LASS' LAW IS KNOCKING AT THE DOOR

Our economy has grown and has been transformed by 60 years of Moore's Law, bringing electronics in any path of life. Moore's Law has now reached its endpoint (although progress in computation capabilities are still continuing, not at the previous pace and, most importantly, not with the cost decrease we have experienced in the last decades) but a new Law is knocking at the door of our economy and our society, promising to be as disruptive as Moore's Lass's Law.

Sherry Lassiter, known as Lass, is the head of the Fab Foundation. A fab, a Fab Lab, is a room full of computers managing tools that can manufacture objects, including 3D printers and laser cutters. The first Fab Lab was created back in 2003 at MIT Center's for Bits and Atoms by Neil Gershenfeld and in 2009 he set up the Fab Foundation. There Lass noticed that the number of tools for manufacturing doubled every year and by 2016 there were over 1,000 Fab Labs around the world.

If Lass' Law will remain valid in the next ten years by 2030 there will be over 10 million fab labs, and clearly they will no longer be confined within research labs: there are simply not enough research labs around the world to host them. By that time fabs will have percolated in small industries, retail stores and some will have found a place in consumers' homes. Give it 10 more years and 150 millions homes will have a fab lab as part of their furniture.

At the same time the whole value chain of manufacturing will be transformed bringing Industry 4.0 into Industry 5.0. Consumers will no longer buy products but products specs and them will manufacture them at home. Of course one can imagine that a new slate of businesses will be there, providing support to customisation. Possibly some of these business will sell "intelligence" to make customisation decision possible at home.

The convergence of Artificial Intelligence with massively distributed / on site manufacturing is going to change the economy, the value chains and the players in manufacturing.

In twenty years time it will be difficult to find a product that is not a melange of atoms and bits. Many products will be aware of their "use" and will be able to re-configure themselves to the point of creating their own offsprings (thanks to the availability of fab labs). The mixing of AI with fab labs and the self-generation of offsprings will result in products evolution with an increasing symbiotic leverage of what is in the product's ambient.

Welcome to Industry 5.0, an Industry having people as player and product component!
Teaching Power Tools to Run Themselves

By Harvey E. Howe

Too big yet for home shop, this MIT milling machine is run by computer-control at left.
Machines that Make

The Machine that Make project at the MIT Center for Bits and Atoms is developing rapid-prototyping of rapid-prototyping machines that can be used in lab labs.

Squidworks
Platonic Gantry Design
The Displacement Exercise
Roller Coaster Tycoon
ATK - AutomataKit
Platonic Gantry Design
Acrylic and 3D Printed Parametric Cages.
DEX: an open source, intelligent materials testing machine.
Parametric Linear Axis: 2D sheets for 3D CNC
Networked Hardware Elements for Accessible Automation

Mother Mother
Claystacking at Haystack
Madison Park Vocational Machine
MTM class
Modular Machines and Mods
Desktop Wire-EDM
A Generalist, a Mechanical Broadside. The Year of UPS.
Mud Machine Live
Mud Machine Live
Modular Machines controlled with Modular Software
A Wire-EDM that fits on your desktop

Modular Robot
Tube carver
[m]MTM: modular machines that make
Reconfigurable Stages
foldatab
DIY EDM
Reconfigurable modular robot with Interchangeable end-effectors
Milling machine for round stock
More modular machines out of prototyping materials for prototyping
Reconfigurable one-axis stages for multi-purpose motion
A disposable medium format CNC router
An entry-level EDM machine for making carbide/HD bolting and/or road screws

5 Axis Timing Belt MTM
POP Fab
Multi-processes lathe
Virtual Machine Network
Timing Belt MTM
Fab-In-A-Box
Low cost 5 axis machining
A suitcase milling machine, 3d printer, and vinyl cutter
The additive lathe is a 3D printer that prints on rotation objects
Modular control for the MTM project
A design without lead screws, reducing cost
Fundamental Design (FUN Design)

Dr. Jan Vandenbrande

The goal of the Fundamental Design (FUN Design) program is to determine whether we can develop or discover a new set of building blocks to describe conceptual designs. The design building blocks will capture the components' underlying physics allowing a family of nonintuitive solutions to be generated. Successful outcomes of this program will give the designer the ability to evolve and adapt designs rapidly in response to changing requirements and provide a thorough understanding of trade-offs early in the design process.

