How can we realize our vision of Barba space and the fully adaptable environment? We start with the individual body and visualize the space an individual moving person needs and creates. We can use this to start imagining interaction between individuals. We then add specific tools to create furniture or openings. Eventually, tools for structure, services and light are developed to support Barba houses and villages.

While in this chapter the fully adaptable environment is a virtual space, the tools employed within it are real. Connected to motion-tracking devices, they allow us to see and imagine how it might feel to live in a fully adaptable environment.

The tools presented here can be imagined in use in many different scenarios. They are general tools, things that can be used to analyse, create, plan or design in varied relation to the human body and its flexible spaces.

Space Makers

The Why Factory and ETH Zürich: Adrien Ravon,
The Why Factory research team and the Transformer at ETH Zürich studio

The Why Factory research team:
Adrien Ravon with Ulf Hackauf, Sander Mulders, Stefan Wülser, Kaegan Walsh, Arslane Benamar, Lex te Loo

Transformer at ETH Zürich studio:
Paolo Birrer, Tania Carl, Riccardo Caruso, Melina Cerfeda, Elena Chestnova, Nicholas Ganz, Marcel Hodel, Léone Kündig, Marisa Muscionico, Sebastian Oswald, Kai Peter, Pascal Ruckstuhl, Enrique Ruiz, Paula Schilliger, Vera Schmidt, Henry Stehli, Ying Yi Tan, Yangzom Wujohktsang
Teachers: Winy Maas, Ulf Hackauf, Adrien Ravon, Stefan Wülser

Muybridge Revisited

Tool of Measurement

Arslane Benamar, Paolo Birrer, Tania Carl, Melina Cerfeda, Stavros Gargaretas, Ulf Hackauf, Lex te Loo, Sander Mulders, Sebastian Oswald, Kai Peter, Adrien Ravon, Henry Stehli, Kaegan Walsh, Stefan Wülser

The flexible, programmable, transformable Barba material we've speculated about potentially allows for a new and very precise way of defining architectural spaces, interiors and objects. It would require a new, dynamic ergonometry. Today, we are accustomed to sitting on a chair with an average height, walking through corridors of average width and sleeping in beds of average length. With Barba, spaces and objects fit perfectly to the ergonomic needs and the spatial desires of the user. Reading the human body is thus essential.

In 'Muybridge Revisited', we therefore take the body as the starting point for defining space. In this interactive installation, we use a motion-tracking device to record and visualize human bodies and movement.

In the Barba scenario, 'Muybridge Revisited' would be the first step in developing interaction between the user and the fully adaptable environment.

Today, it can be used for explorations of the relation between body, space and time. It can be part of artistic choreography as well as useful in ergonomic studies that start from the body.

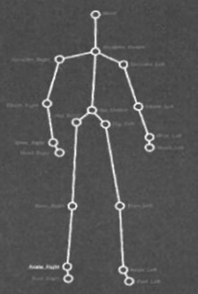
Watch the movie:
www.thewhyfactory.com/barba

The human body forms the starting point for the interaction between the user and his transformable environment. We developed an installation that allows the user to experience her own movements and the space she occupies or creates through immediate feedback. In the late nineteenth century, American photographer Eadweard Muybridge worked on a series of stop-motion photographs of animals and humans in motion. With these photographs, he revealed details that the human eye had never before been able to see. His work influenced not only scientists, but also artists and figures in popular culture. Like Muybridge's photographs, our study provides an accurate, real-time analysis of the body's positions and movements. It helps us to understand how we move and how we occupy space.

For this first study, we work with a simplified representation of the body, a virtual skeleton. We visualize the skeleton and play with it. The trace of the body is shown. Movements in space become visible. The data is recorded. 'Muybridge Revisited' is an interactive installation that can track, record, save and overlay the movements of the body. It records the image of the skeleton for a few seconds before it fades away, depicting a brief history of the user's movements and enacting a phenomenon we've thus referred to as 'inertia'.

The inertia introduced within this installation could be an important element in developing the reactivity of the fully adaptable environment. By analysing past movements, Barba could predict those that followed, extending space in accordance with what it anticipated. The quicker the movement is, the larger the space of anticipation would be. The fully adaptable environment would require more complex algorithms than we've used so far in order to really allow for useful anticipation. It would also require distributed and smaller sensors for complex motion tracking.

As an installation capable of use today, 'Muybridge Revisited' reveals patterns, analyses movement and, moreover, notably provides a visual experience of a body's movements and the space they create.



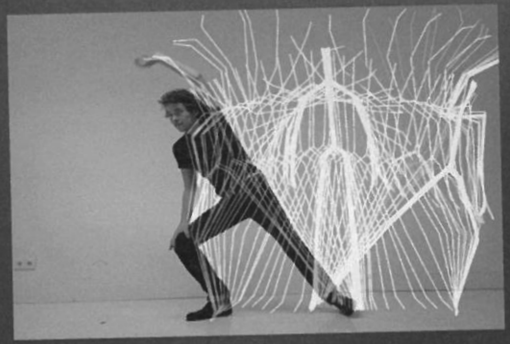
In order to track, measure and record bodily movements in space, we need sensors. For our research, we choose the Kinect motion-tracking device.[1] This tool uses infrared sensors to scan environments, detect depth in space, recognize the human body and its movements, and translate this information into a reduced number of nodes that together form a simplified skeleton.

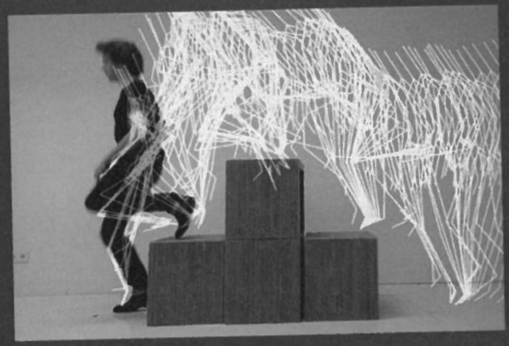
This virtual skeleton can be used not only in games but also in other software. We chose the three-dimensional-modelling software Rhinoceros with several plug-ins for visual programming, most importantly Grasshopper and Firefly.[2] The complex data generated by a human body moving in space is reduced and made workable for our experiments. Every ten milliseconds, the position of each of the skeleton's single nodes is recorded, stored and visualized. An established limit of data collection determines when these traces expire and when information fades away.

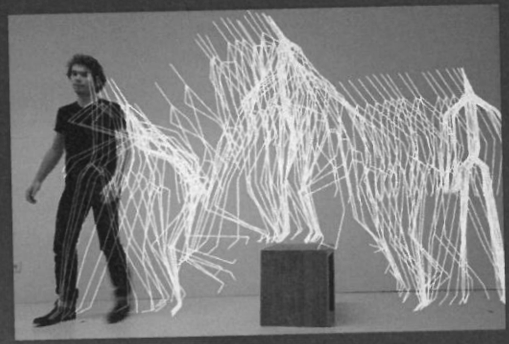
The installation uses one Kinect for the skeleton tracking, Rhinoceros for three-dimensional modelling, Grasshopper for visual scripting and Firefly to connect the Kinect with the scripts in Grasshopper.

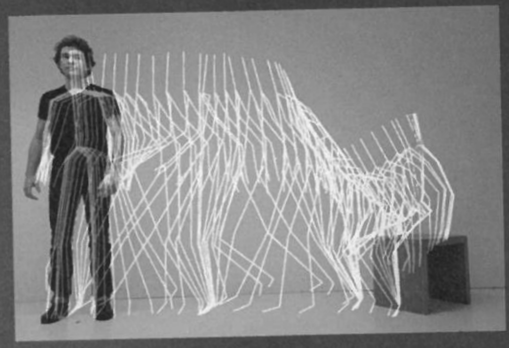
1 Kinect® is a motion-tracking device originally developed by Mircosoft® as an input for video games. It can effectively serve other applications as well. See <www.microsoft.com>.

