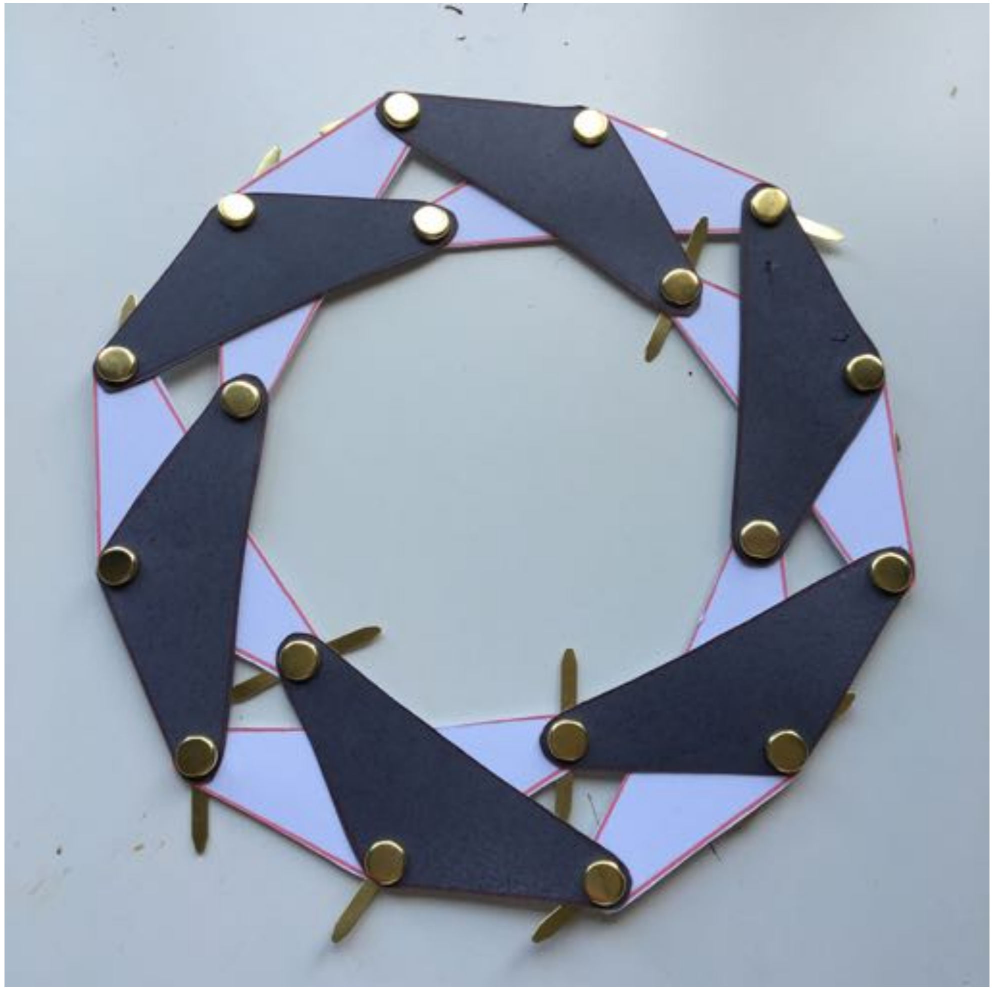


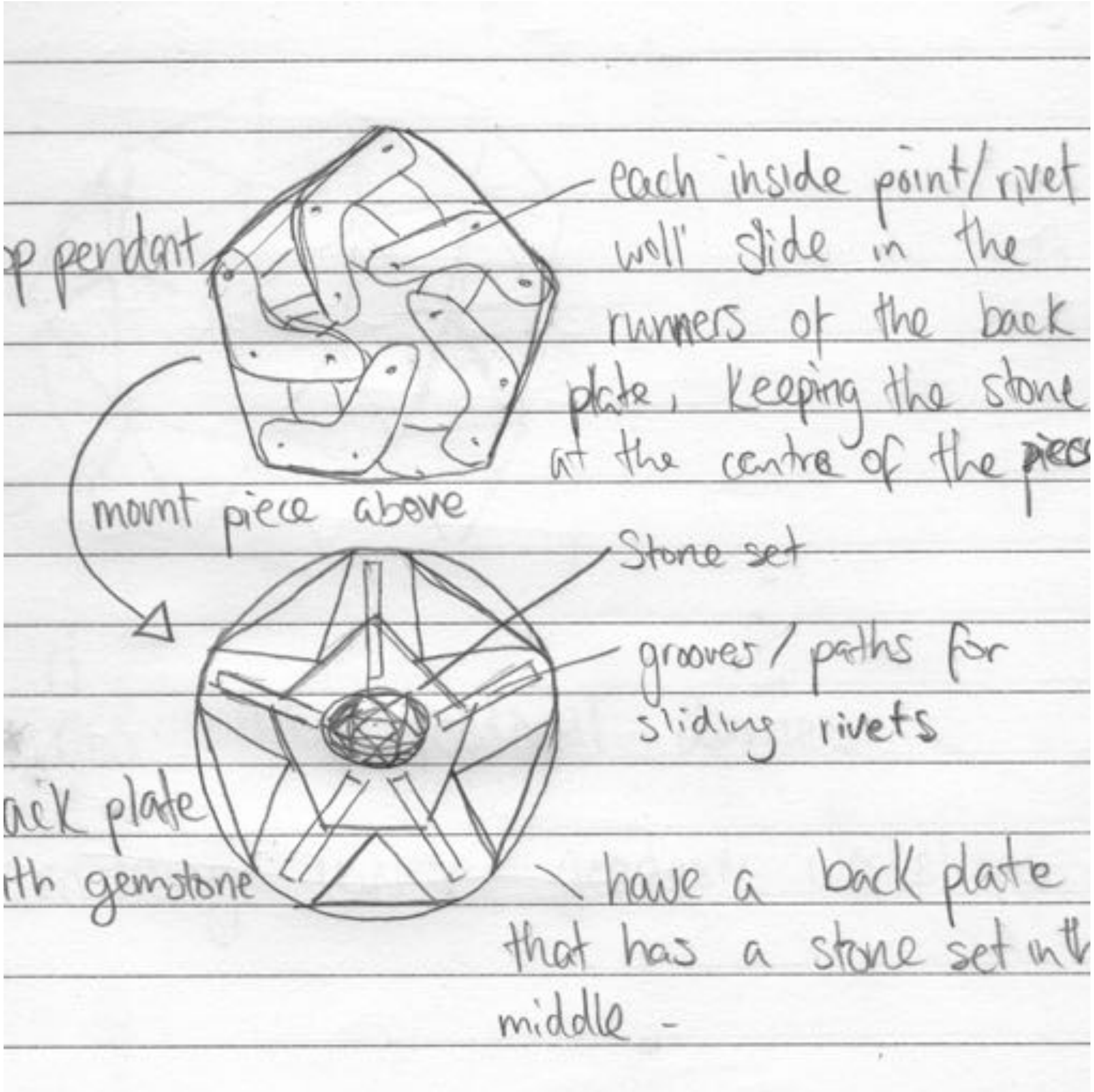
The same process goes for this hexagonal version.

Whilst using less material in its build, the hexagonal piece may suit lighter jewelery such as earrings if made in a thin enough sheet of silver such as 0.5mm.



