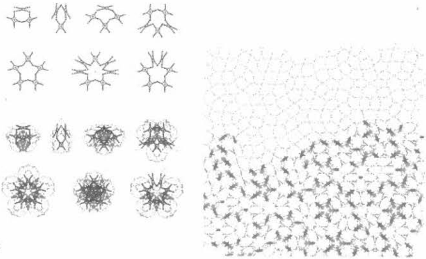
Case study Meshes as interactive surfaces

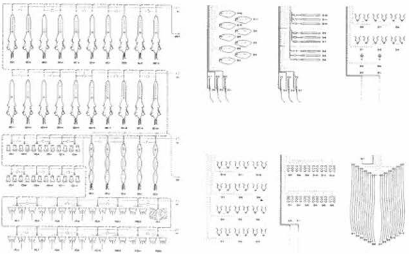
Phillip Beesley—Hylozoic Ground, Venice, 2010.

Hylozoic Ground is an immersive, interactive environment that moves and breathes around its viewers. Part of the Hylozoic Soil series developed by architect and sculptor Philip Beesley with collaborator Rob Gorbet, an expert mechatronics engineer, this environment can "feel" and "care." Next-generation artificial intelligence, synthetic biology, and interactive technology create an environment that is nearly alive. The design of the components, assemblies, and actuated devices of the Hylozoic series is a collaborative, evolutionary process. Design hypotheses, sketch models, experiments, and tests are produced in many cycles for each component. This process incrementally refines and improves the structure in specific ways—strengthening a local weakness, preventing a joint cracking, or increasing range of motion. Initial production tends to focus on the component itself, clarifying and refining its individual qualities. Interface between an individual component and other devices is addressed in further cycles. Understanding how a component functions in its larger context—at the level of the assemblies, actuated devices, or integrated systems of which it is part, and of the environment as a whole—is fundamental to individual component design.

A



B

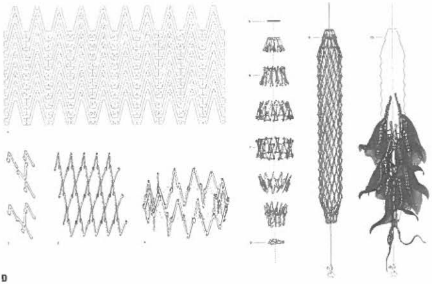


C

A, B, AND C Acrylic, copolyester, and silicone—resilient, flexible, self-supporting materials—are used to manufacture components in the environments. The most commonly used material is sign-grade impact-resistant (IR) acrylic. Resistant to distributed bending stress, IR acrylic is free of "grain" or directionally biased stiffness. IR acrylic is used for the chevrons that comprise the Hylozoic diagrid meshwork and the "skeletons" of most Hylozoic assemblies and devices. The transparency of the hard IR acrylic is preserved by the particular laser-cutting process used in the studio, which polishes the edges of the plastic.

D Localized, or point, stress can cause cracking and failure in the acrylic. To take advantage of its strengths and prevent weaknesses, a number of features have been developed including snap-fit joints, crack-stop corners, and gussets. Copolyester is more flexible than IR acrylic, with increased resistance to cracking and corner stresses but at the cost of a somewhat cloudy appearance. These qualities make it suitable for hinges and flexible ribbons, seen in the "tongue" cores of the sensor lashes and breathing pores.

E Specialized snap-fit acrylic joints are predominantly used for joining mechanisms required by the Hylozoic meshwork, assemblies, and devices. Snap-fit joints are common in industrial and product design, where they appear in such forms as the lip of a felt-tip pen or the snaps on vacuum-formed retail packaging.
A standardized joint recurs within the system.
The joint, which has undergone many iterations and stages of refinement, connects two laser-cut acrylic components axially, tangentially, or in parallel. IR acrylic has proven effective and reliable for manufacturing snap-fit joints, and requires no other mechanical fasteners or adhesives. The length and thickness of the "jaws" and size of the ridges can be varied to produce loose, temporary connections or tougher, more permanent joints. While the flexibility and hardness of IR acrylic make it an excellent choice for snap-fit joints and bendable hinges, the flexural stresses on the material tend to concentrate at sharp corners, leading to cracking and failure. "Crack-stop" detailing involves filleting or rounding the interior angles to distribute stress over a greater area. The amount of filleting or easing required is often fairly small relative to the size of the component. In some cases, the easing can be pushed into an internal cavity in the component. This approach is often used when a part's U-shaped "crotch" needs to provide a positive stop to secure and limit the movement of another part. Crack-stop corner detailing is employed in a variety of components, including latching clips employed to secure air muscles in "swallowing" columns, tightly fitted voids for modular jacks in actuated devices, and buckle fasteners for securing whisker sensors.



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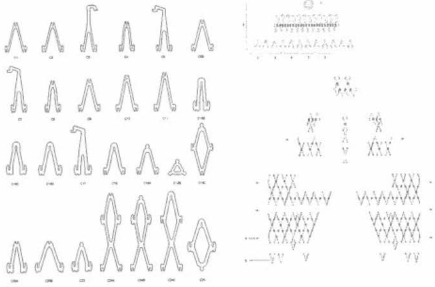
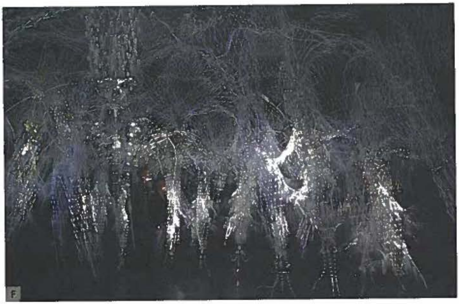


E

The manufacturing stage is fundamental to the advancement of component design. Arrayed components are reconciled with the rectangular dimensions of a sheet of IR acrylic, scaled to fit the bed of a CNC laser cutter. The organization of the array prior to cutting can add another variable to component design, especially for components that will be produced in greater numbers. In order to use materials efficiently and reduce waste, the shape of the component is refined so that it fits as tightly as possible with duplicates and other components on the same sheet. In the case of the chevrons comprising the expansive mesh lattice, the tessellation of the component has been refined to the point where they are fully nested and share edges. This makes it possible to remove overlapping lines, greatly reducing cutting time and virtually eliminating material waste. IR acrylic responds well to laser cutting, which produces smooth, clear edges. The laser's heat tends to vaporize the upper surface more than the lower, creating V-shaped cuts and beveled edges. The greater the thickness of acrylic, the more power is required to cut through the material—resulting in more pronounced sloping of the cut edges. Tuning both snap-fit and simpler, slotted joints becomes increasingly difficult in components cut from the thickest acrylic, since the diameter of a slot at its upper edge may be significantly wider than that at the lower. Given this eccentricity of laser-cut pieces, thinner IR acrylic stock material is selected wherever possible; this has the added benefit of reducing weight and cutting time.


F

F, G, AND H The interactive geotextile mesh "senses" people in proximity to it and responds with peristaltic wave movements, appearing to "breathe" around its occupants.


G


H