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KNOWLEDGE ABOVE ALL

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ADDITIVE MANUFACTURING

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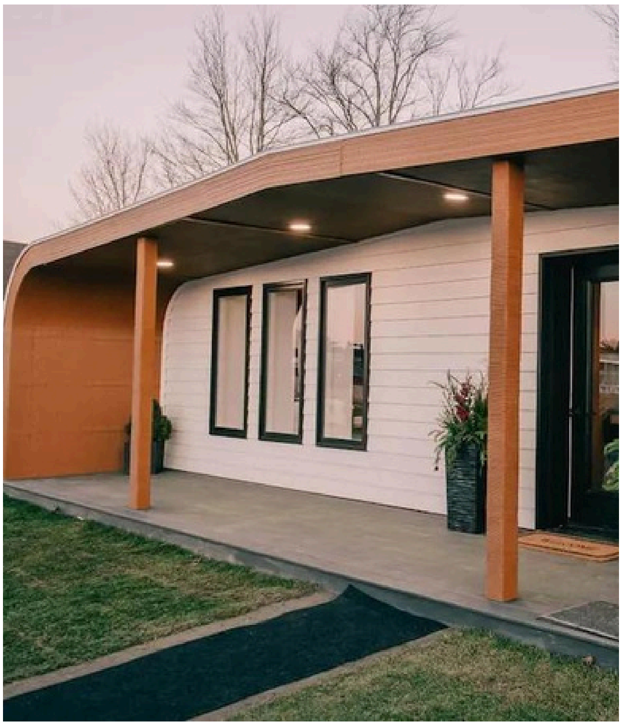
MAKERS OF THE WORLD'S LARGEST 3D PRINTER JUST BEAT THEIR OWN RECORD

After a five-year tenure as the world's largest 3D printer, the University of Maine's MasterPrint has been surpassed by a new model developed at the same institution. At a recent unveiling, designers from the Advanced Structures & Composite Center (ASCC) introduced the "Factory of the Future 1.0" (FoF 1.0), which is four times larger than its predecessor. Capable of printing structures measuring 96 by 32 by 18 feet, FoF 1.0 can utilize over 500 pounds of eco-friendly thermoplastic polymers each hour.

Given that global construction contributes around 37 percent of greenhouse gas emissions —primarily from traditional materials like aluminum, steel, and cement—shifting towards sustainable building methods is critical for addressing climate change. This has led to increasing interest in large-scale 3D printing innovations like FoF 1.0.

However, the arrival of the new printer doesn't render MasterPrint obsolete. In fact, the two machines are designed to operate in tandem, allowing for collaborative production of building components.



ASCC researchers aim to leverage these industrial-sized printers to help meet Maine's projected need for 80,000 new homes over the next six years. MasterPrint previously contributed to the stylish and sustainable 600-square-foot BioHome3D prototype. ASCC director Habib Dagher emphasized that the goal is not merely to create affordable housing, but to design homes that people aspire to live in. With FoF 1.0, these ambitions could scale to entire neighborhoods, potentially allowing for the construction of a modest single-story home in about 80 hours.

Funding for FoF 1.0 has come from various sources, including the Department of Defense and the Army Corps of Engineers, who are interested in using such technology for lightweight, quickly deployable structures. Moving forward, ASCC plans to explore additional bio-based polymer materials, particularly utilizing wood residuals from Maine, the nation's most forested state.

THIS 3D-PRINTED SOFT ROBOTIC HAND HAS ‘BONES,’ ‘LIGAMENTS,’ AND ‘TENDONS’