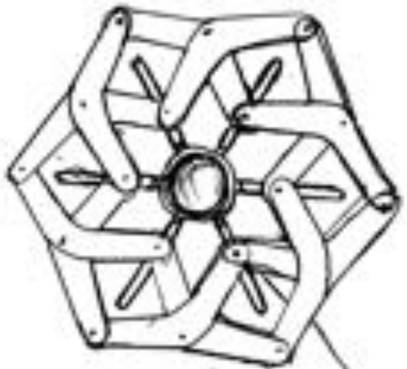




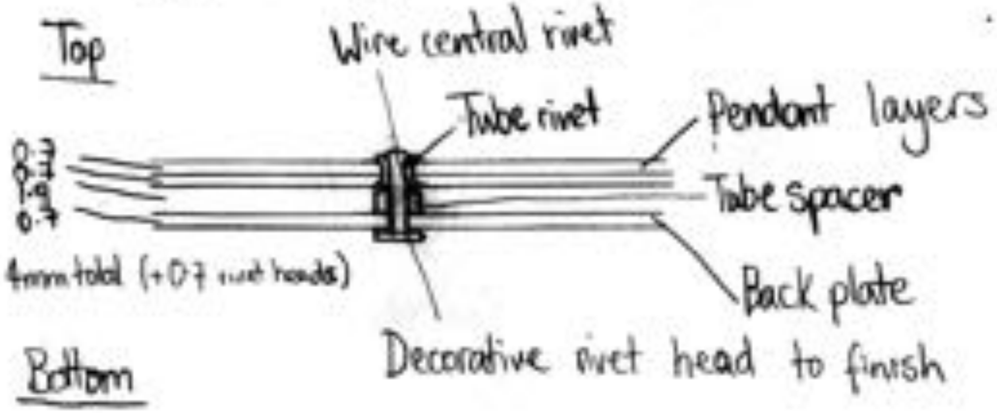

p pendant
each inside point/rivet will slide in the runners of the back plate, keeping the stone at the centre of the piec
mount piece above
Stone set
grooves / paths for sliding rivets
ack plate
ith gemstone
have a back plate that has a stone set in th middle -

Stone Set Design - 4-6mm Cabochon in a bezel casing

To add more value to the expandable design, adding a Cabochon stone to a rear plate that the pendant is fixed to, will allow the pendant to articulate around its centrepoint of movement. The centrepoint of the mechanism would then be turned into a feature with the addition of a stone.



Rivetting / Fixing Process



Tube = 1.2mm outer - 0.8mm Inner
Wire = 0.8mm silver
Sheet = 0.7mm silver

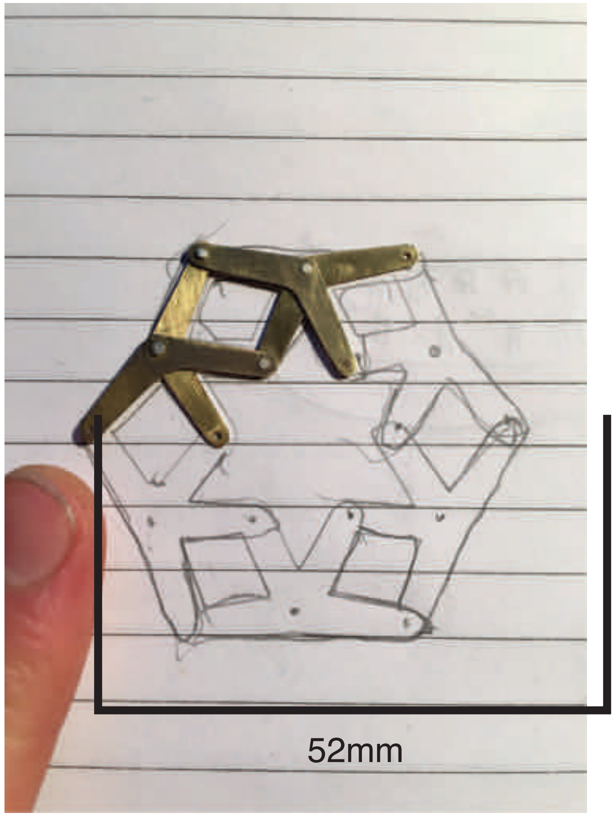
Stage 1: Build the pendant layers, assembling the with tube rivets. File the tube rivets flat on the bottom side of the pendant.

Stage 2:
Make the wire rivets + solder to decorative head. Cut the 1.9mm tube spacers. Add the rear plate + rivets from the bottom side. Snip rivets close to top face, file flat, dome over to seal the rivet mechanism + finish removing and burr.


- I first made a copper test piece which failed as the copper was too sofft and warped when i finihsed the rivet. I was also in a slight rush with it which didn't help at all.

