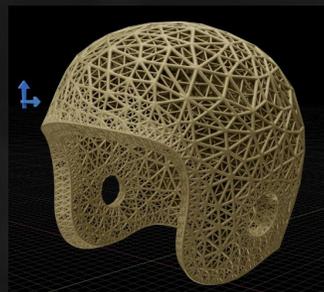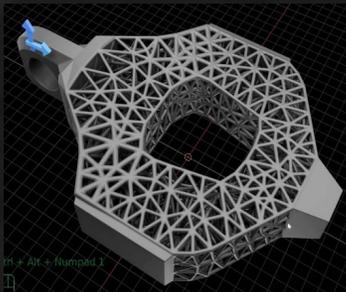# ABĒMIS

Hyperstructures

"Beyond Lattices"

Ultra-light, Ultra-strong, Conforming, Vibration-damping **metastructures.**

US utility patented (US10585420B2)

Todd Doehring, Ph.D., Founder/CEO
tcd@abemis.com, 215-385-4568

ABĒMIS LLC

Advanced BioEngineering and Meta-Intelligent Systems
http://www.Abemis.com   Cleveland, OH 44122

Hyperstructures (Hgons)

We have developed a new class of mesh-based *"intelligent metastructures"* that have a novel tetrahedral-hybrid shape basis (utility patented), instead of the simple cell-lattices that <u>all</u> other companies use.

Hgons have vastly improved capabilities over all current software's repeating lattice structures.

- Much stronger than lattices, with deep spectral anti-vibration properties.
- Automatic conforming, scale-able, and <u>*adaptive*</u> in ways *never before possible*.
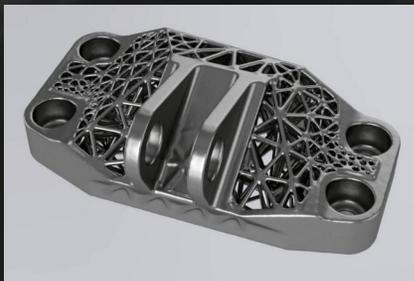
Hgons are Ultra-Conforming

Our GE Challenge result, 379 gm., 80% weight reduction
- Much stronger than the challenge 'winner'

Hgon test prints. From large to tiny.

~10 μm dia struts

Penny

Rice

Hgon hyper–structures
ABEMIS.com

Hgons are super scale-able

Todd Doehring, Ph.D., tcd@abemis.com, txt or phone, 215-385-4568

Hgons: *Solving* a major long-standing problem with lattices: non-conformity

The Problem with ALL lattices

All other software companies, such as <u>nTop</u>*, currently use lattice *periodic-cell (*or Voronoi) methods…

Lattice

✗

* Basic lattice result from the nTopology software (ntop.com)
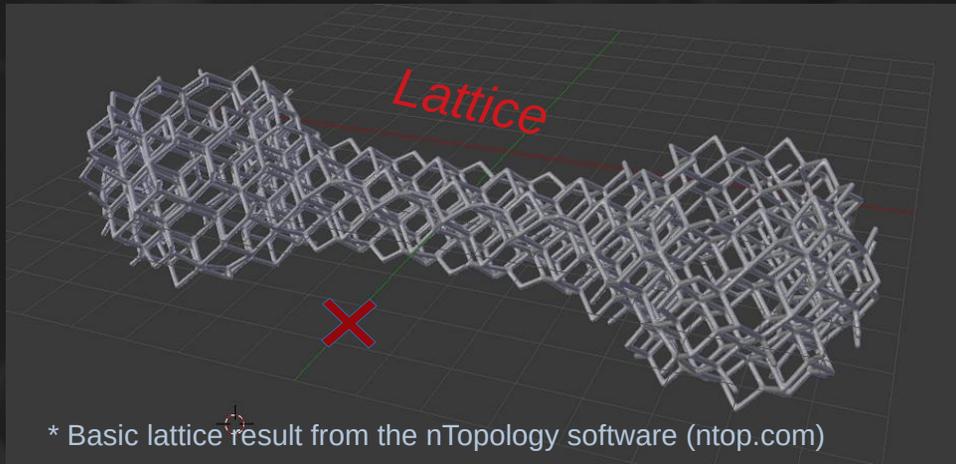
- *Lattices <u>cannot conform</u>* to complex objects
- Very limited density control

Our Solution: Hyperstructures (Hgons)

