Reflective Practise

SLQ Wiki Fabrication Lab 2026/01/11 23:29

Reflective Practise

Jan 2021: Re-making the Shark with a Wobbly Tooth: Preliminary Thoughts

Peter Musk

1. File version control

Original design files were available but in fragmentary and unannotated form. This is a forseeable consequence of the staffing for the original build – each structure was the job of a single staff member, with little collaboration possible in the time available.

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Advantages: different approaches can be explored simultaneously and
reflection should determine an optimum process
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Disadvantages: time constraints made sharing of ideas difficult and
innovations spread only on an ad-hoc basis
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Solution: Since timelines and workstyles make continuous sharing unlikely,
an asynchronous method for harvesting examples of best practise could be
used (such as this wiki). A single repository for design files could be
established, subject to an agreed method of commenting and annotation.
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Further issues arose marking out file for cutting…some variations in scale had occurred during file duplication (perhaps between software packages). Numbering was also absent in many cases.

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    Solution: Final check for consistent numbering and uniform scaling
before files are stored. Check for changes in scale before use.
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2. Unavailability of the CNC knife attachment

The software glitch that made the knife inoperable is a trivial concern, and easily fixed (though time delays are involved). More important is the suggestion (thanks Simon) that the oscillating knife may not be the best tool for cutting large files given a history of breakage, and the rapid wear of blades due to the material used. A drag knife was to be preferred, though modification of design files to reduce tight radii would be necessary. In emergency, the pen attachment and manual cutting was enough to begin work.

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Suggestion: explore the drag knife as an alternative tool for this job.
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Cutting by hand from a CNC drawn design turned out to be relatively quick and easy, and this could

be a time saving during final production. Many volunteers with knives could deal with the output from the CNC in a way the limits delay. Using the pen also helps include registration marks without weakening the material.

3. Structural design did not suit the material

The double-ply cardboard (6mm) did not have sufficient strength to hold up at the sizes required. The Y – Z axis shapes could not stand up during (or after) attachment. Particular problems came from some Y elements (those perpendicular to the floor) being suspended in space.

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Suggestion: The re-build focused on Y elements only, with horizontal shape
to be applied later as ribs rather than large sheets.
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See https://www.youtube.com/watch?v=kK-SGFdbNGA for a possible approach. Note that this object is very small.

A better solution is shown in another Youtube, (https://www.youtube.com/watch?v=RBfxfOX5zyM) where a central skeleton of Y-layers joined along central spines (cardboard tubes) is used to begin a much larger figure as seen below:

4. The original design was a single piece, and so prevented from re-location.

The shark, when finished, is about 2.5m high, 2m wide, 3m long and hollow, with a substantial overhanging snout.

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Suggestion: Redesign so the object is made in modular pieces, each small
enough to be transported easily. In this first instance, this was addressed
by cutting the design into 4 quadrants.
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Findings: registration marks were devised and drawn onto the pieces. This
required marking a central perpendicular on each piece of the design
(estimated in this case). The height of the bottom pieces was arbitrarily
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set above the height of the gullet space and marked using the slots for Z-
pieces already in the design to determine a horizontal plane (these slots
were assumed to be parallel to the floor). Luckily, there was enough
variation in the spacing between Z-slots for congruency to be established
between the different Y-pieces.
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5. Making the object in pieces requires a (reversible) way of joining them securely again.

When finished, the shark will be covered completely with a skin, and so any internal fixings will be out of reach. Joining the pieces should be done in a way that holds them secure against attack by enthusiastic patrons, and is able to support the stress from the weight of any attached pieces.

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Suggestion: reinforcing plates (maybe of MDF, or multi-layers of cardboard)
may be required at either side of the attachment points. Using metal
hardware will be costly, and increase the weight of the build. Having to
reach both side of the fixing at the same time further increases the access
problem.
Access could be provided by including removable (or sacrificial) trapdoors
set in the skin.
Using captured wedges rather than bolts will spread the load, are easier to
make in-house, and reduces the need for tools.
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6. A cantilevered design means some form of counterbalancing will be required.

If a suspension point is available, then the design needs to incorporate some strong, internal attachment point. A captured eyebolt mounted on MDF might be a solution.

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Suggestion: If the pieces are securely joined, then weighting the floor
segments might be sufficient. Using overhead attachment may also be
possible, but this makes assembly/disassembly more complex.
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A note about nomenclature

As this document has developed, a way to refer to different (but recurring) parts has developed. Open to discussion, but this is what follows:

element refers to the slices (or layers) made from the 3D model that have been drawn to scale on the CNC, and cut from cardboard. Thus, the verticals in the construct that follows are labelled Y-elements (following the axis convention shown in the image of the model below). Horizontal bits (that may be used to transfer lateral shape to the model later) will be Z-elements.

module is used to refer to each of the sections that have been arbitrarily imposed to make the

construct relocatable. Simple labels (like Left Hand Side (LHS) bottom) describe how they fit together - remembering that LHS is as viewed from the front.

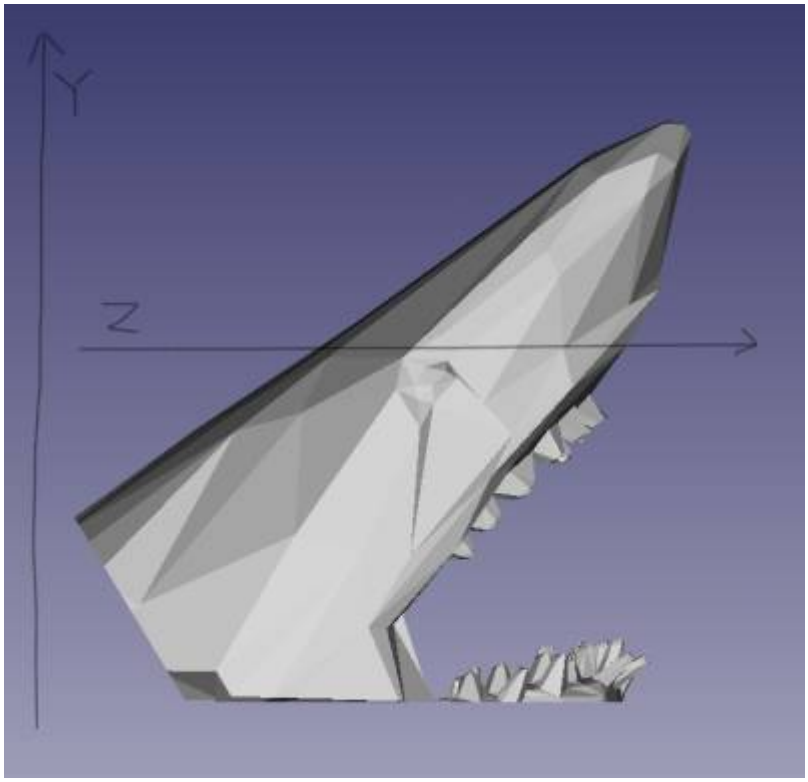
plate or 'join plate' has been used to label the flat sheets that separate the modules. For example, the lower LHS module will have a plate on top that joins to an identical plate on the bottom of the upper LHS module. These plates are what the wedges press on to hold everything together, and give rigidity to the modules when they are disassembled. The upper LHS module will have a central join plate as well (but not the lower LHS, since this part of the construction is hollow).

rib refers to the triangular constructs used to join the elements. Ribs are supposed to be aligned with the X- and Z- axes of the model (that is, square to the Y-elements, and parallel with the floor)

Jan 2021: Rebuilding the shark: Practical Issues

1. Assigning axes to the model

The 3D model of the shark was put through slicing software, and regularly spaced layers chosen for the Y- and Z- elements. Naming convention as shown below:



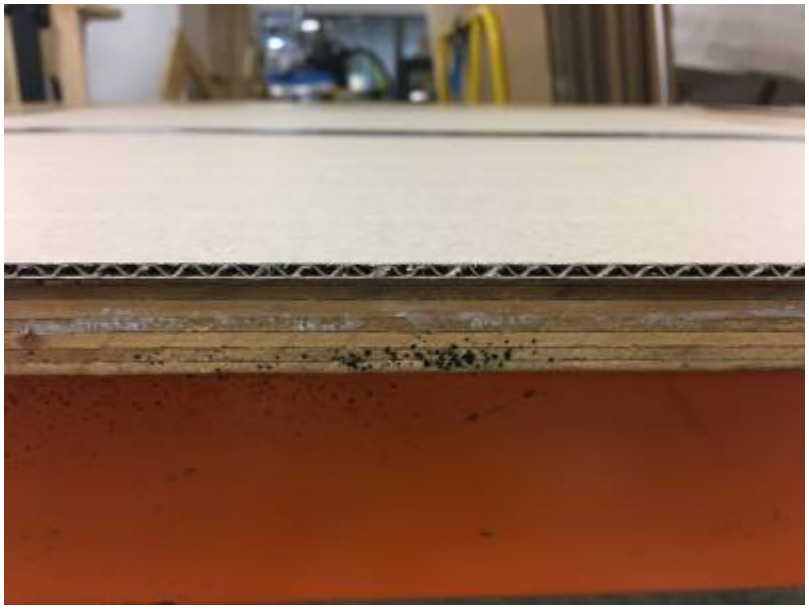
2. Design of supporting ribs

In place of the unstable Z-layers, a system of ribs was devised to separate Y-layers. Key attributes:

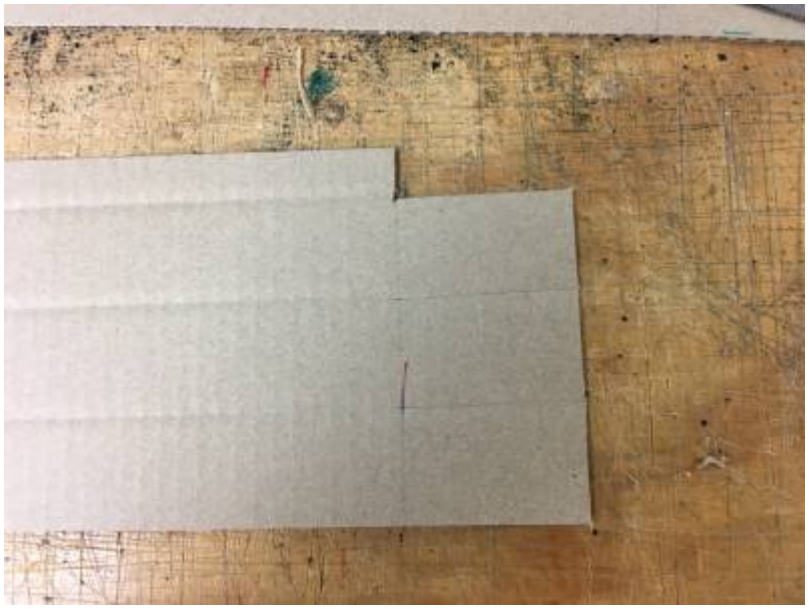
- standard length (46cm) between attachment points. This dimension was derived from the spacing between slots in the Z-layer models. Using this dimension allows for efficient use of material - two ribs can be cut from each length of pallet pad cardboard. Pallet pads are approx 1150mm square, so half (575mm) gives 115mm excess (or 57mm at each end) for attachment.
- triangular section for strength
- each face of the triangular rib 35mm (the width of a standard 1m metal ruler), with half that as overlap for gluing closed.
- double length ribs used (with the flat side up) as supports for suspended Y-elements


Rib layout, with scoring tool (use the ROUNDED corners so the cardboard is not cut)


Scoring completed - note that cardboard is NOT broken along the score. This maintains strength.


Grain (corrugations) runs across the long edges of the rib for strength.


Cut the rib down the middle of the fourth parallel - this gives a gluing tab to both adjacent ribs.


Remove corners of the tab as shown to make it easier to open up and bend back the attachment tabs.

Gluing the Ribs

After trial and error, the following seems the easiest method for closing the ribs while ensuring a securely glued product:


Start by folding the creased rib along the first complete score line


Continue to the next fold, rolling the triangle towards the glue point. Keep downward pressure on the vertex with your hands.