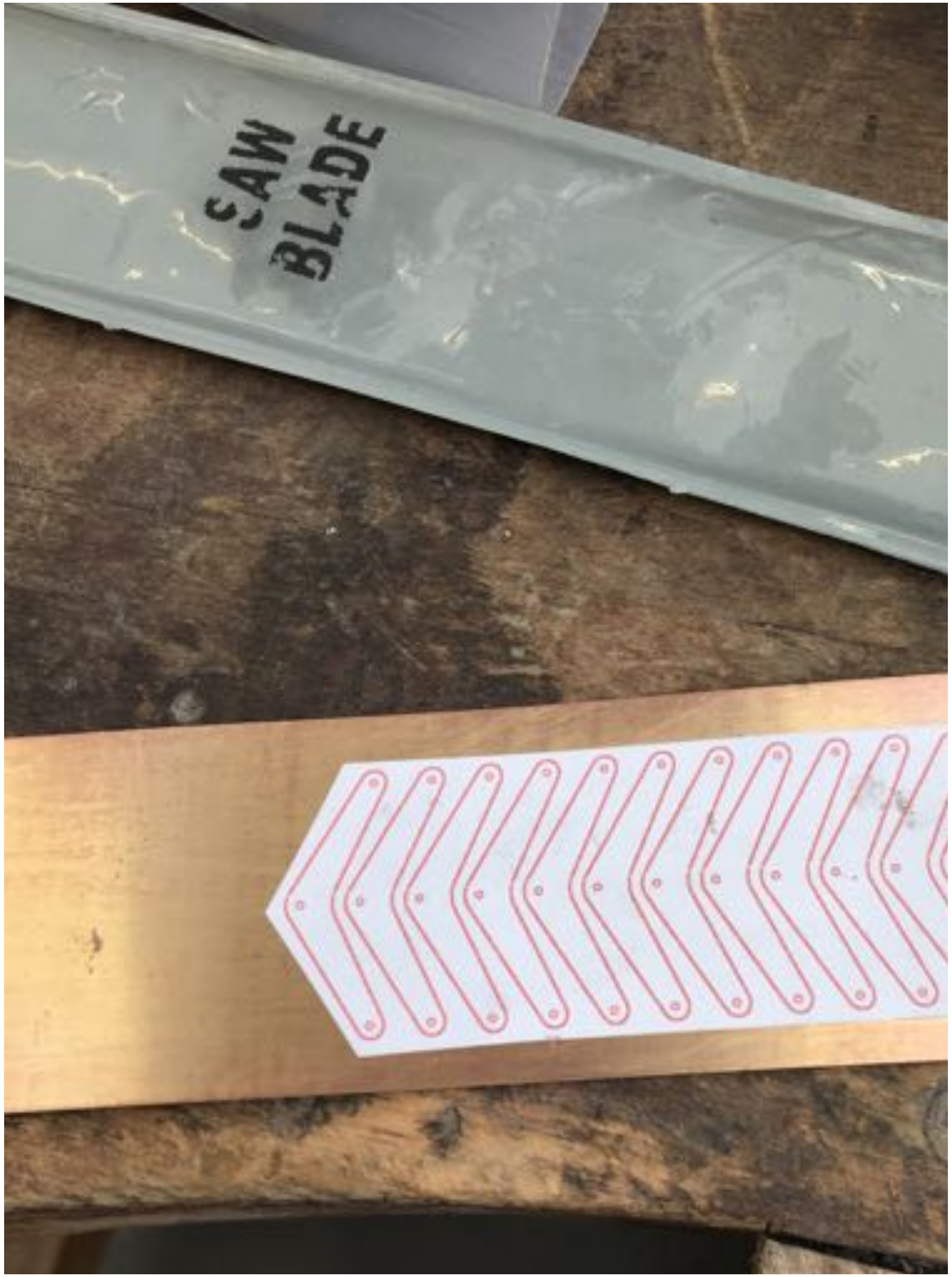

- I then made a version in guilding metal which is stronger material. With more care and attention the test worked out pefectly and produced a pretty smooth working model.

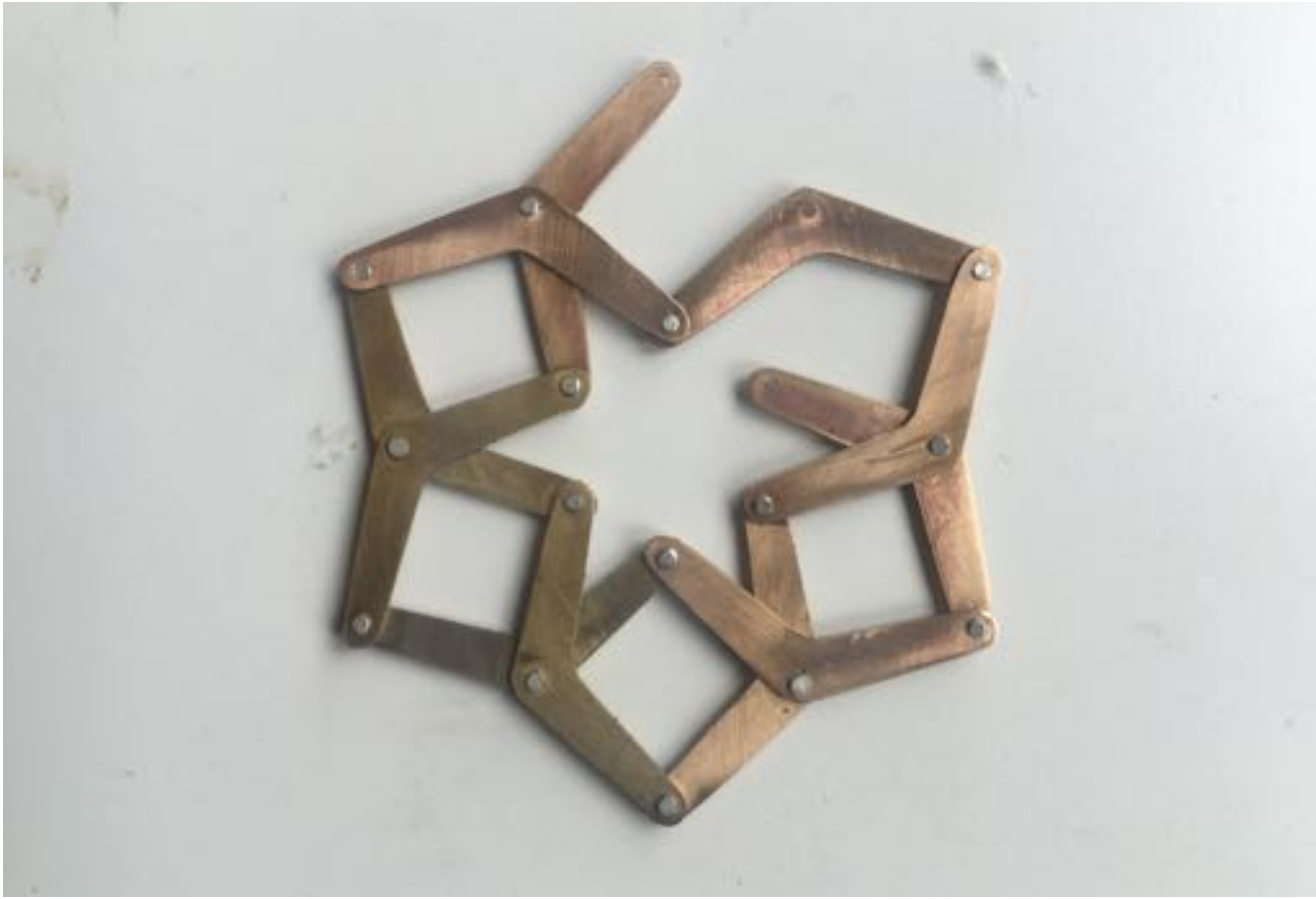

- Weighing in at 1.9grams, the final piece will be 3 times the amount of linkage and weigh roughly 5.7 grams.

