AIM 2013 Conference
Advances in Sustainable Production

3D PRINTING: THE WAY TOWARDS SUSTAINABLE MANUFACTURING

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AIM
INSISOC SOCIAL SYSTEMS ENGINEERING CENTRE
European Academy for Industrial Management
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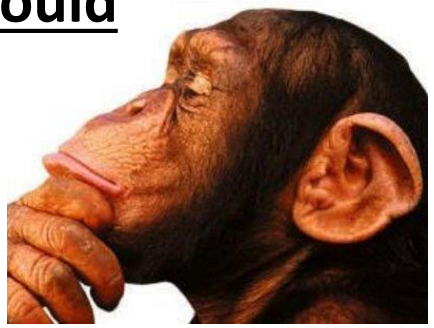
Split (Croatia), 19-22 September 2013

Aim…

"Just as nobody could have predicted the impact of the steam engine in 1750—or the printing press in 1450, or the transistor in 1950—it is impossible to foresee the long-term impact of 3D printing. But the technology is coming, and it is likely to disrupt every field it touches.
Companies, regulators and entrepreneurs should start thinking about it now…"



"**Print me a Stradivarius.**
How a new manufacturing technology will change the world"
The Economist (Feb 10th, 2011)
http://www.economist.com/node/18114327?story_id=18114327

Agenda

1. 3D Printing: Disruptive Technology
2. Applications
3. Impact on Global Sustainable Development

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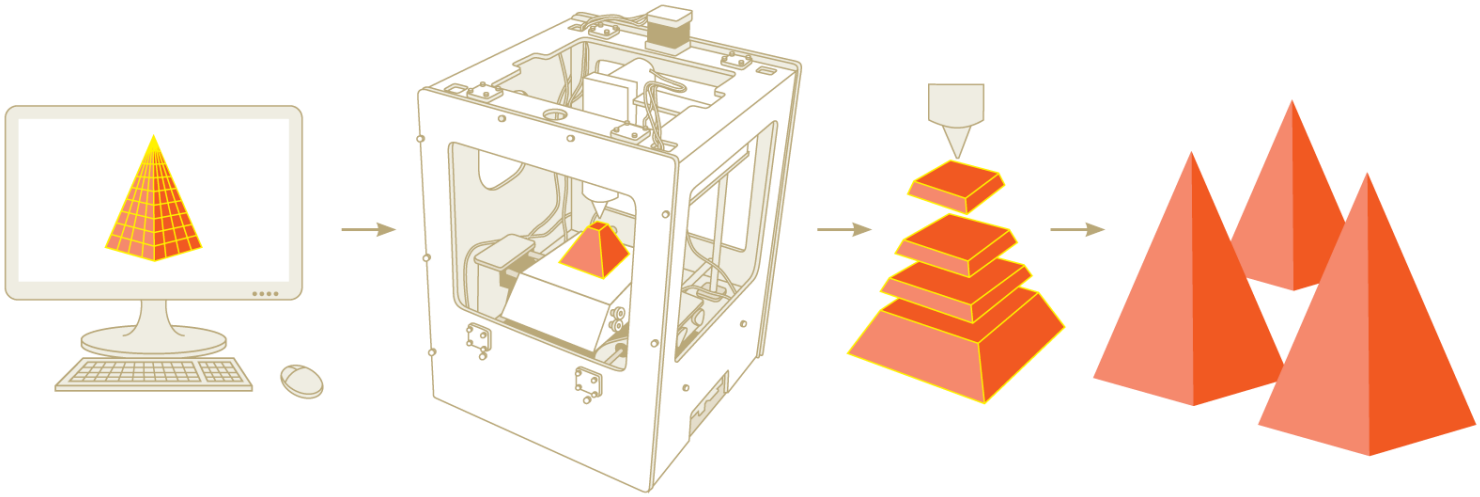
3D Printing

"3-D printing employs an additive manufacturing process whereby products are built on a layer-by-layer basis, through a series of cross-sectional slices"



Berman, B. (2012), "3-D printing: The new industrial revolution", Business Horizons, 55: pp 155-162

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3D Printing: Disruptive Technology

