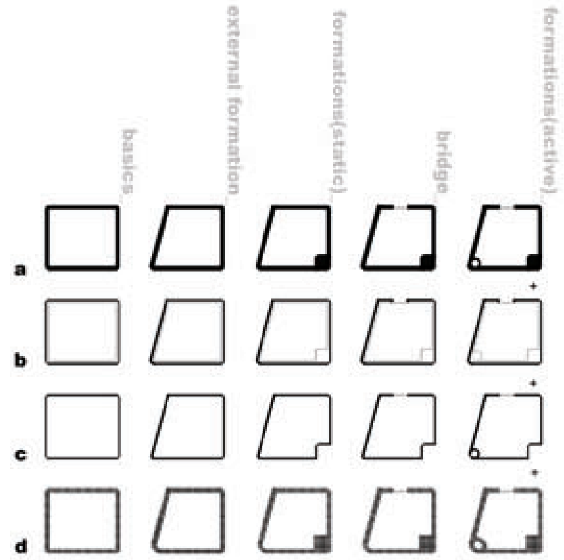
01
system research

programatic guides_The programatic response was intended to be some type of deployable disaster relief shelter. At the begining of the laboratory investigations the only real programatic ideas guiding the studies were abstract concepts of:

expandable
protective
and only later **insulative**

types_	primary function_	how_
1_speaker enclosure	1_creating a resonance chamber to amplify sound+depth	1_solid or isulated moulded form provides an air chamber, which can be either closed or ported
2_building enclosure	2_blocking out unwanted things/elements/people/views etc.	2_material or material combinations seek to create a response to a desired condition
3_jacket as enclosure	3_protection from elemental extremes cold/rainy/bullets etc	3_outside material+filler material+lining material+form= jacket functional properties
4_shoe as enclosure	4_protects foot from debris and sharp objects	4_durable exterior, flexible rubber sole, interchangable washable lining
5_car as enclosure	5_protects operator and passenger from other enclosure, static and active	5_steel skeleton in combination with plate steel and crumple zones
6_skull as enclosure	6_protects soft/fragile brain	6_hardened skull bone contains protective fluid surrounding brain and dampers impacts
7_trashcan as enclosure	7_accumulates trash in a single confined area	7_rigid semi-open shell holds disposible linings which contain trash
8_tupperware as enclosure	8_keeps food from spoiling or spilling	8_washable plastic doesnt harbor bacteria, air tight seal keeps contents fresh while the form provides the neccessary rigidity
9_dvd case as enclosure	9_protects scratch sensitive dvds as well as advertising product within	9_plastic case holds dvds without scratching while exterior plastic envelope provides space for inserts
10_soda can as enclosure	10_protects liquids from contamination while providing as a vessel for consumption	10_aluminum is shaped to be a structural pair with the liquid within, end caps serve as means of storage and consumption
11_human skin as enclosure	11_contains and protects the living fluid mass	11_semi-elastic nature of skin connects to other tissue to permit a limited range of stretch without tearing

group paterns emerge_



basics_

a_fluid capable of shaping into any number of structuraly solid positions based on a formwork of some nature that contains or guides the fluid

+'s_a single material capable of making an infinite number of shapes

-'s_2nd material needed to form bridge, operable or not_all or nothing construction_massive

b_composite system relies on a build up of different materials typically one responding to an external condition and another responding to an internal condition, materials share a symbiotic relationship

+'s_independent internals_one material system can rely on another if needed_bridging

-'s_two material interfaces regardless_potential redundancy_

c_single material manipulated in order to achieve properties that suit both the exterior and interior condition as best as possible

+'s_a single material is manipulated in order to make a responsive form constrained only by the materials properties

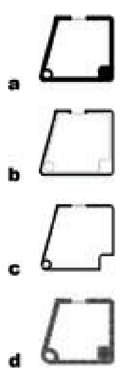
-'s_internals dependant on externals+visa versa_bridge must be additive

d_multiplicity of a modular element establishes relationship geometry and all formal moves respond based upon the geometry of the irriducible unit

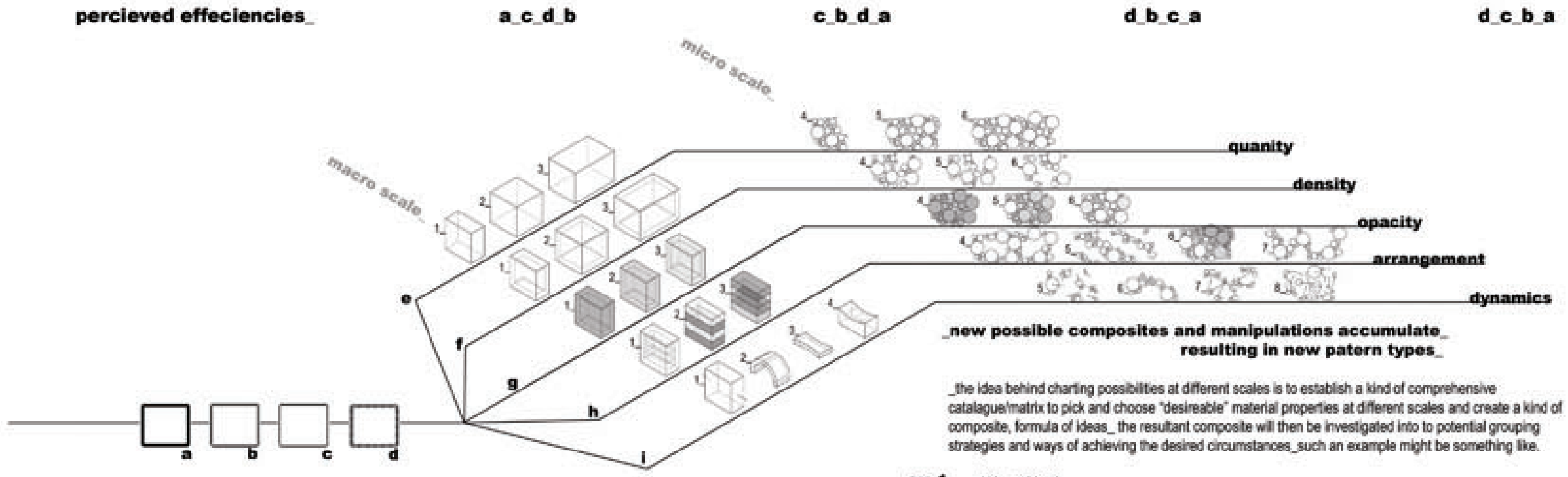
+'s_a modular element defines a narrow but specific structural geometry range_one standardized part can define many different spaces or forms

-'s_geometry may not be specific to function via modularity

= in any combination, a derivative enclosure



	production_	assembly_	deconstruction_	reconstruction_
a	a_premanufactured rough material is produced in a non structural state waiting activater in assembly	a_rough material fills void of formwork and completes itself inside,chemically until final form is structuraly non reliant	a_stable form dinegrated in some manner, usually unable to form again unless disinegration is a non-physical proccess	a_reconstuction occurs through addaptive reuse if possible or through recyling. reconstruction can rarely occur with rough disinegration in the same way
b	b_materials made seperately and assembled/joined at, or just prior to assembly, a kind of pre-assembly	b_parts join together to form designed composite in order of decided logic, structural or otherwise	b_parts break down and disassemble into whatever basics are possible, with out destruction occuring	b_parts can be reconstructed from basics given they were designed to do so
c	c_rough material manufactured in a generic way until further manipulation is asked	c_rough material arrives to a place were appropriate manipulation can occur until final form is achieved	c_material either disinegrated or unmanipulated, the reverse as it was assembled	c_material can be re-manipulated unless material fatigue does not allow this
d	d_complete modular element produced as a finished irriducible unit, ready to become part of a multiplied system	d_modules are nested in whatever way designed into the irriducible unit untill complet form is achieved	d_complete form is disinegrated back into the irriducible units	d_irriducible units nest in the same manner as the assembly phase
percieved effeciencies_	**a_c_d_b**	**c_b_d_a**	**d_b_c_a**	**d_c_b_a**



new possible composites and manipulations accumulate resulting in new patern types_

the idea behind charting possibilities at different scales is to establish a kind of comprehensive catalague/matrix to pick and choose "desireable" material properties at different scales and create a kind of composite, formula of ideas the resultant composite will then be investigated into to potential grouping strategies and ways of achieving the desired circumstances_such an example might be something like.

ex_1 g123 e123 i8

g123 implies that the enclosure will have the ability to shift between different degrees of opacity via_i8 a fluid micro structure that could atain the desired opacity change via_e123 where the fluid body shifts its own material alowcation

a.

***ex_5** i2 i7 f456 g123 abcd

a flexible enclosure i2_ with elastic properties i7_ allows the micro desnity to be altered/ spread out and condensed f456_ in a way to effect the overall opacity of the object g123

b.

