SIEMENS

Ingenuity for life

3D printing: an open source revolution for hardware

White Paper

This white paper examines the technology of 3D printing and discusses its impact on traditionally different concepts in manufacturing and coding, and how it opens a new challenge for product and application lifecycle management (PALM) tools.

A white paper issued by: Siemens PLM Software

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Preface

If you read the article about 3D printing on Wikipedia[1], the first short abstract may look boring for you: "various processes used to synthesize a three-dimensional object," "successive layers of material are formed," etc. In reality, everyone is talking about 3D printing and 3D printers as a revolution; one which could change our lives dramatically. Could you imagine not going to a store for making any purchases, but printing necessary items instantly – from small items, like a toy for a child, to large objects, like furniture, walls or whatever you may need? Doesn't it sound fantastic? It's not far from becoming a reality. 3D printers have already entered 2st1 century life.

There are medical printers, which allow production of tooth and bone replacements. There are models of Lego pieces to be printed for children. There are 3D-printed guns and rifles. There are even 3D-printed airplanes that can actually fly.[2]

The U.S. Navy is installing 3D printers on ships instead of stocking pre-made replacement parts[3]. Shoe manufactures Adidas and Nike announced rapid prototyping with the 3D printers.[4] Someone has even initiated a food printing project. [5]

Industry has developed many disciplines and methodologies to achieve success with their innovations, to have cost-effective production, to be environment friendly and so on.

Those disciplines are well covered and supported in product lifecycle management (PLM), typically for hardware manufacturing, and application lifecycle management (ALM), typically for software tools.

This white paper discusses how 3D printing can narrow (if not close) the gap between traditionally different concepts in manufacturing and coding, and opens a new challenge for PALM (product and application lifecycle management) tools.

3D-printed aircraft successfully takes flight.
(http://www.geek.com/news/3d-printed-aircraft-successfully-takes-flight-1523821/)

The winds of change

What does the 3D revolution mean for industry, for large enterprises and for small companies?

First of all, it's a change in thinking about the manufacture of physical items. You may find an analogy with the software industry 30 years ago, when you had to write a program on paper, then put it on punched cards, and only then could you see how the program ran. This made a sort of discipline for programmers and the way they work.

For hardware manufacturing, the process was (and, to a large extent, still is) pretty similar – an engineer creates a model, a description of the piece to be manufactured; the description gets into a press or computer numerical control (CNC) machine or robotic line production or similar production tool. Then the pieces go through the steps of manufacturing, and some time later the engineer will see the final product. For production of a piece, a new line often needs to be built, which can mean months or years of waiting before you'll see a real thing evolving.

In conjunction with simulation tools, 3D printing opens the possibility to see the physical results almost instantly (in time units of hardware production). One can produce even a half-ready product to better understand how to improve the final version. The only thing you typically need is a digital model composed in some software, and time of waiting for the printer to get through all the surfaces. The time required is not yet comparable to paper printing. It may take hours to get the final product in hand, but compared to traditional manufacturing it's negligible.

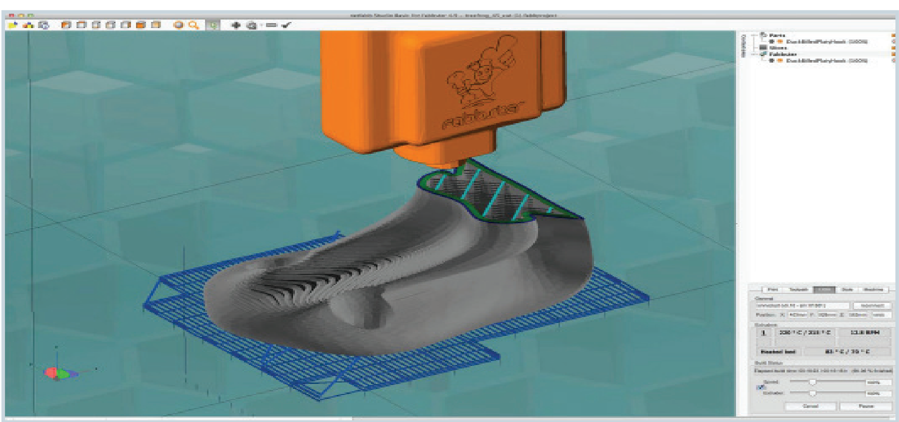
Hardware meets software

Even for traditional hardware production, the core design is kept in software – various computer-aided design (CAD) systems for drawing and modeling the pieces, managing the supplied units to make an assembly, simulation software to get virtual testing of the assembly, and so forth.