Run a bead of glue along the glue tab (both ends and a bit in the middle is usually enough).

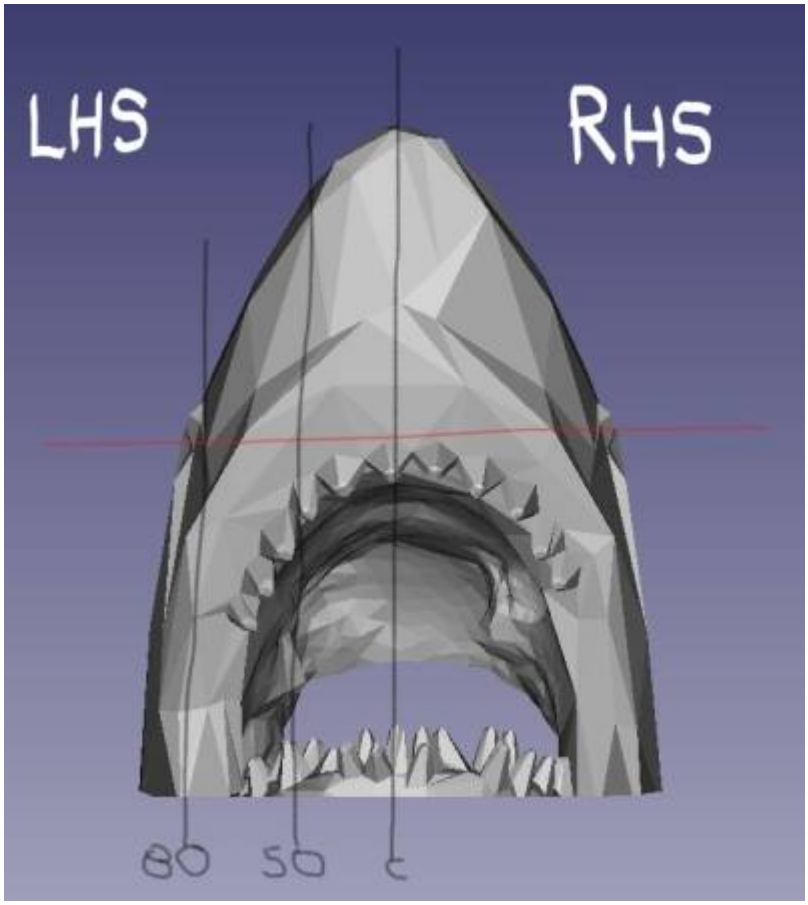

Roll the rib onto the glue, and hold down ward pressure until the glue sets.

This method gives a firm fix along the length of the rib, assisted by downward pressure along the length of the rib. It is easier to keep alignment along the folds by pressing towards the centre simultaneously. (press down and towards yourself).

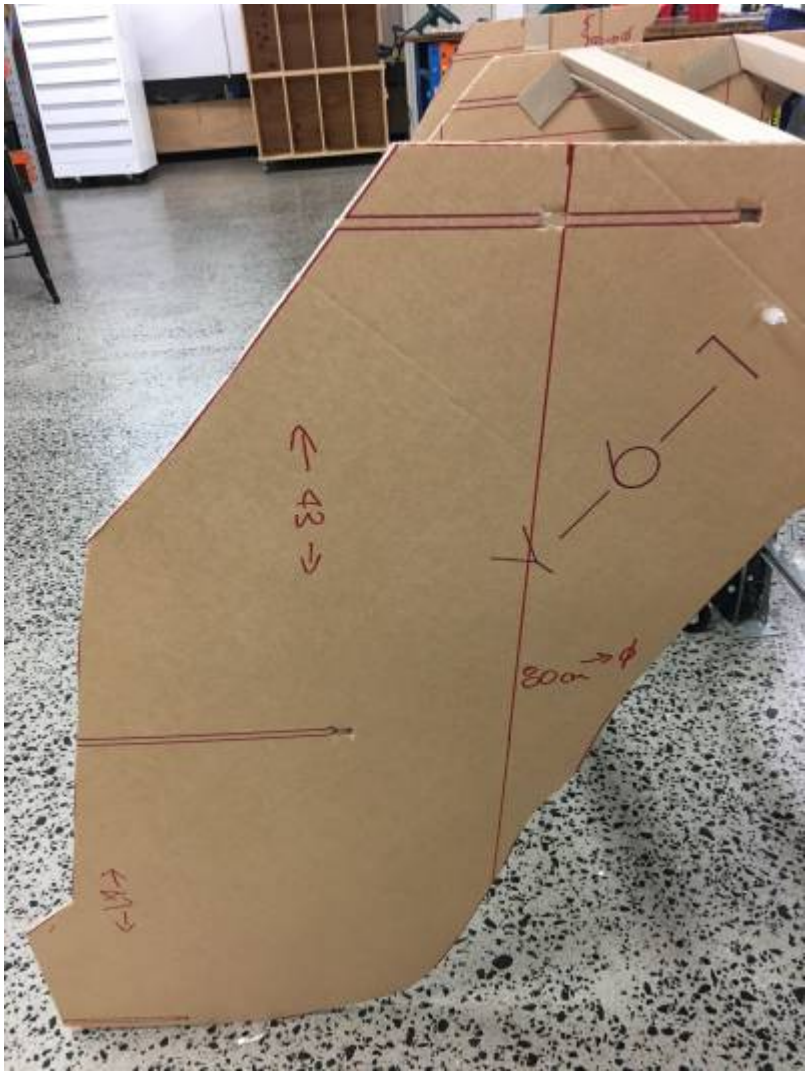
3.Add registration lines to the sheets

RHS and LHS were designated as viewed from the front of the shark

The model was cut into 4 sections to make transport easier: vertically down the centre, and then horizontally at a point ABOVE the central hollow. Cutting above the hollow ensured that the bottom quarters would meet during assembly, and that they would have a vertical face to allow them to be attached before adding the top sections.



A vertical centre line was drawn on each Y-element, and then vertical registration lines drawn on each Y-element at 50 and 80 cm out from the centre. The Z-element slots that were in the design gave a horizontal to work from, and their irregular spacing allowed the heights to be kept aligned.

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   Suggestion: a system of registration lines is essential for future
models. Adding a scaling key would also help to check that re-sizing had not
been introduced.
   Advantage: having registration in both dimensions made aligning pieces
easier, especially after they had been flipped or rotated during layout for
the CNC.
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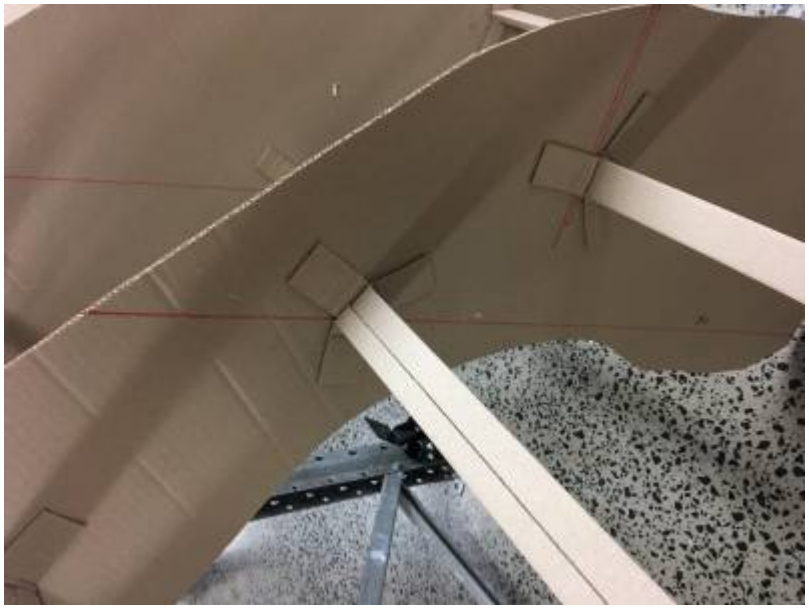
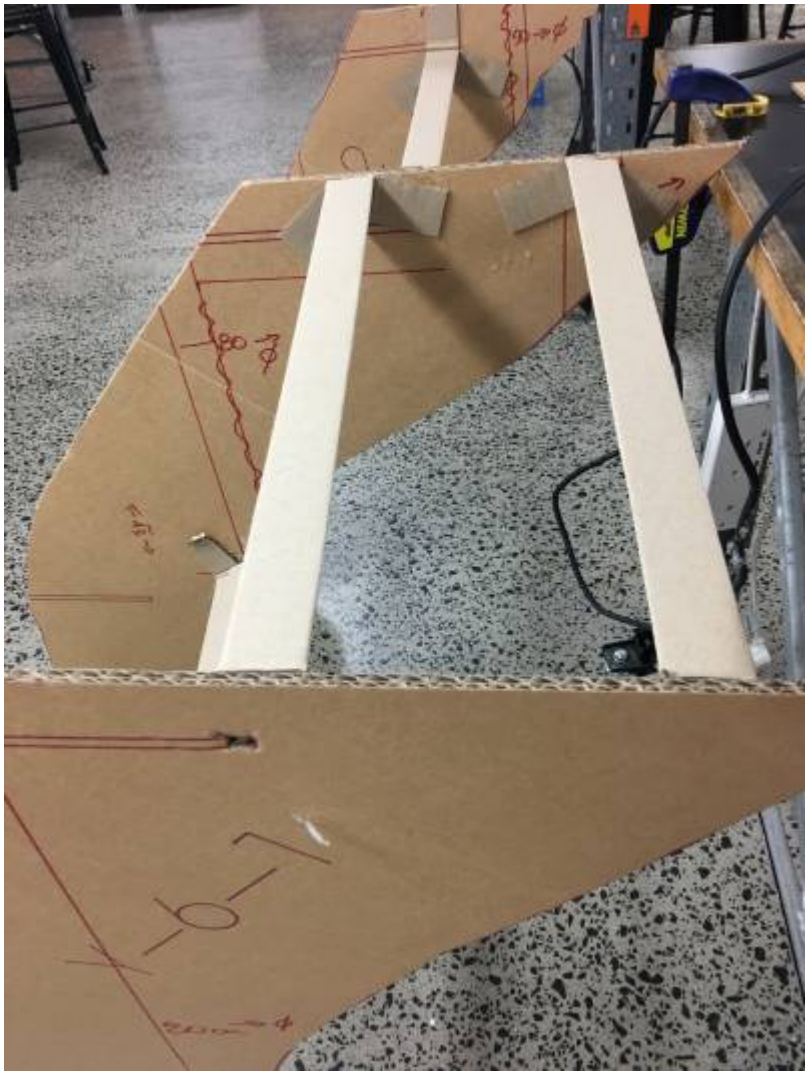
3. Attaching the ribs

The ends of the ribs were opened up by cutting down the vertices to the 46cm mark. Each face was then opened up, and glued flush to the Y-element.



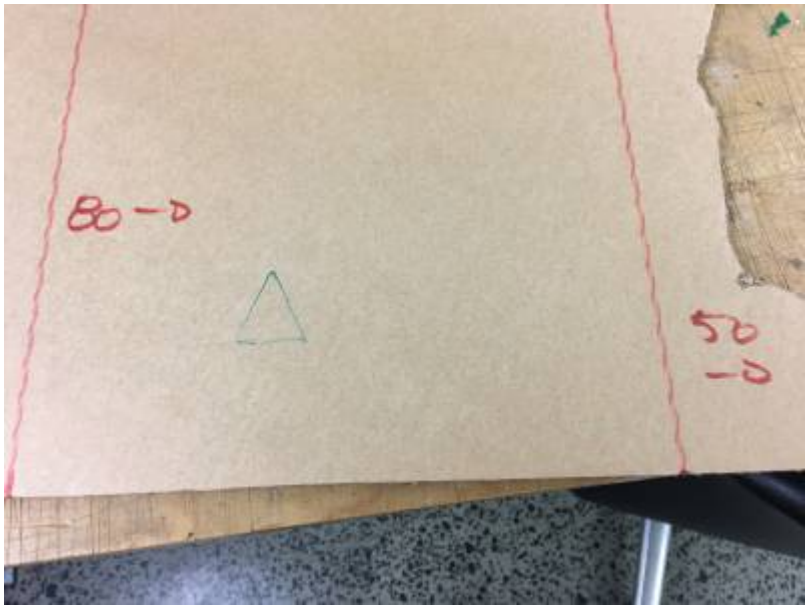
Aligning ribs to keep them horizontal and parallel to the centre axis of the model was an issue (another reason for lots of registration marks).