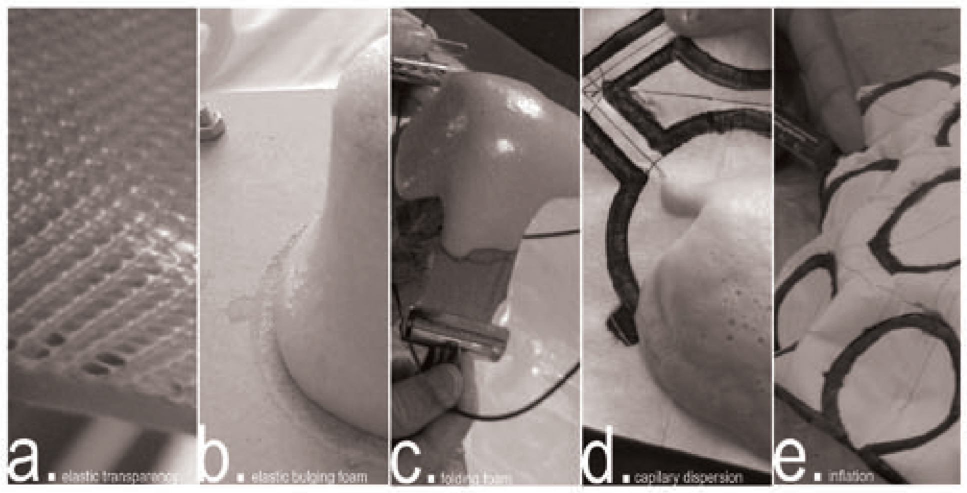
***ex_3** h7 h1 f456 abcd

h7 a structural micro structure formed by an increae in the material to space ratio_f456 into a cellular/structured form h1

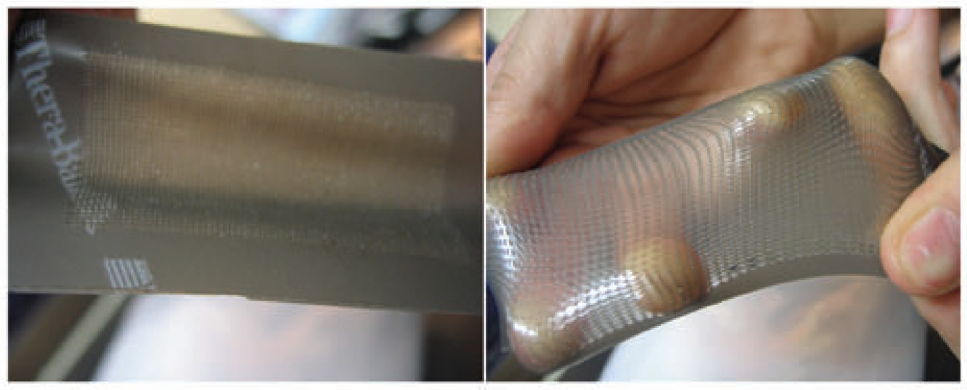
***ex_10** e4 h2 +/0r h5 i7 abcd

a small amount of material e4_ that is able to transfer from a cell structure of pockets h2_ into a permeable structure h5_ from elasticity at the micro level_ i7

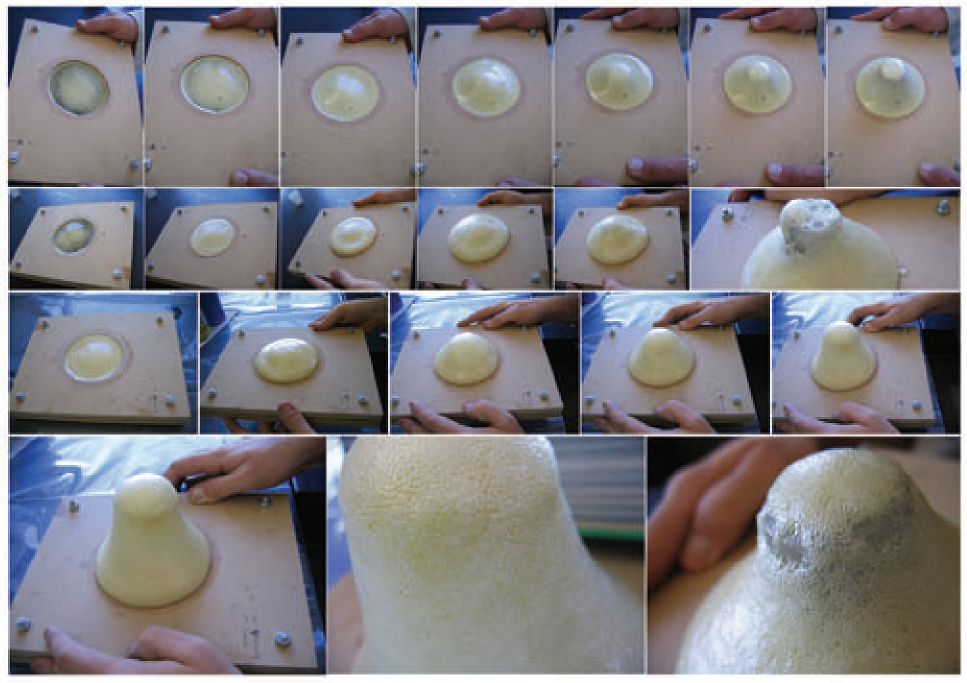
02
material research



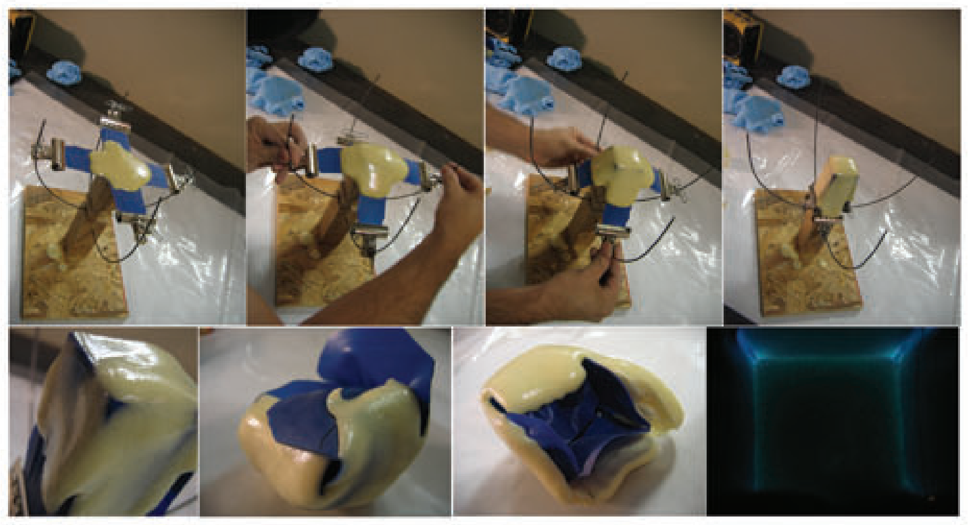
a_ elastic transparency was investigated as a direct result of the material matrix. By altering laser etching patems and patem density the latex was able to dramatically alter transparency from a simple stretching operation.



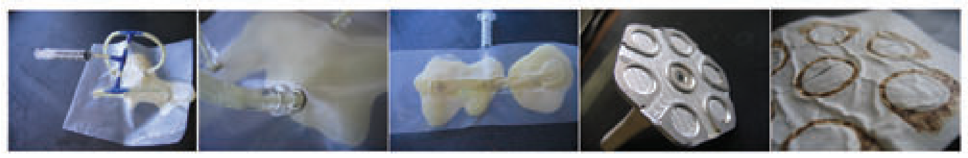
b_foams were investigated in isolation and then in combination with the elastic membranes from the investigations in set 3. In this set the elastic surface was directly below the liquid foam surface, as the foam began to cure an armature was pushed up under the hardening foam, deforming the elastic skin and forming a hollow foam shell. The product resulting was a thin foam shell with varying wall thickness.



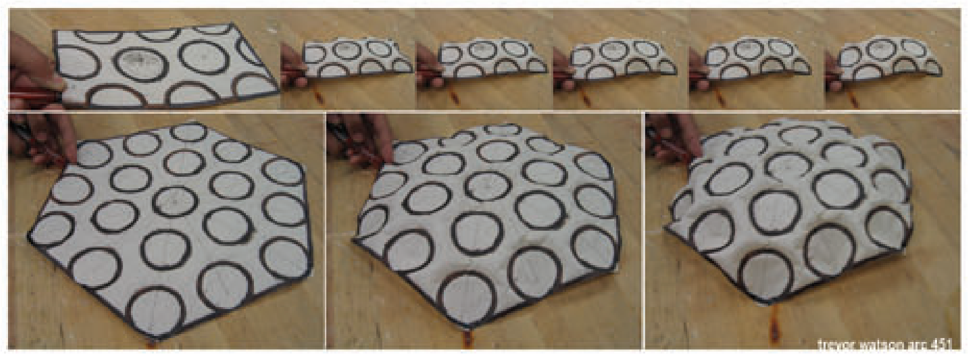
c_taking clues from the previous investigations, a new way of forming the foam was investigated. Here, the elastic membrane is pre-stretched and the curring liquid foam is placed evenly (as possible) over the surface. As the foam continues to cure the elastic surface is folded down along a stressing armature, as the edges begin to meet the foam self joints along the corners creating a rigid volume.



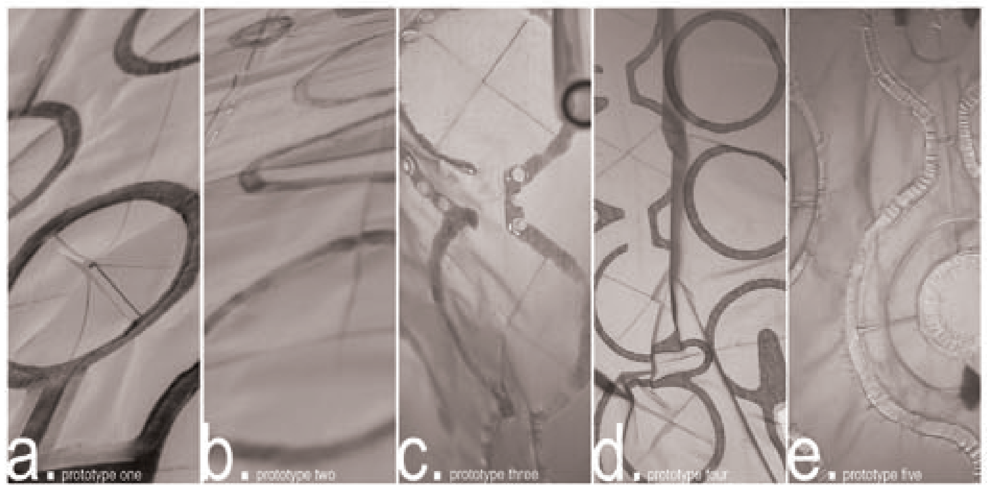
d_controled surface dispersion was investigated as an alternative to the previous pouring method. Here a capilary network distributes foam on to the plastic surface via a disconected network of tubes. Additionally tests were completed to realize the potential of heat sealing the distribution network directly in to the double palstic surface, including "branding".