Dr. Jan Vandenbrande
Defense Sciences Office (DSO)
Program Manager

Dr. Jan Vandenbrande joined DARPA as a program manager in July 2015. He is interested in developing math and computational tools to radically improve the design of mechanical products. Topics of specific interest to Dr. Vandenbrande include: exploiting new design possibilities enabled by new materials and fabrication processes (3-D printing, composite fibers, micro truss structures) and enhancing design discovery.

Before joining DARPA, Dr. Vandenbrande was a technical fellow and senior manager of the Applied Math Geometry and Optimization group at Boeing. He leveraged his knowledge in geometric reasoning, production automation and design processes to create several advanced geometry processing systems to change how products are designed and made. Boeing uses these tools to conduct design trade and optimization studies, to enable proprietary composite layup fabrication processes, and to visualize metal machinability issues.

Dr. Vandenbrande authored several parametric air and spacecraft models for design trade studies such as the hypersonic X-43C and the Orbital Space Plane study.

At Unigraphics, now Siemens NX, Dr. Vandenbrande worked on the architecture of the next-generation Computer Aided Manufacturing (CAM) system, improving tool path generation performance and revamping the CAM user interface. He received his Ph.D. in Electrical Engineering from the University of Rochester for his work on machinable feature recognition.
Development cell by cell
With a trio of techniques, scientists are tracking embryo development in dazzling detail

By Elizabeth Perkins | 20 December 2018

From at least the time of Hippocrates, biologists have been transfixed by the mystery of how a single cell develops into an adult animal with multiple organs and billions of cells. The ancient Greek physician hypothesized that moisture from a mother’s breath helps shape a growing infant, but now we know it is DNA that ultimately orchestrates the processes by which cells multiply and specialize. Now, just as a music score indicates when strings, brass, percussion, and woodwinds chime in to create a symphony, a combination of technologies is revealing when genes in individual cells switch on, cueing the cells to play their specialized parts. The result is the ability to track development of organs and organs in stunning detail, cell by cell and through time. Science is recognizing that combination of technologies, and its potential for spurring advances in basic research and medicine, as the 2018 Breakthrough of the Year.

Single-cell mapping of gene expression landscapes and lineage in the zebrafish embryo

Daniel E. Wagner, Caleb Weisbrob, Zach M. Collins, James A. Briggs, Sean G. Megason,* Allen M. Klein*

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High-throughput mapping of cellular differentiation hierarchies from single-cell data promises to empower systemic interrogations of vertebrate development and disease. Here, we applied single-cell RNA sequencing to >52,000 cells from zebrafish embryos during the first day of development. Using a graph-based approach, we mapped a cell state landscape that describes axis patterning, germ layer formation, and organogenesis. We tested how clonally related cells traverse this landscape by developing a transposon-based barcoding approach (“TracerSeq”) for reconstructing single-cell lineage histories. Clonally related cells were often restricted by the state landscape, including a case in which two independent lineages converge on similar fates. Cell fate remained restricted to this landscape in chordi deficient embryos. We provide web-based resources for further analysis of the single-cell data.

First release: 26 April 2018
www.sciencemag.org
DIM3: Discrete Inverse Methods for Multiphysics Modeling

Partial Differential Equations

“Macromolecular Dynamics”

Atomic Physics

Solid Mechanics

Fracture

Rheology

Experiment (metamaterial)

CMods (particles)

NASTRAN (FEA)
Reversibly Assembled Cellular Composite Materials

Kenneth C. Cheung* and Neil Gershenfeld
Center for Bits and Atoms, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.