- Hype Cicle Review 2011-2013
- Governmental Support
- Industry Reports

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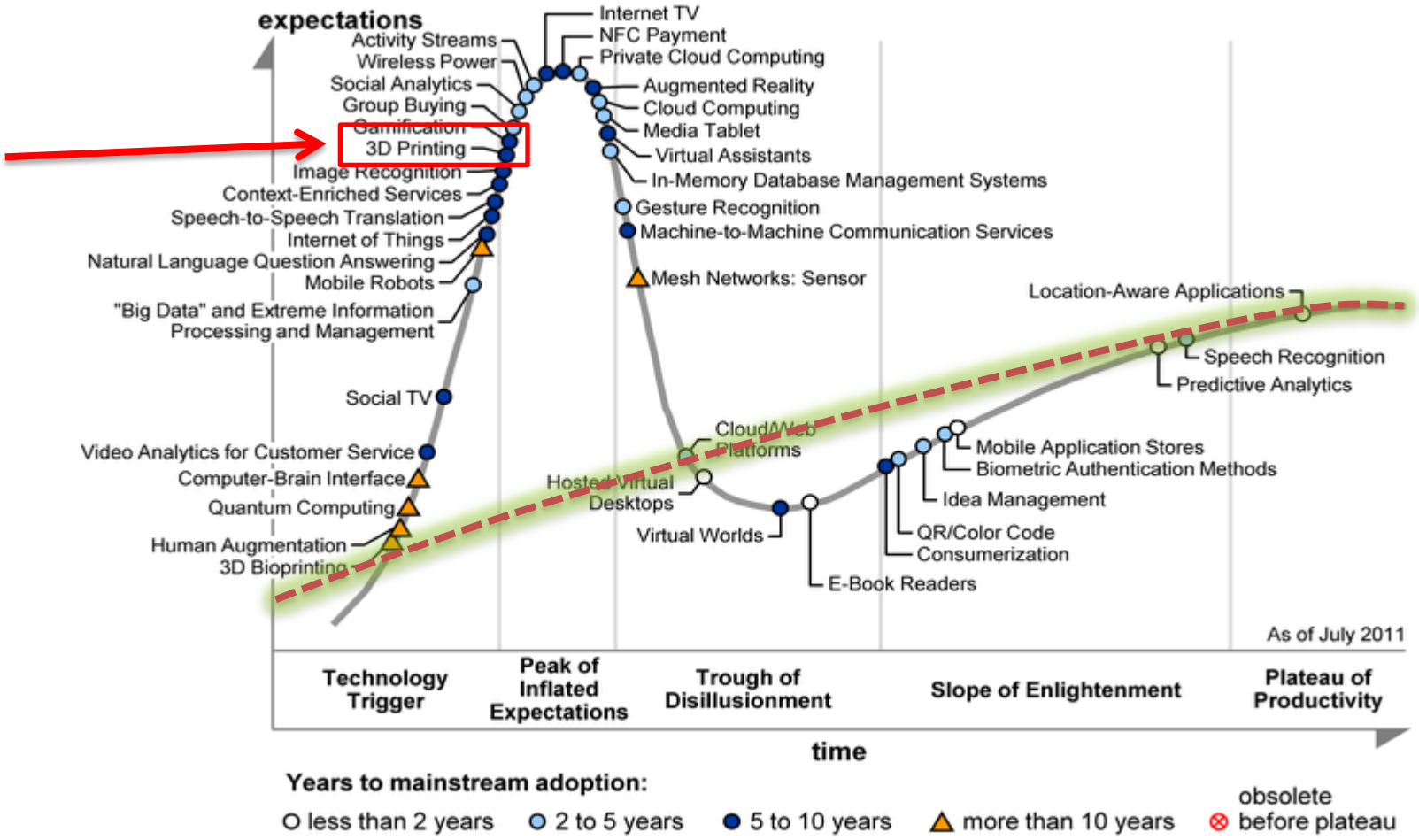
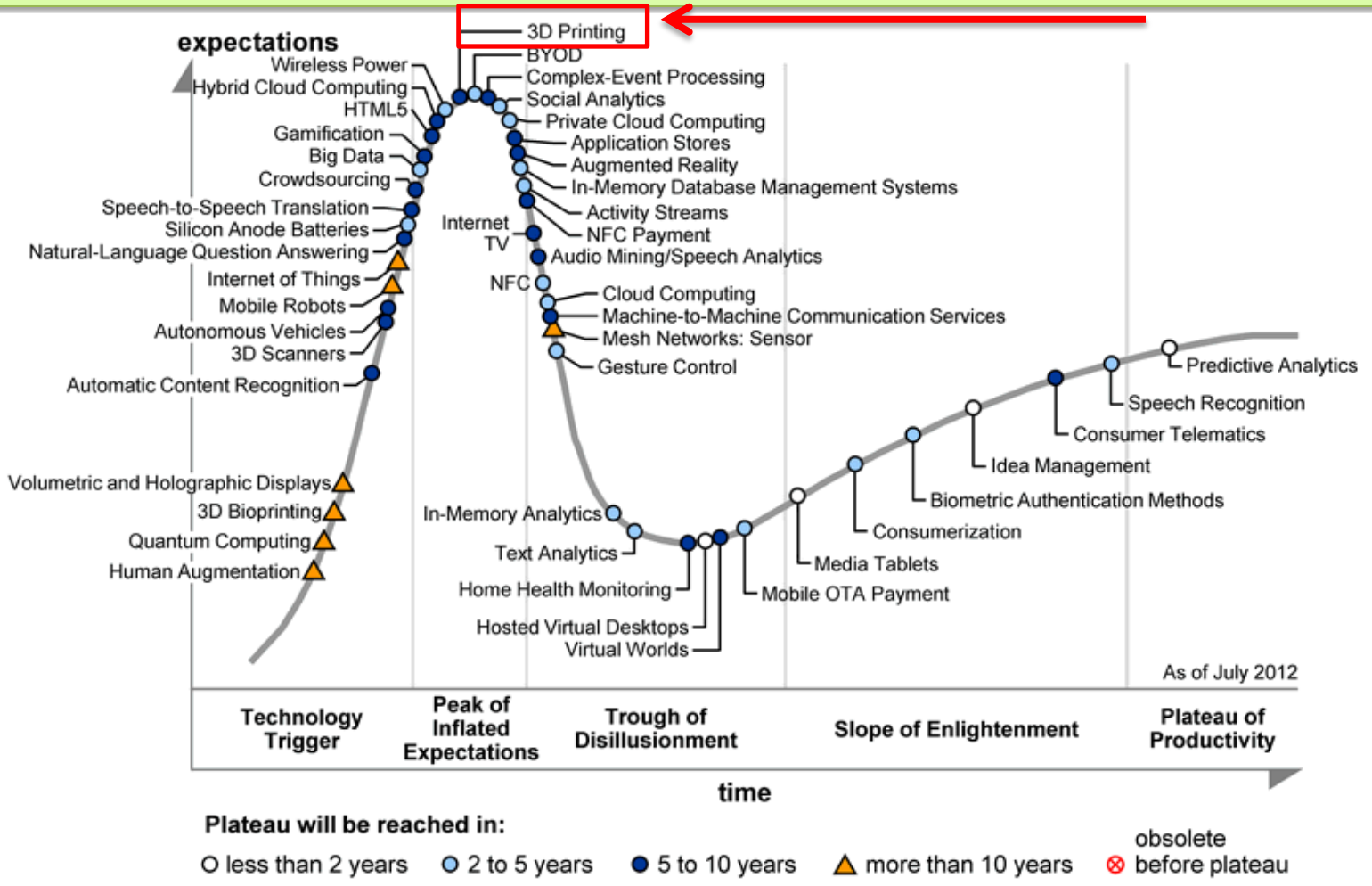
Gartner 2011: Emerging Technologies