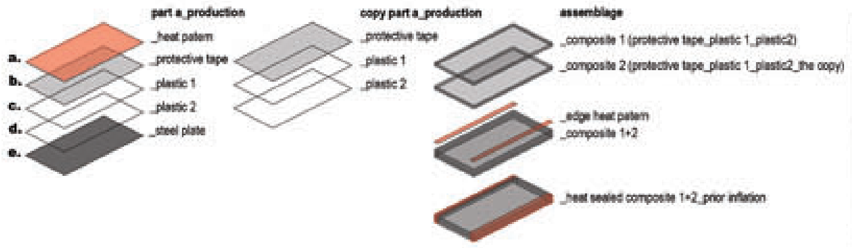


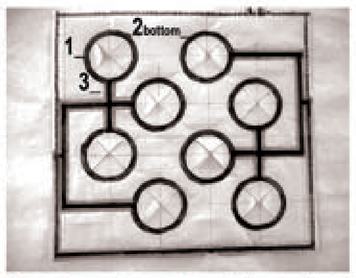
e_inflation was investigated as a means of creating a temporary "foawork". Here two layers of plastic were heat sealed and tape was placed on the top surface as a protective barrier so that the heat world not damage the plastic, and only seal. The unexpected result however was the volumetric forms based in part on the heat sealed geometry and also in part because of the difference in material rigidity from top to bottom layer. Using this method, a temporary rigid "foamwork" can be erected in seconds with only a heat sealed double layered plastic membrane.



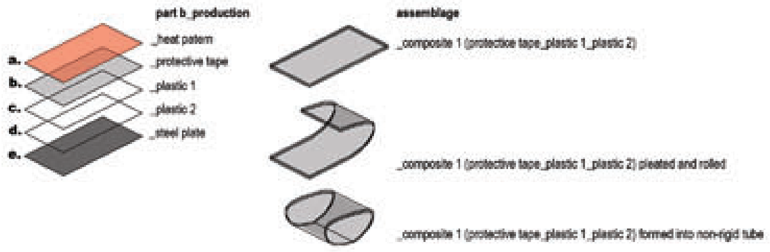
03
prototype research

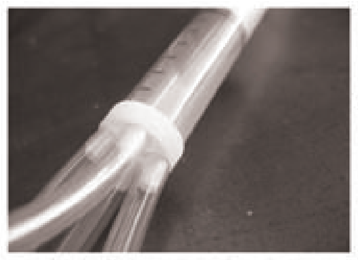


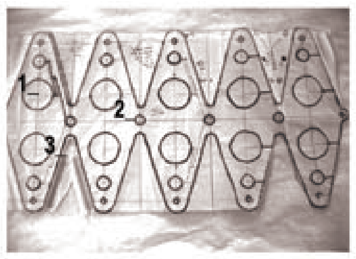




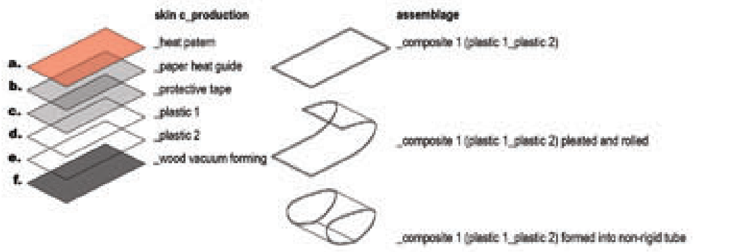
prototype one was the first plastic skin system that was able to inflate and contain a capillary network within the same two layers of heat sealed plastic. Detail 1 shows the cut top surface from which the injected foam travels. Detail 2 shows the back side of the same dispersion point where the area of heat sealing is evident. Detail 3 shows the essential problem with this prototype, all capillary networks are flat (not three dimensional) and network movement is to abrupt to push foam through, durring inflation all foam networks crimp.

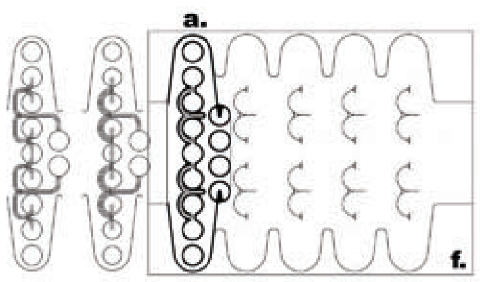


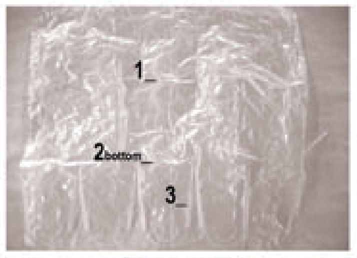




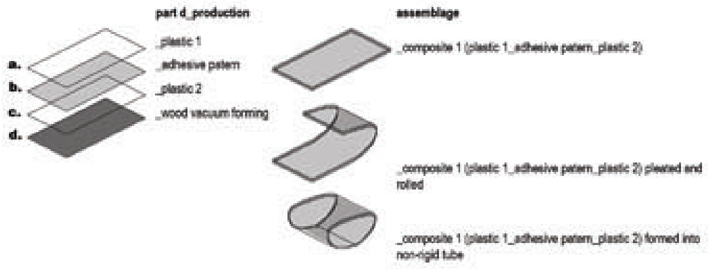
prototype two investigated ideas of tiled heating paterns and having specific areas of non-inlation that would allow for predictable areas of crimping. Detail 1 shows the foam dispersion node, here aligned in the center of the patern to help reduce crimping in the foam network. Detail 2 shows the center axial node that was created to induce multi-directional bending, curling in both directions.Detail 3 investigated one option of connecting the pleats using existing "zip-loc" technology. Foam injectors were prototype in parallel for max. fluid disp.

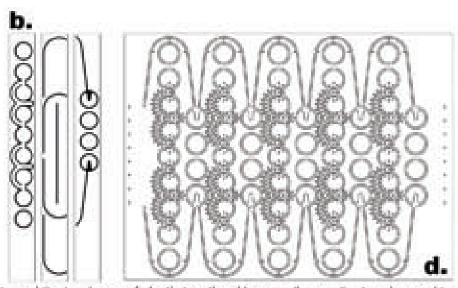


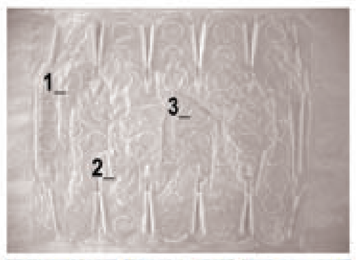




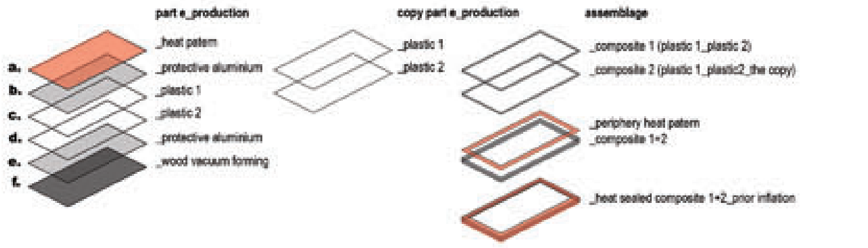
prototype three condensed the dipersion patern into a single long unit. This prototype was not inflatable due to poor heat sealing. Detail 1 shows the heat sealing occur over the vacuum pulling holes resulting in frequent membrane penetration. Detail 2 looks at the required tube network required (10 in all) for this prototype to fully foam, in addition to 10 new plastic connections. Detail 3 looks at the pleated area where sticky backed velcro was used, resulting in an easy way to conect adjacent pannels.

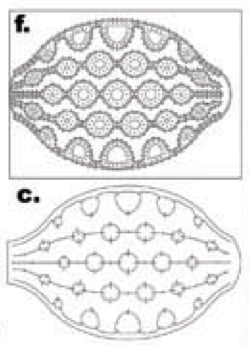


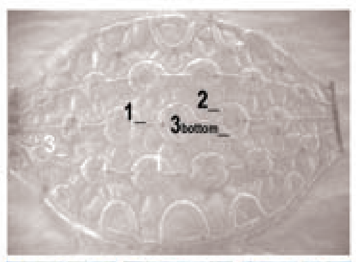




prototype four looked at a double sided laser cut adhesive to seal the two layers of plastic together. However the resultant seal proved to be neither air tight, nor inflatable more than once resulting only in a tube structure. In details 1+2+3 the sticker equivelent is shown. Despite the possible specificity of the sticker the overall form resulting after the initial inflation was very undefined. Edges didnt bend because of the overly stiff velcro patches and, the linked middle dispersion area acted like one large zone rather than points, restricting deformation.