*Corresponding author. E-mail: kcheung@mit.edu

We introduce composite materials made by reversibly assembling a three-dimensional lattice of mass-produced carbon fiber reinforced polymer composite parts with integrated mechanical interlocking connections. The resulting cellular composite materials can respond as an elastic solid with an extremely large measured modulus for an ultralight material (12.3 megapascals at a density of 7.2 mg per cubic centimeter). These materials offer a hierarchical decomposition in modeling, with bulk properties that can be predicted from component measurements, and deformation modes that can be determined by the placement of part types. Because site locations are locally constrained, structures can be produced in a relative assembly process that merges desirable features of fiber composites, cellular materials, and additive manufacturing.

Carbon fiber reinforced composite materials can improve efficiency in engineered systems (for example, airplanes) by reducing structural weight for given strength and stiffness requirements (1), but challenges with manufacturing and certification have slowed their adoption. High-energy systems such as large nuclear fusion facilities require robustly scaled components to ensure design credibility, and pressure vessel components need to resist high pressures and temperatures. Here, we explore a way of rapidly assembling a scalable material system that can be configured with 3D printing on an entire plane in one gigantic piece.

The dependence of this scaling performance on geometry is seen in non-stochastic lattice-based materials that have nearly ideal \( E' \) scaling, with high coordination numbers (most connected) relative to stochastic foams (5, 6). These structures have been implemented thus far only in relatively dense engineered materials. For the ultralight regime below ten milligrams per cubic centimeter (7), the \( E' \) scaling seen in dense stochastic cellular materials has recently been reported for electroplated tubular nickel micro-lattices (17), as well as carbon-based open-cell stochastic foams, including carbon nanotube aerogel (16), and graphene cork (18). Reversibly assembled cellular composite extends mesh-dominated lattice-based materials to the ultralight regime, with three-dimensional symmetry derived from the linked geometry. The high performance characteristics of these new materials depend on the framework rigidity of the non-stochastic lattice geometry with high coordination number, the slenderness that can be achieved in buckling-limited fiber composite strut members, and the scaling of the density cost of reversible mechanical connections.
Discretely assembled mechanical metamaterials

Benjamin Jenett, Christopher Cameron, Filippo Tortomolussi, Alfonso Parra Rubio, Megan Ochalek, Neil Gershenson

Mechanical metamaterials offer exotic properties based on local control of cell geometry and their global configuration into structures and mechanisms. Historically, these have been made as continuous, monolithic structures with additive manufacturing, which affords high resolution and throughput, but is inherently limited by process and machine constraints. To address this issue, we present a construction system for mechanical metamaterials based on discrete assembly of a finite set of cells, which can be composed to form a range of properties such as rigidity, chirality, thickness, and acoustic behavior. This system achieves desired continuum properties through discrete parts, with fabrication and assembly governed by local mechanomaterials. We describe the fundamental concepts of mechanical metamaterials and the mechanical design, fabrication, production process, numerical modeling, and experimental characterization of metamaterial behaviors. This approach benefits from incremental assembly, which eliminates scale limitations, batch/precise manufacturing for reliable, low-cost part production, and interconvertibility through a consistent assembly process across part types.