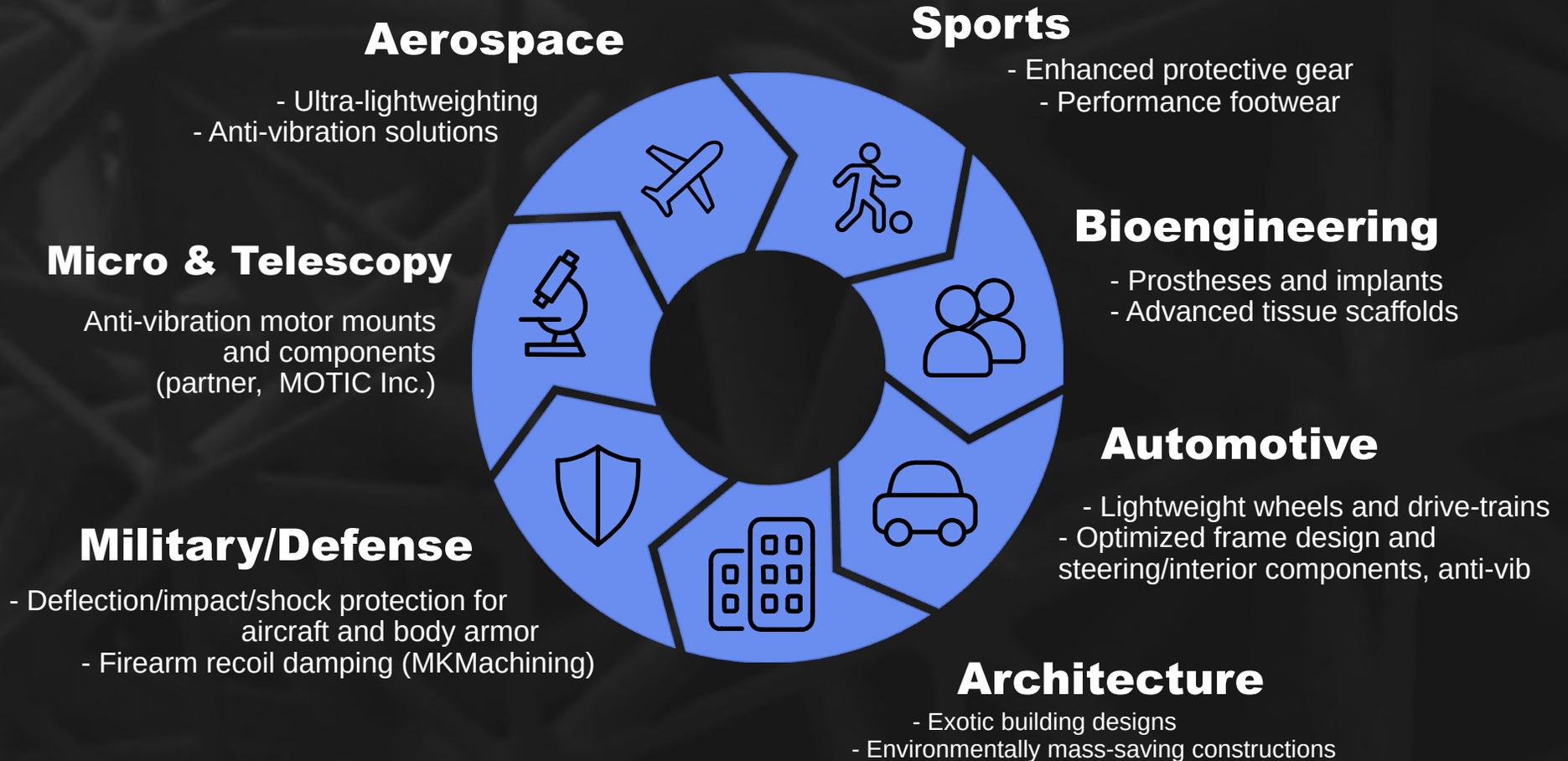*<u>Expands</u>* the 'lattice' concept using a unique FEA based, meta-adaptive approach.