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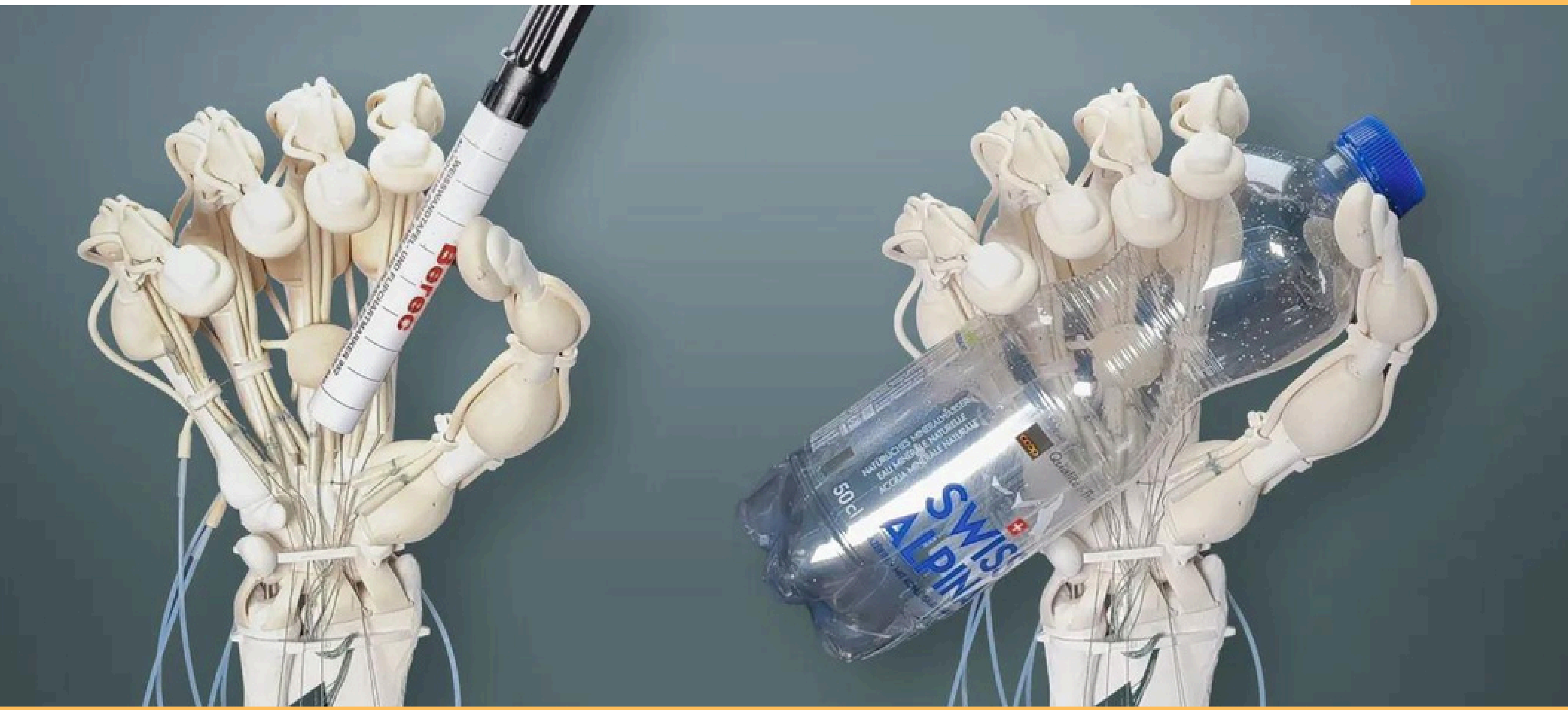
Describing soft robotic hands as "complex" barely scratches the surface. These designs incorporate various engineering considerations, such as material elasticity and durability, often requiring separate 3D-printing processes for each component with multiple types of plastics and polymers. Now, engineers from ETH Zurich and the MIT spin-off Inkbit have developed a method to create highly intricate products using a 3D printer equipped with a laser scanner and feedback learning. Their notable innovations include a six-legged gripper robot, an artificial heart pump, robust metamaterials, and a soft robotic hand complete with artificial tendons, ligaments, and bones.

To address this, the researchers explored integrating scanning technology with rapid printing to overcome the limitations of slow-curing materials. Their recent paper in Nature outlines a system that not only resolves this issue but also showcases the versatility of 3D-printed slow-curing polymers.

Instead of methodically scraping imperfections, 3D scanning provides real-time feedback on surface irregularities. This data is relayed to the printer’s adjustment system, allowing precise material application. Wojciech Matusik, an MIT electrical engineering and computer science professor, noted that this technology enables "real-time and pinpoint accuracy" in printing.

To showcase their method, the team created four diverse 3D-printed projects using soft-curing polymers: a resilient metamaterial cube, a heart-like fluid pump, a six-legged robot with a sensor-equipped gripper, and an articulating hand with sensor pads for grasping objects. While further refinements in production methods and material longevity are needed, this fast and adaptable printing approach could pave the way for innovative designs in industry, architecture, and robotics. Soft robots, for instance, pose less risk of injury to humans and are better suited for handling fragile items than conventional metal robots. The advances achieved so far have already led to designs previously thought impossible with 3D printing technology.



SHIPBUILDERS 3D-PRINTED A PART FOR A NUCLEAR SUBMARINE

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A crewed submarine fundamentally functions to maintain a bubble of air underwater while keeping the ocean out. This core purpose shapes every aspect of its design, from propulsion to sensors. Even seemingly minor components, like a deck drain assembly, are vital for the submarine's long-term viability. On September 25, General Dynamics Electric Boat and Huntington Ingalls Industries announced their successful use of additive manufacturing (3D printing) to create a deck-drain part for the Virginia-class submarine *Oklahoma*. Manufactured from copper-nickel, this part still requires some machining before installation, marking significant progress toward on-demand submarine repairs.