INTRODUCTION

The notion of topologically designing a material from the microscale to the macroscale has been a long-standing goal with broad engineering applications. By controlling local cell properties and their global spatial distribution and arrangement, metamaterials with exotic behavior can be achieved. The foundation for mechanical metamaterials comes from the study of cellular solids, where natural materials, such as wood and bone, or synthetic materials, such as stochastic foams, are understood as a network of closed or open cells (1). In the latter case, edges form a network of beams, and on its basis the connectivity of these beams and their bearing material, macroscopic behaviors can be predicted analytically (2). It was from this insight that the field of architected materials formed, enabling design of periodic structures with enhanced properties such as improved stiffness over foams at similar density due to higher degrees of connectivity (2). Advances in digital fabrication, specifically additive manufacturing, have enabled these complex designs to be realized. Seminal work demonstrated strut, ultra-light lattice materials (6), and has since been improved, resulting in mechanical metamaterials with superior stiffness and strength at ultralight densities (7) with multi-scale lattices (8). Benefits of monocoque forms further expand the exotic property space (9), and architectures featuring cellular sub-plates have shown potential for approaching the theoretical limit for elastic material performance (10). Other designs seek to use compliance, which can be attained through intrinsic geometric compliance or through 'hole-making' strategies capable of large strain (12). Lattice architectures can be designed to transmit or respond to local load conditions, allowing metamaterials to exhibit zero or negative Poisson’s ratio (13). Biomechanical neurectures produce contraction perpendicular to compressive loading, and expansion perpendicular to tensile loading, counter to traditional continuous material behavior (14). Cellular metamaterials exhibit high bandgap onset and high strength due to the grain geometry. These materials produce out-of-plane deformations, such as twist, in response to in-plane loading (15).

Nearly all of the abovementioned mechanical metamaterials are made with some form of additive manufacturing, most of which are summarized in (16). These processes vary widely in terms of cost, precision, throughput, and material compatibility. The lower end of the cost spectrum, such as 3D printed composites (17) and error resulting from build angle for complex three-dimensional (3-D) geometry (18), higher performance, and higher cost processes such as selective laser melting (SLM) and selective laser sintering (SLS) materials such as titanium steel but require extensive setup for particular continuum and can suffer from laser based anisotropy, thermal warping, and geometry inaccuracy (19). Some of the highest performance multi-scale metal microlattice production techniques based on isogrids and projection processes are well studied and reproducible but are highly specialized and labor, time, and cost intensive. Polymer-based fabrication, specifically additive manufacturing, can require up to 4 hours to start up and finish for sample production (16). Large area projection microstereolithography (13,21) is capable of producing lattices with microscale to nanometer scale (1 nm) features on centimeter-scale (10 mm) parts with significantly improved throughput, but extension to macro-scale (1 mm) structures remains out of reach, due to practical limitations in scaling these processes and associated costs per process. The largest structure that can be printed with any given process is typically limited by the build volume of the machine. Therefore, substantial data of the manufacturer is focused on scaling up building volume. Metallc-scale FDM platforms (20) and larger cements deposition machines (22) have been demonstrated, but are limited in scale due to the cost scale of production costs. In contrast, the 100 mm scale of traditional cement-based materials is significantly lower, and this translates to easier and more feasible fabrication at the wafer level.

There are three routes to producing effective, scale, and cost. Commercially available two photon polymerization machines have resolution on the order of 1 μm (23), build size on the order of 100 mm (24), and cost on the order of $500 per machine (22). Macrometric scale FDM machines boost build sizes of 60 cm (25) but are unlikely to have better than 100 μm (26) resolution. Overall, the same dynamic range (scale per resolution) is offered, but with costs approaching $100 per machine, we see a possible superior digital-based scale of achievable dynamic range. Building large, precise machines is expensive, and due to the inherent coupling of machine performance, size, and cost, there are significant challenges to the continuum approximation of the size scale, value for (10 - 0) determined number(19, 5, 73) and 40%, respectively. Discrepancy between experimental and numerical results is also calculated for specimens (10 a to b to c) by ELS, E, A, and 5%, respectively. This can be attributed to the ratio of internal to external beams increasing as wall count increases (fig 1). The internal beams, which are highly constrained and behave as an rigid network, asymptotically govern the effective global behavior. These predicted effective lattice properties over the range of effective are plotted and relevant to constituent values in fig. 2. The slope of the curve containing these points, plotted on a log-log chart, provides the power scaling curve, which is used to analytically predict lattice behaviors at the macroscale (3). Effective lattice modulus and density are related to constituent material properties and density of the size range (27) to be constant across the critical stiffness range of 0.7 ± 0.02 (the empirical Mises criterion calculation), thus we use Euler buckling formula. Because the air-dried material properties vary, we determine the critical load to range from 70 to 1.8 mm, with the mean value of 89 N very closely approximating the experimental value. Thus, there is good correlation between both stiffness and strength based on the design of our discrete lattice material.
Plane wings are traditionally strong, thick and sturdy but a team of researchers led by NASA has created a flexible wing that morphs as it flies.