2 Rhinoceros® is a three-dimensional-modelling software. See <www.rhino3d.com>. Grasshopper® is a graphical algorithm editor designed as a plug-in for Rhinoceros. See <www.grasshopper3d.com>. Firefly® is a set of comprehensive software tools developed to connect Grasshopper with different input devices. See <www.fireflyexperiments.com>.









The Halo Maker

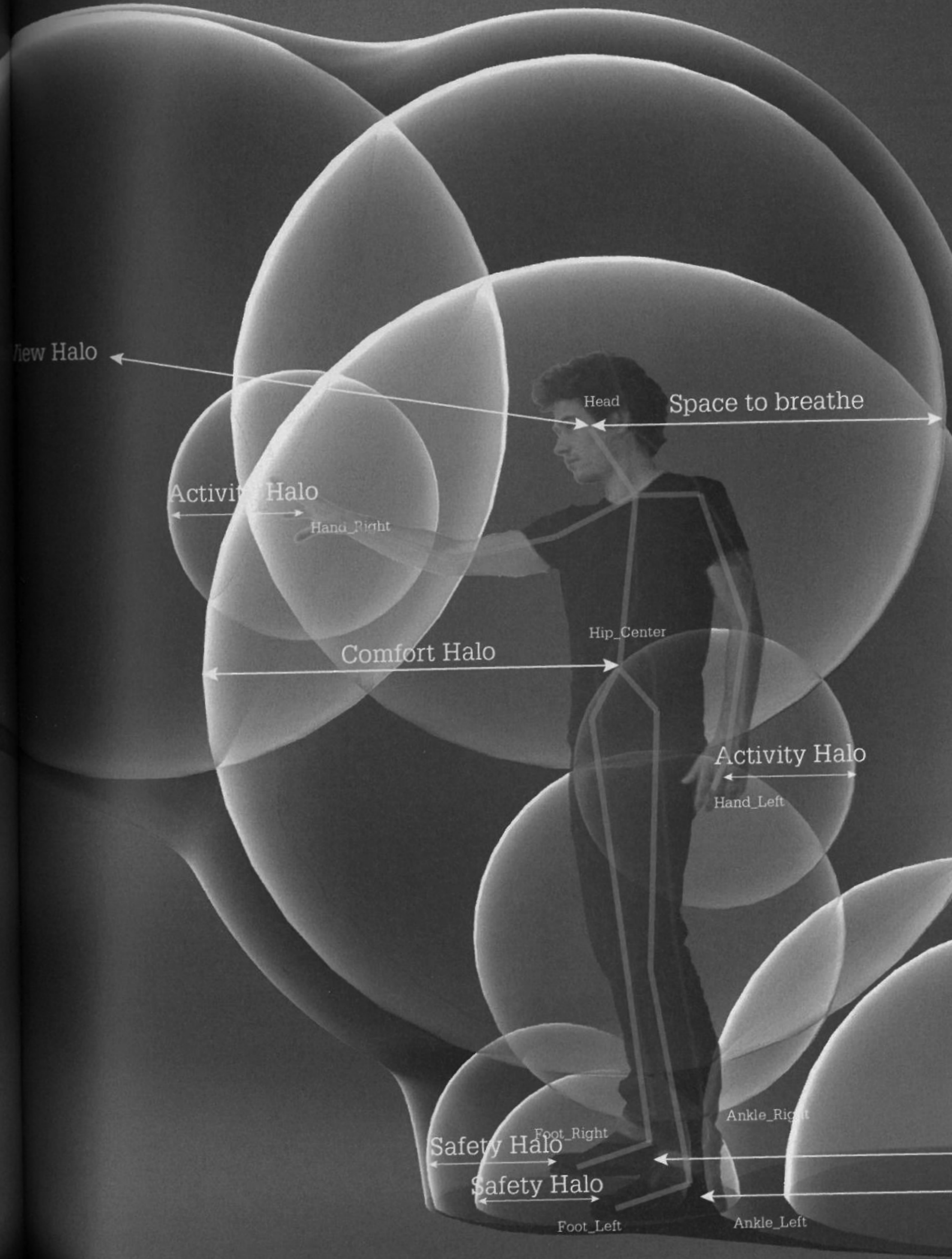
Experience it!

Arslane Benamar, Paolo Birrer, Tania Carl, Melina Cerfeda, Stavros Gargaretas, Ulf Hackauf, Lex te Loo, Sebastian Oswald, Kai Peter, Adrien Ravon, Henry Stehli, Kaegan Walsh, Stefan Wülser

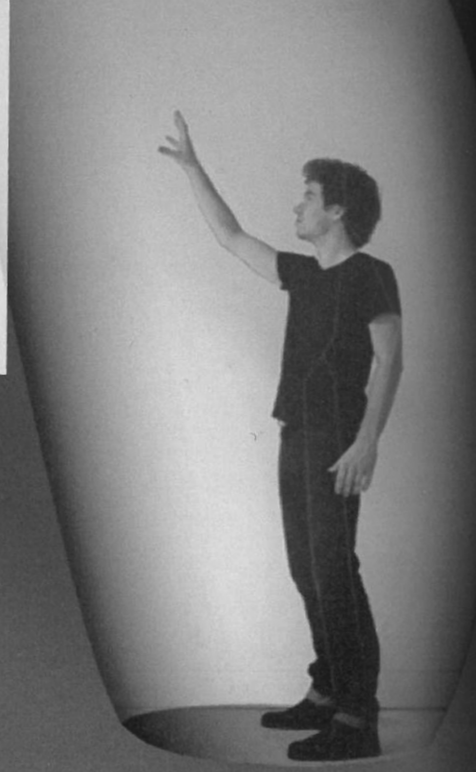
The 'Halo' visualized in this installation could be described as a virtual space that surrounds and follows the body in movement, defining its outline and describing its minimum space. And this 'Halo' can be extended to represent the space of movements, activities and desires. In Barba, the Halo is an important tool for defining and shaping space and for making visible the interaction between user and the fully adaptable environment.

The 'Halo Maker' is an interactive installation that measures personal space in real time. It builds upon 'Muybridge Revisited' by extending the skeleton beyond the human body such that it appears outside, like an aura or halo. This Halo reveals a space around the body, something akin to what American anthropologist Edward T. Hall described as 'personal space'.[1]
In our Barba scenario, the 'Halo Maker' would work as a tool to create space and as a means to interact with the material. Today, it can be used for general studies on spaces related to the human body. It can work as a tool to design spaces that start from the body.

Watch the movie:
www.thewhyfactory.com/barba



The Halo is, in its simplest form, an offset of the body that describes the immediately surrounding space. When it extends, it can carry other meanings and visualize other requirements. We can imagine comfort halos, halos of inertia and anticipation, visible and audible halos, and so on.



The 'Halo Maker' builds upon the virtual skeleton from the previous chapter and attaches 'metaballs' to the skeleton's nodes. [2] These metaballs are connected with a mesh, resulting in a three-dimensional envelope that encompasses the human body. A threshold factor controls how precisely the envelope follows the metaballs. The virtual skeleton with the attached metaballs moves with the user in real time, creating a constantly changing space. For the installation, we project the skeleton onto a screen. The user sees how the skeleton repeats his movements and how the Halo around it changes shape.