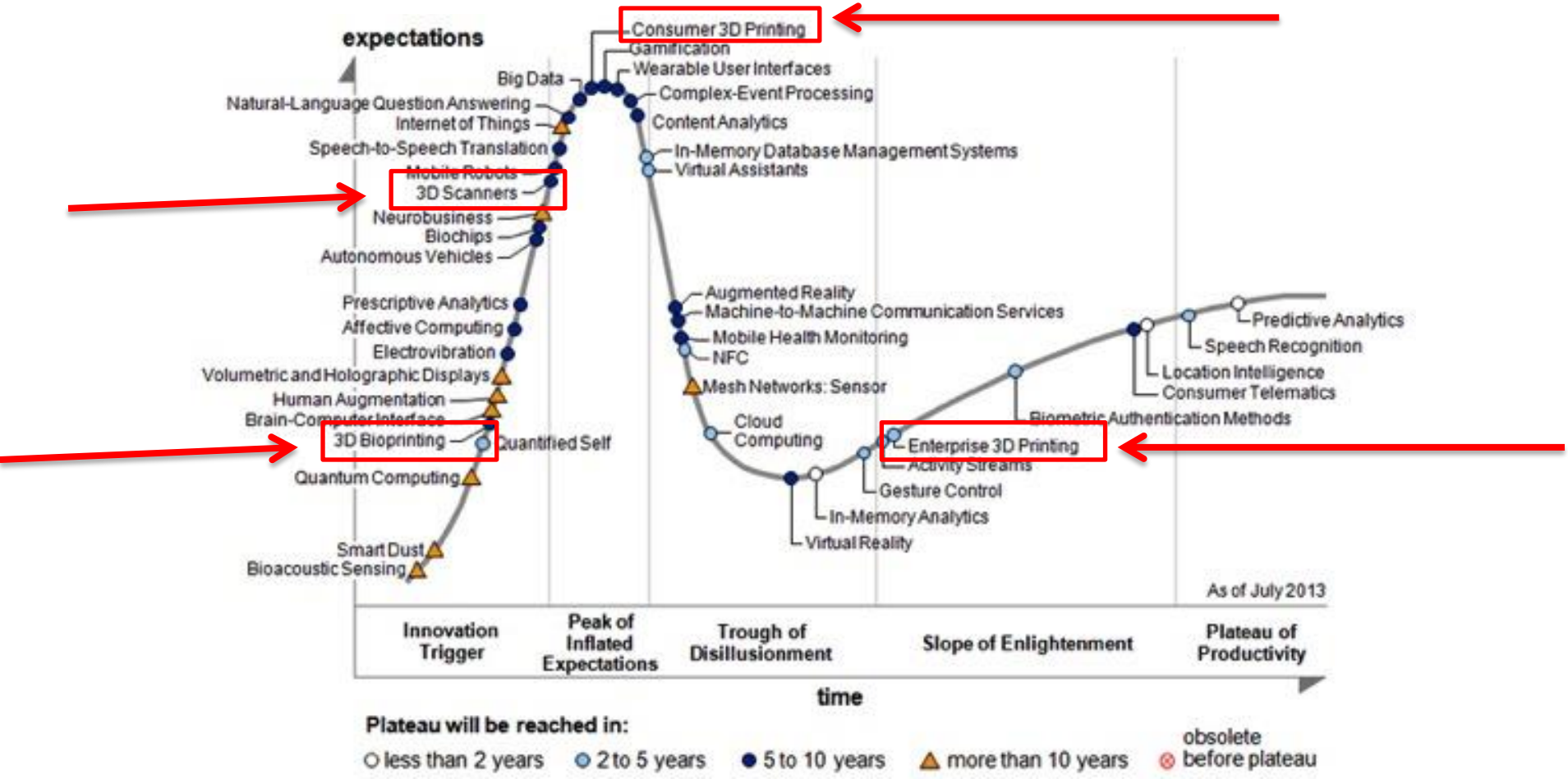


http://www.gartner.com/newsroom/id/2124315

Gartner 2012: Emerging Technologies



Gartner 2013: Emerging Technologies



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State of the Union (Feb, 2013)

"... has the potential to revolutionize the way we make almost everything"

