The First Tileable Stochastic Porous Geometry System

GS-RD Bicontinuous Foam Generator

Patent Pending — May 2026.

THE PROBLEM

Organic porous geometry — the kind found in trabecular bone, coral, and lung tissue — outperforms periodic alternatives across orthopaedic implants, thermal management, acoustic surfaces, and lightweight structural components. It is the geometry that nature selected over hundreds of millions of years of mechanical optimisation. The field does not use it, because it cannot be assembled. Irregular porous structures do not tile. Every joint produces a seam. So engineers settle for TPMS surfaces — gyroid and Schwartz P — which are tileable but identical from unit to unit. Every cell the same. Bone is not like that, and implants that use bone-like geometry outperform those that do not.

THE SOLUTION

A single constraint applied during simulation produces the property that has not existed before — seamless tileability in a stochastic bicontinuous geometry. The resulting tile assembles in translation, in 90-degree crystallographic rotation, or as part of a matched-face pair. The joint closes exactly in every case. Every interior is unique. Every boundary is exact. No post-processing. No manual fitting. No seams.

The system sits at the intersection of reaction-diffusion chemistry, tessellation theory, and morphogenetic biology. The chemistry sets the pattern. The tessellation makes it assemblable. The biology is the proof — because nature already uses this geometry for load-bearing, vascularised, porous structures in every vertebrate on earth.

THE TILE

Each tile is a cube with six faces. Each face carries a distinct boundary profile — a precise cross-section of the bicontinuous surface at that plane. Within any assembly, every shared boundary is identical on both sides: the profile on the right face of one tile is the exact profile on the left face of its neighbour, the top face matches the bottom of the tile above, and so on through all six directions. These profiles are not designed or fitted after placement. They emerge from the simulation and are found to match. The interior of every tile is geometrically unique — no two tiles in any assembly share the same internal structure — while every boundary is exact.

A single generated tile supports three independent assembly modes simultaneously — Face-Pair, Periodic (P1), and Rotational (C4) Crystallographic — plus slab assembly, gradient density, mesh fill of arbitrary volumes, and open interior export for seamless multi-tile fabrication. Eight distinct capabilities. One tile.

ASSEMBLY MODES

Face-Pair Family — Tiles are generated in matched pairs: the right face of tile A is the exact boundary of tile A′'s left face. Both halves of the boundary existed independently before the tiles were ever placed together. Every interior is unique. The joint was not fitted after the fact.

Periodic (P1) Tileability — A single tile repeated in X, Y, or Z without rotation. Interior morphology continues uninterrupted across every joint. Any rectangular or cubic volume filled from a single repeating component. No pairing, no ordering, no gaps.

Rotational (C4) Crystallographic Assembly — The same P1 tile rotated 90° tile-by-tile or row-by-row. Joints remain closed. The foam orientation shifts across each boundary, following the C4 rotational symmetry group and producing a macroscopic crystallographic pattern that no individual tile reveals. Orientation encodes position.

DIFFERENTIATION

nTopology and Grasshopper TPMS plugins offer tileable porous geometry — but deterministic. Every unit is identical. Research groups have simulated stochastic bicontinuous geometry — but it is not tileable and not fabrication-ready. No commercial tool and no published pipeline combines both properties. A search of USPTO records, Google Patents, and the published literature confirms the prior art position. Three provisional patents were filed May 2026. The combination is protected.

The reaction-diffusion architecture is competitive with or superior to conventional architected lattice and foam geometries of similar density while maintaining higher structural connectivity — the result of a generating process that mirrors biological morphogenesis rather than mathematical prescription.

VALIDATION

Measured against published clinical specifications for trabecular bone scaffold design at 3mm tile size, N=64 resolution. Five of six parameters pass directly from simulation:

- Porosity 68.9% · target 65–80% ✓
- Median pore size 469 μm · target 300–500 μm ✓
- Median strut thickness 188 μm · target 100–200 μm ✓
- Solid connectivity 100% · target > 95% ✓
- Face-match tileability 100% all axes · target > 95% ✓
- Minimum throat > 150 μm post-smoothing · voxel measurement artefact documented ✓

An 8×8×8 assembly produces 512 geometrically unique interiors with continuous foam morphology at 312–375 μm pore scale — within the optimal range for osseointegration and vascularisation. To the best of our knowledge this is the first stochastic bicontinuous porous geometry system to achieve validated trabecular bone specifications while maintaining seamless tileability at arbitrary scale.

ROUTE TO MARKET

A Grasshopper plugin is in active development. Grasshopper is the parametric design environment used by the majority of serious computational design practices in architecture, product design, and engineering. The plugin exposes the full generator as a native component — no new software, no file conversion, no workflow disruption. Weaverbird, Ivy, and Kangaroo demonstrate the propagation pattern: a small number of early adopters at influential firms drive adoption across thousands of downstream practices. The geometry is demonstrable in under two minutes. Initial conversations are underway in the orthopaedic and architectural geometry verticals.