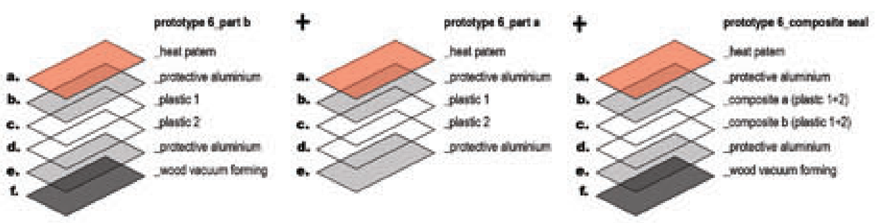


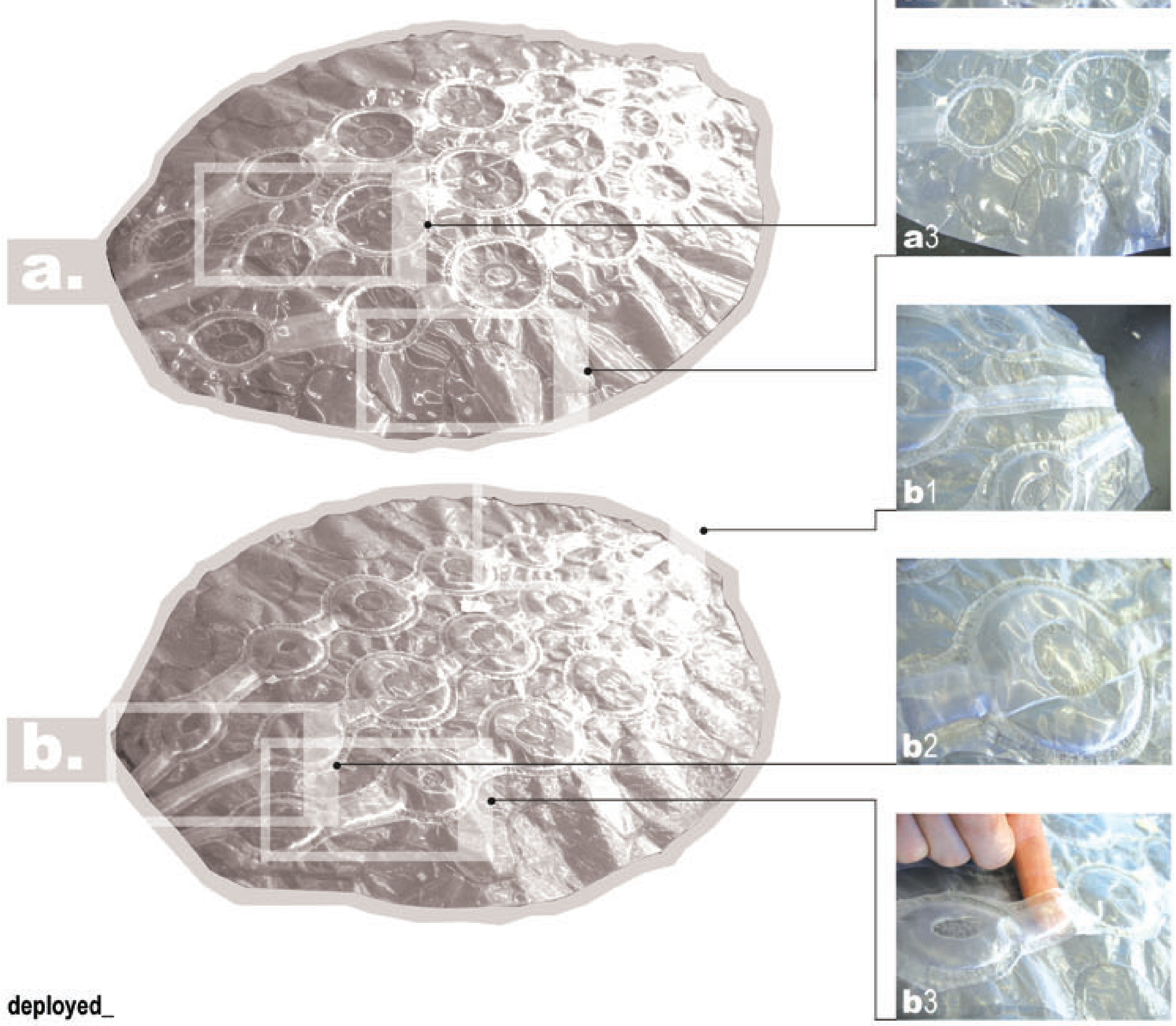


prototype five looked into non equ-distant distribution and instead linked vacuum formed pockets together, Details 1+2+3 . The idea being that the elongated shape would result in an upward deformation squezing the foam out of the pockets through detail 3, a cut top surface. However like all previos models the paradox remains, the foam distribution wants to be linked in some way for effecient distribution, yet the air inflation network wants no connections between nodes.

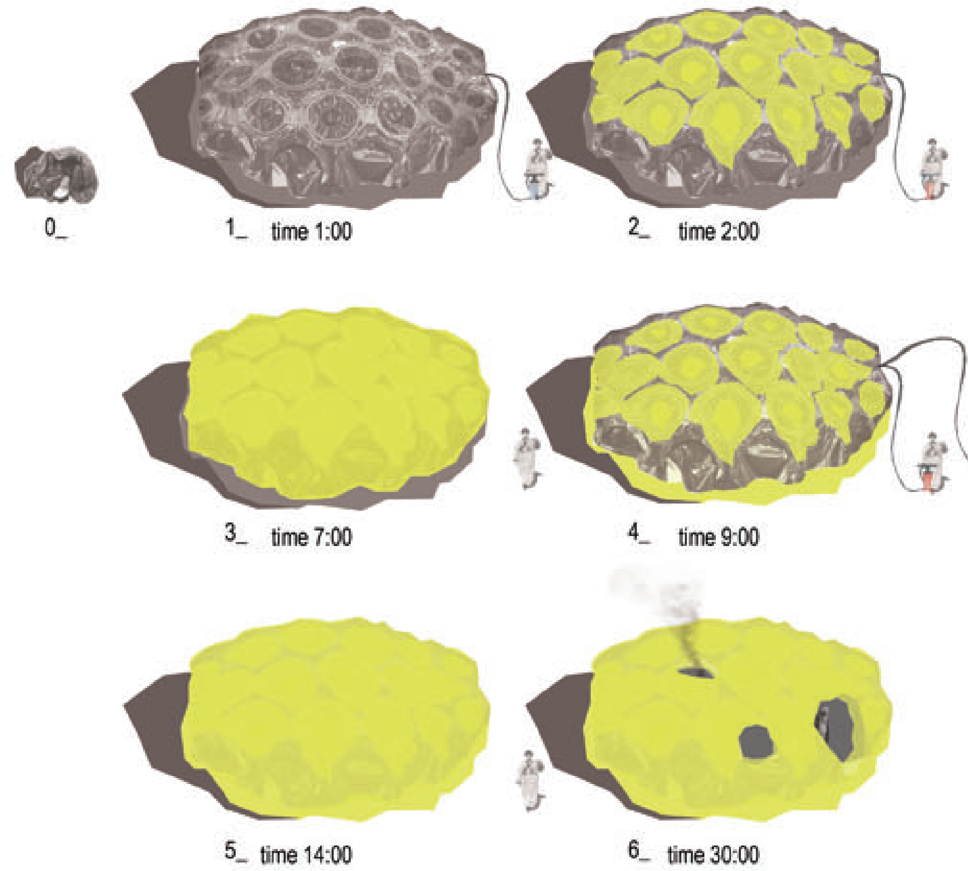
04
prototype 6 + logistics/deployment

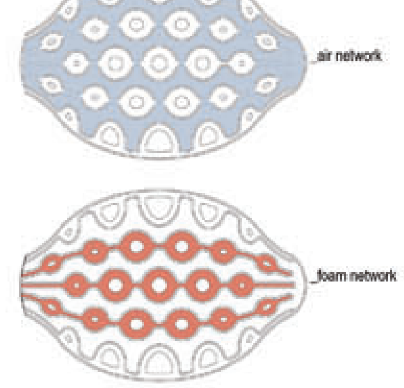
production_





deployed_

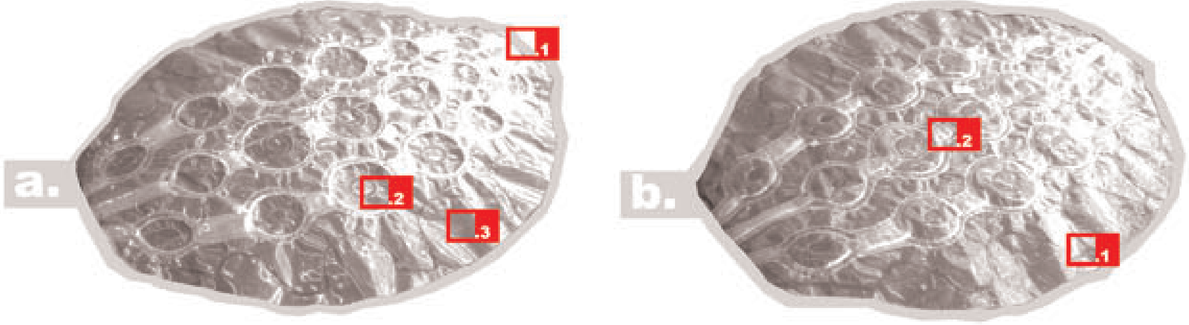




in the deployable sequence_the structure arives on site as a simple inflatable plastic membrane. Half one is inflated and foamed, after aproximately seven minutes the shell is completely covered and self supportive. The entire shell is rolled over where the second plastic membrane (of a different degree of curvature) is inflated and foamed, resulting in a hollow, structual, insulated foam shell. Upon curring of the foam, the occupant may cut out custom "cork openings" with an included wire saw, allowing the plastic membrane to act as a simple window. In this way the structure can be customized to site and any social condition (privacy, adjacency etc) yet because the openings are only cut out, when conditions are such that maximum insulation is required the corks can simply be replaced, creating an almost airtight insulative barrier.