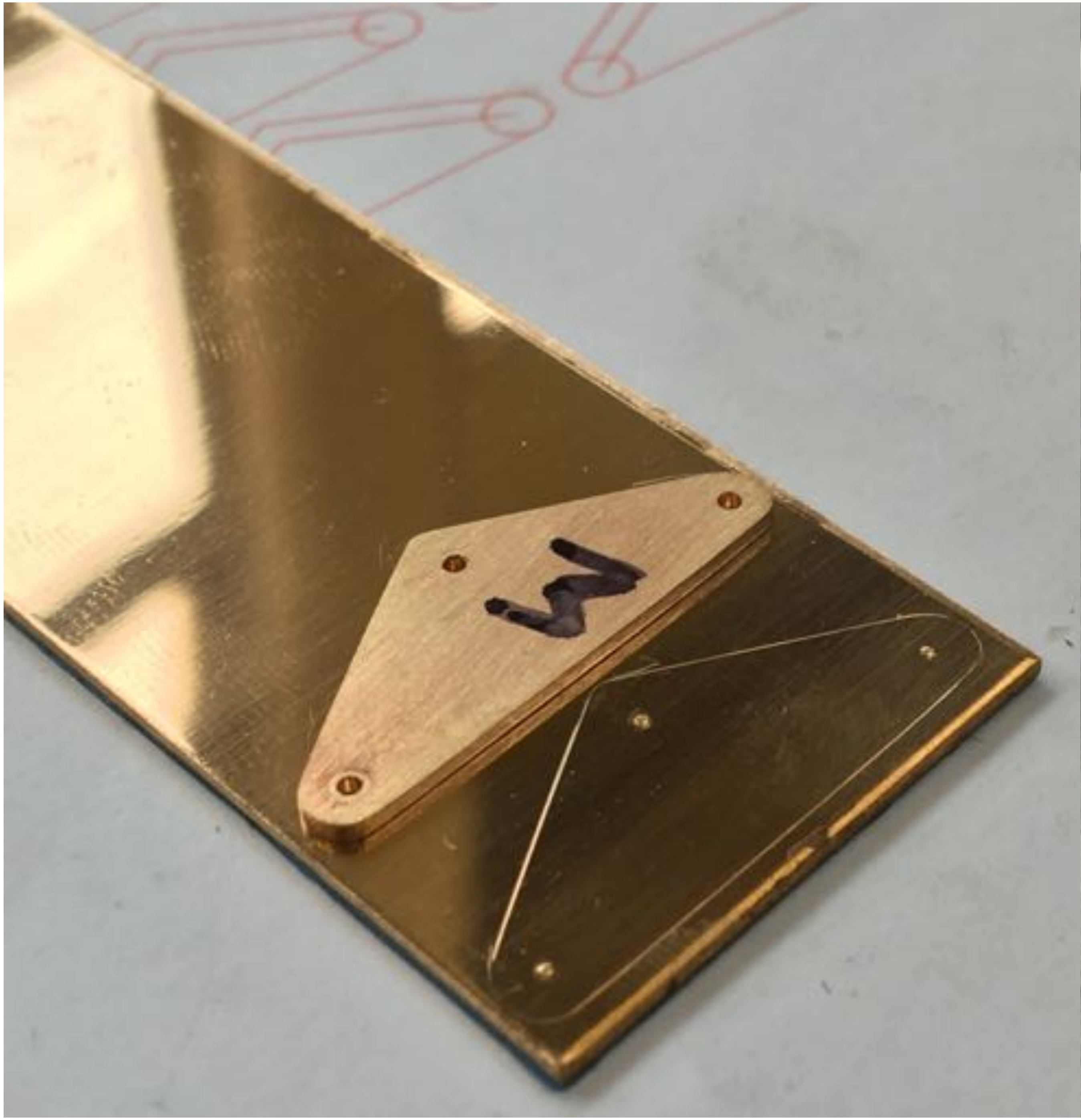


- The piece is currently at the scale of around 5cm closed and 6cm expanded.

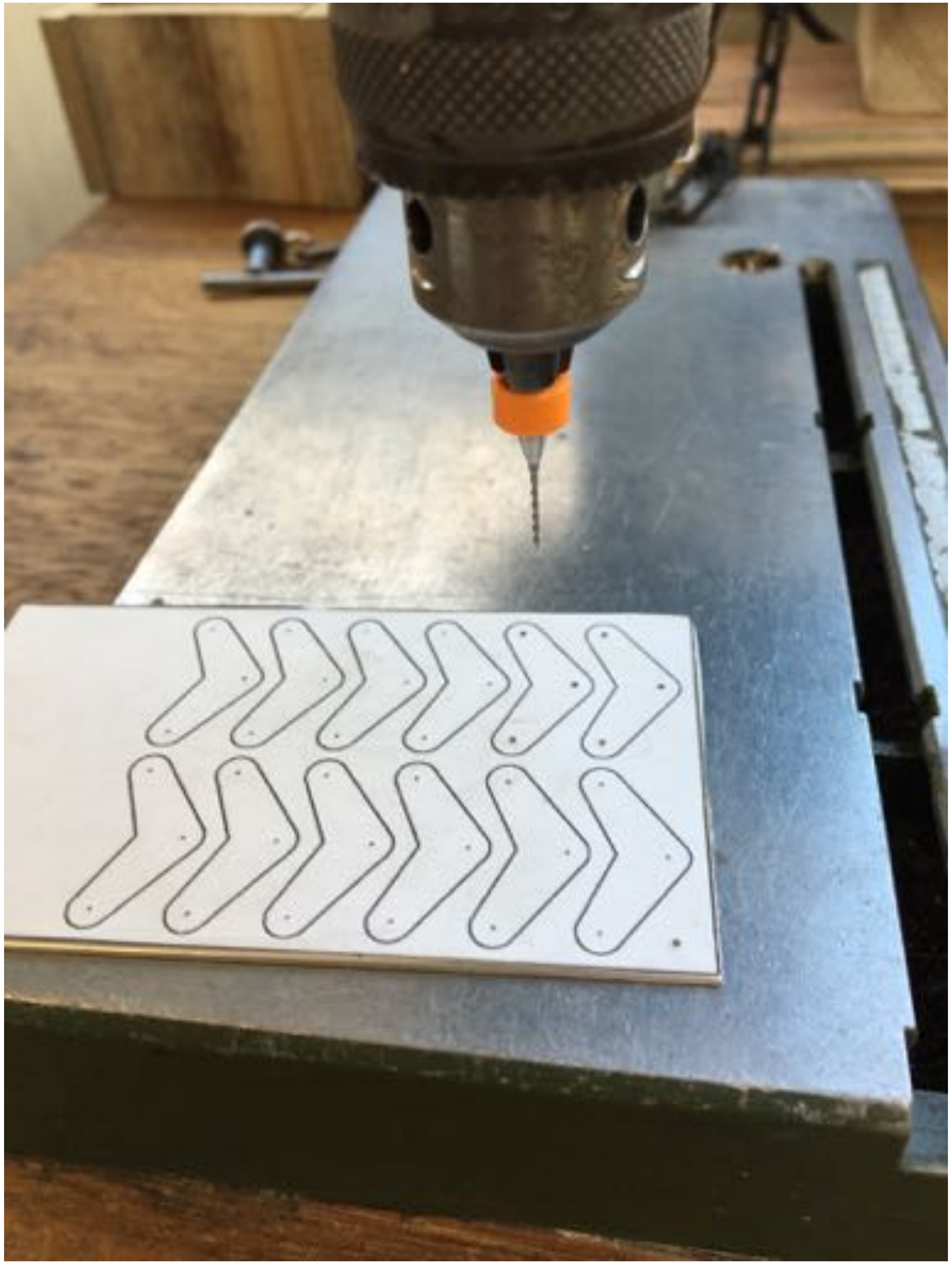
With the weight being expected at 5.7 grams it maybe a slight too heavy and the dimensions a bit large. Im happy that i can cutout smaller pieces with more precission so think i should reduce the size of the pieces by 20 percent to bring down the weight and measurements.


SAW
BLADE





Having produced these 2 unsuccessful pieces due to the requirement of such precision being hard to meet at this scale, I decided to create the vectors in fusion 360 instead of illustrator for the next stage.