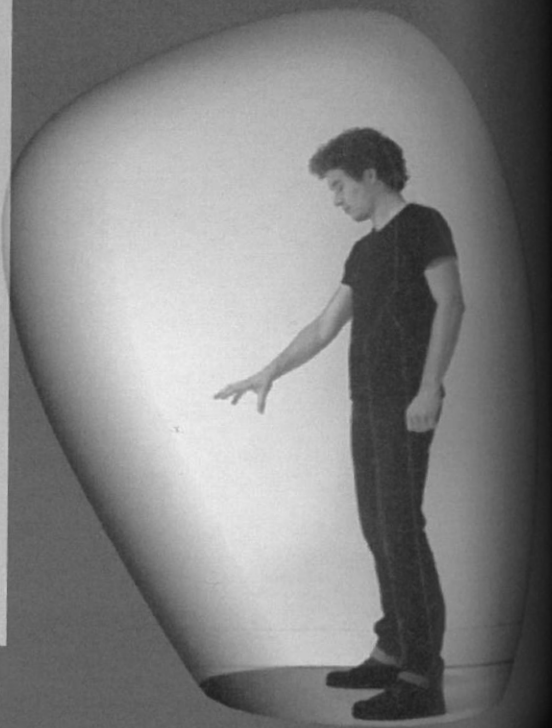
Different gestures are programmed to modify the Halo. For example: holding your hand above waist height increases the 'head metaball'. Holding your hand at one height increases all metaballs and thus the whole Halo. Turning your head moves the 'View Halo'.

The installation uses Kinect for the skeleton tracking, and Rhinoceros, Grasshopper, Firefly and Weaverbird. [3]

1 Edward T. Hall, *The Hidden Dimension* (New York: Anchor Books, 1966).

2 Metaballs are a computer graphics technology invented by Jim Blinn in the early 1980s.

3 Weaverbird® is a plug in for mesh transformation in Grasshopper and Rhino. See <http://www.grasshopper3d.com/group/weaverbird>.

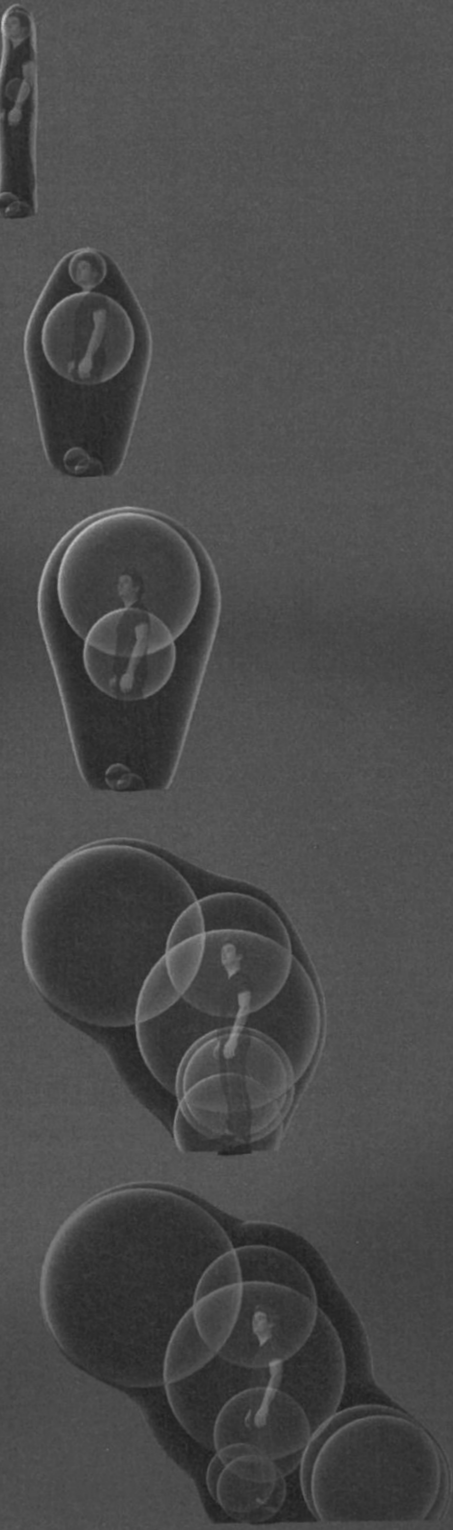


The 'Comfort Halo' would translate basic spatial needs and desires. It would be a buffer against claustrophobia, a mean to ensure that the responsive material remains at a comfortable distance from the body. It could extend based on movement, pulse or breathing.

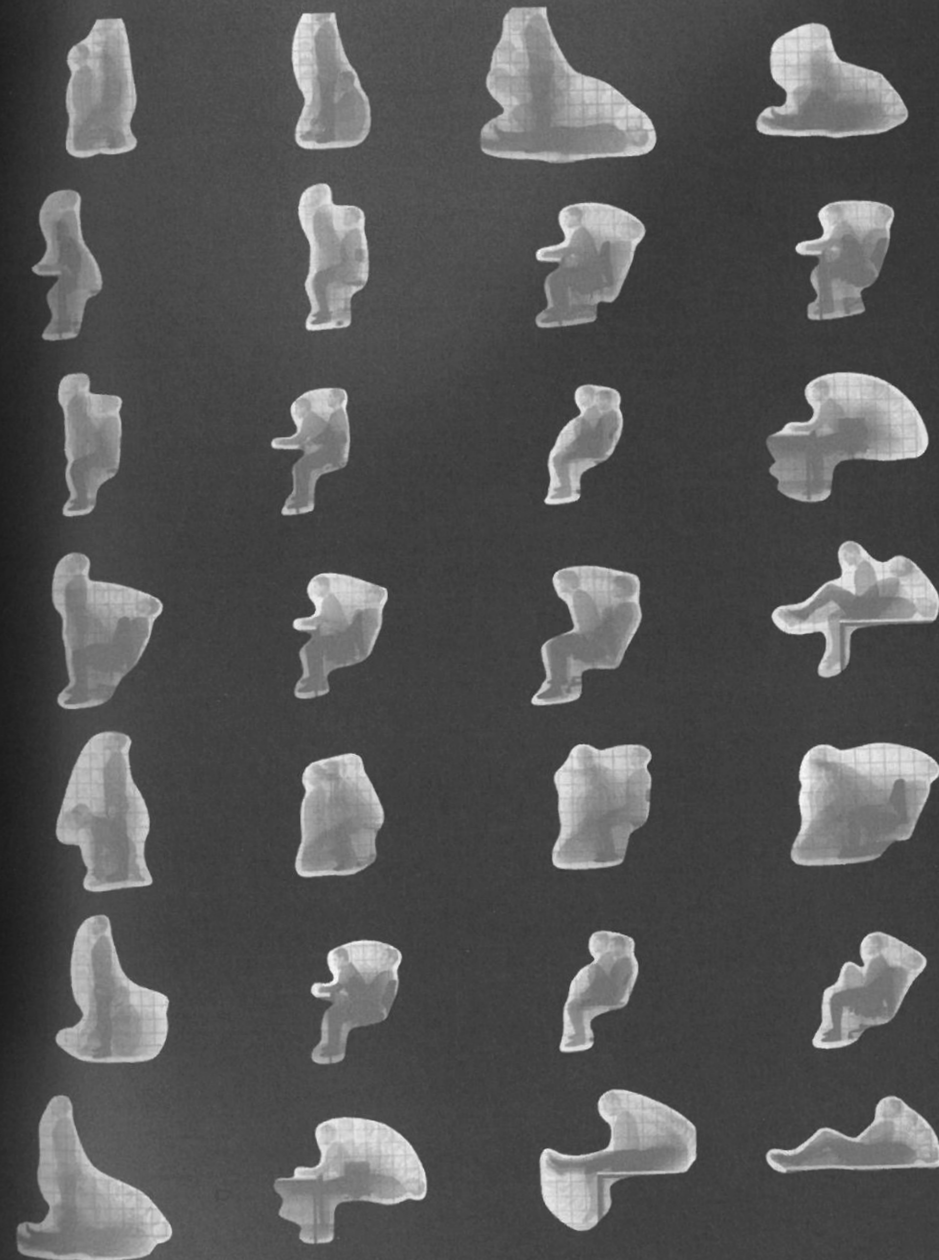
The 'View Halo' would be created through the gaze. By staring at one point, the material would take the form of a cone extending along the view line.