“This collaborative project utilizes Navy authorizations that simplify the requirements for low-risk additive manufacturing parts,” said Dave Bolcar, vice president of engineering at Newport News Shipyard. Additive manufacturing offers rapid prototyping and the ability to produce parts as needed, but ensuring these printed components meet operational standards remains a challenge.

Printing parts on land validates the technology and addresses immediate repair needs. On submarines, every component must fit precisely to maintain airtight and watertight integrity. Space is limited, making stockpiled spare parts finite. Onboard printers could facilitate repairs during missions, while port-based printers would ensure readiness for docked vessels.

For over a decade, the Navy has explored 3D printing to streamline logistics. By storing raw materials rather than pre-assembled parts, the Navy enhances flexibility and reduces supply chain burdens across global bases. Testing large 3D printers on land and aboard vessels, such as the USS *Essex*, aims to evaluate the effects of marine conditions on manufacturing outcomes. The successful production of essential parts demonstrates that submarines can leverage this technology, even if they cannot print components while submerged.

INSIDE THE LAB THAT'S 3D-PRINTING SLEEK CAR CONCEPTS FOR MCLAREN, ROLLS-ROYCE, AND MORE

PRATIK RAUT
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- When major automotive manufacturers need to transform their designers' digital concepts into tangible prototypes, they turn to Vital Auto, a British fabrication expert. Vital collaborates with prestigious brands such as Rolls-Royce, McLaren, Jaguar, and Nissan to create concept cars. The company employs two primary techniques: subtractive manufacturing and 3D printing.
- Subtractive manufacturing utilizes Computer Numerical Control (CNC) machines that carve out parts from solid aluminum blocks based on digital models. In contrast, 3D printing, or additive manufacturing, builds components layer by layer, which can be more efficient as it minimizes waste and allows for complex shapes that traditional methods cannot achieve.

- Shay Moradi, Vital's VP of innovation, explains that clients seek to push technological limits without investing time in experimentation. Vital provides the necessary tools to create exact components efficiently. While 3D printing often garners excitement akin to science fiction, Vital integrates both manufacturing methods to complement one another. Design engineer Anthony Barnicott emphasizes that additive manufacturing doesn't aim to replace subtractive methods; instead, they support each other. This synergy enables them to produce concept models more cost-effectively.

- Since its inception in 2015 with the EP9 concept car for NIO, Vital has incorporated various 3D printers, enhancing their production speed and design versatility. Barnicott praises Formlabs printers for their smooth finishes and material flexibility, crucial for rapid prototyping. This allows for quicker iterations, with some parts ready in under 24 hours, compared to the days required for CNC machining.
- Despite the availability of digital design tools, Moradi insists on the importance of physical prototypes, stating that nothing compares to the tactile experience of handling a well-crafted object. He notes that 3D printing has evolved into an essential element of their production process, highlighting its significance in modern manufacturing.