Measuring 14 feet or four meters wide, the new wing is constructed from thousands of units that fit together and function in a similar way to a bird's wing, says one of the report's authors, NASA research engineer, Nick Cramer.

"Something like a condor will lock its joints in while it's cruising, and then it (adjusts) its wing to a more optimal shape for its cruising, and then when it wants to do a more aggressive maneuver it'll unlock its shoulder. That's a similar response to what we're doing here," he said in a phone interview.

New plane wing moves like a bird's and could radically change aircraft design

Updated 3rd April 2019

Credit: Eli Ganeshkoli, NASA Ames Research Center

The wing's assembly is seen under construction, assembled from hundreds of identical subunits. Credit: Courtesy of NASA
Material-Robot System for Assembly of Discrete Cellular Structures
Benjamin Jenett¹, Amira Abdel-Rahman², Kenneth Cheung³, and Neil Gershenfeld⁴

Abstract—We present a material-robot system consisting of mobile robots which can assemble discrete cellular structures. We detail the manufacturing of cuboctahedral unit cells, termed voxels, which passively connect to neighboring voxels with magnets. We then describe “relative robots” which can locomote on, transport, and place voxels. These robots are designed relatively to and in coordination with the voxel structure—its geometry of the voxel informs the robot’s global geometric configuration, local mechanisms, and end effectors, and robotic assembly ability features are designed into the voxels. We describe control strategies for determining build sequence, robot path planning, discrete motion control, and feedback, integrated within a custom software environment for simulating and executing single or multi-robot construction. We use this material-robot system to fabricate several types of structures, such as 1D beams, 2D plates, and 3D enclosures. The robots can navigate and assemble structures with minimal feedback, relying on voxel-sized station to achieve successful global positioning. We show multi-robot assembly to increase throughput and expand system capability using a deterministic centralized control strategy.

Index Terms—Assembly; Space Robotics and Automation; Path Planning for Multiple Mobile Robots or Agents

I. INTRODUCTION

AUTOMATED processes for material deposition and manipulation are becoming more prevalent in state-of-the-art production of structural systems. Additive manufacturing can produce hierarchical, architectured metamaterials with novel properties unattainable with traditional engineering materials [1]. High performance, continuous fiber composite aircraft components can be made by automated tape lapping, utilizing large gantleys, tooling, and autoclaves [2]. In these examples, high repeatability is achieved with computational control systems and stationary machines with stiff motion axes. However, the scale of the built object is limited to a fixed bounding envelope.

The new work appears in the October issue of the IEEE Robotics and Automation Letters, in a paper by Jenett, Gershenfeld, fellow student Amira Abdel-Rahman, and CBA alumni at R. D. Schmaltz. This work is sponsored by NASA’s 3D Manufacturing Development Program through the Armadas project, which is led by Benjamin Jenett, and the Armadas project is sponsored by NASA’s Ames Research Center. The project is being conducted in cooperation with the Center for Bits and Atoms, Massachusetts Institute of Technology, Cambridge, MA 02139 USA. The authors thank NASA for her support.

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In this paper, we are motivated by the automated production of large scale, lightweight, high performance structures, with applications in aviation and aerospace. Aircraft manufacturing relies on expensive and precise tooling to produce designs which stray little from the "tube and wing" motif, primarily due to the reliance on legacy as a basis for cost, safety, and performance risk reduction [3]. Non-standard geometries are economic non-starters, even with performance gains [4], due to the cost-sensitive and risk-averse nature of the aviation industry. The ability to produce arbitrary aerostatic geometries at low-cost can potentially disrupt this trend [5].
Tiny motor can “walk” to carry out tasks
Mobile motor could pave the way for robots to assemble complex structures — including other robots.