Z-element slots were used to keep ribs horizontal, and vertical registration lines to keep them parallel.

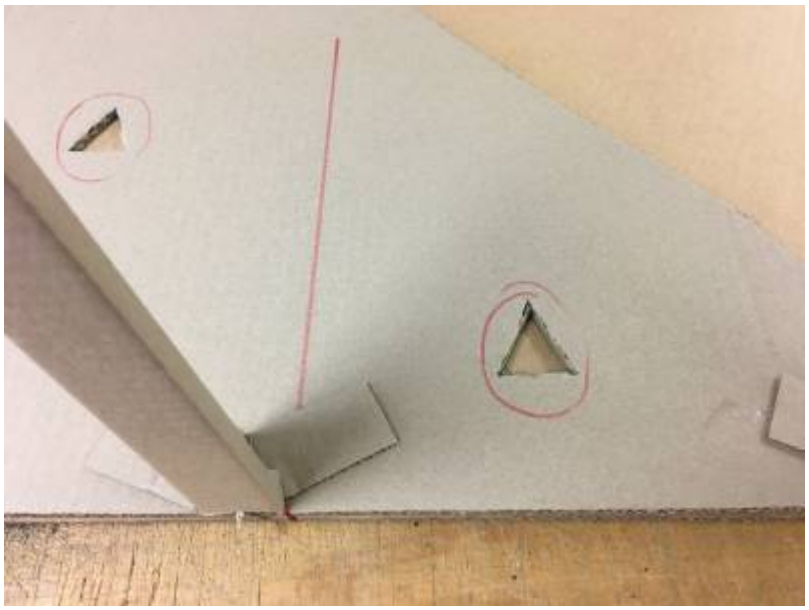

Ribs glued with a flat face flush to the top edge kept this face horizontal, and gave a surface for gluing on a top plate. (Note that one of the rib glue tabs has been removed, rather than bending it over the edge, and so introducing bumps).

4. Dealing with a hanging part

One of the internal Y-elements did not touch the floor, and so double-length ribs were introduced to support it. In this case, the Y-elements on either side did reach the floor, and so provided support to the hanging beams.

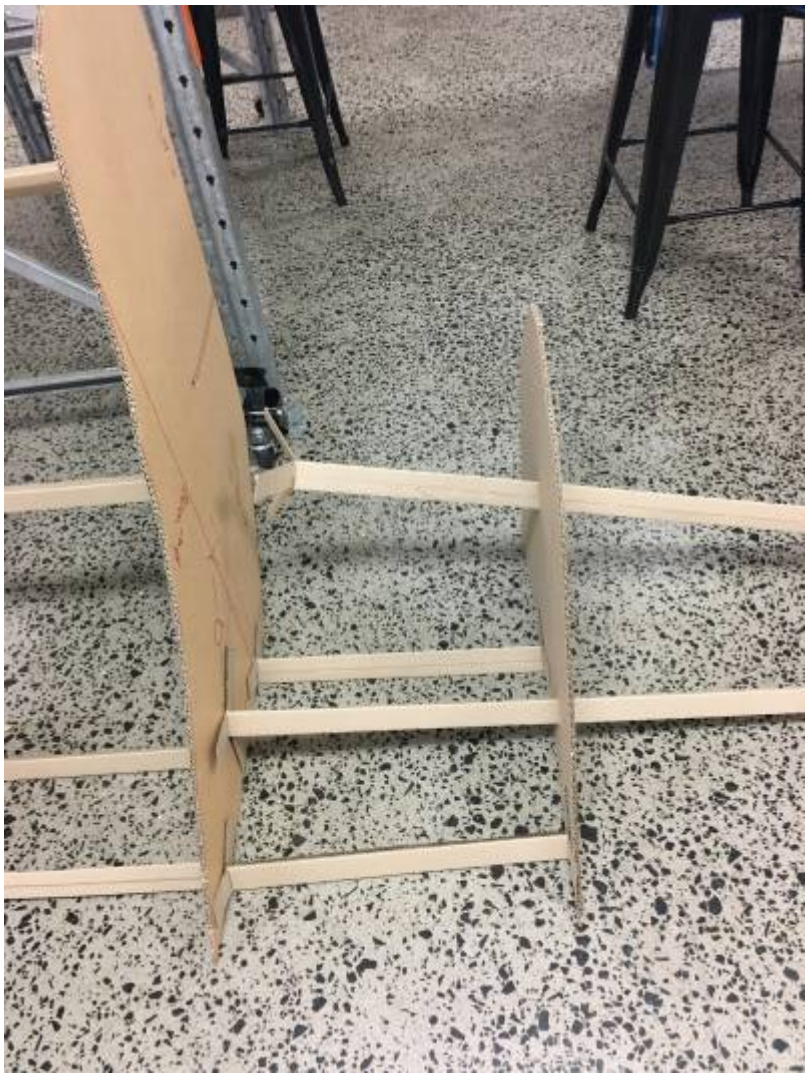


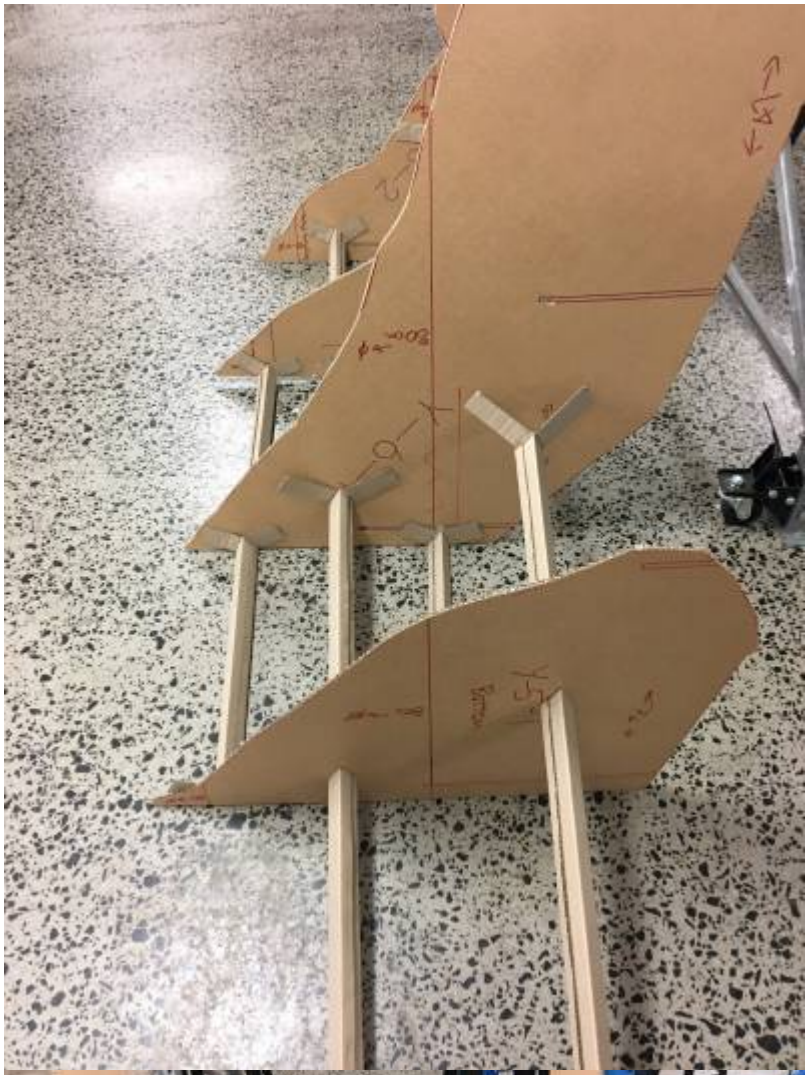
A short piece of rib was made as a template for drawing the beam holes.



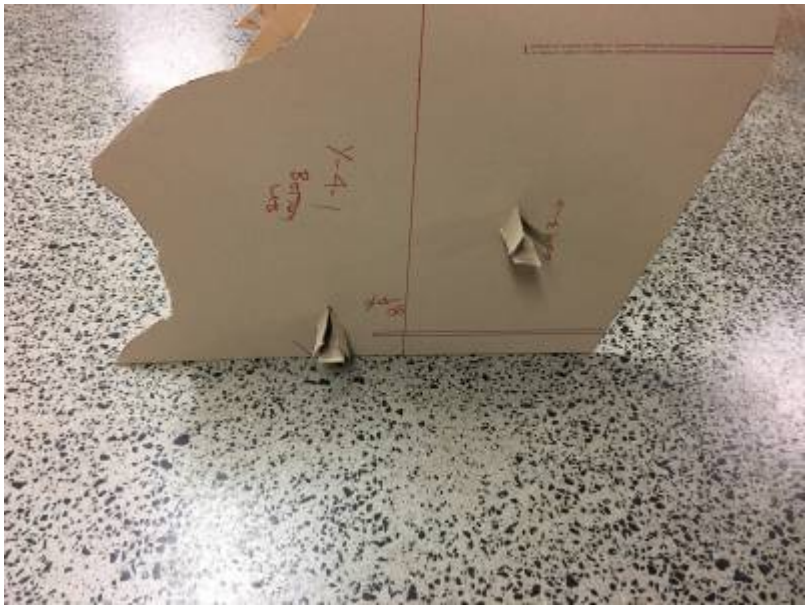
Holes were cut in the hanging element.


The piece was place upside down so that a consistent flat edge across the whole model was on the floor.





The support beams were pushed through the holes, and butted up to the adjacent Y-element. They were also located through holes in the next Y-element along to get them horizontal before gluing in place.



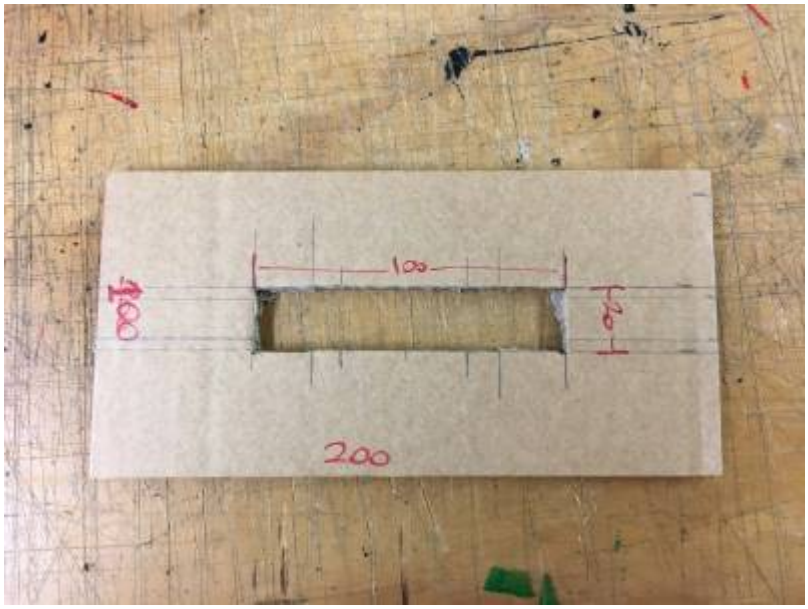
Protruding ends were trimmed off, and gluing completed.

Finally, the part was turned right way up again for the top plate to be added.