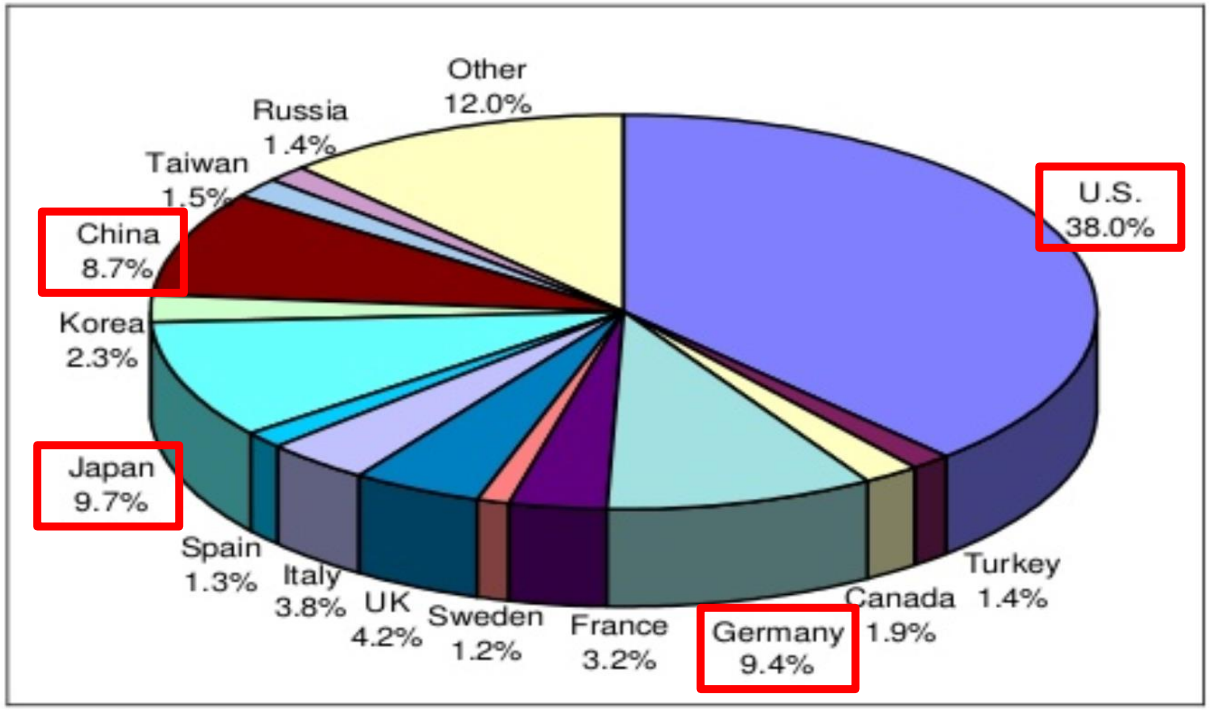
*Last year, we created our first **manufacturing innovation institute** in Youngstown, Ohio. A once-shuttered warehouse is now a state-of-the art lab where **new workers** are mastering the **3D printing that has the potential to revolutionize the way we make almost everything**. [...].*

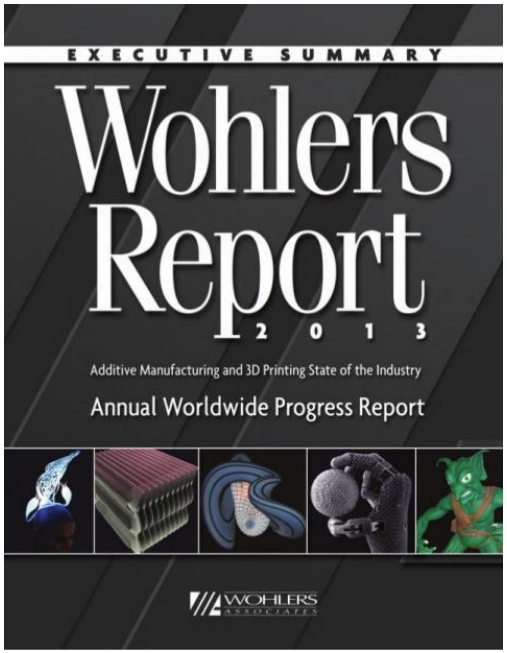
So tonight, I'm announcing the launch of three more of these manufacturing hubs, [...]

*And I ask this Congress to help create a network of fifteen of these hubs and **guarantee that the next revolution in manufacturing is Made in America**.*

Industry Reports

"The global market for AM products and services in 2013 grew 28,6% to $2.204 billion…"





AM Systems installed by country (1998-2012)

Government Support

UK businesses are set to benefit from a **£14.7 million investment** to develop 3D printing projects, Business Secretary Vince Cable announced. Jun/2013

The **Japanese** government plans to support domestic makers to develop cost-effective 3D printers. They plan to launch a 3D-printer project next April and to **allocate it about 45 million dollars** in the budget plan for fiscal 2014. Aug/2013

Singapore Government will **invest $500 million** over five years to boost country's skills in advanced manufacturing, including in the rapidly emerging 3D printing industry.