David L. Chandler | MIT News Office
July 2, 2019

Years ago, MIT Professor Neil Gershenfeld had an audacious thought. Struck by the fact that all the world’s living things are built out of combinations of just 20 amino acids, he wondered: Might it be possible to create a kit of just 20 fundamental parts that could be used to assemble all of the different technological products in the world?

Gershenfeld and his students have been making steady progress in that direction ever since. Their latest achievement, presented this week at an international robotics conference, consists of a set of five tiny fundamental parts that can be assembled into a wide variety of functional devices, including a tiny “walking” motor that can move back and forth across a surface or turn the gears of a machine.
What are you trying to do?
- Direct-write assembly of integrated three-dimensional electronics

How is it done today ...
- Separate development of chips, boards, blades, and systems
- ... and what are the limits of current practice?
  - Diverging development cost and time, global supply chain dependency

What's new in your approach ...
- Cross between pick-and-place and 3D printing, with spatial programming
- ... and why do you think it will be successful?
  - Demonstration of all of the enabling technologies in seed program

Who cares? If you're successful, what difference will it make?
- $O(10^5)$ reduction in HPC power consumption
- Secure and trusted systems from untrusted components
- AI software adapting its hardware (and vice versa)
- Novel integrated electronic system form factors
- Field reconfigurability and reusability

What are the risks ...
- Interconnect overhead (vs surface/volume), assembly throughput (vs recursion)

... and the payoffs?
- Alternative to existing fab vulnerabilities
First Draft of a Report on the EDVAC
by John von Neumann
Contract No. W-470-ORD-4926
Between the United States Army Ordnance Department and the University of Pennsylvania Moore School of Electrical Engineering University of Pennsylvania June 30, 1945

Theory of Self-Reproducing Automata
JOHN VON NEUMANN edited and completed by Arthur W. Burks University of Illinois Press URBANA AND LONDON 1966

The chemical basis of morphogenesis
by A. M. Turing, F.R.S. University of Manchester
(Received 9 November 1945—Revised 15 March 1948)

It is suggested that a system of chemical substances, called morphogens, mixing together and diffusing through a tissue, is adequate to account for the main phenomena of morphogenesis. Such a system, although it may originally be quite homogeneous, may later develop a pattern or structure due to an instability of the homogeneous equilibrium, which is triggered off by random disturbances. Such reaction-diffusion systems are considered in some detail in the case of an isolated ring of cells, a mathematically convenient, though biologically unrealistic, system. The investigation is chiefly concerned with the onset of instability. It is found that there are two essentially different forms which this may take. In the most interesting form stationary waves appear on the ring. It is suggested that this might account, for instance, for the bilateral patterns on Hydra and for whirled larvae. A system of reactions and diffusion on a sphere is also considered. Such a system appears to account for gastrulation. Another reaction system in two dimensions gives rise to pattern resistant to any amount of diffusion. It is also suggested that stationary waves in two dimensions could account for the phenomena of phyllotaxis.

The purpose of this paper is to discuss a possible mechanism by which the genes of a species may determine the anatomical structure of the resulting organism. The theory does not make any new hypotheses; it merely suggests that certain well-known physical laws are sufficient to account for many of the facts. The full understanding of the paper requires a good knowledge of mathematics, some biology, and some elementary chemistry. Since readers cannot be expected to be experts in all of these subjects, a number of elementary facts are explained, which can be found in textbooks, but whose omission would make the paper difficult reading.