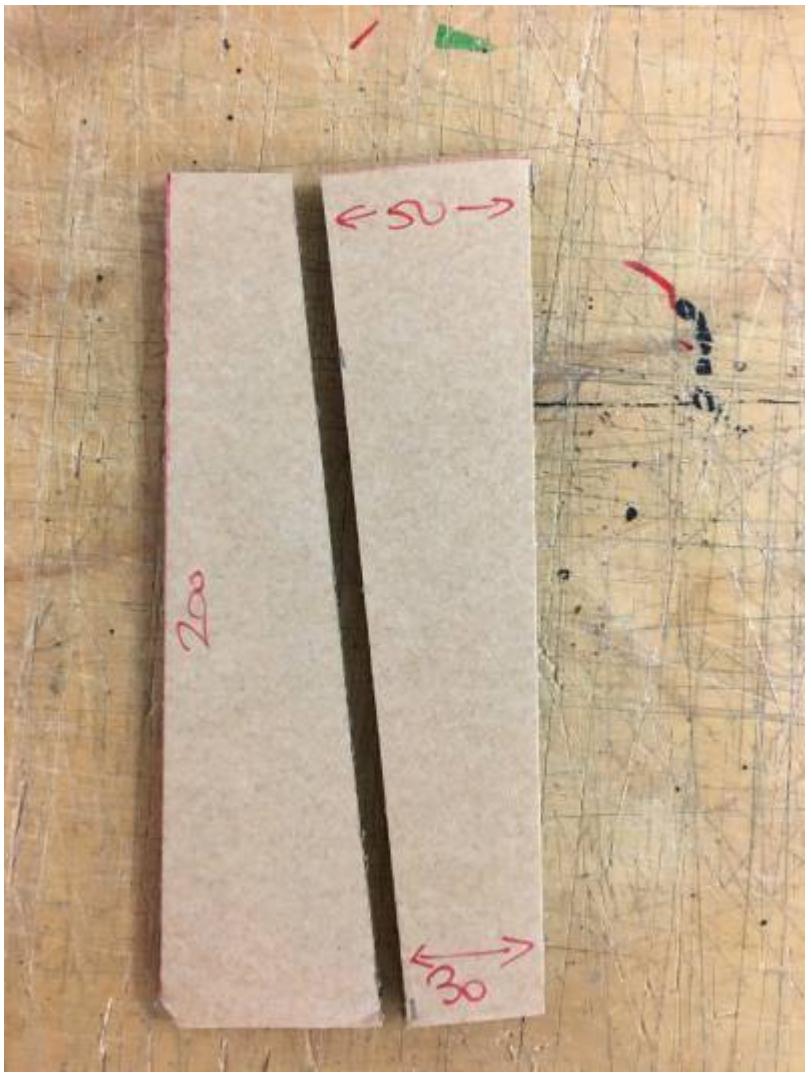
5. Joining the sections with wedges

A system of wedges was devised to join the sections together. A connector is pushed through a slot cut in each of the plates between two sections, and wedges tapped in to secure them in place while at the same time pushing them together. The advantages of this system are

- it uses cardboard, maintaining the integrity of the concept
- it requires no tools or hardware
- it is cheap

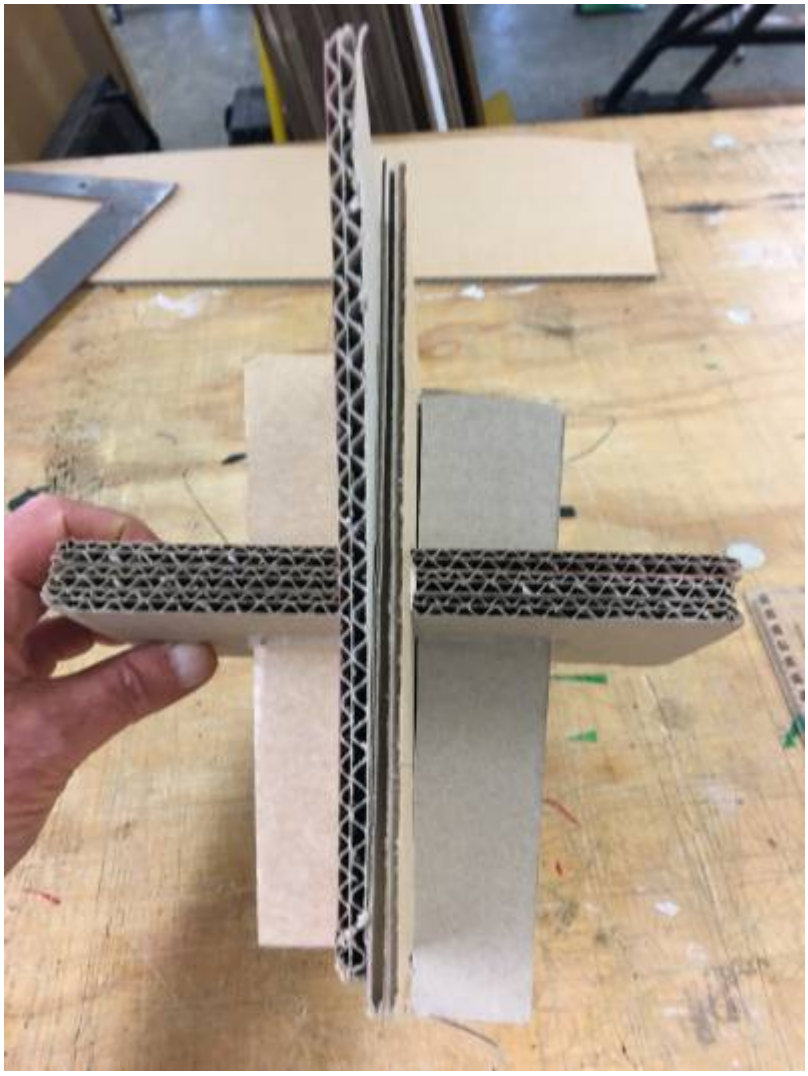


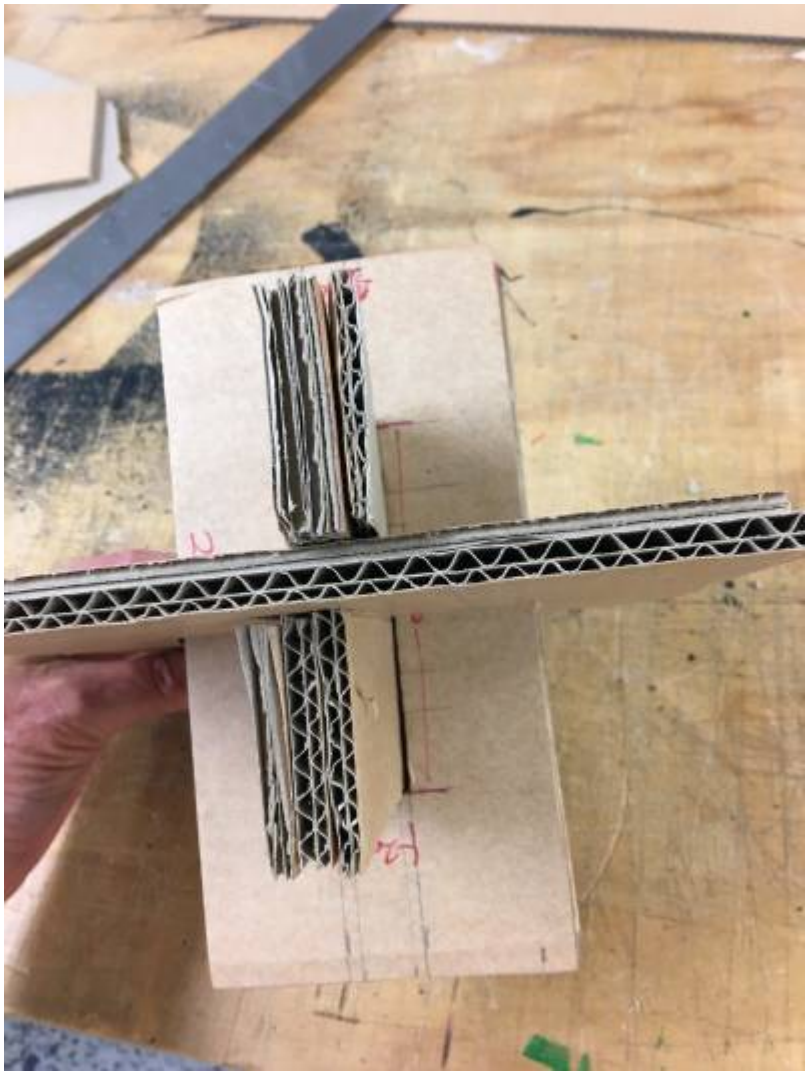
First, make a connector by gluing 3 pieces of double ply cardboard together (6mm thick) with the dimensions shown. This can also be used as a jig to draw the slots onto the sheets as required.



Cut out a couple of wedges, also made from 3 layers of 6mm cardboard.

Cut two 100 x 20 holes in the sheets to be joined, and hold them together so the holes align. Push the connector through.