Hgon

✓
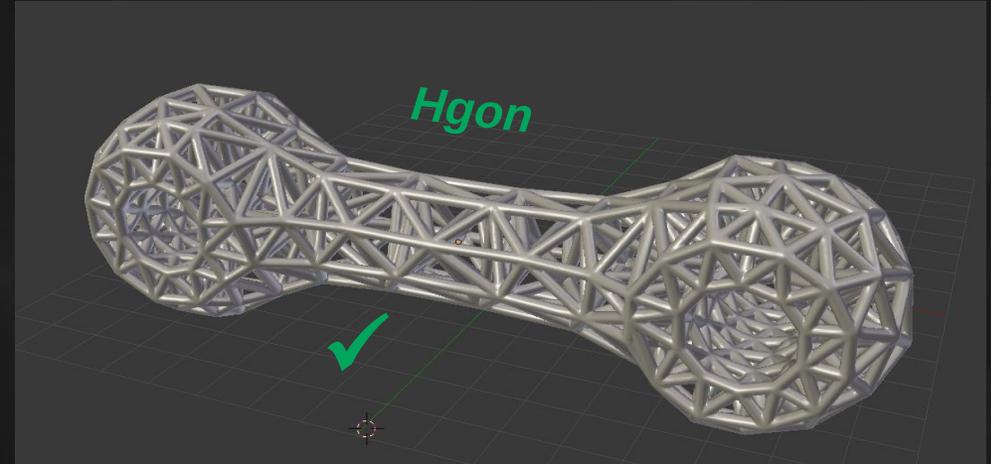
- Hgons *<u>automatically conform</u>*
- FULL density control

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568
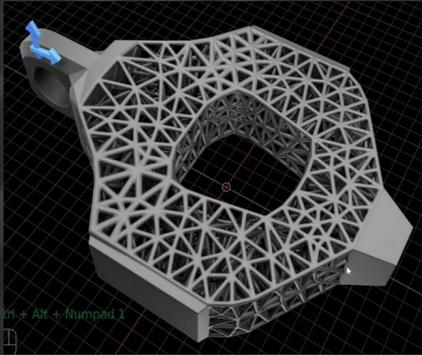
More Benefits of Hgons:

Performance + Value

- Large savings for companies *and environment;* $$$ in weight-mass.

- Unprecedented <u>anti-vibration</u> and lightweight performance.

- New capabilities for exotic component design, unlike anything that has been achieved before.

- Integrable with emerging Design for Additive Manufacturing (DfAM) and <u>AI enabled</u> workflows.

- Customizable for specific AM hardware platforms and materials (high licensing potential).

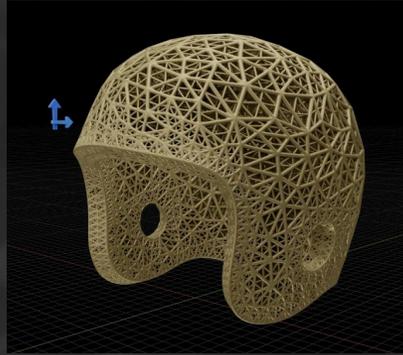- We have the Utility PATENT : US10585420B2

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Many Applications

Aerospace
- Ultra-lightweighting
- Anti-vibration solutions

Sports
- Enhanced protective gear
- Performance footwear

Micro & Telescopy
Anti-vibration motor mounts
and components
(partner, MOTIC Inc.)

Bioengineering
- Prostheses and implants
- Advanced tissue scaffolds

Military/Defense
- Deflection/impact/shock protection for
aircraft and body armor
- Firearm recoil damping (MKMachining)

Automotive
- Lightweight wheels and drive-trains
- Optimized frame design and
steering/interior components, anti-vib

Architecture
- Exotic building designs
- Environmentally mass-saving constructions

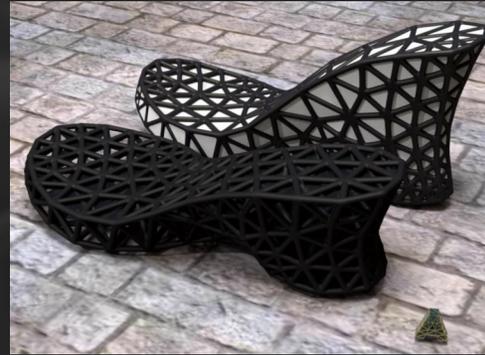Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

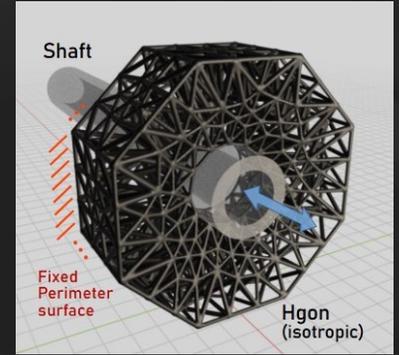# Some Examples: Prototypes we have recently made