A 3D-PRINTED TITANIUM 'METAMATERIAL' DESIGN SOLVED A LONGTIME ENGINEERING ISSUE

VINIT RAUT
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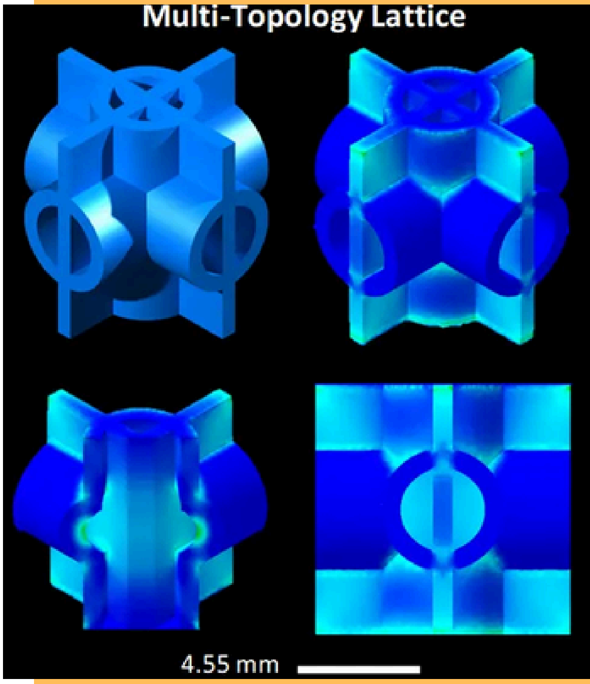
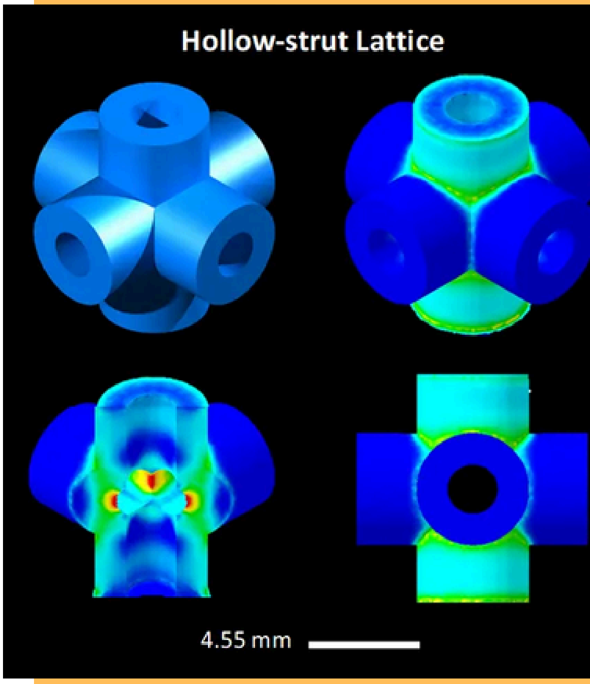


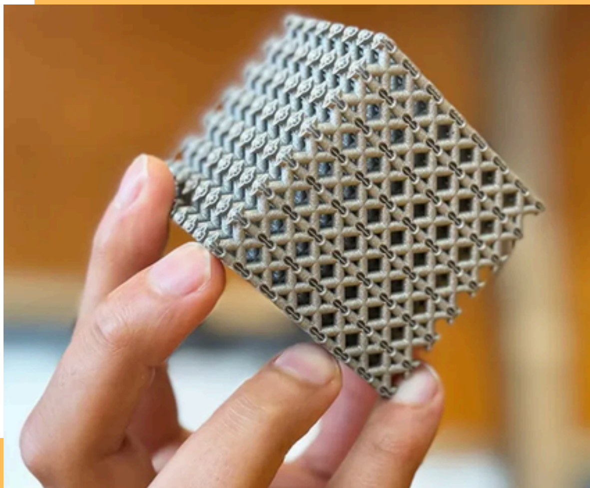
Metal alloy cellular structures hold great potential for enhancing everything from bone implants to rocket components, but they often crack under pressure. Researchers have struggled for years with uneven weight distribution in these artificial "metamaterials." However, a recent study from RMIT University in Australia indicates a breakthrough inspired by plants and coral, combined with innovative 3D printing technology.

Using a titanium alloy, engineers created lattice-like structures featuring hollow struts, each reinforced with a thin band throughout. Ma Qian, an RMIT Distinguished Professor and co-author of the study, explained that by integrating two complementary lattice structures, the team effectively distributes stress and eliminates weak points where it typically concentrates.



The researchers employed an advanced manufacturing method called laser powder bed fusion, where a powerful laser melts titanium granules into place layer by layer. Stress tests on a cube made from this new lattice showed it could bear 50% more weight than a similarly dense magnesium alloy, WE54, commonly used in aerospace.

Currently, this resilient metamaterial can withstand temperatures up to 350 degrees Celsius (662 Fahrenheit), but using more heat-resistant titanium alloys could increase this limit to 600 degrees Celsius (1,112 Fahrenheit). Such advancements could expand applications to rocket manufacturing and firefighting drones. Additionally, these lattice structures may benefit bone implants, as their hollowness could promote bone cell regrowth.



However, widespread adoption of the titanium metamaterial may take time. As lead author and PhD candidate Jordan Noronha noted, "Not everyone has a laser powder bed fusion machine." Yet, advancements in technology and greater accessibility to equipment are expected to facilitate the broader use of this innovative design.

THE FIRST 3D PRINTED ROCKET LAUNCH WAS BOTH A FAILURE AND A SUCCESS

DR NIYATI RAUT
HOD

Relativity Space faced another setback with its Terran rocket after two previous scrubbed attempts. The 110-foot rocket, primarily made of 3D-printed materials, successfully lifted off from Cape Canaveral Space Force Station on Wednesday night but ultimately failed to reach its target orbit of 125 miles. The second stage ignited briefly before shutting down and crashing into the Atlantic Ocean. Despite this, there are positive takeaways for the startup, which hopes to compete with established players like SpaceX and Blue Origin.