"…, the White House has proposed a series of measures to accelerate advanced manufacturing, including […] a $1 billion program to create 15 national institutes aimed at developing new manufacturing techniques in areas such as 3-D printing and nanotechnology."

McKinsey & Company Report (2013): Disruptive technologies: Advances that will transform life, business, and the global economy

"3D printing will have a direct economic impact of between $230 billion and $550 billion a year in 2025"

Exhibit 11

Sized applications of 3D printing could have direct economic impact of $230 billion to $550 billion per year in 2025

Sized applications	Potential economic impact of sized applications in 2025 $ billion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Consumer use of 3D printing	100–300	• $4 trillion in sales of consumer products that might be 3D printed	• 5–10% of relevant products (e.g., toys) could be 3D printable, assuming easy consumer access	• 60–80% value increase per 3D-printed product – 35–60% cost savings to consumers – 10% added value from customization
Direct product manufacturing[1]	100–200	• $300 billion spending on complex, low-volume items such as implants and tools • $470 billion spending on complex, low-volume parts in transportation	• 30–50% of products in relevant categories replaceable with 3D printing	• 40–55% cost savings to buyers of 3D-printed products
Tool and mold manufacturing	30–50			
Other potential applications (not sized)		• $360 billion global market for injection-molded plastics	• 30–50% of injection-molded plastics produced with 3D-printed molds	• 30% production cost reduction using superior 3D-printed molds
Sum of sized potential economic impacts	230–550			

1 Focuses on use of 3D printing to directly manufacture low-volume, high-value parts in the medical and transport manufacturing industries. Other potentially impactful applications might include manufacturing of low-volume, high-value replacement parts for other industries.

NOTE: Estimates of potential economic impact are for some applications only and are not comprehensive estimates of total potential impact. Estimates include consumer surplus and cannot be related to potential company revenue, market size, or GDP impact. We do not size possible surplus shifts among companies and industries, or between companies and consumers. These estimates are not risk- or probability-adjusted. Numbers may not sum due to rounding.

SOURCE: McKinsey Global Institute analysis

Rapid Prototyping

DIY (Do-It-Yourself)

Mass Customization

Digital Manufacturing

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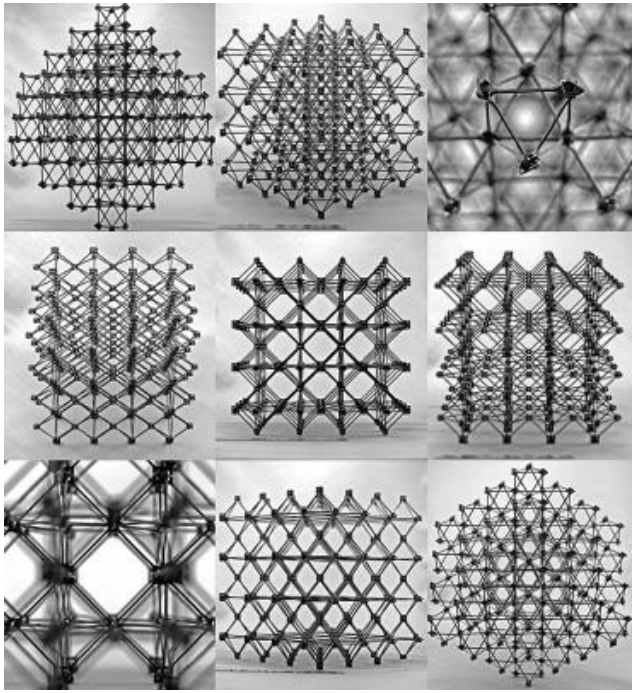
Rapid Prototyping

97% Cost Reduction; 83% Time Reduction All 188 components were produced in 4 weeks and assembled in 2.5 weeks for a total production time of 6.5 weeks