MARKET

Orthopaedic and spinal scaffolds — a $50 billion total implant market. Porous scaffold geometry commands a per-device premium of $3,000–$8,000 per spinal cage; the addressable scaffold geometry slice is estimated at $2–4 billion annually. Computational design — comparable Grasshopper plugin licences sell at $120–$600 per seat annually across a concentrated market of influential firms. Defence and aerospace — ballistic absorption, thermal management, and lightweight structural infill are active procurement areas with documented requirements for novel porous geometry. Platform licensing to CAD software companies — precedent transactions for geometry IP with active patents and demonstrated clinical application range from $500,000 to $15,000,000.

WHY THIS INVENTOR

Building this system required spanning computational geometry, reaction-diffusion mathematics, 3D simulation, mesh extraction, and fabrication-aware design simultaneously — and understanding how the output gets physically made. The inventor's background covers physical fabrication and cabinetmaking, digital fabrication instruction at the University of Arizona, CAD drafting, interior design, and independent software development. That combination — hands that have built things and a mind that can simulate them — is not available in a single academic lab or engineering firm. It is what made this system possible and what no institution was positioned to produce independently.

Three provisional patents filed. A validated clinical specification. A working large-scale assembly. All built without a lab, a grant, or a team. The Grasshopper plugin, the GPU acceleration, and the non-provisional filings require the same discipline. The track record is the evidence.

RISKS

Patent prosecution — manageable. Priority dates are secured. Non-provisional cost is known and budgeted within this raise. The risk is timing, not uncertainty. This is the first use of capital for exactly this reason.

Grasshopper adoption — the real commercial risk. Propagation in the computational design market depends on early influencer uptake and is not guaranteed. The mitigation is a curated beta programme with ten selected firms before public release. That is how Weaverbird and Kangaroo spread. It is not certain but it is the proven mechanism.

GPU acceleration — not a dependency. The browser simulation is validated and working today. The Grasshopper plugin ships on CPU first. GPU reduces bake time from minutes to seconds and is a performance upgrade, not a launch requirement.

Clinical pathway — the specification is validated computationally. Physical validation requires a printed sample and optical cross-section — achievable within the first capital deployment. Regulatory approval for clinical use requires a device partner and is a subsequent raise, not this one.

Timeline — the twelve-month plan is optimistic. A realistic range is twelve to eighteen months. The patent prosecution deadline is fixed at May 2027 regardless of everything else.

INVESTMENT

$150,000–$225,000 over twelve months. Three sequential priorities in order of non-negotiability:

> Patent prosecution — non-provisional filings across three families by May 2027. $30,000–$55,000. The IP position expires without this.
>
> Software engineering — GPU acceleration, Grasshopper plugin, clean API, watertight mesh export. $75,000–$115,000. Begins month two.
>
> Market development — legal structure, operations, initial commercial engagement. $25,000–$50,000.

Revenue timeline: subscription browser tool — immediate on launch. Grasshopper plugin per-seat licence at $120–$600 annually — six to twelve months post-engineering. Platform licensing to CAD software companies — eighteen to twenty-four months. Geometry royalties on products using this surface — long-term highest value.

Acquisition: from $300,000. Licence: $75,000–$150,000 upfront plus 2–4% royalty. Structure: direct equity, convertible note, or strategic partnership — open to the right fit.

WHY NOW

The non-provisional filings are due May 2027. The prior art window is open. A competitor who independently arrives at the same constraint and files before the non-provisionals closes the IP position. That risk is real and time-bounded. The geometry is validated. The system works. The Grasshopper plugin is executable with this capital. The cost of waiting is not delay — it is the possibility that the window closes before the position is secured.

TIMELINE

Month 0 — NDA. Live demonstration. Review geometry and outputs. Month 1 — Patent counsel. Term sheet. Month 2 — Patent prosecution begins. Software engineer engaged. Month 6 — Grasshopper plugin beta to ten selected firms. Month 12 — Public plugin launch. Non-provisional filings complete. Months 12–24 — Platform licensing conversations. Defence and orthopaedic co-development engagements.

INTELLECTUAL PROPERTY

Three provisional patent applications filed May 2026. Claims cover the tile architecture, the bidirectional cellular automaton — reaction-diffusion coupling mechanism, and the wall-proximity density gradient method. USPTO records, Google Patents, and the published literature have been searched. Prior art position confirmed. Non-provisional filings due May 2027. A live browser demonstration is available immediately. Portfolio document and provisional abstracts available under NDA.

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