Topology and Geometry

*The Hylozoic Mesh*

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The scaffold that supports Hylozoic Ground is a resilient, self-bracing, diagonally organized space-truss that shapes and informs the system’s geometric organization. Distributed responsive systems, colonies of assemblies, and actuated devices within the Hylozoic environment are rooted in this meshwork foundation.

Curving and expanding the mesh creates a flexible hyperbolic grid-shell that stretches and deforms to embrace visitors in the space. The meshwork is composed of flexible, lightweight chevron-shaped linking components. The chevrons interconnect using snap-fit fastening to create a pleated diagonal grid surface—a *diagrid*. Columnar elements extend out from the diagrid membrane, reaching upward and downward to create tapering suspension and mounting points. The recursive nature of the geometric involutions and evolutions of the mesh give rise to a fecund surface—a second skin of the Earth, rich in possibilities and thick in pleasures. The actuated surficial geotextile offers an extension of the Earth’s living crust.
The core unit of this structural mesh is a bifurcated chevron link, an optimized laser cut form with an interlocking ‘snap-fit’ receiver at each of its junction points. The V-shaped chevron design contains thickened feet and head, strong shoulders, and slender arms that are capable of twisting slightly. The design of this element, intimately coupled to material characteristics of the acrylic, gives the Hylozoic mesh its substantial geometric flexibility.

The underlying chevron-shaped geometries of the Hylozoic mesh relate to herringbone patterns used in traditional fabrication systems such as masonry, woven textiles, and embroidery. Early explorations of the Hylozoic chevron unit were based on space-filling tessellated tile systems with components laid back-to-back, completely filling stock material sheets. Shaping these components to achieve full tessellation involves an iterative design process where successive generations of components are refined in numerous cycles of testing.

When the Hylozoic chevrons are snapped together foot to foot, the two-dimensional herringbone pattern expands to form a structural diagrid. This corrugated chevron sheet offers a flexible structure, capable of acting in both tension and compression. This basic structural geometry was the catalyst for generous form-finding exploration during the initial development stages of the Hylozoic topology.

Columnar forms emerge by assembling loops of connecting diagrid strands in rows. Expanded sheets of assembled diagrid strands create flat panels that can warp into arched forms. By connecting progressively lengthening diagrid strands in rows, more complex fabric forms emerge, including conical caps for columnar elements, and double-curved hyperbolic arched sheets. The lily-like forms of the Hylozoic Ground canopy are created by combining sets of hyperbolic arched sheets and conical caps.

Individual chevron components and the assembled mesh topology have evolved in parallel. The physical geometry of the basic chevron has developed as demands on its flexibility and strength have increased. Alterations have been made to the profile thickness, the width of the arms, the dimension of the snap-fit, and the scale of the piece itself, in order to accommodate new formal and structural explorations of tiling patterns and component arrays.
The choice of a specific geometric system implies an ordinance, the authoritative geometric figure which grounds the possible arrangement of subsystems and components. Universal geometric ordinance systems have long cultural histories. Multiplication of the ordering units of three, four, and higher multiple-sided units in regular arrays reveals efflorescent, crystalline fields of possible formations. However, while transcendent orders recur in the Hylozoic series, they are heavily modified by local circumstance. On the other hand, the ordering system of the Hylozoic series is far from a pure, chance-driven ‘aperiodic’ system that avoids repetition. The combined effect of local variation and generalized orders produces heterogeneous, reticulated ‘quasiperiodic’ fields of material.

The Hylozoic topology has pursued driving factors of variation, flexibility, and order in its evolution. Initial explorations into non-repeating two-dimensional systems employed Penrose tessellation derived from preceding projects including Orgone Reef, Orpheus Filter, and Implant Matrix, and more recently in the filter layers that appear within the Hylozoic series. Penrose tessellations, invented by British physicist Roger Penrose, are generated from sets of ‘prototiles’ that make up the particular tessellation patterns. These prototiles may possess rotational or reflection symmetry, but general translational symmetries do not appear. While local symmetries and repeating clusters of units appear throughout a Penrose tessellation, the fabric as a whole does not repeat its patterns.

Alongside the quasiperiodic system of rhombic tiles, a regular tiling system of hexagons has been used which exploits the diagrid surface structure to become infinitely expandable, both horizontally and vertically. Variability and flexibility in the rigid geometric pattern is achieved by varying the introduced components and by inserting bifurcations within ordered arrays.

The hexagonal pattern is constructed by stitching together six identical flat meshwork ‘petals.’ When joined, the petals erupt into a three-dimensional lily structure that can be multiplied vertically and horizontally to form hyperbolic canopy elements. In early generations each lily terminated in a
columnar growth which, depending on the orientation of the lily, attached to either the floor or the ceiling. Triangular, vaulted structures, called treos, were introduced in the interstitial spaces among lilies to relieve the build-up of stress within the meshwork. These variations on the lily structure employed three panels compressed into arched volumes.

Recent iterations of the Hylozoic environment has replaced the treos with three way lilies and separated the columnar forms from the canopy, inviting those elements to develop freely as independent bodies placed in interstices of the continuous meshwork. By adopting this new tiling pattern of both three- and six-way lilies, circular apertures have been created within the hexagonal grid canopy. Through these apertures, angled stainless steel tension rods with toothed clamps bite into the ceiling and floor surfaces, supporting new freestanding columns. This revised geometry releases the canopy from the weight of the columns and pore mechanisms, and allows the columns to float dynamically in relation to one another.

Two basic petal tiles, both following a three-dimensional herringbone pattern, are preassembled before installation. Overlapping arched sections of petals remain uncoupled, releasing the arch forms and permitting flat packing. Due to their modular form, these petals can then be stacked and transported in small containers. The process going from chevron to mesh is quite beautiful: one begins with a flat material and a geometric shape that arrays to fill the two-dimensional plane. It lifts out of the surface, snaps together, and expands into a three-dimensional diagrid that is subsequently recompressed into a stackable, repeatable tile. Finally, it is expanded again to its fullest extent when the tiles are stitched together into the final Hylozoic mesh topology.

topology evolution

The original Hylozoic mesh used relatively few chevron types. Particular geometries were achieved by introducing bifurcations and complex patterning in the row-by-row assembly of the tiled units. In order to increase stability at points of weakness, the chevron was adapted by substituting the regular snap-fit joint with hook connections to suit the amplified tensile forces required by these areas. In transitional areas of the mesh, many
Chevrons possess both snap-fit and hook connections to equip them for varying levels of force.

In high-stress regions of the mesh where the geometries generate intense torsion, the acrylic chevron was initially replaced with a vinyl chevron capable of adjusting to this twist. Later, specialized acrylic chevrons were introduced in these locations. The chevron’s snap-fit joints were replaced by barbed feet designed to connect via resilient silicon tube details.

Chevrons have also been developed to taper, widen, and lengthen in order to increase the flexibility of the mesh geometry. Another category of chevrons encompasses those designed for specific roles such as device and mechanism connections, collar connections, and hanging connections. In the Hylozoic Ground installation at the Venice Architecture Biennale, approximately thirty different chevron types make up the mesh canopy and column system. After many successive generations, and out of relatively simple components, a topology of increasing complexity and diversity is emerging.