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Fall 2017

OPEN SOURCE HARDWARE

The

BRIDGE

LINKING ENGINEERING AND SOCIETY

Hardware: The Next Step toward Open Source Everything

Alicia M. Gibb

Freedom Reigns in Desktop 3D Printing

Ben Malouf and Harris Kenny

Reevaluating Intellectual Property Law in a 3D Printing Era

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Impacts of Open Source Hardware in Science and Engineering

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The Maker Movement and Engineering

AnnMarie Thomas and Deb Besser

3D Printing for Low-Resource Settings

Matthew P. Rogge, Melissa A. Menke, and William Hoyle

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The

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The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

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Editor's Note



Joshua M. Pearce is a professor cross-appointed in the Departments of Materials Science & Engineering and Electrical & Computer Engineering at the Michigan Technological University, and director, Michigan Tech Open Sustainability Technology Lab.

Introduction to Open Hardware in Science and Engineering

The articles in this issue look at how the development and use of free and open source hardware (FOSH or simply “open hardware”) are changing the face of science, engineering, business, and law.

Free and open source software (FOSS) has proven very successful and now dominates the development of software on a global scale. It is available in source code (open source) and can be used, studied, copied, modified, and redistributed either without restriction or with restrictions only to ensure that further recipients have the same open source rights.

Similarly, FOSH provides the “code” for hardware—including the bill of materials, schematics, instructions, computer-aided designs, and other information needed to recreate a physical artifact. Use of FOSH can improve product innovation in a wide range of fields. In this issue authors from a variety of disciplines and work environments discuss how this open model of innovation will drive the future of engineering.

First, Alicia Gibb, founder and executive director of the Open Source Hardware Association (OSHW) and director of the ATLAS¹ Blow Things Up (BTU) Lab at the University of Colorado Boulder, argues that hardware is the next step to open sourcing everything. She touches on intellectual property (IP) issues, cites the benefits of open source hardware, introduces and explains the role of OSHW, and hints at the future of open hardware.

The open source paradigm is already making deep inroads in the hardware space in 3D printing. With the development of the open source RepRap project (a 3D printer that can print itself) the cost of 3D printers has dropped to a point where nearly anyone can afford one for rapid prototyping and small batch manufacturing.

Ben Malouf and Harris Kenny of Aleph Objects describe their company’s approach to the use of open hardware in every aspect of their business to create the popular Lulzbot 3D printer. Their primary product is open—and consistently wins one of the top spots in *Make*: magazine’s annual 3D printer shootout, ahead of proprietary 3D printers from much larger companies with far greater resources. Lulzbot printers, and those of many other manufacturers, are rapidly increasing in sales as the number of free and open source 3D printable designs erupts on the Web, making distributed manufacturing a reality.

In this context, law professor Lucas Osborn at the Campbell University School of Law takes us on a deep dive into how IP law will need to change in this new 3D printing era. After summarizing the basics of IP law and explaining why it was created, he discusses how it could both benefit and hinder 3D printing technology. His arguments will challenge readers independent of their views on patent law. For those with conventional IP leanings, he shows how IP law can hinder innovation. For those born in the Internet age, where sharing is second nature and little thought is given to licenses as long as the code is posted on Github, he offers some important lessons. He ends with a challenge for engineers to make more of an effort in helping form IP law that will benefit innovation.

If these lessons on IP and open hardware replication with 3D printers are turned to experimental research in science and engineering, there is an important opportunity to radically reduce the costs of experimental research while improving it. In the next article I argue that by harnessing a scalable open source method, federal funding is spent just once for the development of scientific equipment and then a return on this investment (ROI) is realized by digital replication of scientific devices for only the costs of materials. With numerous examples I show that the ROI climbs into the thousands of percent while accelerating any research that the open

¹ Founded in 1997 as the Alliance for Technology, Learning, and Society.

paradigm touches. To harness this opportunity, I propose four straightforward and negative-net-cost policies to support FOSH development and improve access to scientific tools in the United States. The policies will directly save millions in research and STEM education expenditures, while providing researchers and students access to better equipment, which will promote advances in technology and concomitant benefits for the American economy.

Thinking about the future and the changes needed to support this development in STEM education, AnnMarie Thomas and Deb Besser of St. Thomas School of Engineering consider how engineers and engineering educators can use maker methods to introduce students to engineering and build their technological literacy. They show that the maker movement is closely tied to open hardware and sharing as well as the traits of successful engineers. Makerspaces and fabrication (fab) labs (what Gibb calls hackerspaces) are physical hubs of the maker culture.

Although these trends are clearly important for the United States, this cultural change and open hardware ethos can have dramatic impacts in the developing world. Matthew Rogge, Melissa Menke, and William Hoyle of TechforTrade explain the potential for open source and 3D printing to produce many needed items in low-resource settings, where lack of infrastructure

makes local production impractical and high tariffs, unreliable supply chains, and economic instability make importation costly. Saving 90 percent on medical or scientific tools is nice in my lab, for instance, but it literally saves lives in a developing world context.

The contributions conclude with an op-ed by Tom Callaway, a senior software engineer at Red Hat, Inc., an open source software company with revenue over \$2 billion last year (up 15 percent year over year). What makes this business accomplishment so impressive is that all of the company's software products are available for free. Although old ways of thinking demand that companies secure a monopoly and certainly not give away "intellectual property" for free, Red Hat's success comes from offering its customers support, collaboration, control, and a high-quality product. Tom argues that the proven open source software mentality is porting to hardware, opening up incredible opportunities for humanity. He concludes, "open source and open innovation work... They also empower society and make it possible to push the limits of what is possible. When the barriers to collaboration are lifted, people can accomplish incredible things."

As all of the articles show, open source tools in the hands of this and future generations of engineers will be incredible indeed.