ABĒMIS

Ultra-light anti-vibration camera mount

Sports, Military Impact (multi-density)

Footwear, both fashion and orthopedic
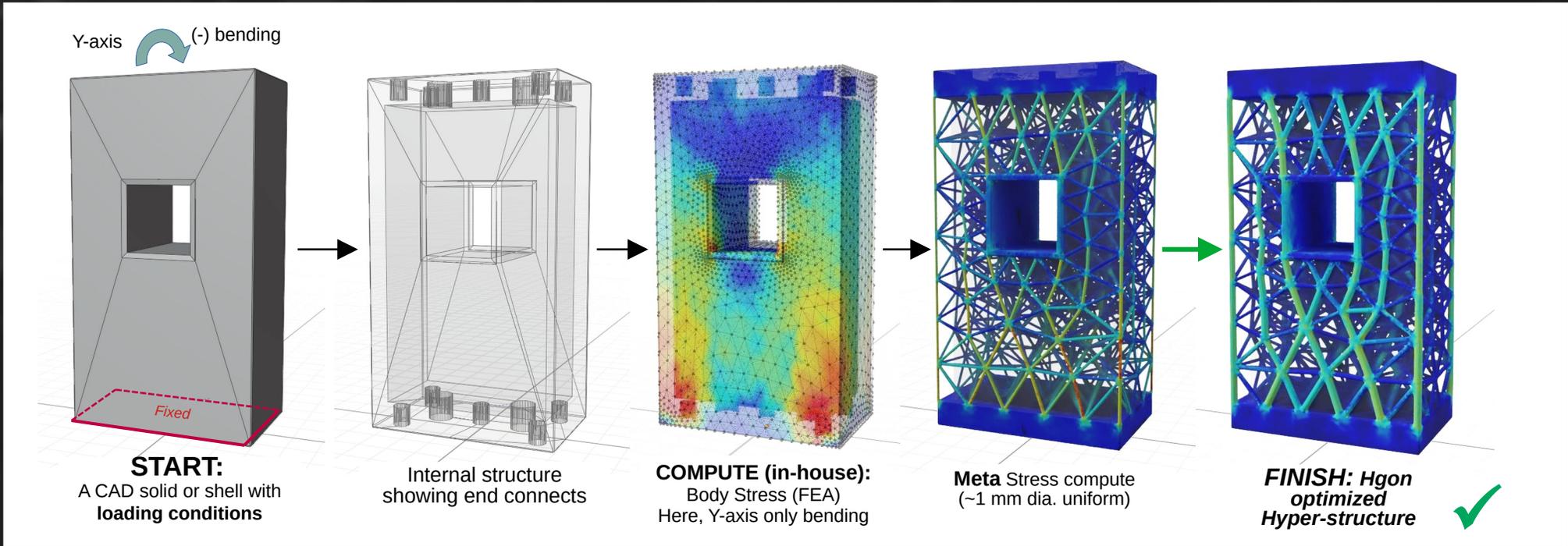

Anti-vibration Bearings/linkages

Ultra-light Stepper motor mounts

1-wood

Golf: clubs, handles, bags

# How we do it: This basic process works *for <u>any</u> CAD**

Y-axis (-) bending

Fixed

START:
A CAD solid or shell with **loading conditions**

Internal structure showing end connects

COMPUTE (in-house):
Body Stress (FEA)
Here, Y-axis only bending

Meta Stress compute
(~1 mm dia. uniform)

FINISH: Hgon optimized Hyper-structure ✓

✓ RESULT: A '*Smart*' meta-structure that ***adapts*** strut width to the loading conditions.
* *Fully* isotropic *and directed field metastructures from CAD and FEA.*
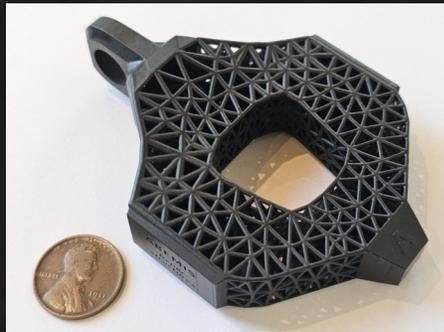☆ No other company/group can do this, and <u>we have the Utility Patent</u>.