What we've called the 'Inertia Factor' would help to create a more stable surrounding environment. By adding time and inertia to the Halo, the fully adaptable environment would react in less hectic ways; the space it created would be smoother.

These different halos would serve as the main means of interaction between the user and his environment. The particles of the material could wrap around the Halo, never intruding upon it but using it as a kind of mould. Physical space thus becomes a direct manifestation of the virtual, personal, comfortable and desired space around a person.



For the development of 'Muybridge Revisited', we produced a catalogue of movements. By overlapping these movements to create a smooth transition from image to image, we explored the transition between different activities.



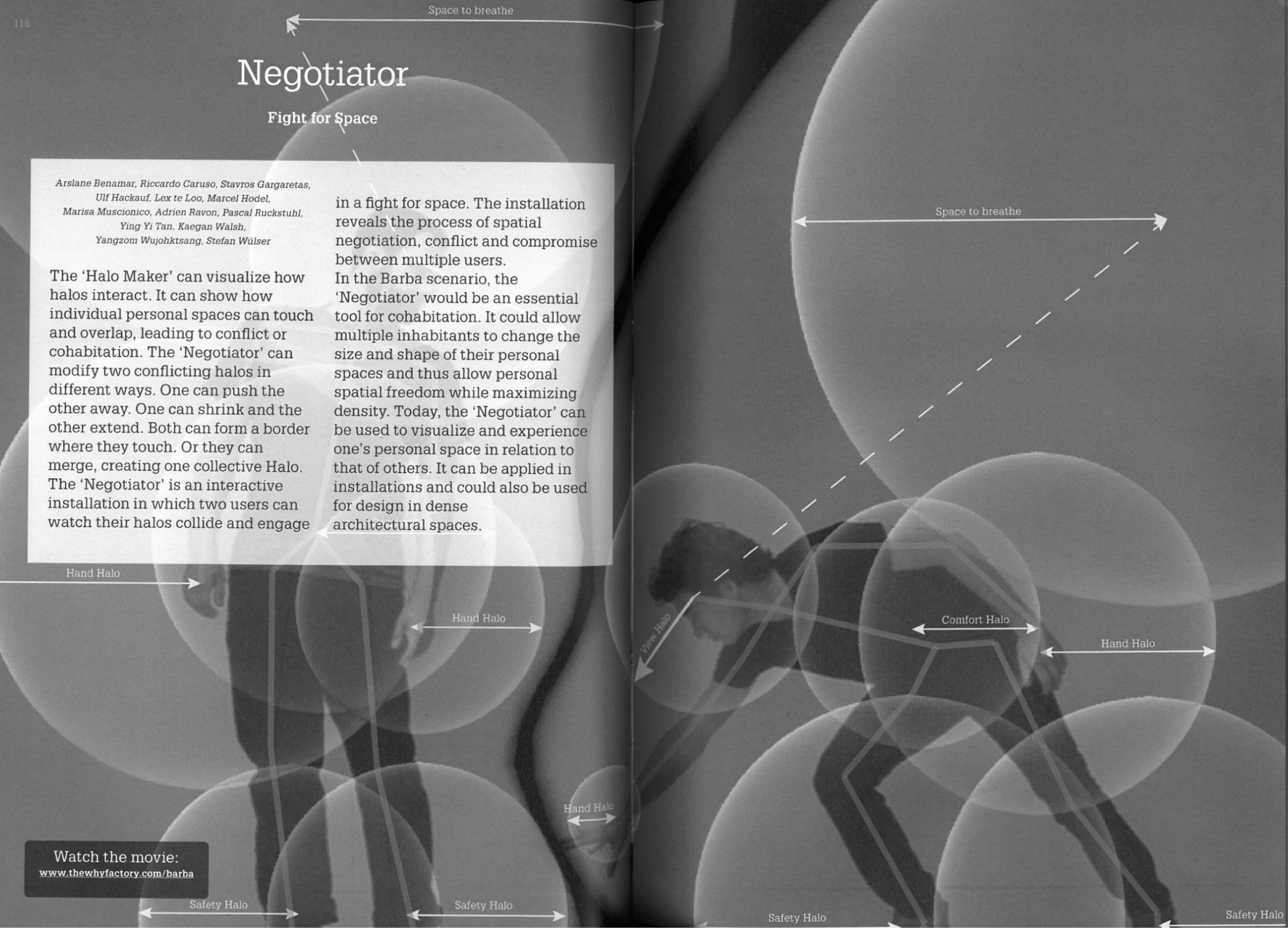
By translating these images into contours, we illustrated minimum ergonomic shapes based on different postures or activities.

Negotiator

Fight for Space

Arslane Benamar, Riccardo Caruso, Stavros Gargaretas, Ulf Hackauf, Lex te Loo, Marcel Hodel, Marisa Muscionico, Adrien Ravon, Pascal Ruckstuhl, Ying Yi Tan, Kaegan Walsh, Yangzom Wujohktsang, Stefan Wülser

The 'Halo Maker' can visualize how halos interact. It can show how individual personal spaces can touch and overlap, leading to conflict or cohabitation. The 'Negotiator' can modify two conflicting halos in different ways. One can push the other away. One can shrink and the other extend. Both can form a border where they touch. Or they can merge, creating one collective Halo. The 'Negotiator' is an interactive installation in which two users can watch their halos collide and engage in a fight for space. The installation reveals the process of spatial negotiation, conflict and compromise between multiple users.
In the Barba scenario, the 'Negotiator' would be an essential tool for cohabitation. It could allow multiple inhabitants to change the size and shape of their personal spaces and thus allow personal spatial freedom while maximizing density. Today, the 'Negotiator' can be used to visualize and experience one's personal space in relation to that of others. It can be applied in installations and could also be used for design in dense architectural spaces.



Watch the movie:
www.thewhyfactory.com/barba

Conflicts between multiple users can be visualized as overlapping halos. These can be spatial halos – I want my room to extend into yours, for example – but could also, for example, be acoustic halos – as in, I want to keep your noise out of my space. As the halos change with the users' movement and activity, the overlaps and conflicts between users would constantly change.
The 'Negotiator' can react to these conflicts in different ways:
The user who moves more could dominate. His Halo would push the other's Halo away. Each person would need to constantly fight to maintain the integrity of her personal space. If a neighbour were to become too intrusive, for example, a person could push him back. His Halo could in turn extend to the other side, solving the conflict by moving away.
Or we could watch personal space shrink in reaction to a neighbour's activity. The quieter a person is, the smaller her Halo would be.
Another configuration takes the form of a win-win or lose-lose situation. If both individuals are fighting with the same strength and intensity, then a straight line can form where the two halos overlap, something like the shape created when two soap bubbles touch. This shape of compromise could be reorganized in real time but could also react much more slowly. As a result, a steady line of separation between the users would appear, a more standardized organization with average volumes. If Barba learns from the conflicts between its inhabitants, it can offer optimized compromises between the different users' desires. New spatial qualities and architectural typologies could emerge from such a scenario.

The 'Negotiator' is an interactive installation based on the principle of metaballs. It uses three-dimensional Voronoi diagrams – which separate a plane or a volume populated by a collection of points into cells or regions – to define the limit between two spaces. These regions are defined by the proximity of the different points. The regions represent the zones of influence of each point in relation to the ensemble of all points.
As in the 'Halo Maker', spheres are attached to each of the skeleton's nodes. The user's movements control the radius of each sphere, and the limit separating personal space is defined by the sum of the zones of influence of each point in relation to the ensemble.