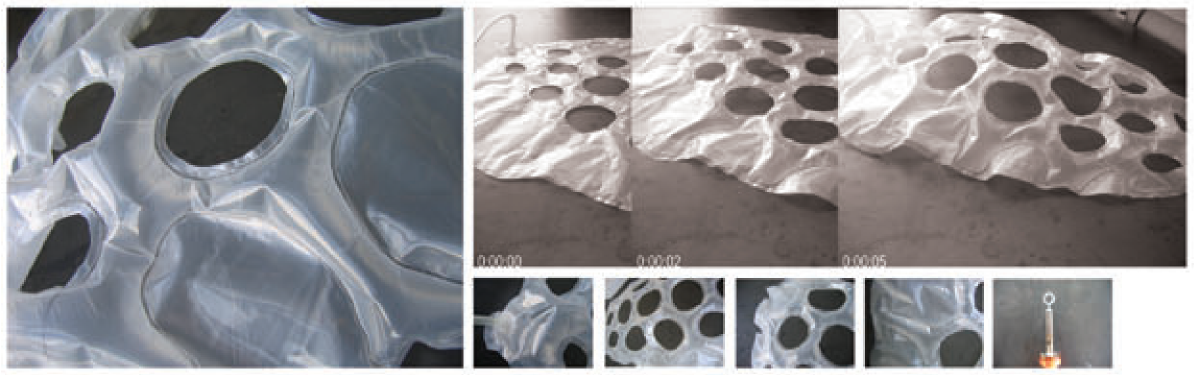
05

material manipulation+ through method refinement

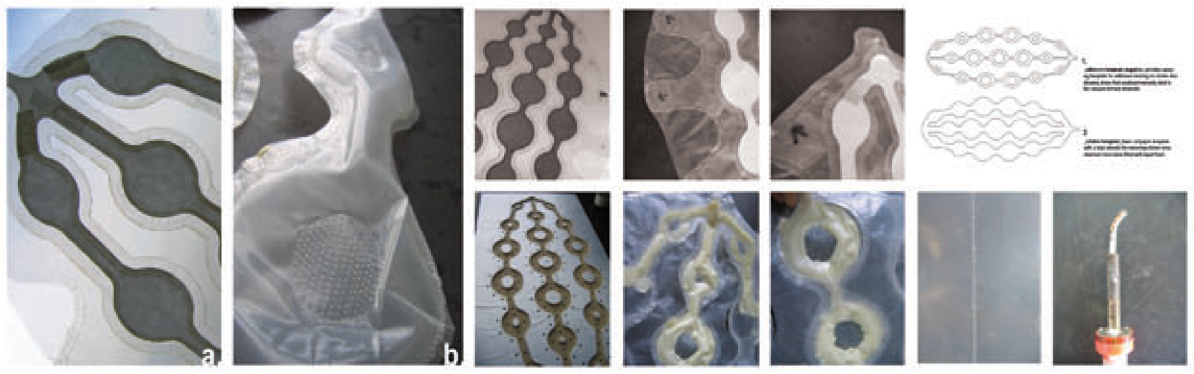


semester one unresolved issues_Despite the relative success of semester one's cumulative prototype, there were several major issues yet to be resolved within the system. These details could very well determine the overall success or failure of the cumulative prototype, for as the prototype existed in its current state, it was un-testable. **1**_First and foremost in order to provide a stable form for the foam to form over, the inflatable zones of the skin had to be completely air tight, and once inflated also needed to have a lockable seal such that the shell did not require constant inflation to maintain its desired form. **2**_There needed to be careful consideration to as exactly how the foam exited the capillary network and covered the surface. As the cumulative prototype existed foam was trapped within the network, never able to form a shell. **3**_ If the plastic skin was to be kept and used as a primitive interior skin and potential aperture, the plastic had to undergo severe modification and manipulation so that it would be able to bind itself with the urethane foam. As the cumulative prototype existed the two layers would simply delaminate after curing.

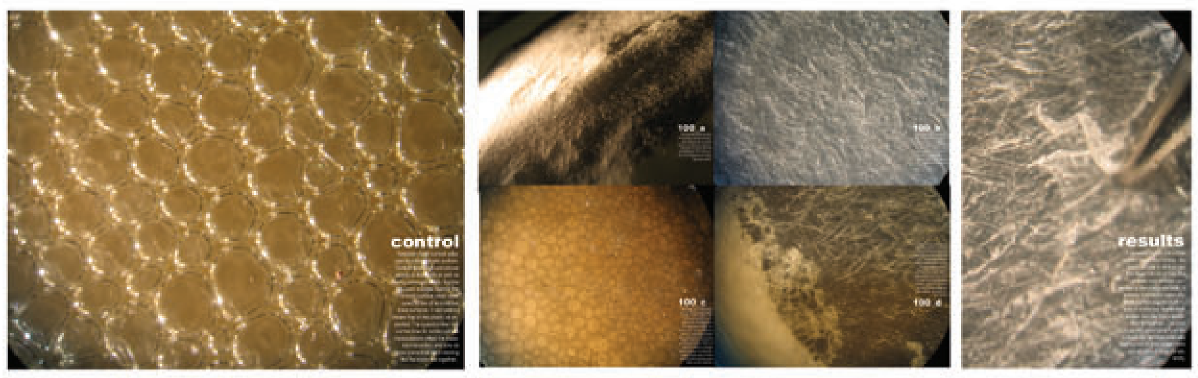
1_the inflatable_Before further development could occur a new method of heat sealing the polyethylene sheets together had to be discovered. After many attempted tool and barrier combinations, a rounded insert into the soldering iron allowed the plastic to seal without bunching. When used in combination with a parchment paper barrier the seal is stronger and cleaner, and when combined with the polyethylene nozzle (tip of a oral syringe) the result is a sealable air tight bladder that is able to retain its form when the nozzle is closed off.



2_foam exposure_In order to test the capillary injection method proposed during semester one, a method for quickly exposing the foam to the air had to be devised. Here two avenues of investigation were explored. One was an adhesive film (a.) that could be peeled away, the other a heat sealed poke (b.) that acted as a kind of velcro-like connection. The sticker method proved overly cumbersome and delicate to produce and apply, in addition the paper tended to stick intensely to the curing foam. The heat sealed poke allowed for very fast delamination while containing the foam however when tested the curing foam, when disturbed as the layers were peeled apart resulted in a catastrophic collapse of the expanding foam. So despite complete exposure to the air this method of foam delivery was not successful, indicating a radical change in foam distribution.

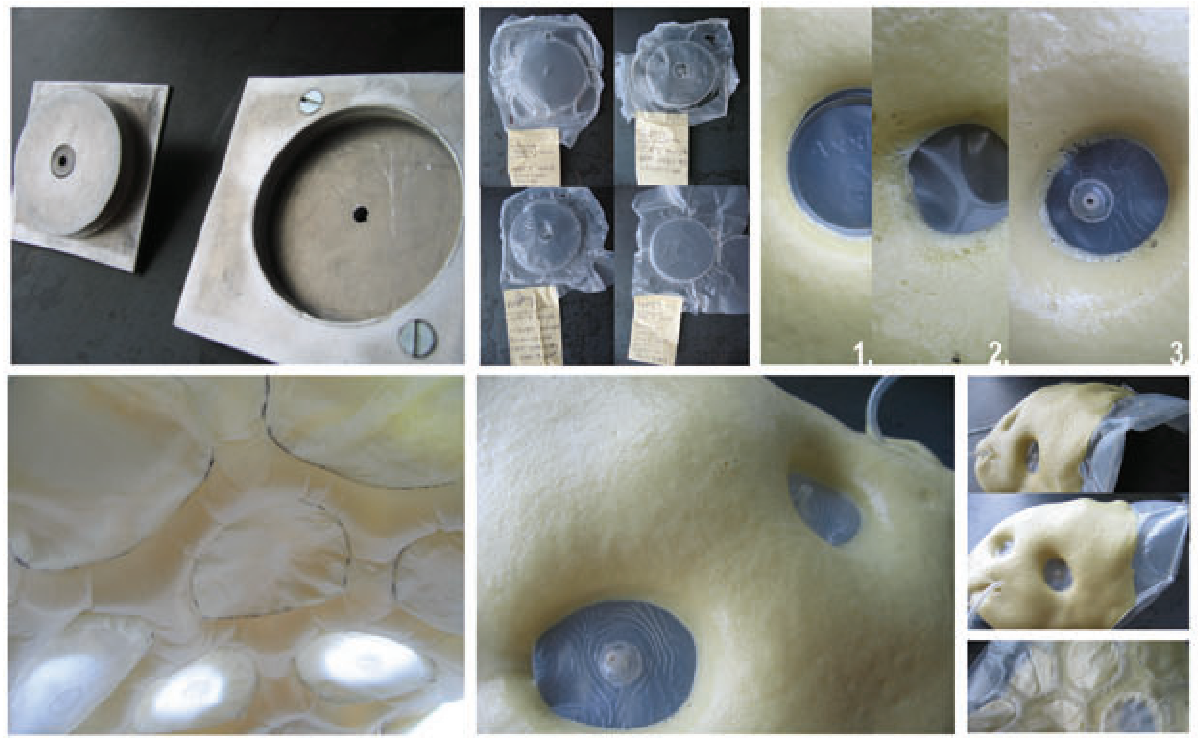


3_adhesive surface_Surface properties of the polyethylene plastic were investigated in a parallel class, where subtle surface manipulations begin to strengthen the bond between the plastic and the cured foam. When the plastic is untreated, the two simply delaminate, resulting in a brittle foam surface. Different grit sand paper was used to rough up the surface of the polyethylene creating a kind of felted "fuzzy" plastic that when in contact with the curing foam resulted in a stick and relatively strong bond.