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Hgons enable complex shapes that are _impossible_ with lattices
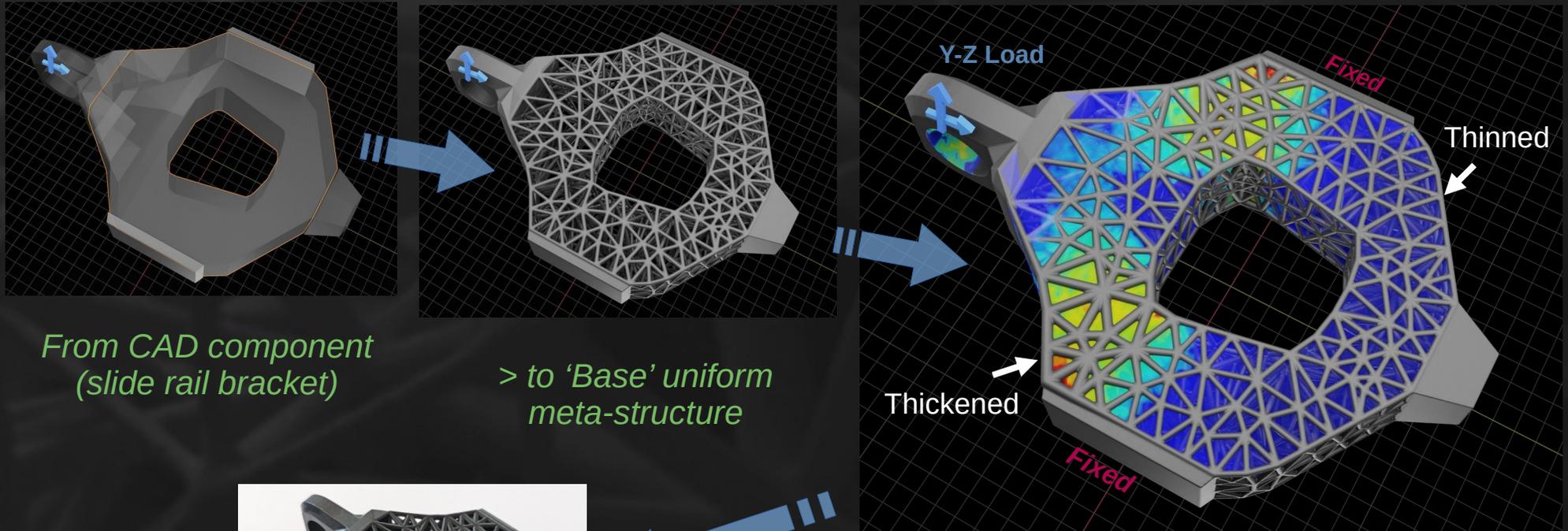
From CAD component (slide rail bracket)