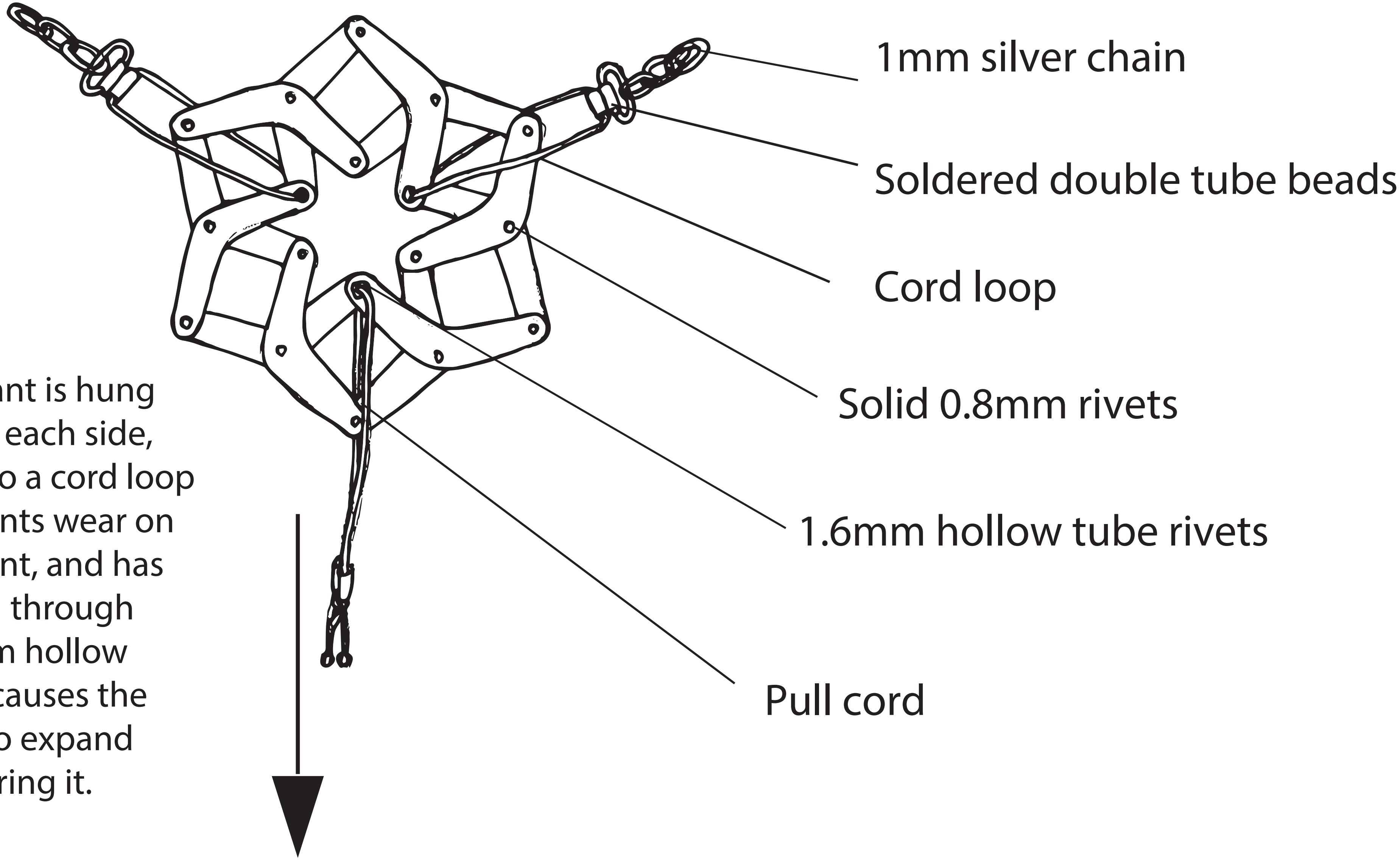


With better templates i achieved a successful result!

SIlver was a lot more manageable to work with than guilding metal, but the proccess of making them by hand was lengthly and to get each part identical with matching curves required either CNC routing, laser cutting or casting.

I enquired at a few companies that offer laser cutting services and found that no-where was willing to do the job due to possible laser reflection from silver damaging the lens.

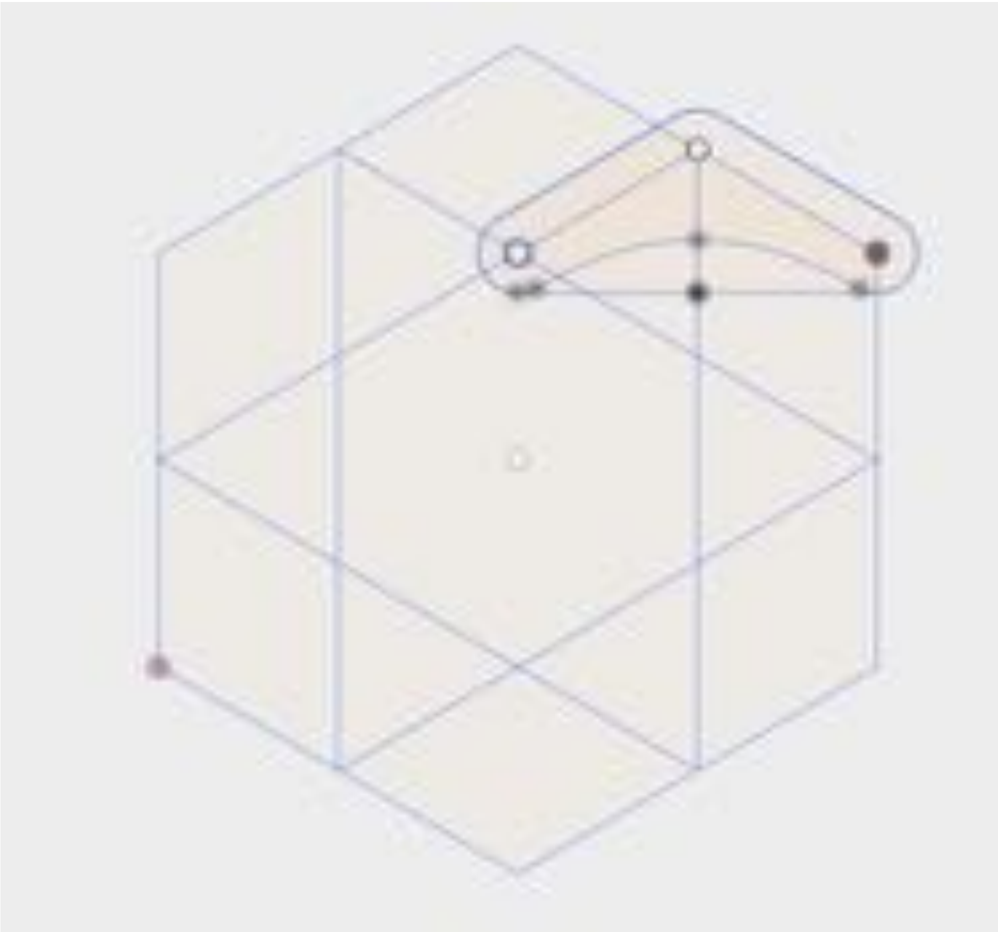
I decided to change the shape of the templates slightly and create a hexagonal pendant.



The pendant is hung by a chain each side, attached to a cord loop that prevents wear on the pendant, and has a pull cord through the bottom hollow rivet that causes the pendant to expand while wearing it.