4_aperture+the shell_After the failure of the injection system despite full foam exposure, a new direction had to be taken. Instead of focusing on the components that *might* make a shell, perhaps starting with the shell itself is a far simpler way of beginning a new prototype. In abstract the principle of the system is simple, create a blanket of expanding liquid foam and deform it. That has been the goal from the onset of the very first investigations, and something yet to be created. So here for the first time a dimensional shell was created very simply by pouring a layer of liquid foam in a deformable "foam-work", letting the foam even itself out and begin to set, then quickly inflating the structure below it resulting in the deformation of the curing foam and the creation of the first space.

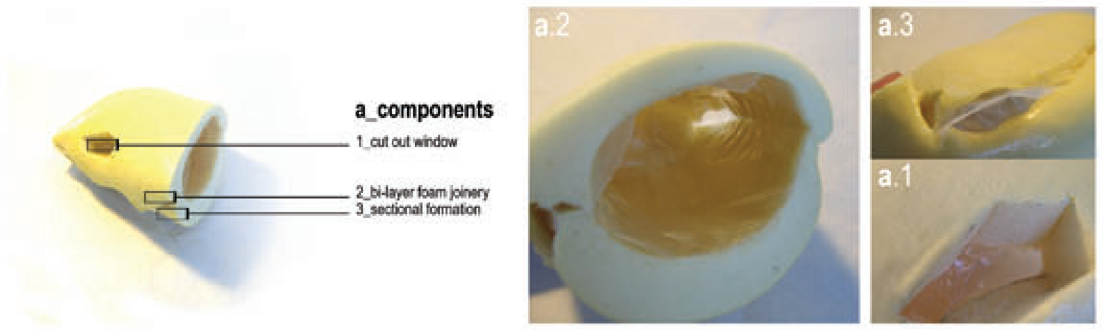
5_however_despite the apparent success, the inflatable structure itself was not sufficiently strong enough to lift itself and the weight of the foam off of the ground. So then the obvious answer became, why not simply inflate a bag with foam over it. Despite the apparent simplicity of the potential new system it had to be explored and developed with the same critical analysis as the previous prototypes.



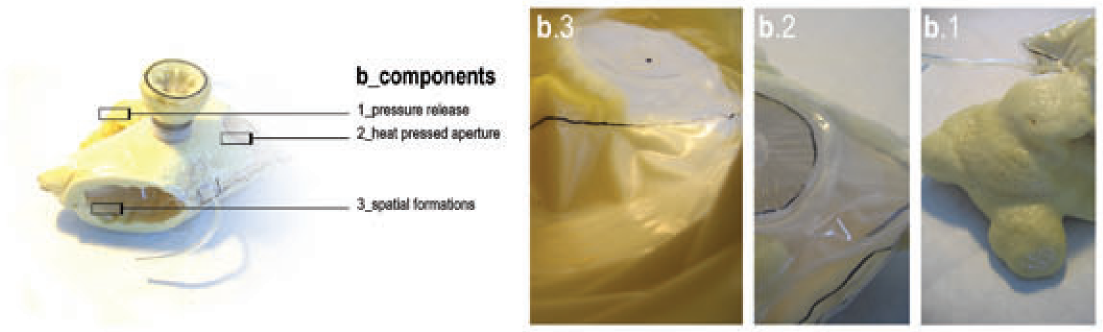
06

double layer method+ logics

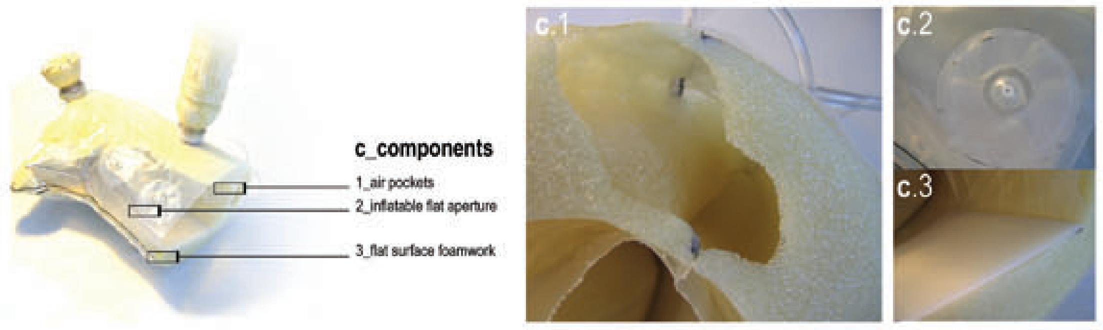
simple bag with lip_
The previous model was so weak that it could not support the minimal amount of foam on the surface. By using a simple inflatable bladder, foam is poured over the flat surface then it is inflated when the foam becomes stable. The second side is made by deflating the bladder, filling the cavity with foam then inflating it at the proper time.
the issues_
Because of the two stage foaming the two shells never actually make a real connection(a.3). Foaming the second side is tricky and hard to repeat successfully, very uncontrolled and imprecise. Apertures that are could result in accidental plastic puncture



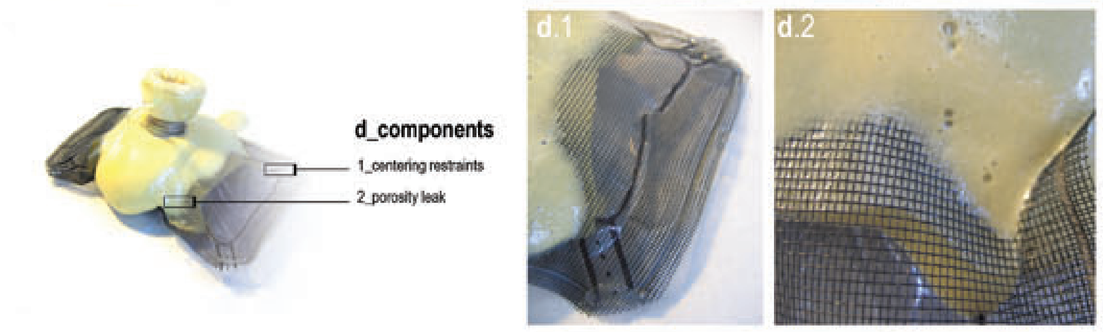
double inflatable with heat pressed aperture_
By distributing a great deal of foam in between two skins a relatively controlled construction sequence could now me imagined. The inner bladder was inflated prior to foam distribution and then cured, leaving the hollow livable volume.
the issues_
Massive pressure build ups resulting from the expanding foam and heated off gasing resulted in a skin rupture, releasing excess foam(b.1). Heat pressed windows also become tricky to seal as they multiply, as well as add extra unwanted bulk to an otherwise thin skin.



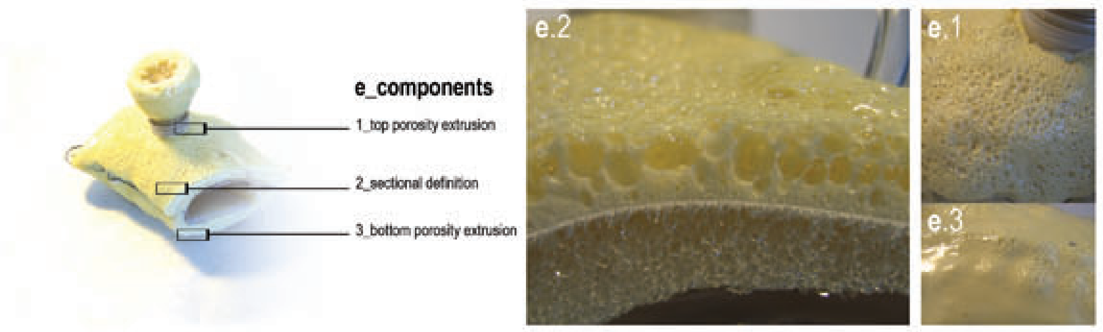
double inflatable with pressure release+flat foamwork_
To address the problems of the previous model the outer layer had an array of air pressure release nozzles such to avoid rupturing. The apertures were made to create a volume through inflation rather then pre-formed pieces.
the issues_
Minimal restraints from inner to outer bladder resulted in the foam moving the inflated bladder towards one side of the outer skin resulting in a non uniform shell. Additionally the air pressure release nozzles were to infrequent to allow air to escape throughout the shell. Foam would block the nozzles and then air pockets(c.1) would begin forming.