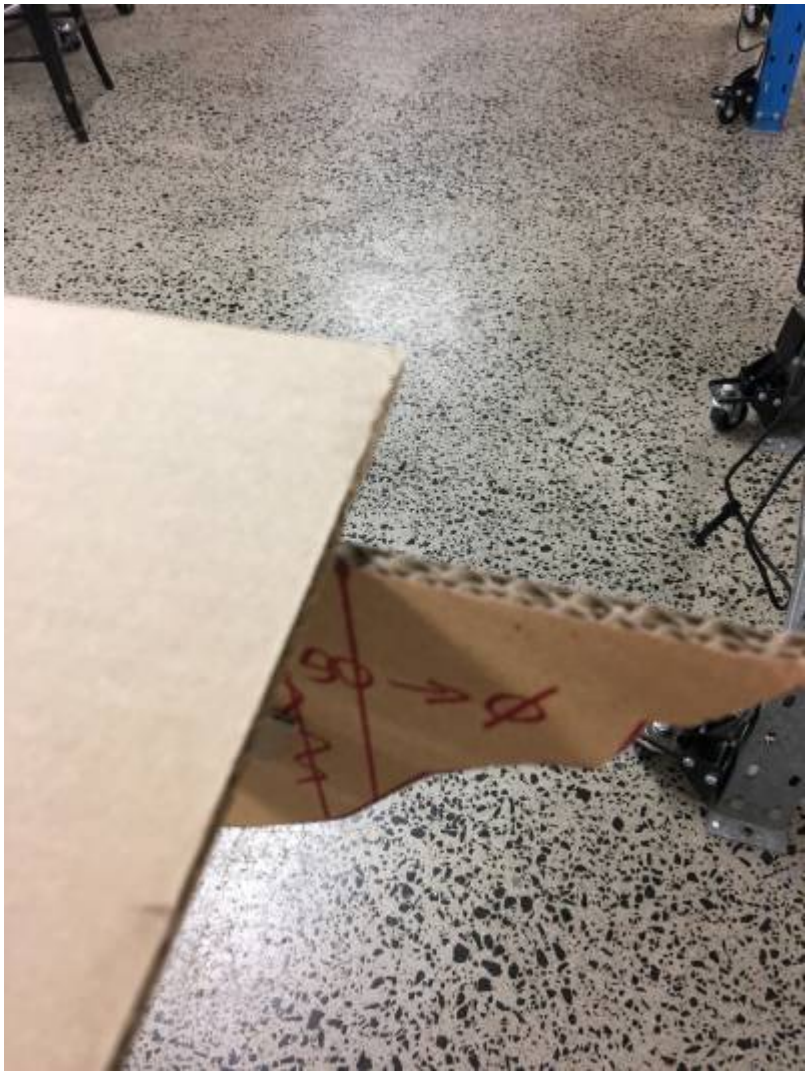




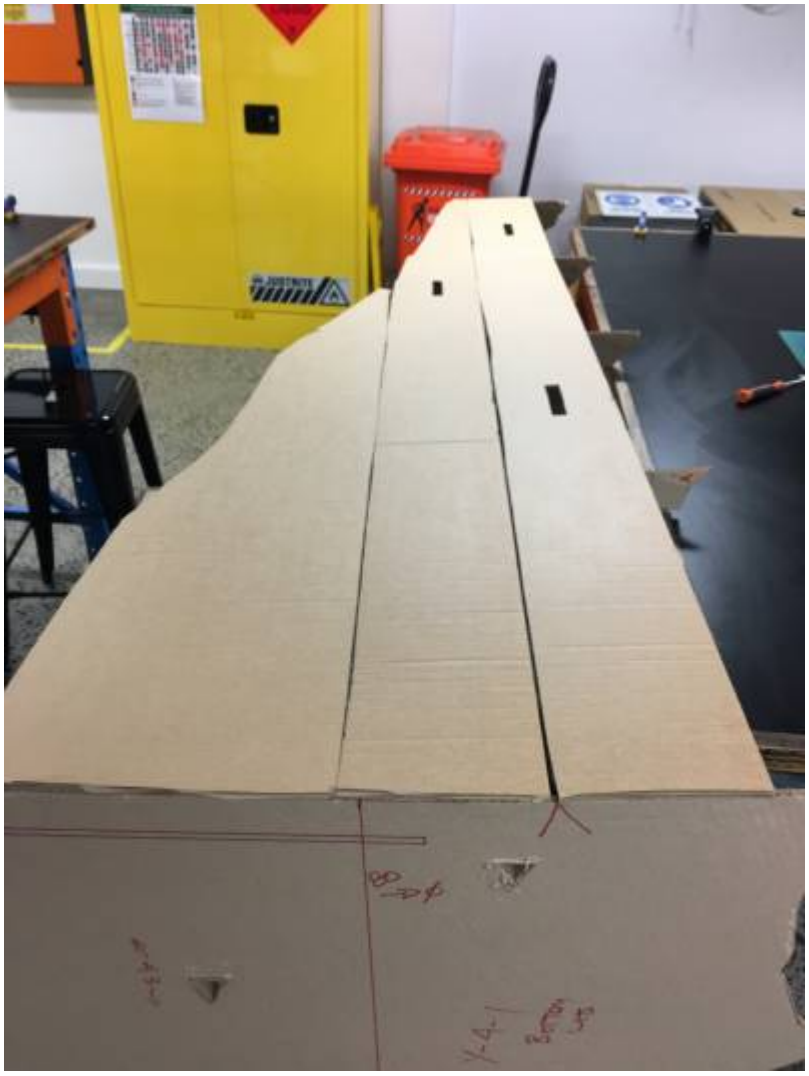
Push a wedge in from either side as shown, and tap them down to make a solid connection. Keep the sheets perpendicular to the connector as you go.

6. Adding a top plate

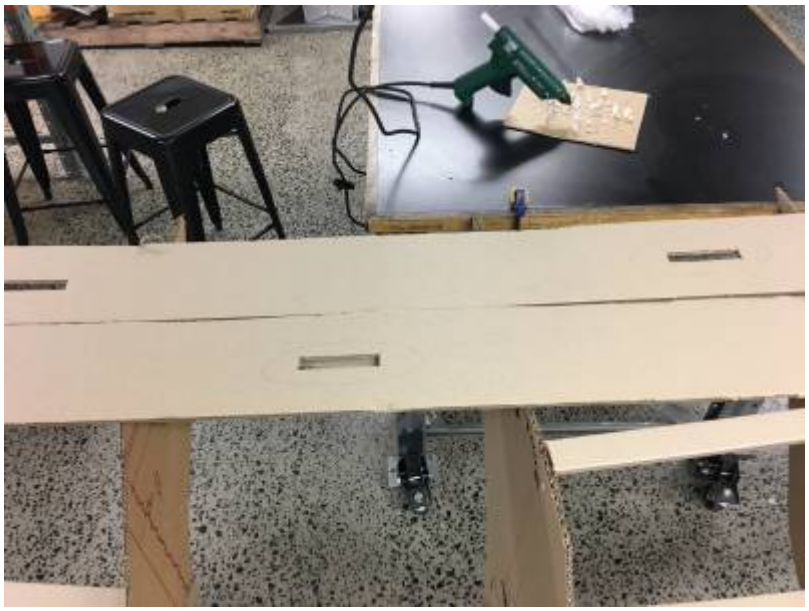
Each section will need a sheet glued on where it joins to other pieces. This sheet will be used for the wedge connectors, and will also help keep the Y-elements aligned. You might need to add some extra ribs along the upper surface to give something to glue the sheet to, and added strength.



Use the registration marks to keep the Y-elements in place as you glue the plate down. Start with one section, and glue successive ones in place as you go, adjusting alignment as required.



Trim the edges to match the Y-elements



Mark and cut slots for the connectors. Note that these slots are THE WRONG WAY ROUND as the ribs beneath will interfere with the wedges. Slots should run perpendicular to the ribs.


When complete, flip the section right way up.

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  Disadvantages:
    * Using scraps to make the top plate was a mistake - a single sheet
would be more stable. Maybe flip the section upside down onto a full sheet,
and cut out the shape from underneath.
    * The slots for the connectors must run perpendicular to the ribs, or
they will get in the way of the wedges.
    * there will still need to be an access point for each wedge after
skinning
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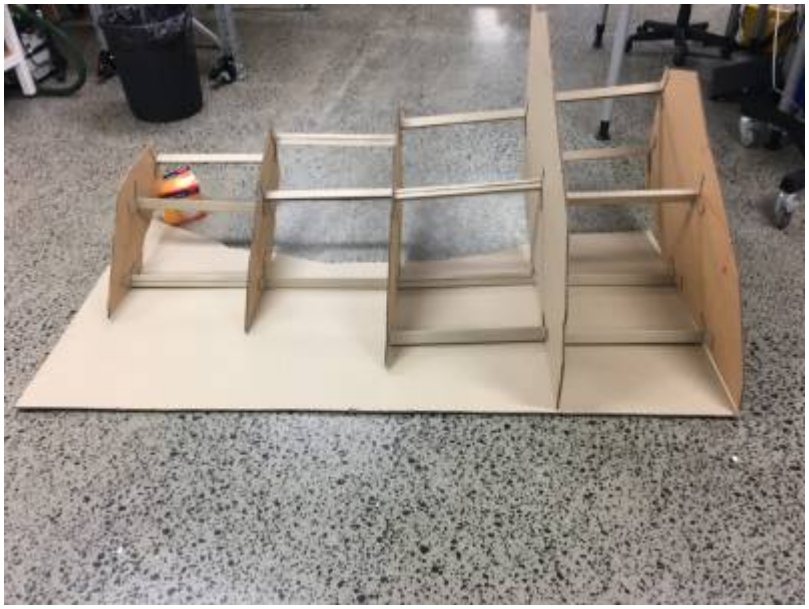
Jan 2021: Rebuilding the shark: Adding the next LHS modular sections

As construction continued, it became obvious that one vertical section had been misaligned - this was shown clearly by a displacement downwards of the Y4 (the end vertical of the module) part due to a mistake in the Z-registration. Another argument for strict file hygiene.

1. Join LHS Top Y-segments

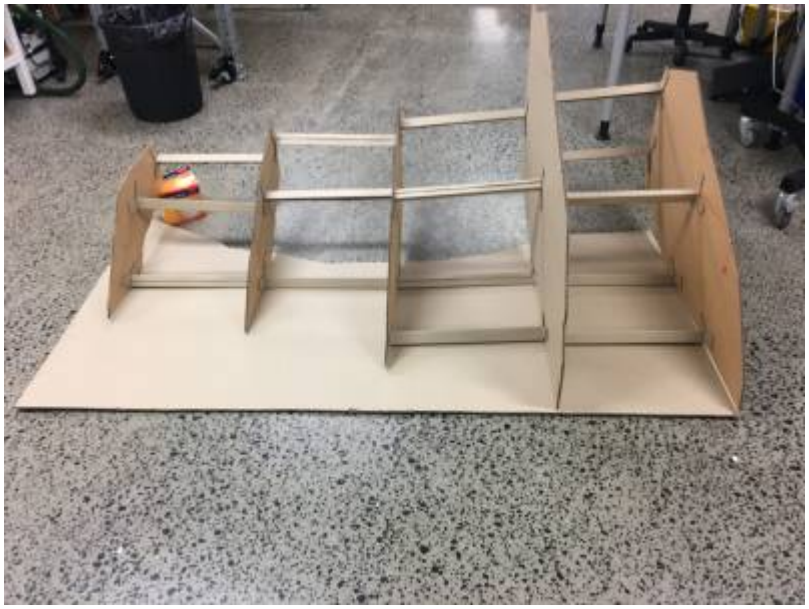
As before, use registration marks and ribs to join the Y-segments together. Keeping ribs perpendicular was again a problem - having registration marks that transfer a common cartesian grid to both sides of the elements would be a good idea.

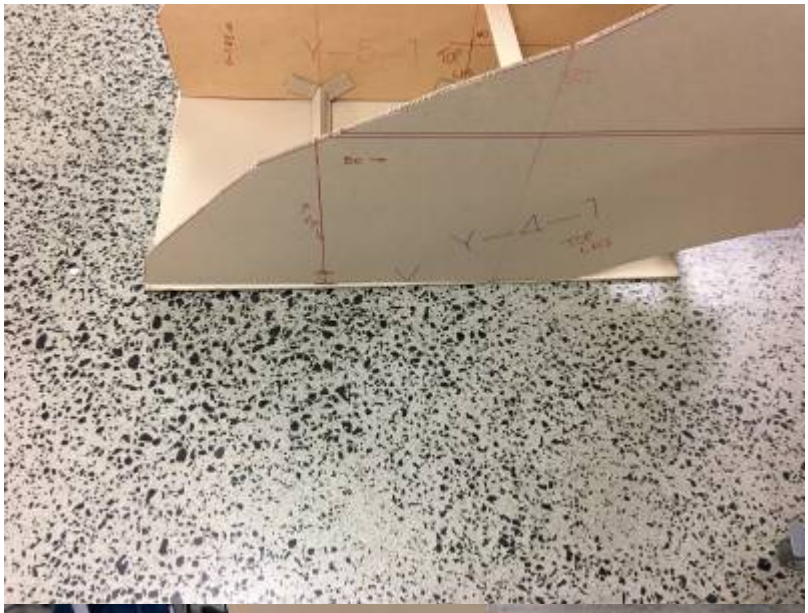
Note the trimmed ribs aligned with the straight sides to provide gluing points for the join plate to come. It is important to keep the folded side away from the flat edge so a single flat plane is available for gluing.

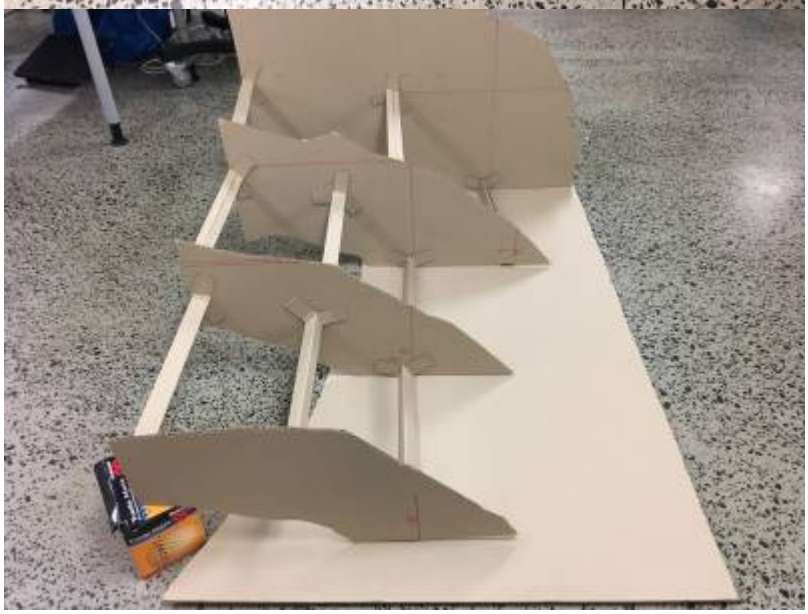

The finished section set out on a single sheet of cardboard to trace and cut the joining plate.