Figure 2. An example of a "duplicated" pattern resulting from a type (c) morphogen system. A number of units is shown. See text, §11.
Lectures

- Principles and practices: project management (Jan 27)
  - Recitation: Massimo Banzi, Arduino co-founder (Feb 1)
- Computer-aided design (Feb 3)
  - Recitation: Pramodha de Filippi, Berkman Center at Harvard (Feb 8)
- Computer-controlled cutting (Feb 10)
  - Recitation: Bruce Ray, Massive Change (Feb 15)
- Electronics production (Feb 17)
  - Recitation: Eric Pan, Seed Studio (Feb 22)
- 3D scanning and printing (Feb 24)
  - Recitation: Viney Gosda (Feb 29)
- Electronics design (Mar 2)
  - Recitation: Kenney Cheung, How to make almost anything in Space (Mar 7)
- Computer-controlled machining (Mar 9)
  - Recitation: Silvio Lindtner, Hackaday Matter Group (Mar 14)
- Embedded programming (Mar 16)
  - Recitation: Nadeva Peak, Machines That Make Machines (Mar 21)
- Break (Mar 23)
- Mechanical design (Mar 30)
  - Recitation: Caleb Harper, Open Agriculture at MIT (Apr 4)
- Machine design (Apr 6)
  - Recitation: Jesel Baker, Provenance (Apr 11)
- Input devices (Apr 13)
  - No recitation (Apr 18)
- Molding and casting (Apr 20)
  - Recitation: Beno Juarez, Amazon Floating Fab Lab (Apr 25)
- Output devices (Apr 27)
  - Recitation: Postponed to May 23: Gian Paolo Bassi, SolidWorks (May 2)
- Composites (May 4)
  - Recitation: James Coleman, A. Zahner Company (May 9)
- Networking and communications (May 11)
  - Recitation: The State of the Fab Lab Network (May 16)
- Interface and application programming (May 18)
  - Recitation: Gian Paolo Bassi, SolidWorks (May 23)
- Applications and implications (May 25)
  - Recitation: Sylvia Martinez, Invent to Learn (May 30)
- Invention, intellectual property, and income (Jun 1)
  - Recitation: Carl Bass, Autodesk (June 6)
Fab City has been initiated by the Institute for Advanced Architecture of Catalonia, MIT Center for Bits and Atoms and the Fab Foundation. Its operation is adjacent to the 1500+-strong fab Lab network, using it as a global infrastructure and knowledge source to challenge cities to produce everything they consume by 2054. Cities are encouraged to join the growing network of Fab City locations once a year at the Fab City Summit.

PARTNER CITIES/STATES

BARCELONA
BHUTAN
SHENZHEN
GEORGIA
CURITIBA
OCCITANIE
PUEBLA
MEXICO CITY
OAKLAND

EKURHULENI
BREST
BOSTON
TOULOUSE
PARIS
SANTIAGO DE CHILE
Velsen
Seoul
Auvergne-Rhône-Alpes

AMSTERDAM
CAMBRIDGE
Kerala
SACRAMENTO
SOMERVILLE
DETROIT
KAMAKURA
SORCABA
ZAGREB
BELO-HORIZONTE
Photos: The Six Wonders of Obama’s ‘Maker Faire’ Tour

The White House hosted a Maker Faire on Wednesday, inviting tinkerers, inventors and entrepreneurs to the nation’s capital on what turned out to be a blazingly hot day. President Barack Obama toured six outdoor displays, ranging from fuel-efficient cars to futuristic steel animals. Here are the highlights, based on the White House pool report, followed by some more photos from Twitter.

1. The Fab Lab
A BILL

To provide a Federal charter to the Fab Foundation for the National Fab Lab Network, a national network of local digital fabrication facilities providing community access to advanced manufacturing tools for learning skills, developing inventions, creating businesses, and producing personalized products.

Section 1. Short title
This Act may be cited as the “National Fab Lab Network Act of 2013”.

Sec. 2. Findings
Congress finds the following:

(1) Scientific discoveries and technical innovations are critical to the economic and national security of the United States.

(2) Maintaining the leadership of the United States in science, technology, engineering, and mathematics will require a diverse population with the skills, interest, and access to tools required to advance these fields.

(3) Just as earlier digital revolutions in communications and computation provided individuals with the Internet and personal computers, a digital revolution in fabrication will allow anyone to make almost anything, anywhere.