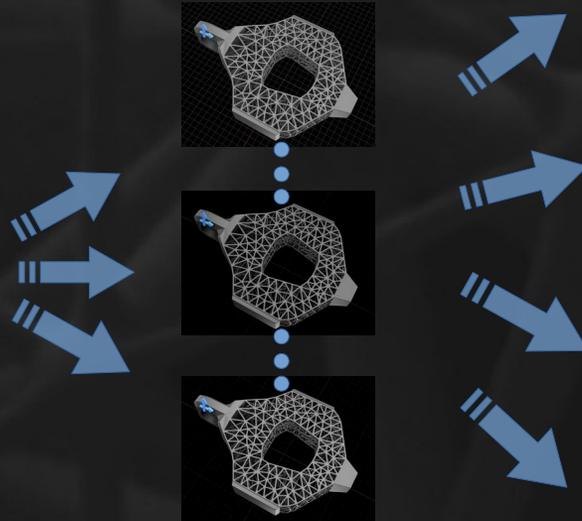_> to 'Base' uniform meta-structure_

Y-Z Load

Fixed

Thinned

Thickened

Fixed

Optimal Result
Field optimized Hgon

3D printed >60% weight reduction _and_ anti-vibration

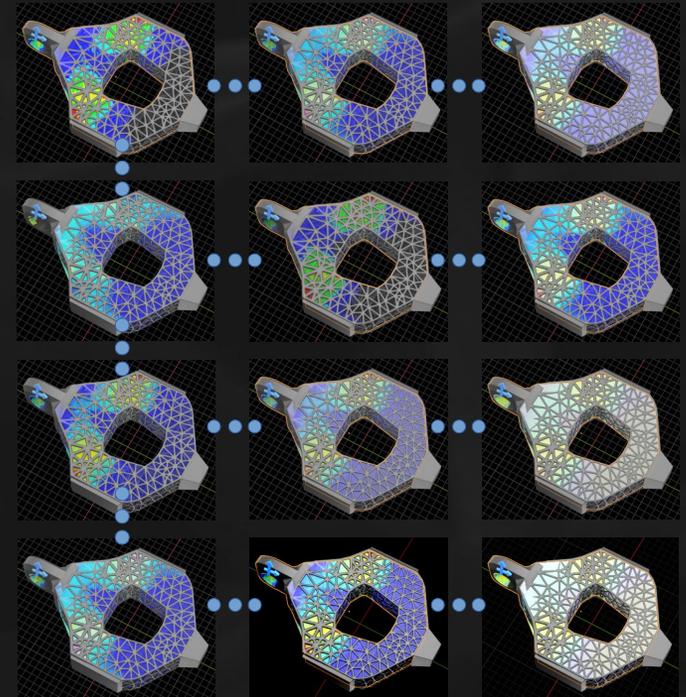Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Work in progress: New AI-training/solver
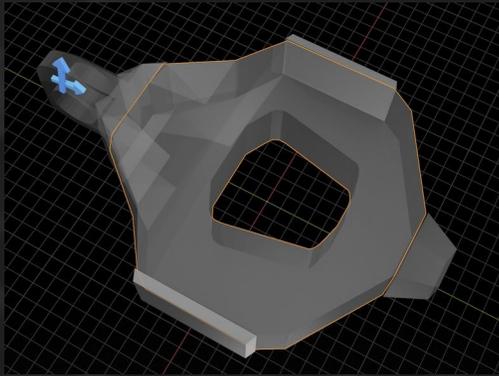
From the original base CAD
or STL shape...

We auto-generate density
variations for AI training

*EXPAND to full FE field parametric
training for 'smart' AI part-generation*

– We have already generated
  large training data sets
– New workflows and methods

← Watch our 10 min walk-through
video for details (goes to youtube)

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Marketing: Short and long term plans

I. <u>Software and IP LICENSING.</u> Industry standard tiered-licensing plans for companies that want to use our US utility patented Hgon IP for their own software ($TBD, est $10k/yr/seat enterprise, could be more.)

- CAD companies, 3D printer companies. AI-generation companies.
- The possibilities are endless… We have the patent.

II. Software/GUI+Hardware packages. For custom high-value installs needing large memory/GPU requirements. Alpha systems installed at Philips Respironics (4 seats), Additech Inc (1 seat). MKMachining (1 seat).

III. In-house *validated* hyper-components, custom testing/production. High value contracts/components for NASA/Govt and <u>high wealth individuals/companies.</u>

IV: <u>Ultimately</u>, longer term (3-4yrs) we anticipate offers for full acquisition and/or exclusive licensing of our current patents/IP and source code.
Estimated conservative value is $40M* based on recent acquisitions:
– e.g. Frustum $70M acquired 2018 by PTC, Simsolid in 2020 for ~$120M by Altair).

* Our IP value has been analyzed/estimated by Meunier Carlin & Curfman LLC.

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Revenue
Projection & Plan

To date:

ABĒMIS has invested over $200k cash and >$2M in person-hours.
- $25k Grant, GLIDE NEOhio

~$440k revenue overall since 2016.

- Base R&D and software is complete.

1st year plan

- Finalize Plug-ins and new AI tech
- Grants: NASA, NSF
- Marketing: high-value clients, name recog
- First Release & licensg.

Grant + Early Licensing
Est. revenue $400k

2-3 Years:

- NASA/SBIR Phase I, II* ($360k + potential 800k)
- Marketing continues
- Extensive licensing of full **AI hyper-generator Product ($5k+/seat)**

Estimate $2-4M rev.

3-5 Years:

- High-value work for NASA, RocketLab, etc
- CORE software licensing, major CAD companies
- Continue R&D on multi-domain/density AI*

Estimate **$30-40M** rev.
Likely exit?: acquisition in $40-50M range+

And further...