The mistake in the vertical placement of Y4 can be seen clearly - instead of continuing upwards to the head, the last vertical is too low. Luckily, this Y-element forms a join face for the next module - so it needs to be duplicated anyway to start the LHS-front module. The front module will be attached at the right height, and traced onto the mis-placed element. Cutting away the bottom will regain the original design.

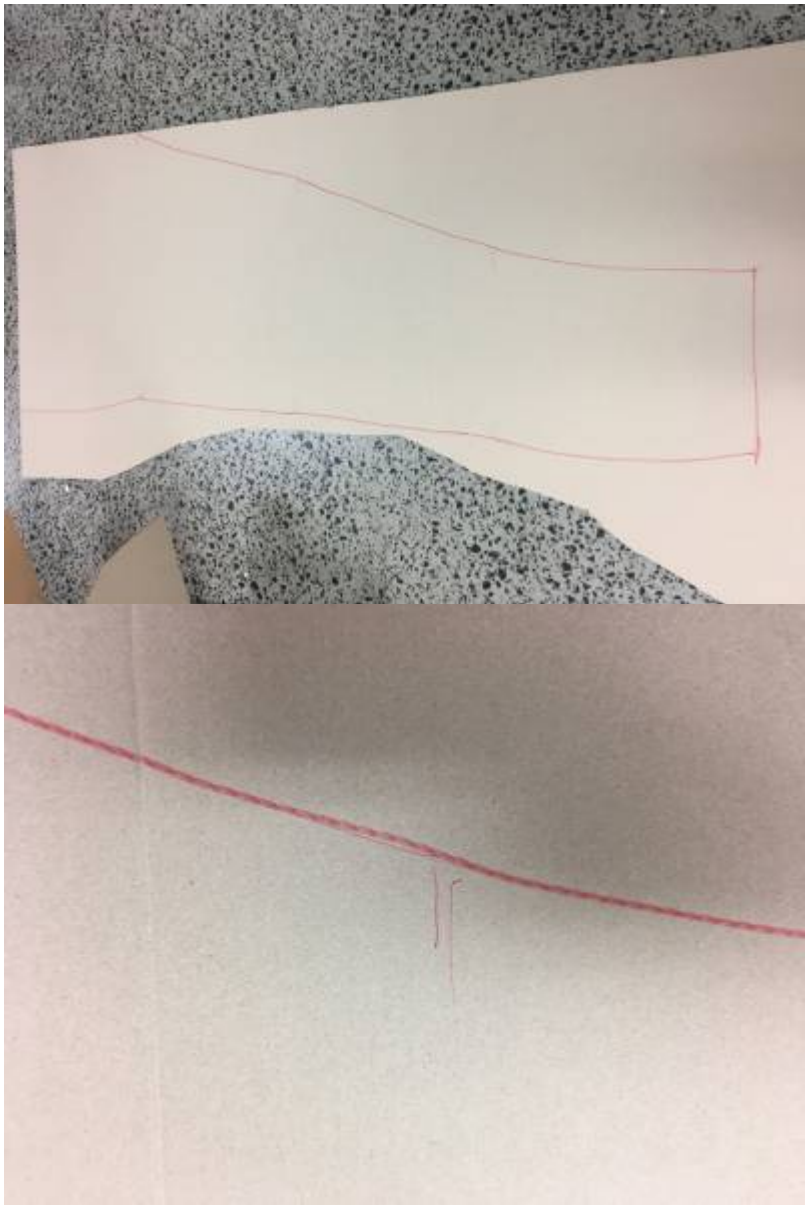
2. Add a join plate







Place the module straight side down on a single sheet of cardboard. If possible, use edges of the plate sheet to align the pieces. Propping was necessary to get all the straight edges flat on the plate.

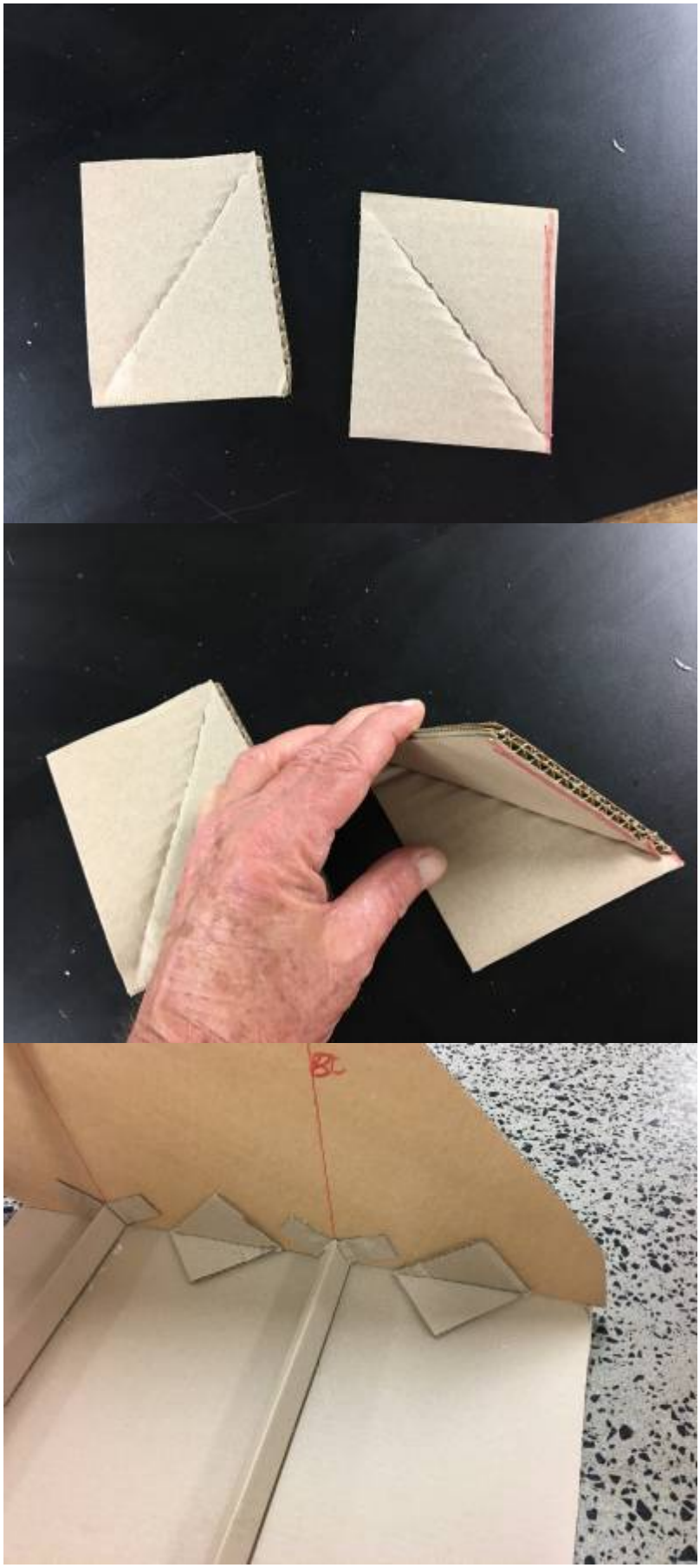


Trace the outline of the module onto the plate, marking where the Y segments sit for easier assembly later. Cut around the outline, and the plate is ready.

> At this stage, it is a good idea to use the plate just cut to make a copy. The copy can have slots for wedges a marked and cut before it is used on the adjoining module. It is much harder to do this when the plates are already attached to the modules.

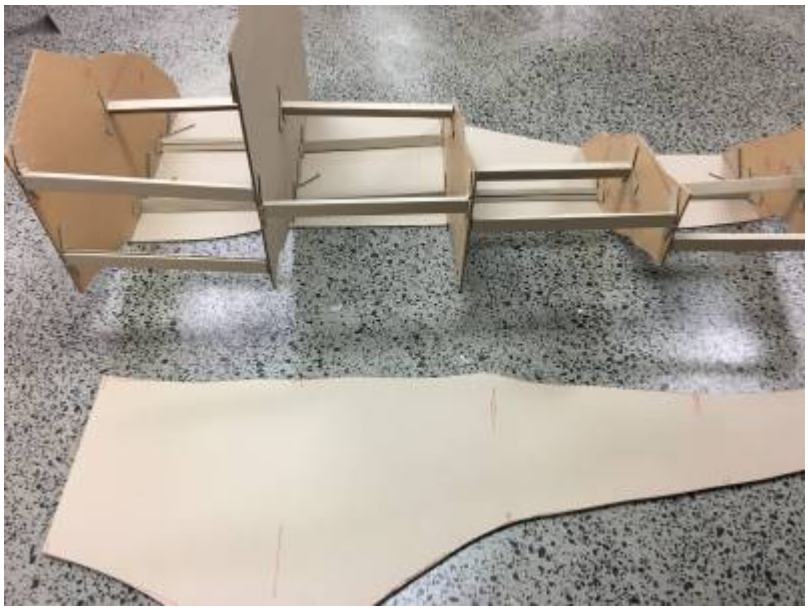
3. Attaching the join plates: adding angle supports

This time, the plate was attached to the module upside down - by laying the plate on a flat surface, and gluing the module onto it, using the Y-registration marks added earlier. Because the module was intrinsically imbalanced, extra supports were devised to help keep the Y-elements perpendicular to the plate. This helped keep all the edges of the Y-elements attached to the plate.



A few rough quadrilaterals were made from waste, then scored and folded along a diagonal axis.

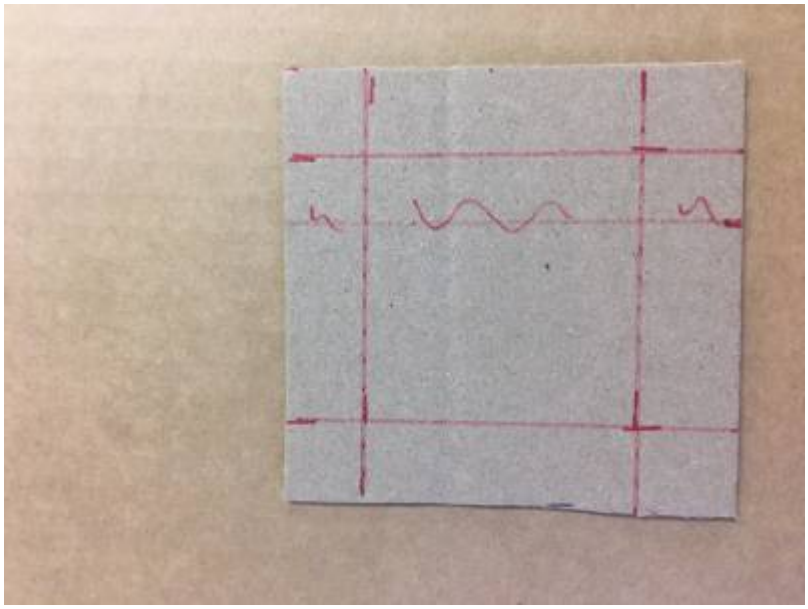
These were folded to make rightangle, and glued in place to anchor the end Y-elements



The same process was used to mark out and cut the centre join plate needed for this module. The lower LHS module did not have a central join plate because the shark is hollow.