The installation use Kinect, Rhinoceros, Grasshopper, Firefly and Weaverbird.

Space Moulder

Sculpting in Time

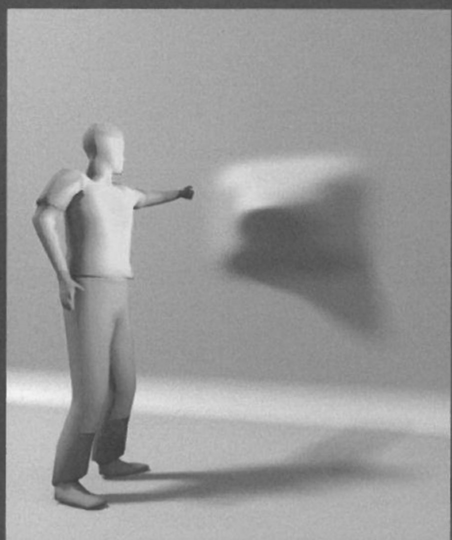
Arslane Benamar, Paolo Birrer, Tania Carl, Melina Cerfeda, Stavros Gargaretas, Ulf Hackauf, Lex te Loo, Sander Mulders, Sebastian Oswald, Kai Peter, Adrien Ravon, Henry Stehli, Kaegan Walsh, Stefan Wülser

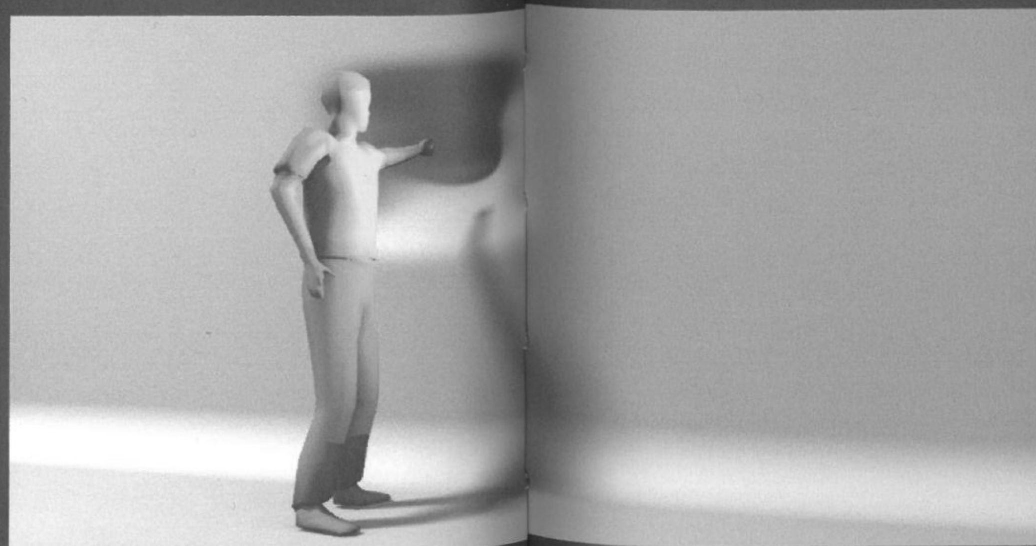
With the previous tools, the Halo always forms an offset of the user. You can increase or shrink your Halo, you can use it to push another user's space to the side or you yourself can be pushed, but as yet you can't touch it. The 'Space Moulder' therefore introduces the possibility of overriding the Halo's reaction. The main override function allows you to freeze a part of the Halo, put its responsiveness on hold and keep it from retreating. This enables you to touch the Halo or even to push through it. You can also use this to consciously adjust the shape of your Halo and to mould your personal space.

The 'Space Moulder' is an immersive installation in which you can interact with, sculpt, freeze and deform your Halo. In this installation the user becomes a model maker and can sculpt her space in real time. She is free to create free forms and shapes with her hands, arms and her whole body.
In the Barba environment, this tool would allow the user to take control of the space around her, to change its appearance and turn the fluid body-based shapes into a sculpted, controlled space. A user could create objects from the material, and she could use the 'Space Moulder' to create furniture.
Today, the 'Space Moulder' can be used to shape virtual, three-dimensional shapes and spaces based on the individual human body.

Watch the movie:
www.thewhyfactory.com/barba

The installation allows you to override your Halo and to freeze or extend some parts by simply moving your hand. You can thereby define the intensity and precision of interaction with your own Halo. Several parameters, such as elasticity, response time and inertia define the Halo's behaviour. Based on gestures, movements and time, it allows its users to experience wholly different ways of interacting with the environment.
The base for this is the Halo developed and described in the previous experiments. The envelope, created from virtual skeleton and metaballs in the 'Halo Maker', is 'frozen'. It becomes a static, three-dimensional mesh that no longer moves with the individual body.
In this new mode, you could begin to consciously transform the virtual Halo. By moving your hands, you start sculpting your space.
Depending on the position of your hand and the distance from your body, this allows you to push or pull parts of the Halo. One hand becomes a sculpting tool, like a large virtual brush. The other hand can control the size of this brush, allowing you to make large changes quickly or to work more slowly or with more precision.
Time is added as a parameter that defines both the material's speed of reaction and the influence of your brush on it. The longer you hold the brush at one point, the larger its effect. Once again – and ever more – your body creates the space that surrounds you.





The installation is based on the principle of attraction and repulsion. The Halo created with the 'Halo Maker' is frozen or 'baked' in Grasshopper, creating an interconnected mesh composed by a series of points. The hand of the user represents a charge point from which a series of vectors depart until they touch a collection of points on the envelope.
The points closest to the hand are either attracted or repulsed. By changing the position of the other hand in height, the user can increase, decrease or invert the attraction or repulsion effect of his hand.
Depending on the speed of her gestures, the user can interact more or less precisely with the envelope.
A time count calculates how many points the user is selecting per second. The points selected increase their value along their vector each time they are selected.
The installation uses one Kinect for the skeleton tracking, Rhinoceros, Grasshopper, Firefly and Weaverbird.

Shape Library

Download and Save

*Arslane Benamar, Paolo Birrer, Tania Carl,
Melina Cerfeda, Stavros Gargaretas, Ulf Hackauf,
Lex te Loo, Sander Mulders, Sebastian Oswald,
Kai Peter, Adrien Ravon, Henry Stehli,
Kaegan Walsh, Stefan Wülser*