- High-revenue licensing can continue *ad-infinitum*
- Further R&D/patents
- Govt/Mil*, Aerospace, more.
(longer-term revenue: $**$B**)

* We are currently at TRL-6 gov/mil level. We have full (installed) working systems, Patent(s), Nature publication, and are now working full time on new GUI and **AI-training systems** (with NAVASTO GmbH).
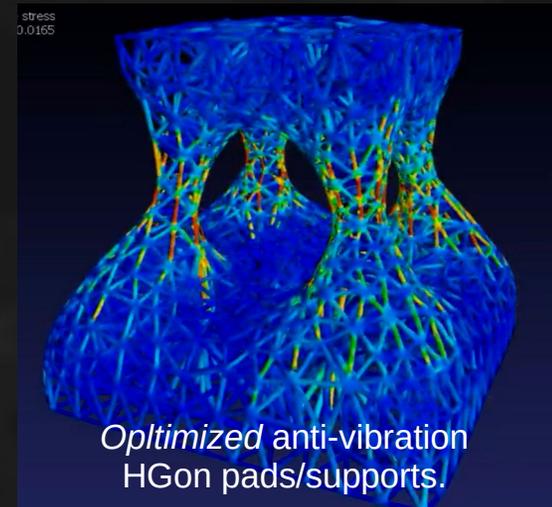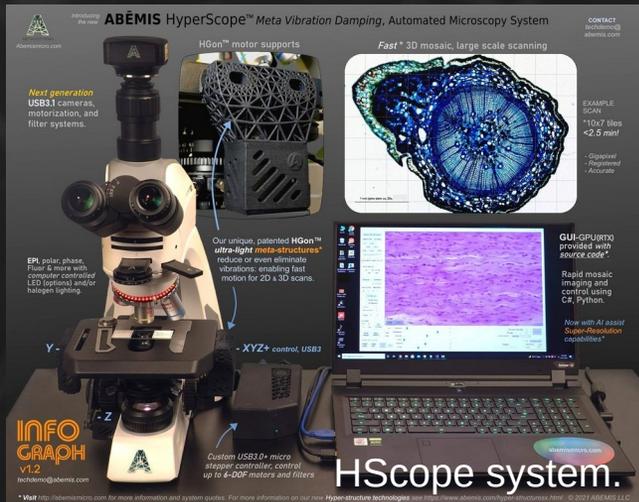
Our Competition: Analysis Table

Factor	ABĒMIS	nTop	Carbon-DE	PTC	AutoDesk
Funding/Invest so far	Seed, $155K	~$650M (of 5/25)	>$40M	$120M+	$165M
Lattice/Voronoi generation	✔	✔	✔	✔	✔
Isotropic tet-edge generation	✔	✘ <u>Only</u> Voronoi.	✘	✘	✘
CAD Integration	Plugins, SaaS (we can do all)	✔ Good GUI, but integration by file	✔ - **only** for their custom printer	✔ - available but limited to lattices	? Only surfaces, crude lattices
Isotropic tet-edge generation	✔	✘	✘	✘	✘
Field optimization	✔ Fast	✔ - **partial,** too slow	✘	X, Tested Simsolid. Results not accurate.	? Possibly, but prelim results not manifold.
Large AI-training data generation	✔	✘	✘	✘	✘

- We are currently far ahead of the competition in math/technical.
- **NTop** Inc. is by far the biggest competitor, with good CAD integration, but again are **limited** to periodic lattices **not usable** for AI training.

Our Hgons are designed and patented for AI and rapid FEA meta-optimization.

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Brief Business History

- ABĒMIS incorporated as an LLC S-corp in 2015, with revenue so far mostly from our anti-vibration Hgon/Hscope microscopy systems (as shown below, ~$400k overall).
- Systems installed at U.Illinois U-C, (q4,22-24), and Marquette U. (q1-20/22), both projects ongoing. Previous clients include Cleveland Clinic (a micro-testing system), Phillips Medical (CPAP masks). Currently working with MKMachining (impact applications), Boston Micro Fabrication (micro/nano-scale components), NAVASTO (AI-training, recently acquired by AutoDesk), and HummingbirdAM (aerospace components, see https://hummingbirdadditive.com).

HScope system.

Anti-vibration HGon motor mount.

Opltimized anti-vibration HGon pads/supports.

Hscope system: 3 recently installed (11-2022/23/24) for Univ. Illinois (Biology Dept), with HGon vibration damping.