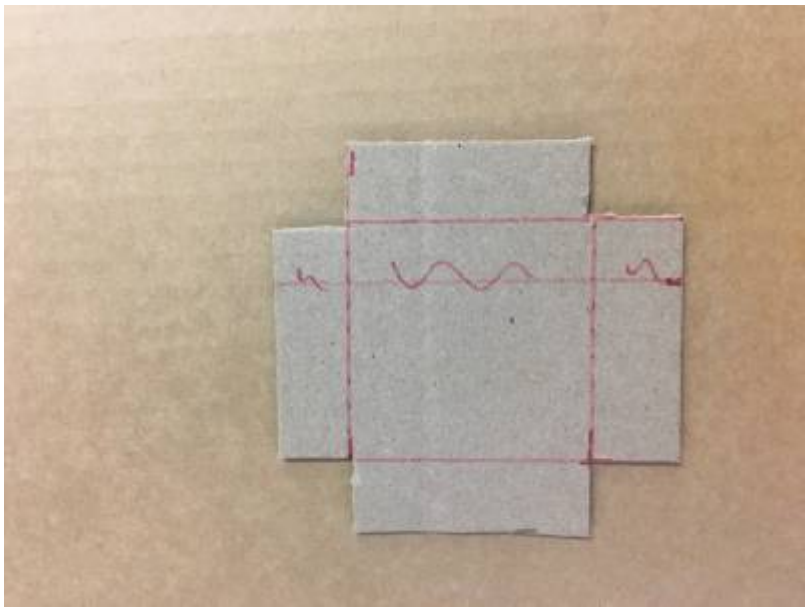
A better (but more labour intensive) design for angle supports

The angle supports used above worked to a point strengthening the join between vertical and horizontal parts, but did not provide much resistance to the Y-elements moving out of plumb. They kept the pieces together, but did not keep them square. Another design was used later, with an extra fold to provide better bracing:

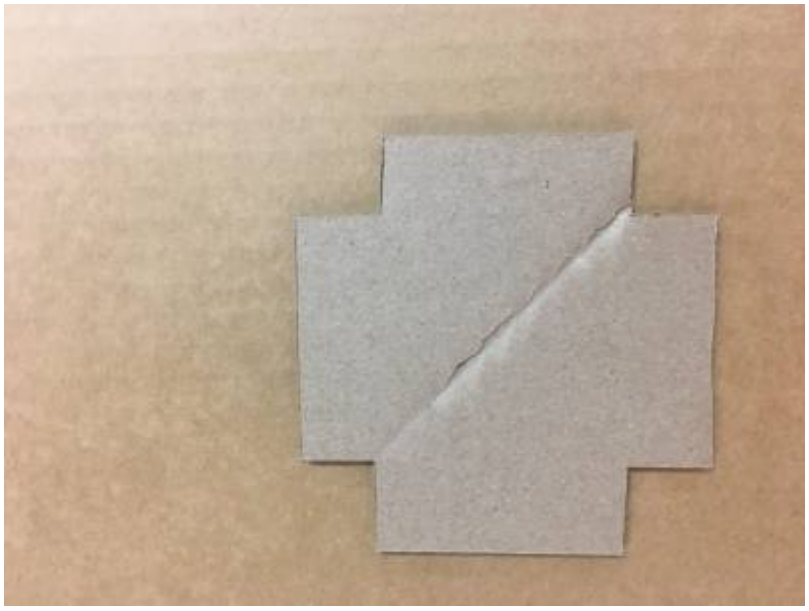


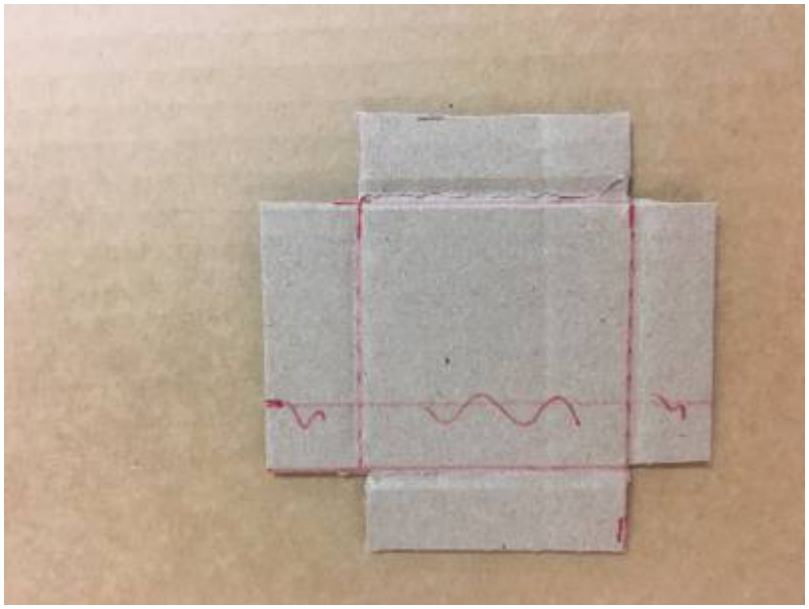
A rough square was cut from scrap material, with a 10-15mm margin marked all round.

The size of this square will be set by the location of the support - it has to fit between ribs, and away from wedge holes.

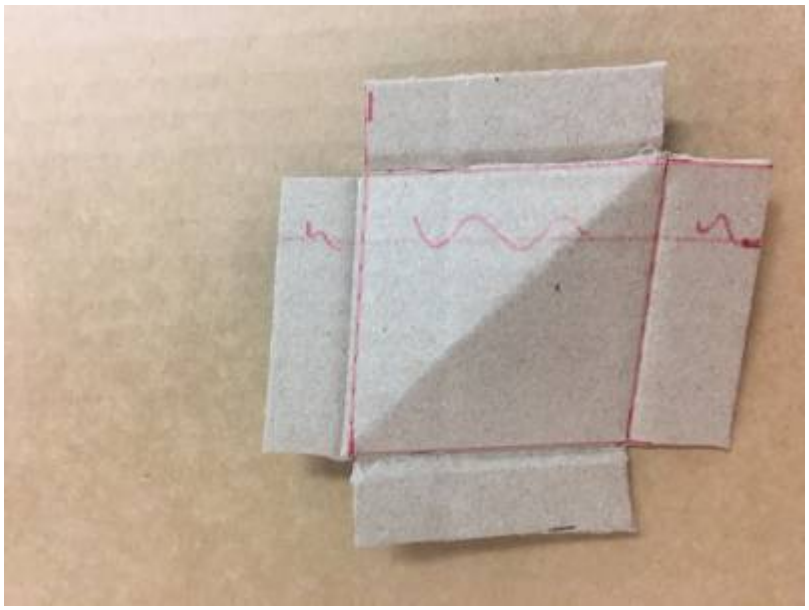


The corners are cut out to allow folding

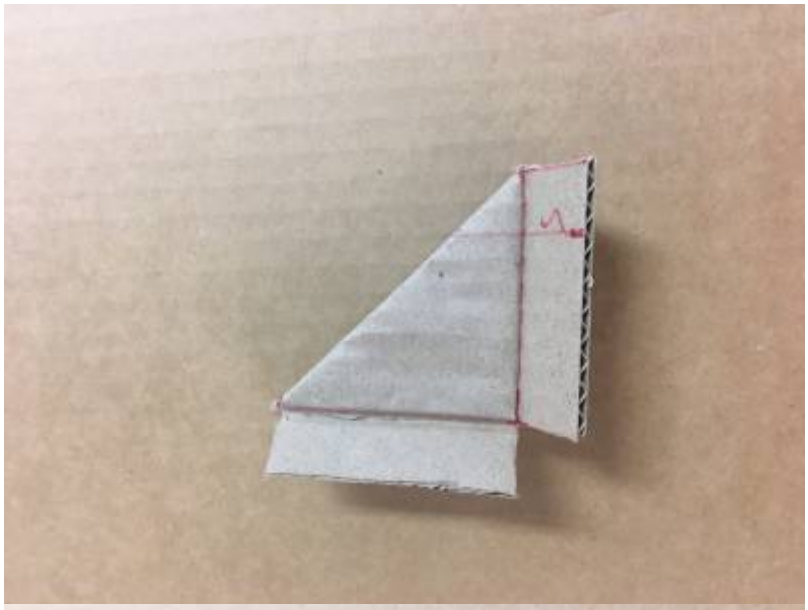


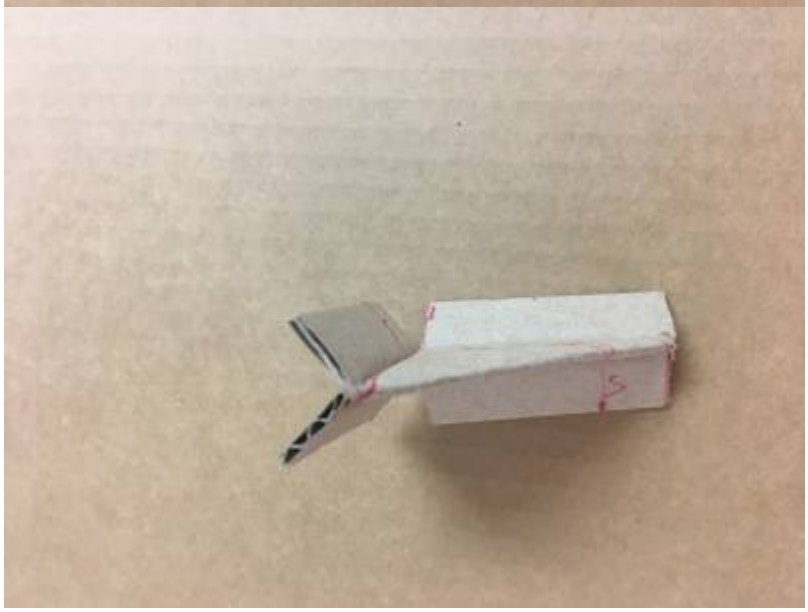


Flip the piece over, and make a diagonal score along the back. On the front, score along the margin lines



Pinch the corners together down the diagonal fold. Fold the margins upwards.

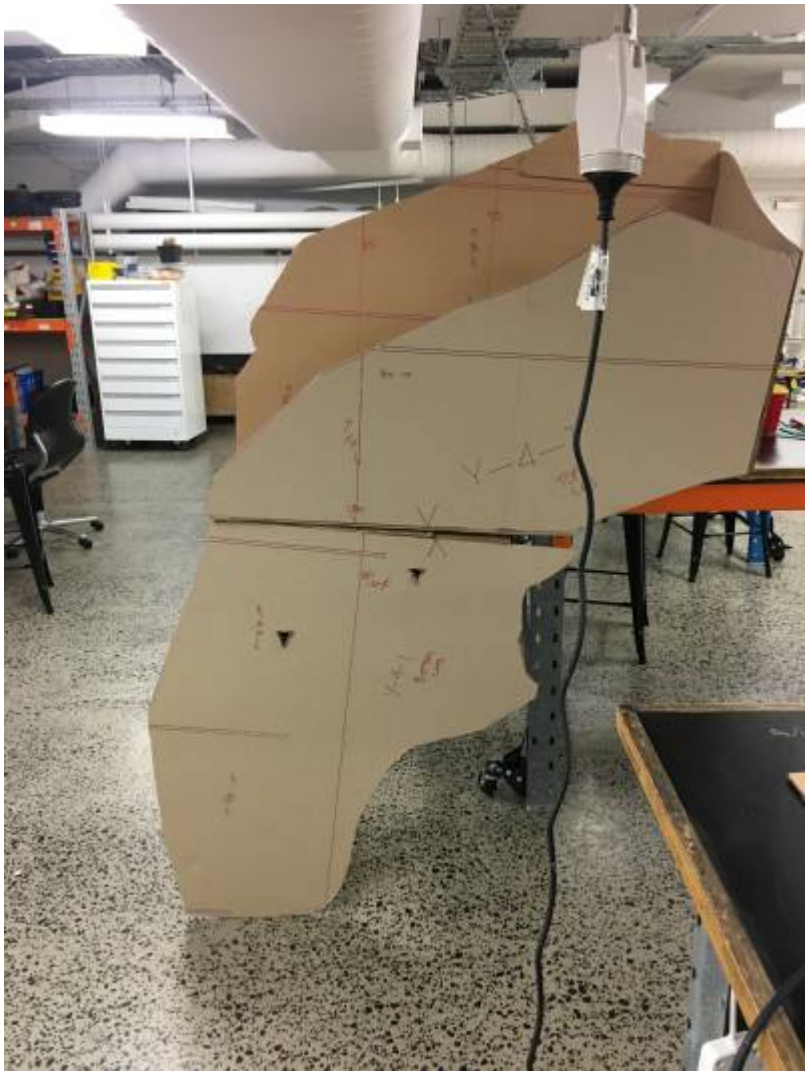




Glue together the centre of the triangle, and press firmly until the glue hardens. Fold the margins out of the way while the glue sets .