3D printing lowers the cost of manufacturing so much that engineers will have the opportunity to make errors and try several times before they get a successful prototype. It can be very important to hold something in hand, instead of seeing it on a computer screen and trying to envision that it is really the exact thing you've imagined.

If you're dealing with something more complex than tables and chairs, it is very likely that your hardware will include software. And during prototyping you want to see full assembly of the hardware components with their software counterparts.

This brings additional challenges to engineers. Sometimes you may adapt your hardware to software to reduce the cost of manufacturing. With the help of 3D printing, the cost in hardware and software will be more and more affected by the diverse complexities and production processes instead of different "materials"' (software/hardware).



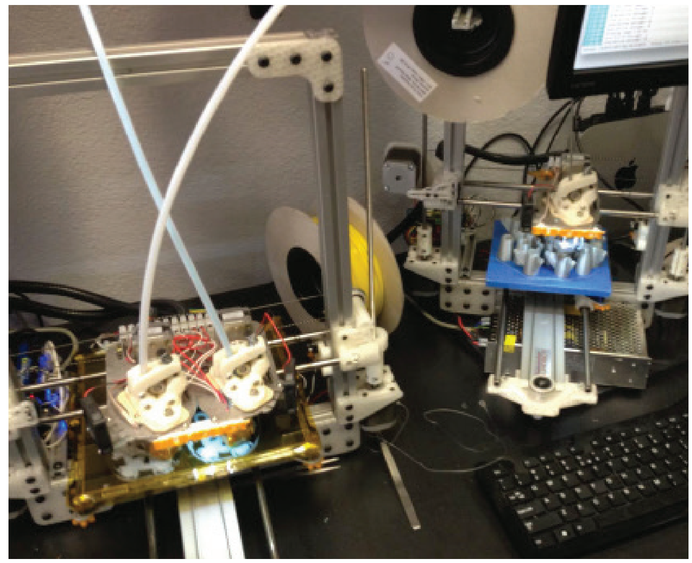
Agile hardware development

For years now, software organizations have been moving toward “agile” methodologies for many reasons, continuously changing requirements first and foremost. Why weren’t such methods implemented in manufacturing? Because the costs of adjustment to the production lines and robots have been so significant, that it’s more effective to stay with the plan, get a return on investment and then plan a modification.

3D printers radically change the paradigm. Since producing a piece takes hours, not months or years, you may produce new version of it virtually every day. This gives you much more freedom to accept growing and changing customer requirements, implement new ideas and explore innovations.

This could be nicely bound to short-term iterations, as recommended in agile development. For instance, in an organization working with the scrum methodology, several teams could work in parallel with hardware and software components, to be consolidated in four-week sprints. That’s an interesting approach – a potentially shippable product by end of each sprint, which includes the full-blown piece, which earlier took months for manufacturing, while the software team spent months in simulation work.

For PALM tools, this would mean managing various artifacts together – especially requirements, specifications and test cases, which will be engineered in parallel for software and hardware components, taking an evolutionary path into consideration, and managing resources in a different way. You might need more CAD designers than manual workers, and of course different skills of management to face the dramatically changed speed of manufacturing.



LA Robotics Club
http://www.flickr.com/photos/laroboticsclub/8327499954/

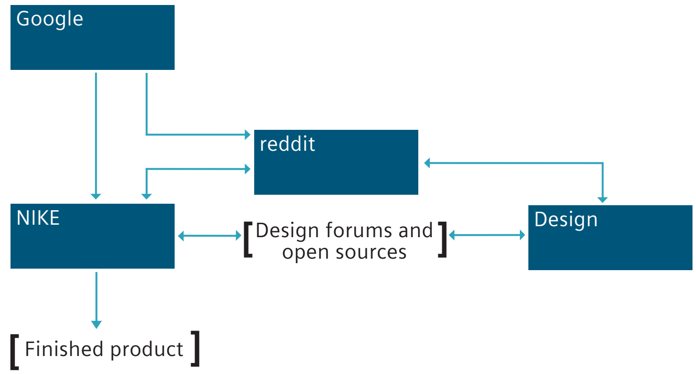
Opening doors for beta testing

Providing early-access programs for customers is a widely used technique in the computer software industry. Before going to production, test customers are selected who can play with the software and provide their feedback. This allows vendors to refine the product to reflect usability aspects, fix problems and be certain of acceptance by the target market.

While beta testing is possible in the hardware industry, it is more complicated. While small things still could be improved, in the majority of cases the refinements address software components. Refinements still may include replacement of materials, small changes in the design, etc., but major changes are not welcome and will be difficult to push through.

3D-printing opens the door for approaching real customers early on, giving them something concrete in their hands to evaluate, and getting their instant feedback. You don't need production lines to produce one or another variant of the piece.