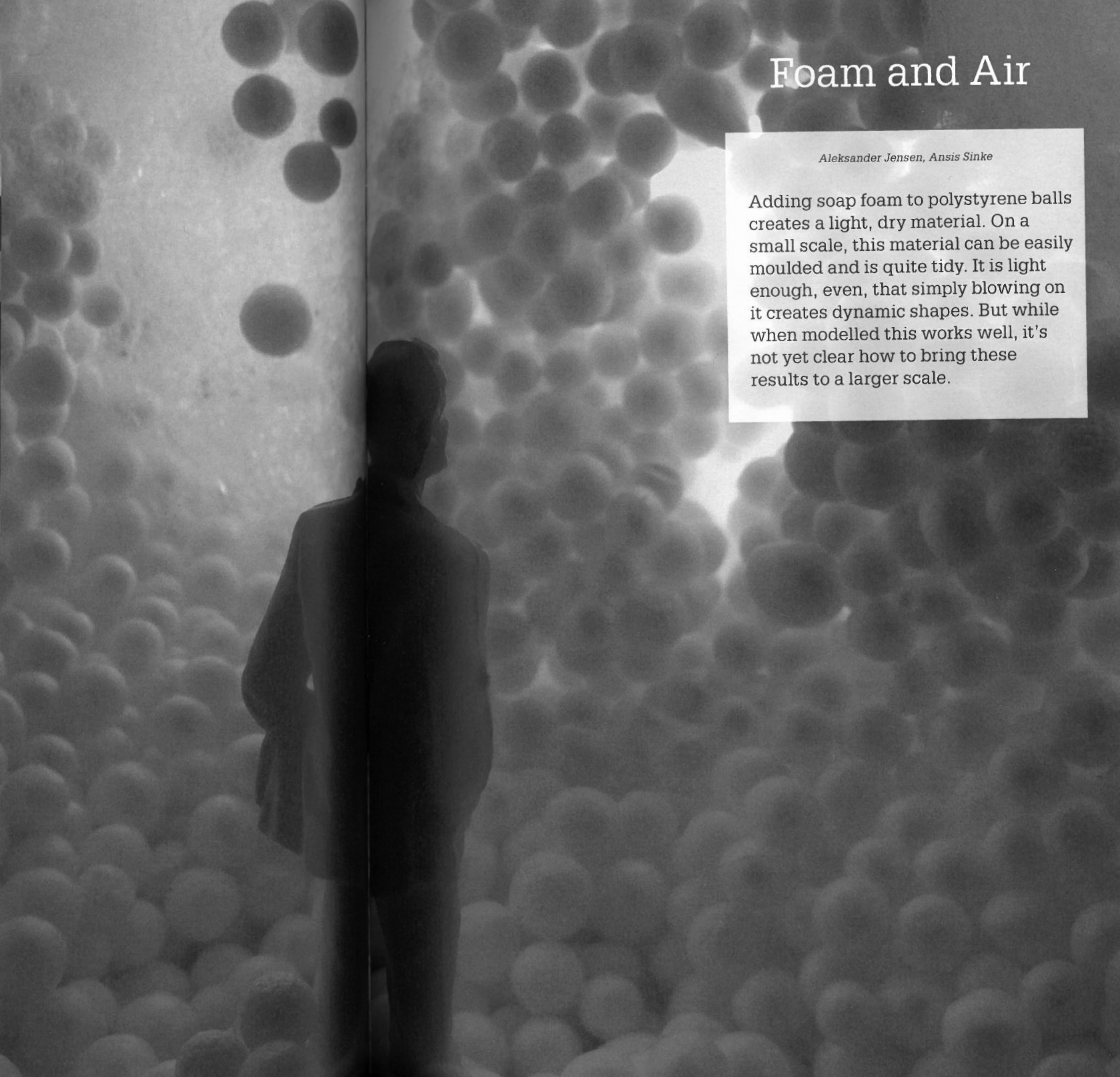
The 'Space Moulder' can be used to create objects and furniture. You can use it to push an indentation into a wall in Barba in order to then sit on it. You can use it to pull a hill from the floor, flatten it and lie on it. And, with more effort, you can carefully shape a whole table, complete with chairs. But to create all the objects you want in your room bit by bit is a lot of work. The 'Shape Library' therefore introduces the function 'store and upload shapes'. You would save a shape you created to a library and then would be able to upload shapes from your library so that they would instantly appear as part of your fully adaptable environment. These could be both shapes created before and shapes derived elsewhere or borrowed from someone else. Once activated, a shape can be modified by changing its scale, location or orientation. You can even stretch or bend shapes.
Say you want to sit and read a book. You could flip through the different types of armchairs included in the library. You could select one and move it to the place you wanted it. And then you could turn it, so that it would face the window. You might want to sit really comfortably, so you could recline more deeply, and the chair would recline with you. And then a friend might join you. You could pull at one side of the armchair and it would become a sofa for two. You could even change its surface. By altering the way it resists your body weight, the chair could gradually change from a rock-hard bench to a soft cushion into which you sink with your whole body. And you could program the behaviour of the furniture to sync with your activities and needs. Like: when you've nearly overslept, it could give you a little push and gently kick you out of bed.
The 'Furniture Maker' is an immersive installation with Kinect that allows for the placement, shaping, orientation, deformation and customization of virtual objects and furniture. In the Barba environment, it would be used to store, upload, exchange and modify complex shapes, furniture or complete interiors. Today, it can add functionality to the uses of the 'Space Moulder' and make it a tool for digital design and fabrication.

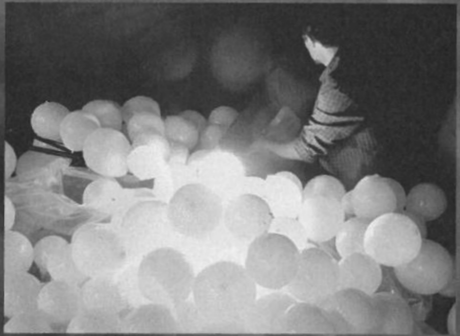
How might we bring Barba and his fully adaptable city to physical reality? This first test is a very direct attempt. Our vision is remade with analogue materials and rendered in film. While jumps in scale are allowed, virtual models are prohibited in this exercise. The aim is twofold, directed towards experience and experimentation. The intention is to simulate the experience of how the smoothly rendered surfaces of the previous chapters could play out in real life, to simulate the texture of the material and how Barba would feel. The test is simultaneously an experiment with simple and available materials. Could these materials themselves hold the key to new building methods? And is it possible that the advanced building materials about which we've speculated are already known to us? That they already exist, are hidden in our kitchens, say?
The results presented are deliberately light and playful. Some work with materials that can easily be scaled up to room size, while others are bound to remain conceptual. The aim of this exercise is, above all, to inspire.

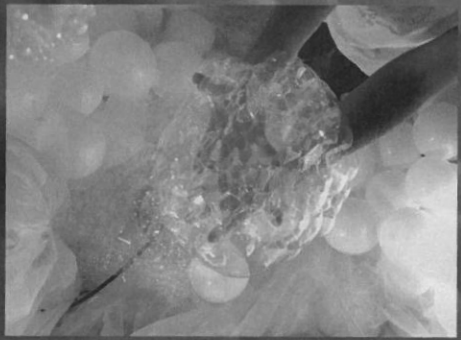
Material Experiments

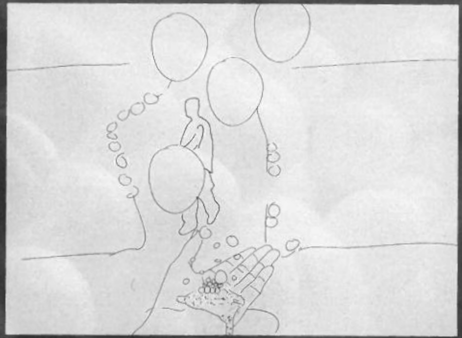
The Why Factory with Buckylab: Building Barbapapa workshop, TU Delft

Building Barbapapa workshop, TU Delft
Callum Andrews, Laura Ospina Botero, Gloria Chen, Maosen Geng, Ching He, Aleksander Jensen, Mark de Klijn, Niek van Laere, Chen Li, Marie d'Oncieu de la Batie, Guendalina Rocchi, Ansis Sinke, Ugur Sütcü, Fei Wu
Teachers: Marcel Bilow (Buckylab, TU Delft), Ulf Hackauf, Adrien Ravon
Guest critics: Ulrich Knaack (Façade Research Group, TU Delft), Winy Maas





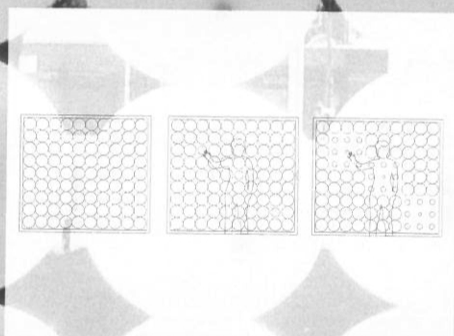




Foam and Air

Aleksander Jensen, Ansis Sinke

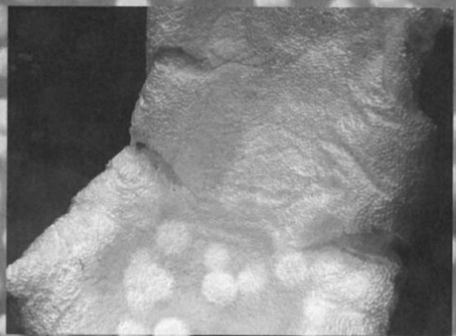
Adding soap foam to polystyrene balls creates a light, dry material. On a small scale, this material can be easily moulded and is quite tidy. It is light enough, even, that simply blowing on it creates dynamic shapes. But while when modelled this works well, it's not yet clear how to bring these results to a larger scale.