Attach the supports by adding glue to the underside of the margin flaps, and pressing it firmly into the angle between the two sheets you are joining. You can see why these supports were made small - there is not a lot of space between ribs in places.

4. Joining the top and bottom modules



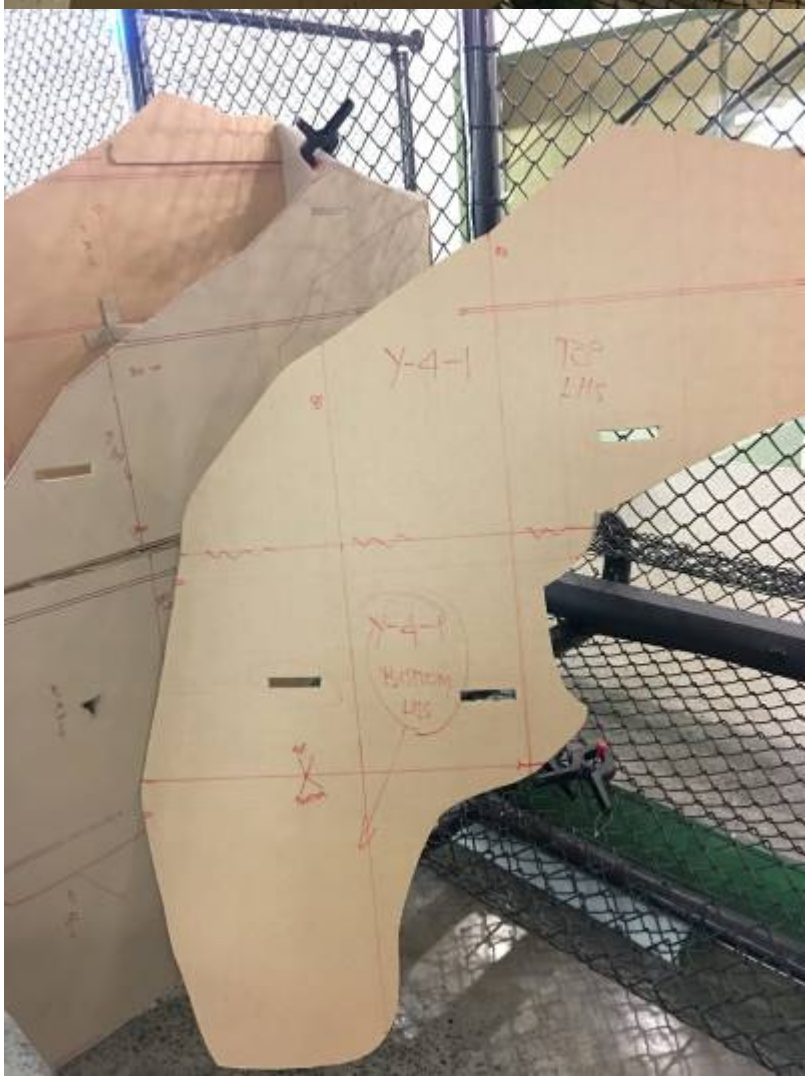
The registration marks were used to align the ends of the two module, but warping meant a good horizontal alignment was not achieved.

So clamps were used to hold the modules together while wedges were added.

Holes were cut through both join plates, wedges prepared and added as shown. Note the holes were aligned so the wedges ran parallel to the ribs to avoid interference.

5. Duplicating the end plate, with wedge locations

This time, a duplicate end plate was traced an cut before assembly. Wedge holes were added to the fixed end, and transferred to the duplicate by tracing. Note the wedge holes were placed to avoid the area to be cut away (the lower part of this element). Registration lines made this possible with some expectation of success.



6. Making the nose - an exercise in defying gravity

The next module had no lower section since it was the raised snout of the shark. Additionally, the Y-

elements get progressively smaller, and more vertically displaced as you go towards the tip. All this meant that the module was unstable when assembled, and tended to droop downwards, no thanks to gravity.

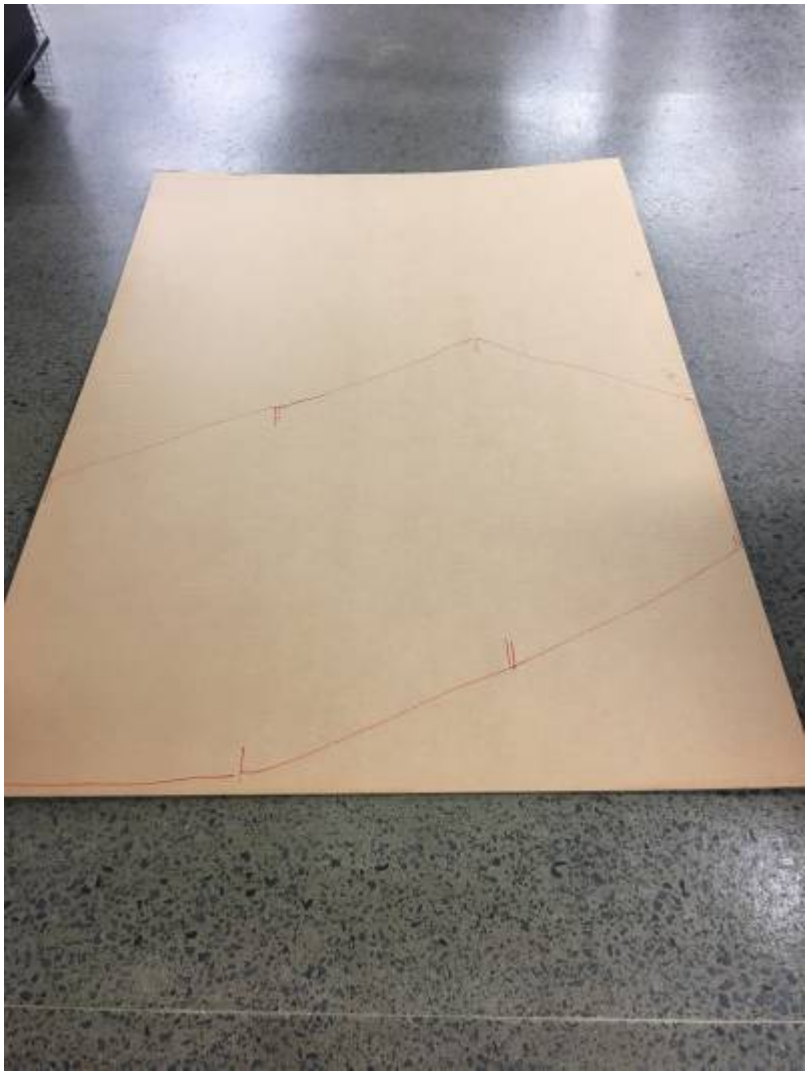
This is a simpler approach than the ribs that pass through a hanging element (described above), but it remains to be seen if it is effective. An extended rib used here would have a single point of secure attachment, since only the first Y-element will be attached to a join plate - basically it would be solid at one end, but hanging in space at the other, unlike above, where the through-rib could bridge between two grounded Y-elements, with a hanging element between.

A rough measurement was made while the sections were held in place, and a single strip brace was made to help support the hanging piece.

This approach was repeated for the other Y-elements in this module. (The side of this construct facing the viewer will be the vertical centre join plate - the braces run from high on the hanging piece, to low on the support piece)

7. Making the nose - adding the join plate

As before, the LHS nose module was placed centre line down on a sheet of cardboard, traced, and a join plate cut.



Once again, a duplicate was made for the other side before marking and cutting wedge holes.

> When cutting out the join plates, give thought to conserving material - because the Y-elements are 46cm apart, a module with 4 of them will fit crossways on a 1200×2400 sheet.

8. Making the nose - attaching a hanging part

After the wedge slots had been cut into the join plates, and wedges prepared, the nose piece could be hoisted into position, and attached.

Note that clamps have been used to hold the hanging nose piece in place during and after attachment.

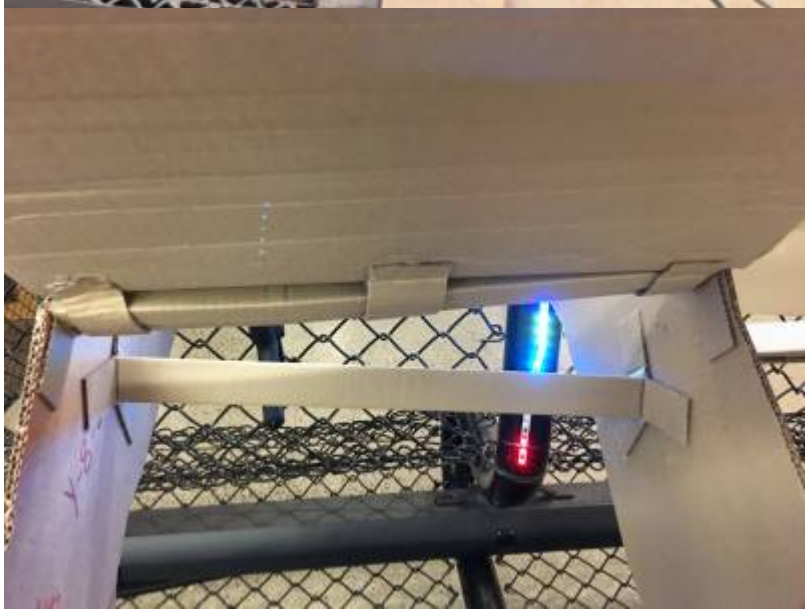
The cantilevered design of this object will require a solution for supporting the weight without damaging the rest of the structure. Making the piece in segments means that support beams running back from the nose to the ground are not easily introduced, and a system for securing a hang point at the tip for installation is under development.

9. Access doors in the skin

A preliminary design for access ports through the skin to allow the wedges to be installed and removed was developed using a simple hinged flap.

First, a triangular rib was put between two of the Y-elements that open to a cavity containing wedges. The rib was placed with a surface flush with the hinge line.

After measuring, a flap was cut, and worked to make a curved surface following the lines of the Y-elements. This means the flap might not always be a square piece. The edge where the flap is attached to the skeleton was crushed from both sides, to make a more flexible join.



A few 50mm wide strips were cut to make the hinge, and thoroughly worked (crushed and bent over the edge of a bench) to make them almost circular. These pieces need to be long enough to reach loosley around the rib, with about 50mm at either end for gluing to the skin.

The finished flap will need to be overlapped by the surrounding skin to hide it.

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 FINAL THOUGHTS
   * the ribs are still a bit flimsy, and prone to collapse. Gluing extra
layers along the surface of the rib did not really help (except as an
emergency repair).
         //Suggestion// Try using more robust cardboard - double ply instead
of single. This will make folding more difficult, and ribs might need to ne
larger.
   * attaching the skin is not resolved. Some way of establishing a surface
shape in the horizontal direction is required.
        //Suggestion// Cut narrow z-strips from the 3D model and fix them
along the Y-elements (this will be screen intensive). Or get an artist to
freehand it.
   * suspended parts in a modular design are tricky. There could be
cantilever supports made to run to the back, but they would need to be in
segments matching the segments
     of the model, and joining then becomes a problem (all the stress then
comes at the join, and droop could be expected.).
        //Suggestion// Make a moulded, robust internal part that could
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anchor a suspension cable. This only  works if the installation site allows
it, and avoiding a tendency for
                                    the suspension cable to tear through the
skin would have to be managed.
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