From another side, you must be sure that your product is in a real beta-quality state, a necessity for collecting feedback from the testers to incorporate it into the final version. That's another part of a PALM solution that may need to be adopted.



A company such as Nike can use mass collaboration and 3D printing.
http://madameeureka.wordpress.com/the-societal-impacts-of-3d-printing/

Collaboration is key to success

Traditionally, hardware manufacturing is much more centralized or localized than software development, where there is much more outsourcing, including floating teams, resources, locations, technologies, etc.

You eventually need to build a factory to produce a small screw and you need to find a market for thousands of them, otherwise production won't be cost-effective.

In the case of tight integration of mechanical, electrical and software components, many people need to speak/collaborate with each other, and teams build dependence on each other.

Unfortunately, planning of real parallel development is traditionally hardly achievable. Some components will be ready earlier, and some later.

Today's reality is that the majority of things can be collaborated on across distance, time zones and mentalities in electronic form. Thus mechanical and electrical parts get designed in CAD and simulation software, which can be easily shared across the globe as files or services. Software components are even easier.

With mechanical parts, only people with access to the plant have ability to see and feel those parts. The statement "better to see it once than hear about it a thousand times" may be reformulated to "better to get final product in hand, than to check it a thousand times in simulation software."

What exactly is provided in electronic form? Copies of documents that can be used by many people in parallel and improved by different methods, and then the best-of-the-best will be merged in the final version.

This is happening within the 3D printing community. There are schematics of pieces already shared in various places, communities are forming to improve them, everyone is enthusiastic to contribute and proud that their invention or improvement is found useful by tens, hundreds, or thousands of other people.

One of the key challenges for PALM on the subject is to offer a unified collaboration platform for all the stakeholders. Particularly, all artifacts of development should be under the same revision control system; they should fall under the same traceability linking (to enable impact analysis on changes to any components); priorities and backlogs need to be synchronized, and so forth.

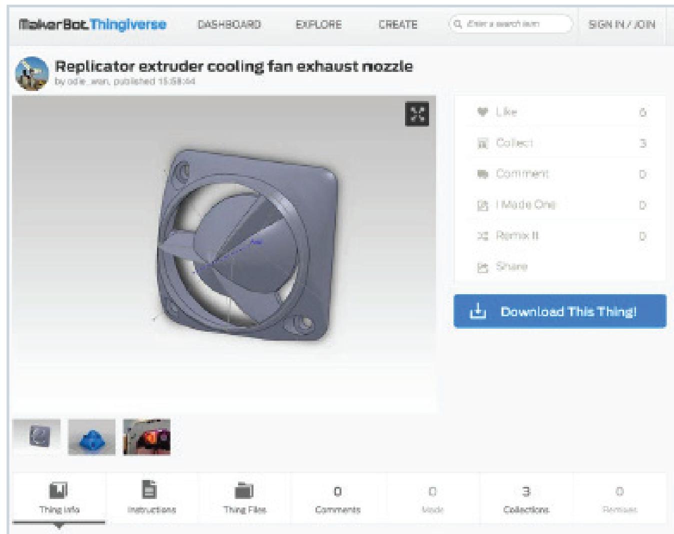
"God created men, Sam Colt made them equal"

The 3D printing revolution will likely have at least as much impact on the world as the Colt .45 revolver had on America's Western frontier. Today, collaborative teams are developing something exciting, and improvements are coming regularly. What is really different in the process?

The difference is that each participant can use a local 3D printer to produce physical objects resulting from the collaborative work. There is no exclusivity about who can play in the simulator, and who stays behind the button to produce the piece and, potentially, who starts using or selling it.

Everyone is aware of the success of open-source software (OSS) – developed once, re-used everywhere. The same is coming now to the world of hardware. This stimulates competition once a nice piece is created, it can easily be replicated or reproduced on the other side of the world.

What makes 3D printing revolutionary is that it makes people much more independent. If you have a schematic of a 3D model, you can print it on my 3D printer, you don't need a factory to make it, a middle-man to stock it, or a shipping company to deliver it. Altogether it is allowing quicker and smarter people to be more successful without having heavy capital behind them to start manufacturing.