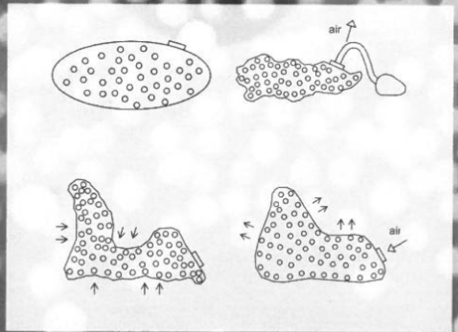


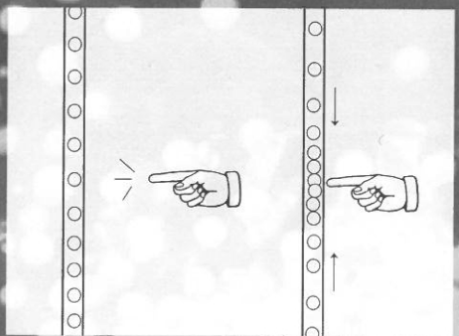
Balloon Transparencies

Marie d'Oncieu de la Batie, Guendalina Rocchi

Inflatable balloons seem a good base for flexible building elements. In this experiment, they form a façade. Changing the size of the balloons, such that their skin is stretched and compressed, adjusts the surface's transparency. Small ventilators and valves could automate this process. In another step, inflated balloons were vacuum-sealed in an airtight envelope, creating a structure that could be adjusted to different sizes and then frozen in a rigid state.



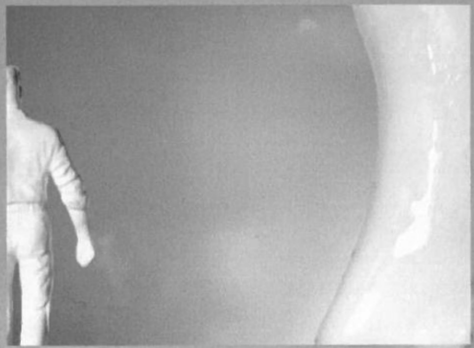


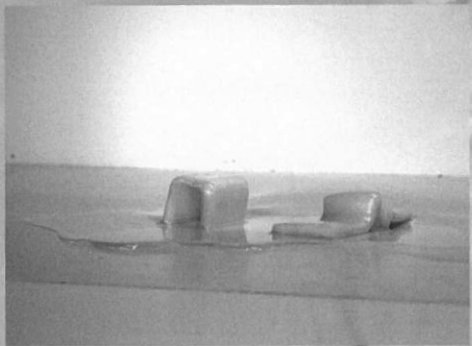


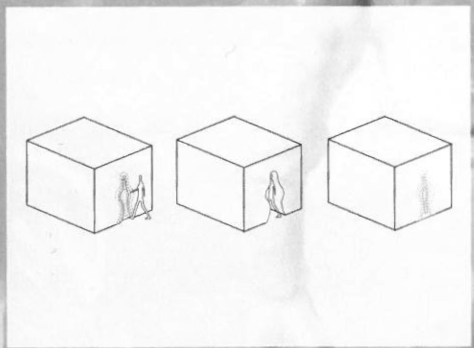
Vacuumed Grain

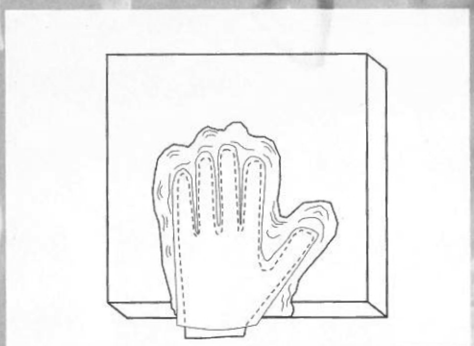
Gloria Chen, Maosen Geng, Ching He, Chen Li, Fei Wu

Polystyrene balls and a vacuum, elements taken from the previous two experiments, are combined here. Attaching a vacuum cleaner to a bag filled with foam balls allows for the transformation of free shapes into fixed forms. This technology enables the construction of both adaptable furniture and adaptable walls with relative ease. The experiment then explores another quality of polystyrene: its potential electrical conductivity. Rubbing the plastic creates static electricity, which attracts the balls. Could this property be applied to façade design as well?