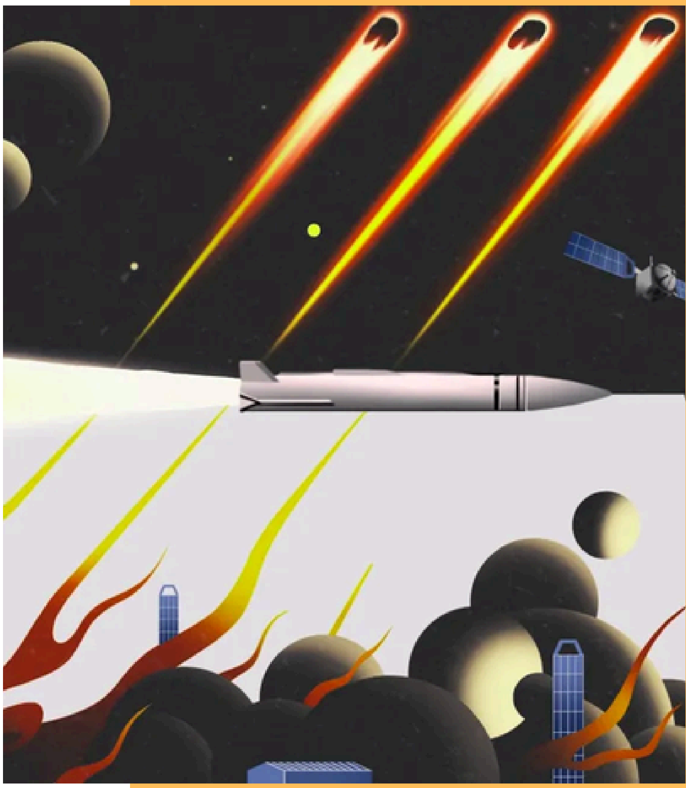
The Terran rocket, composed of 85% 3D-printed metal, represents a significant step for Relativity. Earlier this month, a launch attempt was aborted just seconds before takeoff due to a malfunction in the first-stage rockets. Founded in 2015, Relativity aims to develop fully 3D-printed, reusable rockets for various missions, including plans for the first commercial trip to Mars. Their vehicles are produced in Long Beach, California, utilizing massive 3D printers, AI, and autonomous robotics, resulting in a production process that requires 100 times fewer parts and can be completed in under 60 days.

The commitment to 3D printing extends to their Aeon rocket engines, which feature simplified components in their igniters, turbopumps, combustion chambers, and other systems. Each engine uses liquid oxygen and liquid natural gas as propellants.

While achieving orbit on the first flight is rare, Terran successfully passed critical milestones, including the Max Q threshold, engine cutoff, and stage separation. Relativity's launch commentator, Arwa Tizani Kelly, highlighted the excitement of maiden launches, though it's unclear how this latest attempt will impact future timelines, including the planned 2024 test of their larger Terran R spacecraft.

THESE 3D PRINTED ENGINES CAN POWER SPACE-BOUND ROCKETS—OR HYPERSONIC WEAPONS

UTKARSH TIWARI
STUDENT



On the Colorado Plains, near Berthoud, lies Ursa Major, a space company conducting rocket engine test-fires from a bunker just north of Denver. Founded in 2015 by Joe Laurienti, who has a background in propulsion, Ursa Major focuses on 3D-printed engines designed for both satellite launches and hypersonic vehicles, which have military applications. The company's approach reflects the dual-use nature of rocket technology—valuable for both defense and exploration.

Laurienti's passion for propulsion was ignited during his childhood visits to his father's satellite launches at Ball Aerospace. After working with SpaceX and Blue Origin, he recognized a market gap for specialized rocket engines, leading him to establish Ursa Major. The company aims to simplify the launch process by addressing propulsion-related complexities, which account for over half of launch failures.

Ursa Major's engines, particularly the Hadley model, are designed for versatility, capable of powering both rockets and hypersonic vehicles. Hypersonic technology, crucial for military applications, can reach speeds exceeding five times the speed of sound. The military has shown interest in Ursa Major's engines, funding several programs for their hypersonic research.

While traditional space companies have been slow to fully embrace 3D printing, Ursa Major has integrated this technology, with 80% of their engines being 3D-printed as single units. This innovative approach allows for more efficient designs that take advantage of additive manufacturing's capabilities.

Ursa Major is also developing the Arroway engine, aimed at reducing reliance on Russian rocket engines. Testing occurs frequently, with visitors witnessing powerful static firings that emphasize the excitement and potential of modern rocket technology. The company's work exemplifies the historical connection between space exploration and military applications, emphasizing the ongoing relevance of propulsion technology in both fields.