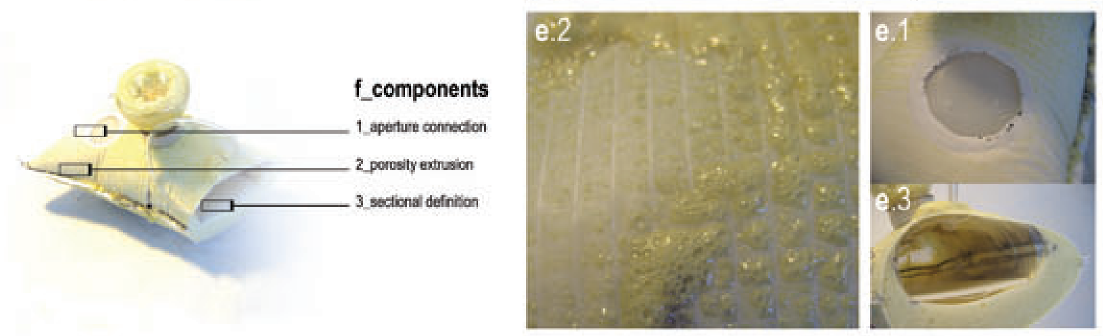
air permeable outer skin(1)+restrained inner bladder(1)_
Since the outer skin no longer needed to be air tight and the air release nozzles would continually clog with foam a permeable mesh was used, the idea being that the mesh would release air pressure while retaining the liquid foam within.
the issues_
The problem was very simple, the material was to porous and was not able to hold the syrup consistency of the expanding foam. It was easier for the foam to escape than to fill so the material took the path of least resistance resulting in no shell.



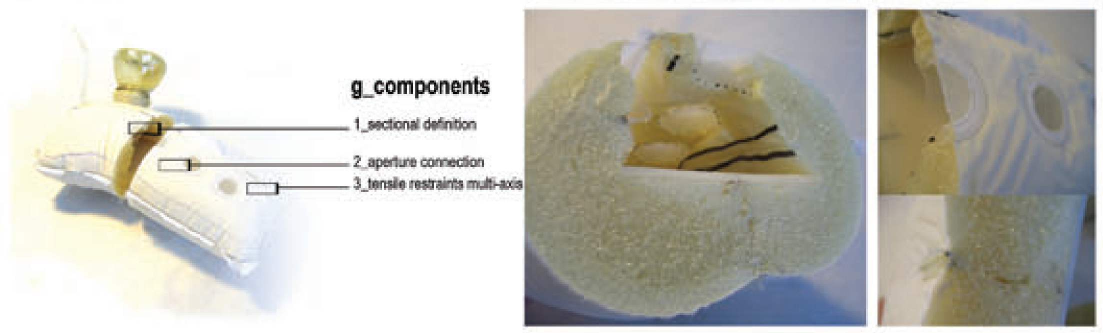
air permeable outer skin(2)+restrained inner bladder(1)_
Here a less porous rip-stop nylon was used. The nylon was able to expel all access air however an unexpected result occurred. The volume of foam put to much pressure on the skin and the foam actually ended up pushing itself through the small air gaps in the nylon resulting in an interesting big bubble foam (e.2) on the top surface.
the issues_
Despite the interest of the extruded surface texture, the surface was actually quite brittle and if this was foamed on site the liquid foam on the outside of the fabric could present a logistical problem when being deployed.



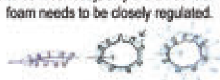
air permeable outer skin(3)+restrained inner bladder(1)_
Here an even less porous rip-stop nylon was used, with relative success. The fabric was able to radiate the heat buildup from the chemical reaction of the curing foam and with that the build up in pressure. Minimal amounts of foam began to seep out of the surface simply because too much foam was put into the cavity.
the issues_
The main problem that was only by chance absent from the previous prototype was that the inner inflated bladder was once again not self centering within the foam resulting in a very non-uniform shell, despite restraints around the perimeter.



air permeable outer skin(3)+restrained inner bladder(2)_
This was the next major attempt to combine all of the components into one shell, aperture, entrance, livable surface and self centering. In this prototype tensile strips were sewn on top and bottom and heat sealed to the inner bladder, the idea being that the inner bladder needed multi-dimensional stabilization.
the issues_
Two unforeseen things happened in this model. The first was the poor inflation of inner chamber. And the second and more important issue was that because the cavity is not inflated prior to being foamed, tension does not work to stabilize the inner shell.



air permeable outer skin(3)+poking inner bladder (3)_
This is *the* method for creating a uniform continuos foam shell. The inflatable bladder in this prototype has small inflatable fingers that push from the inside, on the uninflated fabric. By pressing from the inside there is no way that the air bladder can become offset within the loose fabric.
the issues_
The system works so there are no real issues left in terms of shell creation, detail specificity and other obvious components can now be brought back into the new system with few repercussions. Deploying the structure is very simple and almost impossible to do incorrectly, only the amount of foam needs to be closely regulated.



07

the scenario+ proposed response

application_

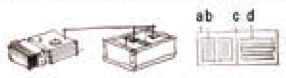
The system has been developed and tuned for application in many scenarios in which adverse conditions render other methods of construction overly difficult. Adverse factors with which this system was tuned to respond include : isolation, limited construction time. lack of local materials, inaccessible site, cold climates, limited to no construction knowledge, temporary habitation.

fabrication_

The fabrication is split into three progressive stages, potentially integrated into one fabrication plant but just as easily (and perhaps more efficiently) split into separate component factories. Factory A (diagram bellow) is responsible for any solid components such as nozzles, apertures, plugs caps etc. The individual components are then shipped to Factory B where the required components are integrated onto the inflatable inner bladder being fabricated. Upon completion of the inner inflatable, the composite inner layer can now combined and completed with the fabric out sleeve from Factory C. Potential equipment necessary for fabrication includes but is not limited to, plastic injection moulder, RF plastic sealer and industrial sewing machines. The raw foam (D) is produced and stockpiled until need arises. After fabrication of the composite deployable enclosure has taken place they can be safely stored and when required shipped with the correct amount of foam to the desired location.

shipping_

The Enclosure system has been developed with consideration to different shipping options. The Enclosure system and the raw foam are both highly resilient simply because they are both so flexible in their pre-constructed state. The flexible enclosure system self protects the inner inflatable from punctures simply with its outer, more durable fabric membrane. The foam containers can also be reinforced and padded in such a way to make them un breakable. When the system is shipped in a kit the appropriate volume of foam and number of enclosures are bundled within another box such that all kits arrive on site with all components such that if a box is found it can be completed without relying on missing components.



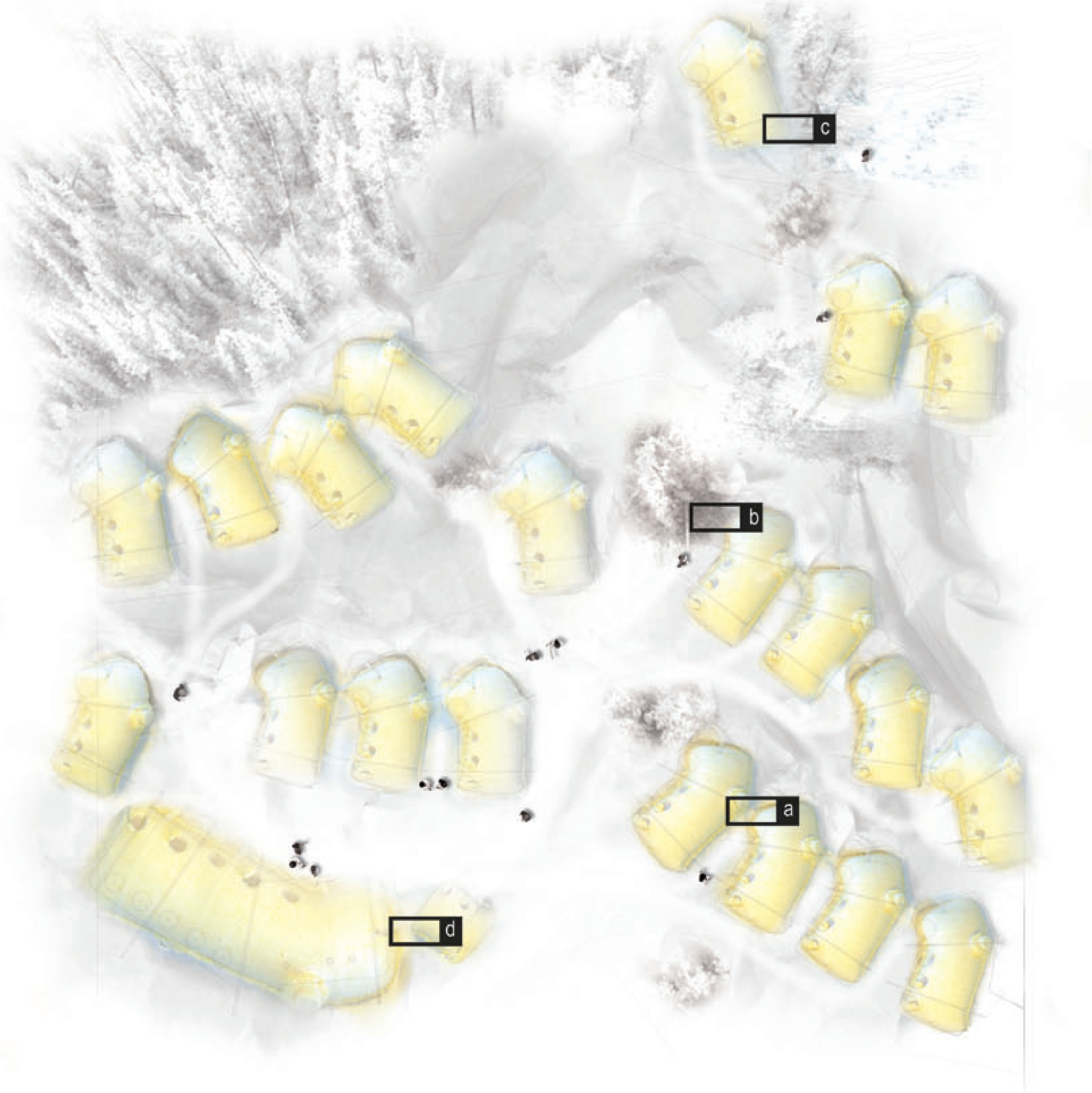
Shipping methods for the system are fairly open. It could be packed in the back of a jeep and taken into the mountains to establish an outpost just as easily as five hundred enclosure systems could be airdropped into in isolated region.

construction_

In developing the Construction logics of the system, the focus has centered around, ease of construction, speed of construction, probability of construction and time frame of construction. As the system has been developed each of these categories continue to become more and more efficient. With in hours of the package drop, several hundred units could be occupied and set up into a community. Additional infrastructure would be required beyond simply the provided enclosures. However that would have to be accessed per each scenario. Instructions would be printed on each enclosure (a). The enclosure would be moved to the desired site (b), inflated, foamed with a movable foam canister (c), tied down and occupied. A detail of this exact sequence follows on board 08.