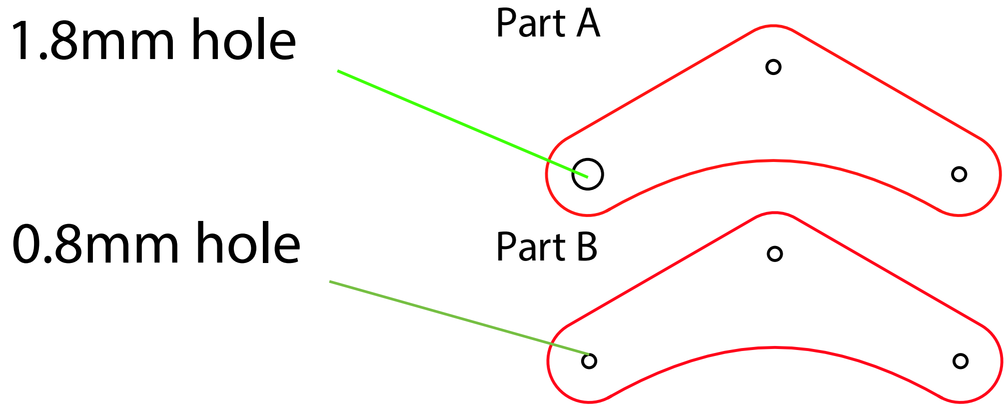
Using a contact who owns CNC routers at a factory in Essex, i decided to get the pieces CNC routed. This would ultimately reduce my working time finishing and assembling the piece and optimize the consistency of the pieces to ensure a high quality finished result.

As a machine process that has not been used much before to create jewelery, it is interesting to liaise with the company as they had not ever used their machines in this manor before.



- Fusion 360 geometric construction of the pieces. I exported the DXF. vectors to send to the CNC company.