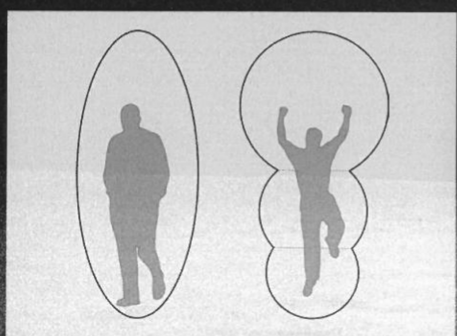


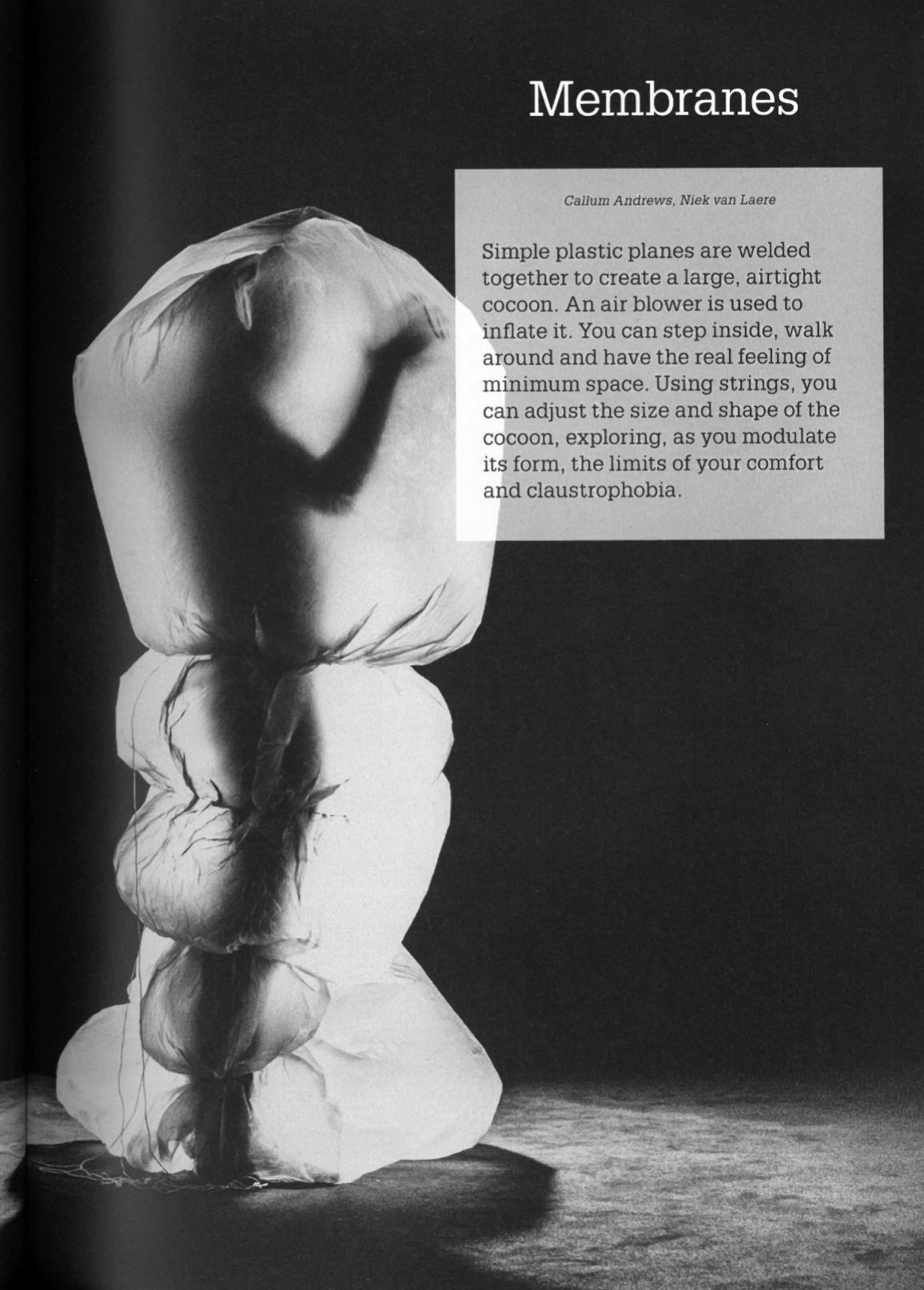


Wax

Gloria Chen, Maosen Geng,Ching He, Chen Li, Fei Wu

Wax is first cast into a mould to mock up pieces of furniture and a wall. The shapes are melted with heat from a blow dryer. The process is filmed and shown in reverse: an illustration of the possibilities of adaptable material and the suggestion an experience. While this work in wax does not directly lead to the development of fully adaptable space, it could be turned into beautiful installations. Imagine if the material's melting point were close to body temperature and if the wax reacted to the very presence of its spectators.

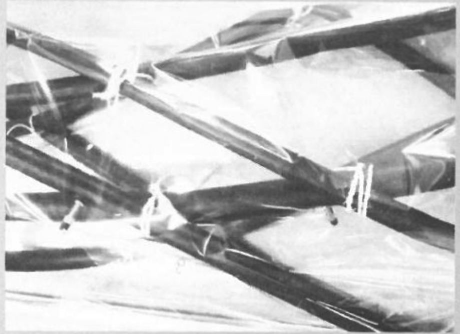


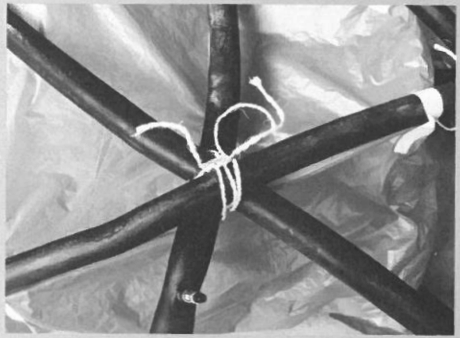


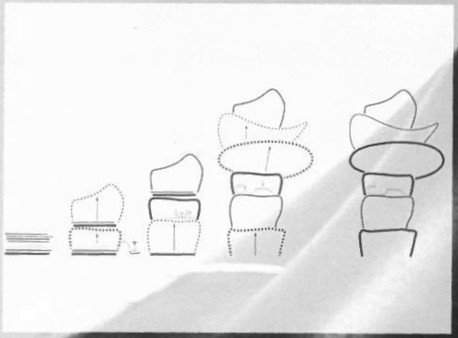
Membranes

Callum Andrews, Niek van Laere

Simple plastic planes are welded together to create a large, airtight cocoon. An air blower is used to inflate it. You can step inside, walk around and have the real feeling of minimum space. Using strings, you can adjust the size and shape of the cocoon, exploring, as you modulate its form, the limits of your comfort and claustrophobia.



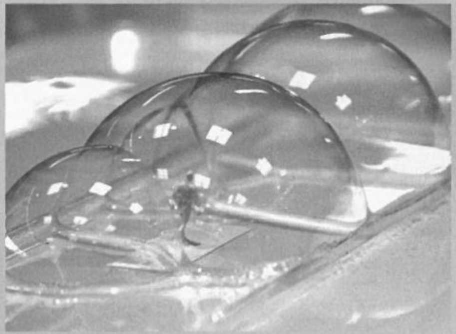


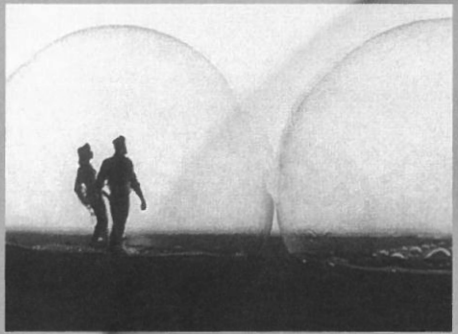


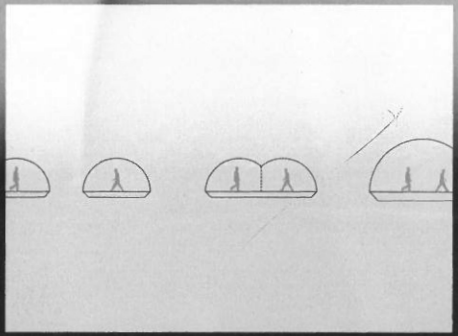
Pneumatic Skeleton

Laura Ospina Botero

What if the strings used in the previous experiment became inflatables themselves? They'd form a pneumatic skeleton, and changing pressure in the different 'bones' would create a dynamic framework. Adding a membrane to this frame would turn it into a flexible space. Taken further, the experiment suggests the possibility of pressurized columns and beams. We could make even these simplest architectural elements flexible; we could create pneumatic high-rises, spaces that shrink and expand.







Bubbles

Callum Andrews, Niek van Laere

The previous experiment points to a promising approach to creating a fully adaptable city using today's existing technologies. But here we'll move back from reality and return to the visionary and speculative. Imagine soap bubbles that form ephemeral spaces around humans. The spaces could be touched, pushed, connected. Enacting this on a larger scale would be hard, nearly impossible. And while bubbles are too fragile to provide any shelter, they visualize personal space and human interaction in a most poetic way.

The previous chapter's explorations serve as starting points for a longer, more thorough set of experiments. These experiments are directed towards a fully adaptable city achievable with today's existing technologies. They result in a series of physical and virtual prototypes, each one using a different material as point of departure. These investigations are both experimentation and simulated experience towards the vision of Barba space. They lead us to ask: How can we make any of this, today or in the near future? And how, then, would it feel?

Models

The Why Factory: Transformer Installations studio, TU Delft

Transformer Installations studio, TU Delft
Roxane Belot, Arslane Benamar, Nicola Campri, Sam Chia, Federico Gobbato, Nadia El Hakim, Ruth Hoogenraad, Cathrina Lee, Lex te Loo, Marine Manchon, Vincent Marchetto, Andrea Migotto, Rob Moors, Piet de Reuver, Dominik Saitl, Robbert Verheij, Hans Vlaskamp, Jordan Yerbury
Teachers: Ulf Hackauf, Adrien Ravon, Sander Mulders, Huib Plomp
Guest critics: Winy Maas, Marcel Bilow, Agata Jaworska