(4) The Center for Bits and Atoms of the Massachusetts Institute of Technology (CBA) has contributed significantly to the advancement of these goals through its work in creating and advancing digital fab labs in the United States and abroad.

(5) CBA’s fab labs provide a model for a new kind of national laboratory that links local facilities for advanced manufacturing to expand access and empower communities.

(6) A coordinated national public-private partnership will be the most effective way to accelerate the provision of this infrastructure for learning skills, developing inventions, creating businesses, and producing personalized products.

Sec. 3. Establishment of national fab lab network
Watch our Live Panel With Neil Gershenfeld About Fab Labs

In this 2005 book, Fab: Dr. Neil Gershenfeld predicted a shift from personal computing to personal fabrication and how manufacturing could be decentralized through networks. The Fab Lab Network is an experiment in bringing Gershenfeld’s vision a reality. Today, with the crisis of COVID-19, fab labs and makerspaces around the world are sharing designs that can be replicated in each community because the tools for digital fabrication are widely distributed. We want to hear what Neil thinks of seeing his vision play such a powerful role in shaping the civic response to COVID-19 but quite possibly providing the basis for a broad recovery.

Join Dorothy, Jean-Davis of Nation of Makers and Dale Dougherty of Make: Community in an open discussion with our guest panelist and the maker community.

Panelists for this event will include:
- Dr. Neil Gershenfeld of MIT Center for Bits and Atoms
- Sherry Lassiter, Executive Director of the Fab Foundation
- Zach Friedlin has been working on rapid prototyping responses
- Cameron Blackham has been working on lab measurements of rapid prototyping responses
- Tim Batworth - Bitcoin Asylum
- Megan J. Smith has been working on the civic response
- Danny Boyce - College of Alameda Fab Lab

Molecular and CFD modeling
Filter media and swab production and testing
curved-crease folded shields and boxes
nanoparticle filter media characterization
Ventilator displays and UVC sterilization

MIT initiates mass manufacture of disposable face shields for Covid-19 response

A team from MIT has designed disposable face shields that can be mass produced quickly to address hospitals’ needs nationwide.

March 31, 2020

Graduate student Zach Friedlin operates the Zund large format cutter in MIT’s Center for Bits and Atoms. The machine was used to make prototypes of the face shield.

Image: Center for Bits and Atoms
The Promise of Self-Sufficient Production

As global supply chains have revealed their vulnerabilities during the pandemic, digital fabrication technologies demonstrate a promising way forward.

BY JOEL CUTCHER-GERSHENFELD, ALAN GERSHENFELD, AND NEIL GERSHENFELD

It was a matter of life and death. During the early days of the COVID-19 pandemic, a hospital in Besozzo, Italy, was running out of ventilator valves. The nor-
mall suppliers couldn't meet the rapidly increasing demand for the parts, which were essen-
tial for keeping patients alive. So, in a moment of desperation, the hospital turned to the local
community for help. A company in Besozzo with rapid prototyping capabilities, responded to the call—frozen, exasperated, pro-
typing, and then producing hundreds of 3D-printed valves that provided a life for the emergency. The
same company then developed an innovative idea to transform a 3D-printing mask into an emergency
ventilator. Since these emergency ventilators were needed extensively all over Italy, history com-
menced: the digital fabrication community to make the materials available to the local hospitals,
reported Martina Gherardi, founder of Feldfluf Western Srl. Thousands of ventilators were pro-
duced and donated to hospitals across the region. A distributed ecosystem of digital fabrication facili-
ties—some community-based fabrication labs, some commercial—had become an important part of the local supply chain to provide health care
facilities with personal protective equipment (PPE); grow parts, and medical devices.

As more global supply chains and large-
scale manufacturing are being revealed to be fragile and vulnerable, the role played by digital fabri-
cation technologies shows us how to survive and thrive in the Third Digital Revolution.

DESIGNING REALITY

How to Survive and Thrive in the Third Digital Revolution