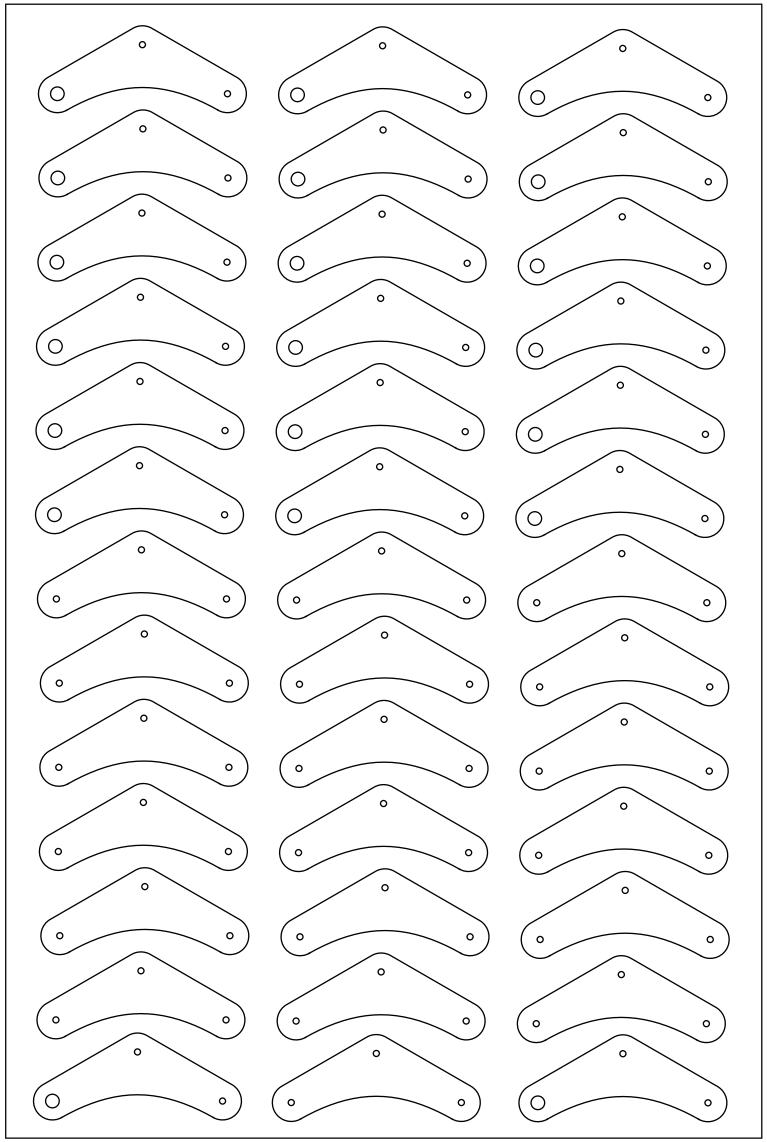
100mm x 150mm Layout



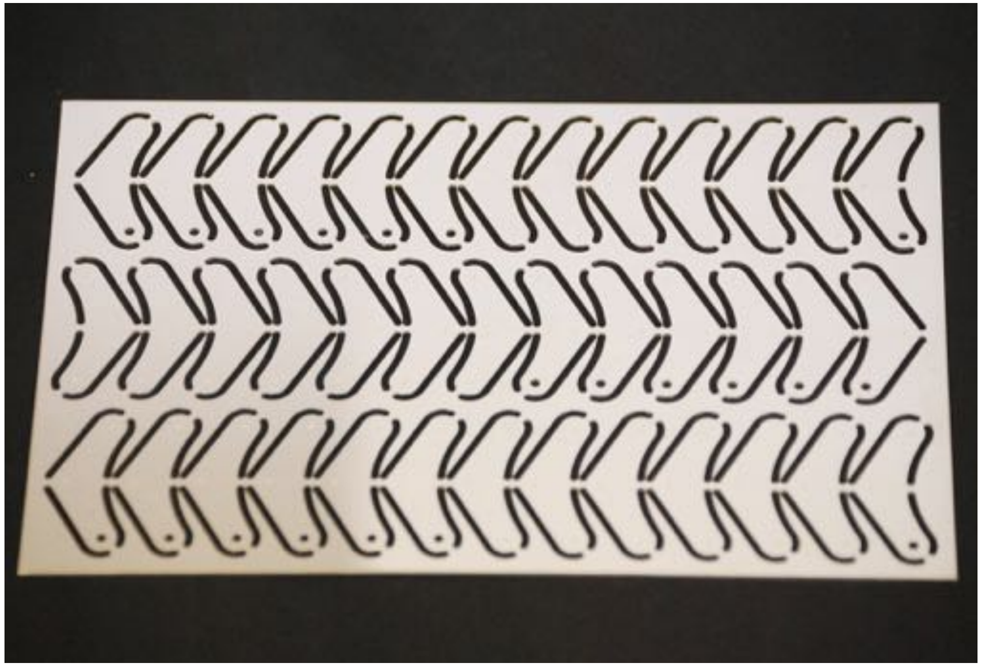
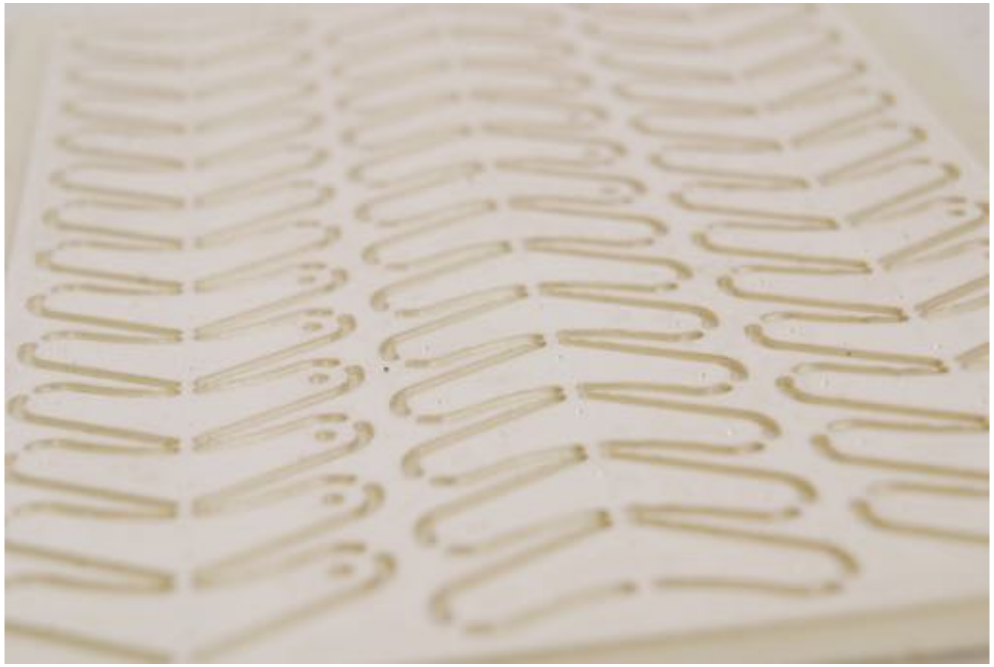
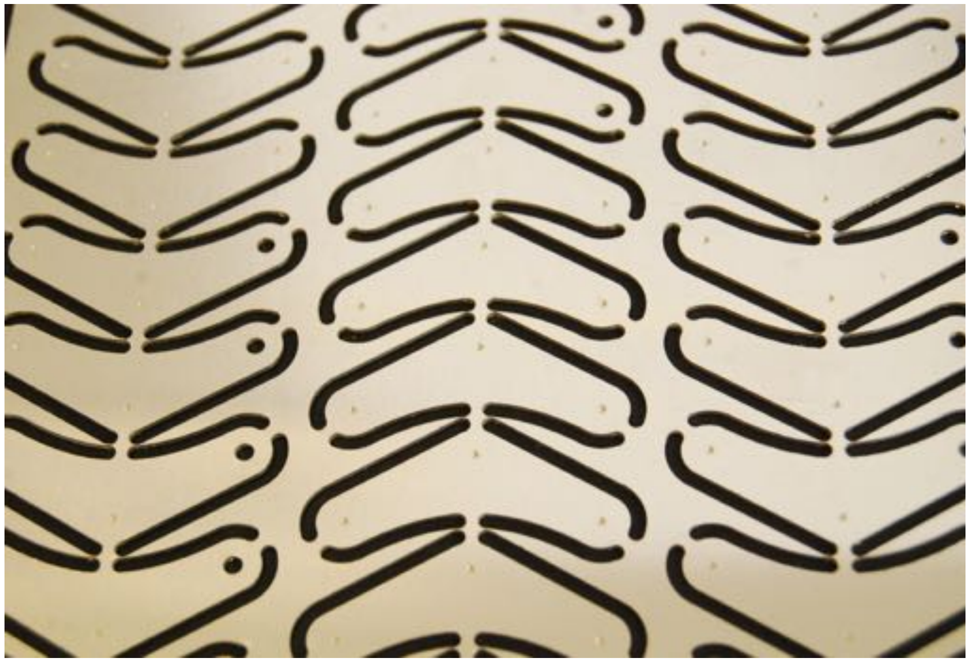
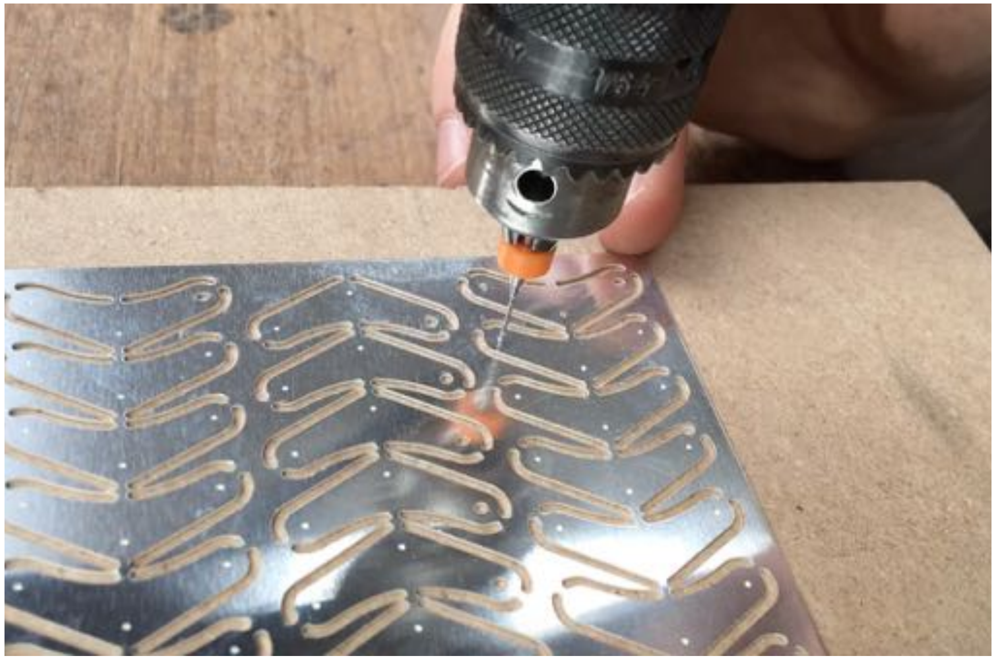
I aim to make as many of these objects out of the sheet of 0.6mm silver that you have at the Sildie.
Each final objects consists of :
6 x Part A
6 x Part B

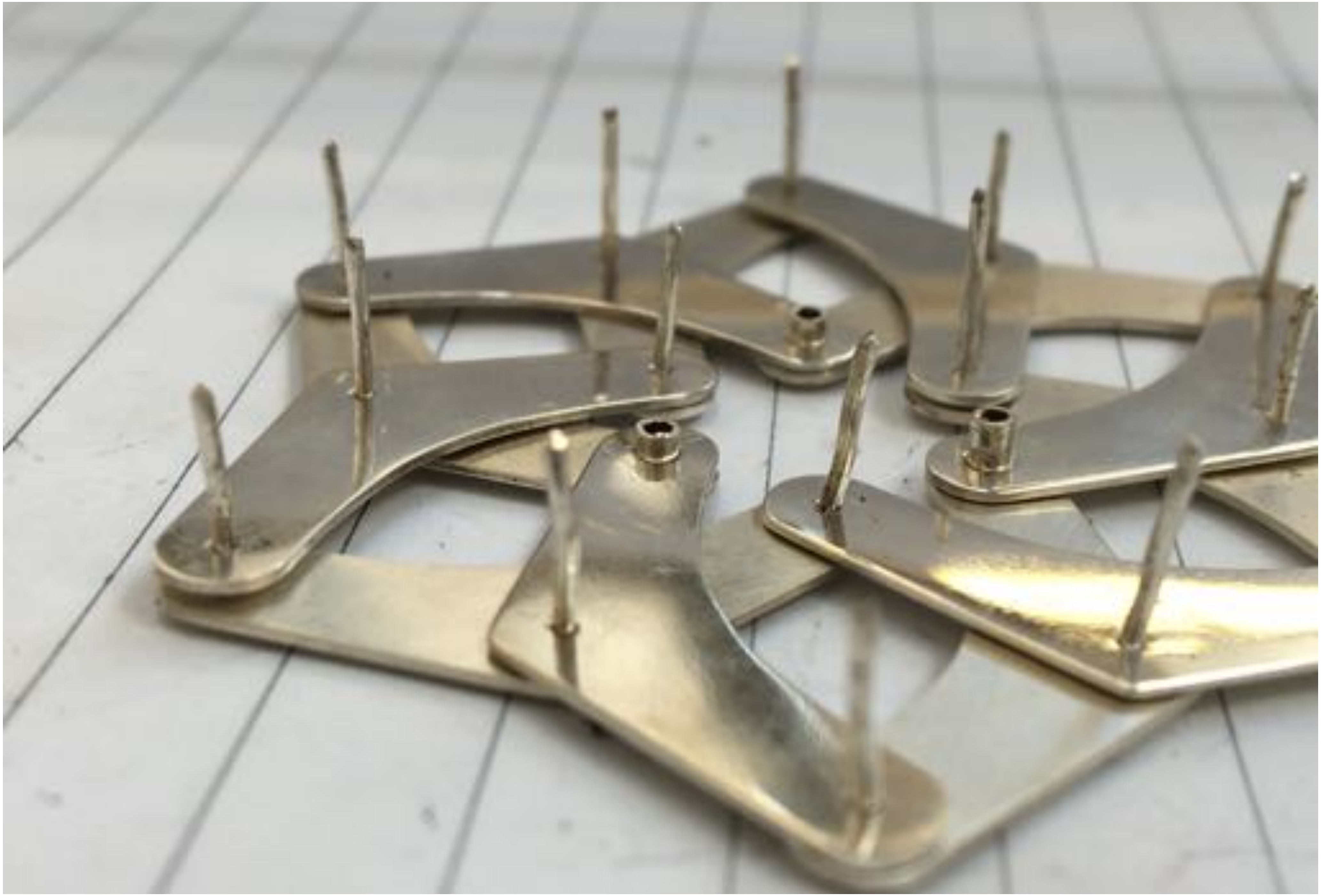
There are no angled tools needed for this job, all tools are straight through vertical cuts.