08

positioning+formative base relationships



09

construction phasing + logics

1 unpacking+positioning
phase_a_time 00h00m00s

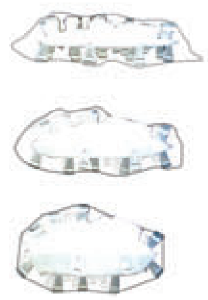
_The enclosure system is taken out of shipping container and placed on desired site. Adjacency and clustering with other units is desirable because of the resultant protective cove that can be established. Resultant foamed shell will be less wide then its unfoamed counterpart so clustering of the enclosure systems can be quite tight.

_During initial positioning of the system, the outer fabric membrane protects the inner inflatable from puncturing. Handling of the enclosure is through a set of small handles positioned around the periphery. When choosing a site, set up of the enclosure during construction sequence does not require a flat site.

2 inflation
phase_b_time 00h10m00s

_Inflation occurs with a hand pump or small automatic air pump.The inner bladder is inflated along with the door and apertures. This inflation also establishes the required air gap between the two skins by inflating long cylindrical tubes that push out against the air permeable outer skin. The thrust from these tubes establishes a consistant air space that allows the inner bladder to "float" equidistant from the outer fabric on all sides.

_Below is a sectional diagram depicting what is happening inside of the flexible exterior during inflation prior to foaming.

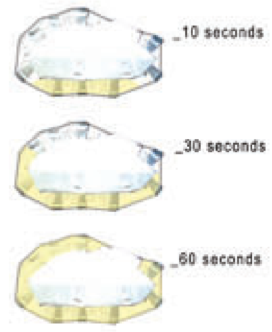


3 mixing+pouring
phase_c_time 00h15m00s

_Equal parts a+b foam are mixed together and poured into the air cavity created by the inner inflatable bladder. Mixing occurs for approximately thirty seconds as sequential buckets of the liquid foam are poured in. Upon putting the required volume of foam in the cavity, the cavity is sealed off as the liquid foam begins to expand.

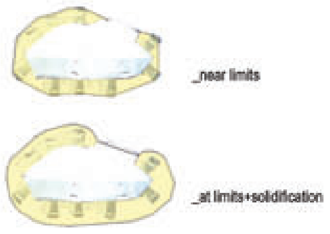
4 foaming+expansion
phase_d_time 00h17m00s

As the foam begins expanding it applies a load to the inner inflatable attempting to move it up in addition to expanding around it. However the inflated tubes keep the inner bladder suspended equidistant within the outer fabric, resisting the foams inward force while providing and easy path for the foam to expand into. The foam expands twenty five times its original volume as it begins to solidify.



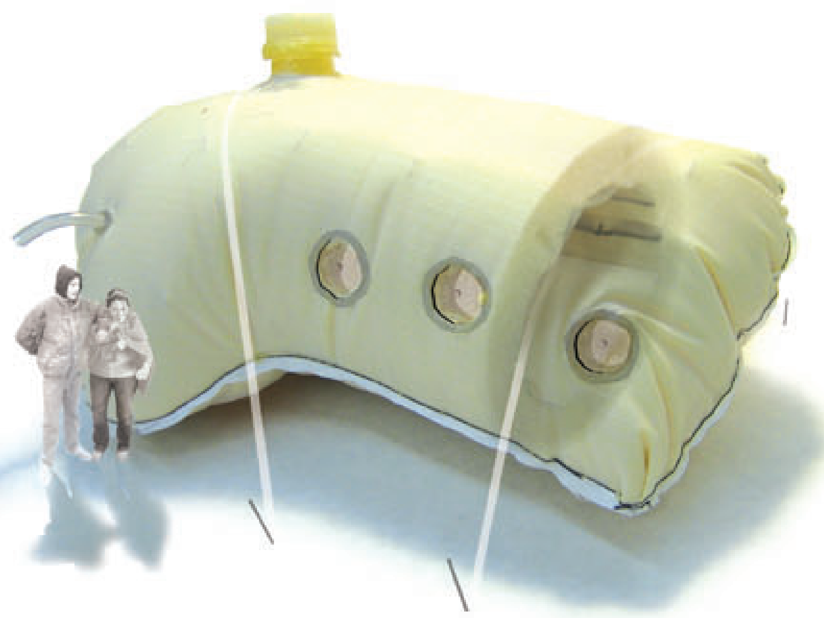
5 expansion+solidification
phase_e_time 00h18m00s

The foam continues to expand beyond the initial reach of the tubes, bringing the outer most skin into tension. It is at this moment that the expansion of the foam ceases and the structure begins to solidify. Some foam seepage might occur as the internal pressure builds and it is this stage where the air permeable outer layer is most important. Any air pockets forming within the enclosure will be pushed out throught the permeable surface just before solidification.



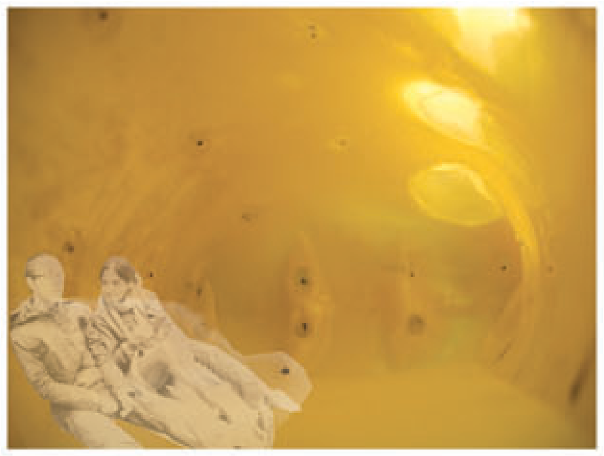
6 solidification+habitation
phase_f_time 01h00m00s

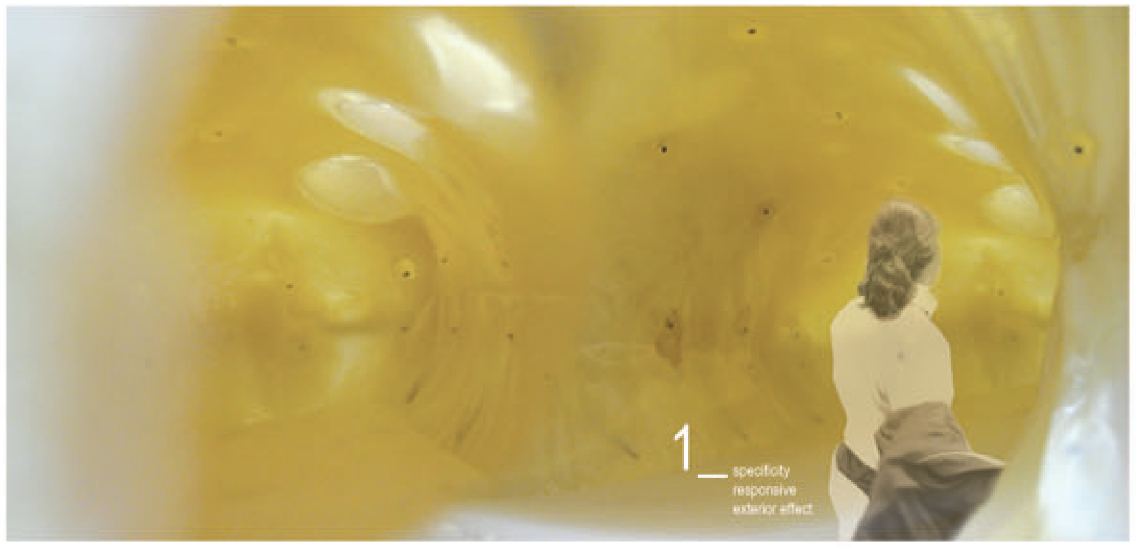
After approximately one hour from start to finish, the enclosure is ready to be occupied. The foam will fully cure within two hours but is structurally sound after one. The now rigid shell is tensioned down to the ground with straps that would be sewn onto the outer fabric skin.



10

**system potentials+
new derivative logics**





spatial logics_

Now that a functioning system exists, it needs to be taken back through a new combinatory matrix such that new SYSTEM SPECIFIC spatial relationships can be derived and tested for potential application. The diagrams below are the start of what is to come in the system development. Sectional specificity and the relationships between multiple adjacent spaces will be investigated to further the new enclosure system's response. Grouping units begins to make sense as sharing partitions makes more efficient use of material, and seems appropriate on some levels to apply to the intended cold climate response. The idea of a more specific section also seems to make sense with regards to the system. Sectional specificity is relatively easy to achieve simply by increasing the length of the tubes pressing on the inside of the air permeable layer, at specific points. Sectional specificity can begin biasing foam towards more thermally active zones, and can also begin effecting the outside space, where overhangs are now a possibility. Interior specificity is also now addressable. Inflatable interior forms seem appropriate to system logic, allowing one space to be actively configurable dependant on desired use. Additionally flat panels are able to establish level/flat surfaces within the inflated bladder.