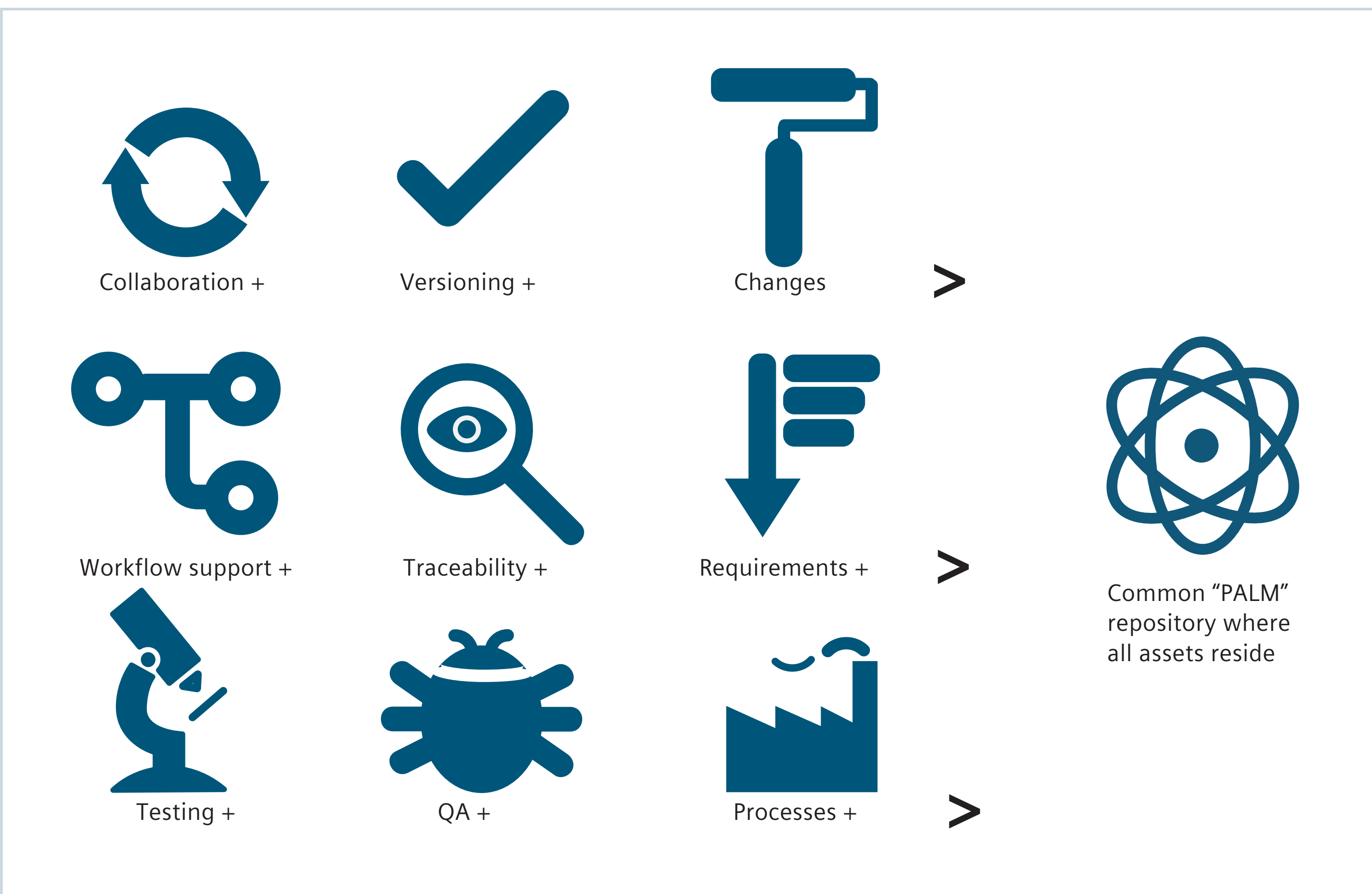
3D print model sharing community
http://www.thingiverse.com/

Siemens PLM Software's recipe for PALM

Siemens PLM Software's Polarion ALM is an open ALM environment, built on a unified foundation providing collaboration, traceability, requirements management, test management/ quality assurance (QA), software standards support, knowledge management, item and component re-use and forensic reporting for software development organizations.

Most of the capabilities outlined above are immediately available to any PLM user, making Polarion ALM the first PALM backbone. Its capability has been widely recognized by customers, and has led Polarion ALM to become the sole ALM solution to be certified ISO 26262 compliant by TüV Technical Inspection Association.

Siemens PLM Software as a company follows the extremely exciting development of 3D printing, and its products offer unsurpassed opportunity for new technologies to be incorporated in the development cycle in a PALM environment.



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Siemens PLM Software, a business unit of the Siemens Digital Factory Division, is a leading global provider of product lifecycle management (PLM) and manufacturing operations management (MOM) software, systems and services with over 15 million licensed seats and more than 140,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with its customers to provide industry software solutions that help companies everywhere achieve a sustainable competitive advantage by making real the innovations that matter. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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