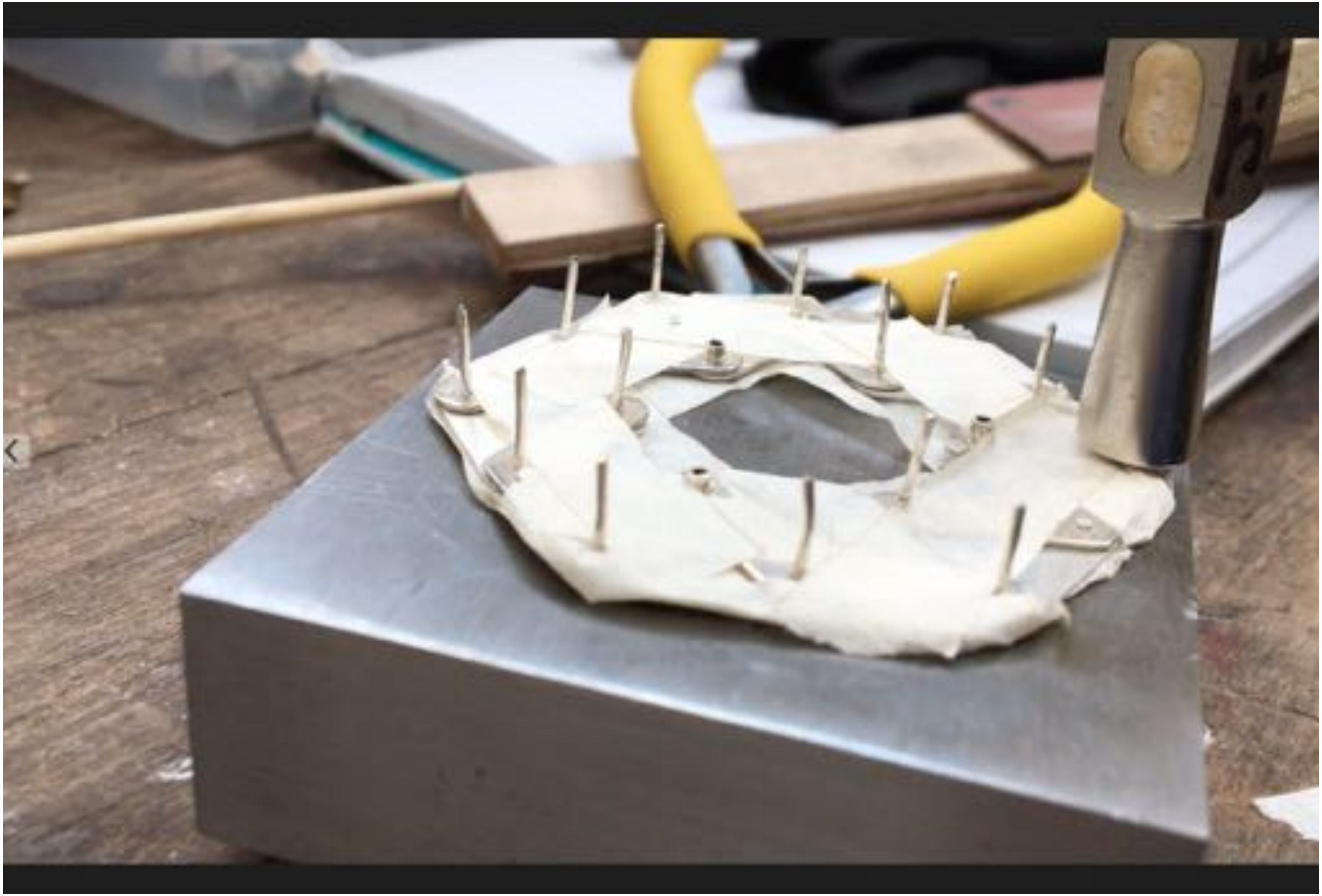
- The outside paths need to be machined on the outside of the lines.
- Holes have to be drilled to the exact centre points for the geometry to match up when the piece is being assembled.



1:1 scale vector





Critical Review of ‘Motion’ Pendants

The Good Points

I have achieved to produce some solid functioning finished pieces of articulate jewelery that have exercised my investigations into transformable shapes.
Working from a hand making process, and advancing toward a more modernized production method of CNC routing has been a success in every way. The machining has enabled me to increase the quality and accuracy of the end result, whilst also reducing my working time. CNC routing is a machining method which i would like to continue using.

Points to further focus on

- Investigate creating more natural organic forms that can still be constructed in a transformable shape.

- Create lightweight earrings.

- Surface colouring and texturing of the parts i.e. etching the surface when CNC routing.

- Make stenciled parts that have pierced designs reducing the final weight for earrings.

- Re-apply the transformable geometry and investigate how it can be stretched and formed in a tubular dimension (as if you extrude the pendant parts)

- Push the possibilities of scale and miniaturize the pieces as much as possible.

- Create some further designs that incorporate stone setting.

- Develop more ways to operate the expanding mechanism.

References.

- Geodesic info: https://simplydifferently.org

https://www-tc.pbs.org/wnet/americanmasters/files/2001/12/BuckminsterFuller.jpg

Information courtesy of: https://www.bfi.org/about-fuller/biography

https://www.kickstarter.com/projects/942255452/hubs-geodesic-domes-made-simple

http://www.designboom.com/project/macian-dens/

Image Sources from Google Image searches - related captions.