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Management and Team

Todd C. Doehring, Ph.D., CEO

2015-current, ABĒMIS LLC Founder (80%)

2006-2015, Assistant and Adjunct Professor Drexel University, Bioengineering

- Research and teaching in Biomechanics, Robotics, VR
- Advanced software tools for 3D imaging and modeling/simulation
- Staff Researcher, CCF, Lerner Res. Inst.
- Research in Aortic valve and similar soft tissue structures (3D modeling, Polarized light imaging of 3D structures)
- Winner of Y.C. Fung Investigator Award 2002.
- 2001, Graduated Ph.D. University of Pittsburgh, Advisors Lars Gilbertson, Savio L-Y Woo

William J. Nelson II

2015-current, ABĒMIS LLC Co-founder (20%) and prev **CFO,** 2003-current.

Medical Laboratory Consulting 1993, Accutest Clinical Lab, Inc. – Company acquired by Laboratory Corporation of America (LabCorp Inc,)

Experienced Businessman with **years of success** *in transforming Medical and Related Industries.*

Matthias Bauer

Dr.-Ing. CEO, NAVASTO Gmbh
matthias.bauer@navasto.de

Advisor/Grant, AI-development

NOTE: Navasto was recently acquired by AutoDesk, 7/25.

Nathan Nicholas (Student, now graduated 2025)

2019-2021, University of Akron Bioengineering INTERN and Grad Student

- Graduated. Available for contract/consulting.

Expert in 3D modeling and design

Additional Support:

We have great R&D science advisors from BU, CWRU, Marquette and TAMU faculty, and students that have contributed. Funding will enable further student recruitment (Cleveland State U, CWRU).

Thomas Harris, Brownstone Orbital Technologies.

Alan Freed, Prof. TAMU Note: Recently retired Consult role (Math)
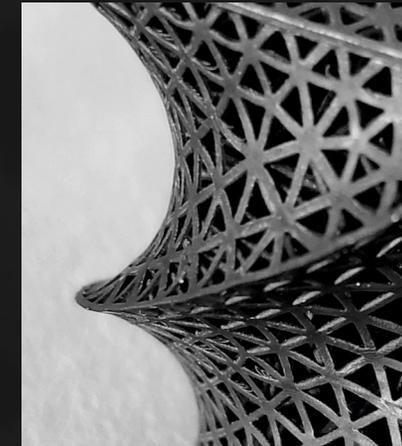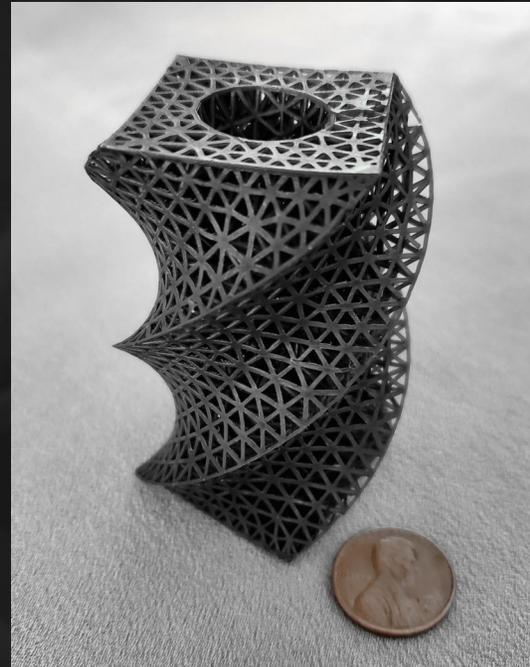

Lab team past students, Drexel and Upenn. We look forward to new students at CSU and CWRU.

Todd Doehring, Ph.D., CEO, tcd@abemis.com, 215-385-4568

Wrapping up!

ABĒMIS
Meta-structures and Systems

"Beyond Lattices..."

New Hgon generation products,
tools, and strong, high value IP.
We are ready to go.

Learn more: https://www.abemis.com/hyper-structuresx.html

Our NATURE publication: https://www.nature.com/articles/s41598-020-78239-9

US Utility Patent: https://patents.google.com/patent/US10585420B2/en

Examples and prototypes: https://www.abemis.com/galleries.html

Contact: Todd Doehring, Ph.D., tcd@abemis.com, txt or phone, 215-385-4568