MIT: applications to aerospace industry, construction, etc.: 10 times stiffer and lighter than existing ultralight materials…

Local Motors won the XC2V competition, they were given a mere 14 weeks to build a prototype of their "FLYPMODE"

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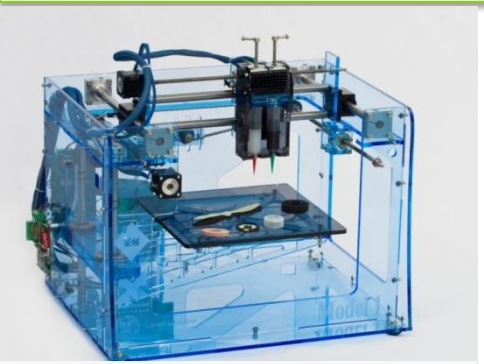
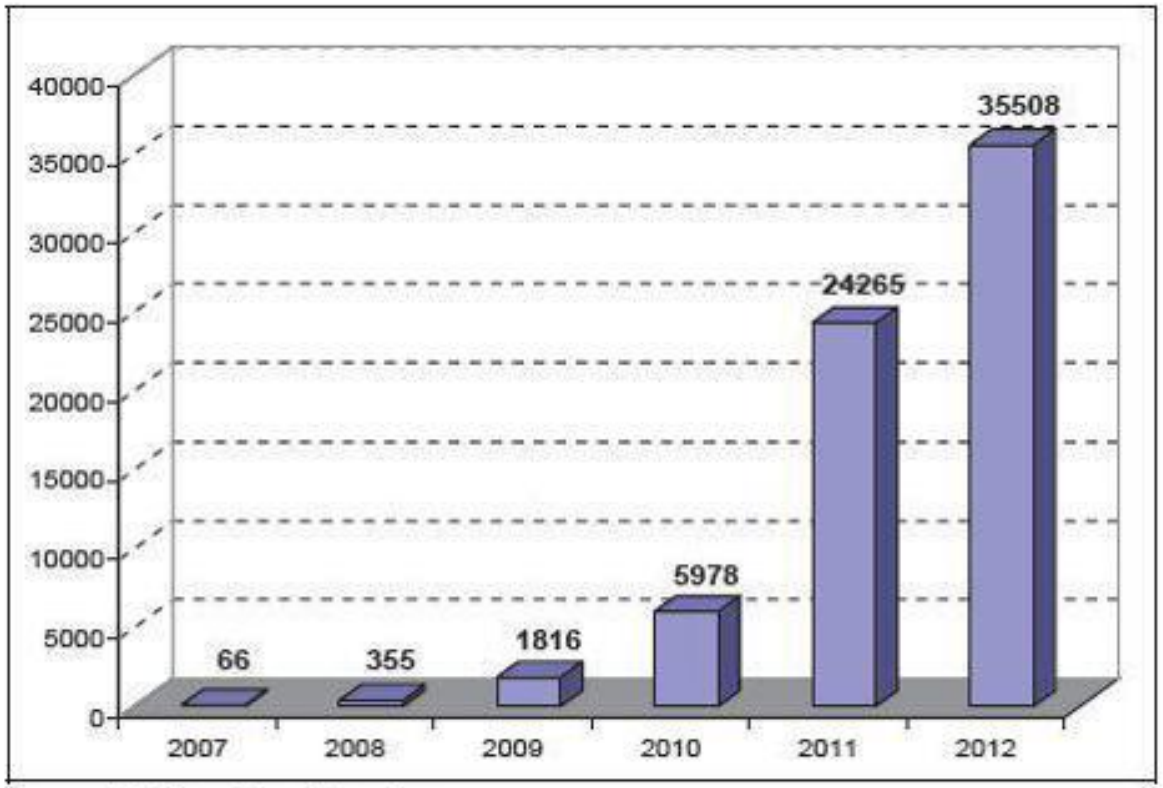
DIY: ‘Domestic’ Printers





Source: Wohlers Associates, Inc.

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Mass Customization






Direct Digital Manufacturing

It takes only 4 months to manufacture the injector as compared to a year using traditional process and cuts the cost of production by as much as 70%. NASA recognizes this as a game-changer and will potentially transform the way rocket engines or even complete spacecrafts will be made in future…

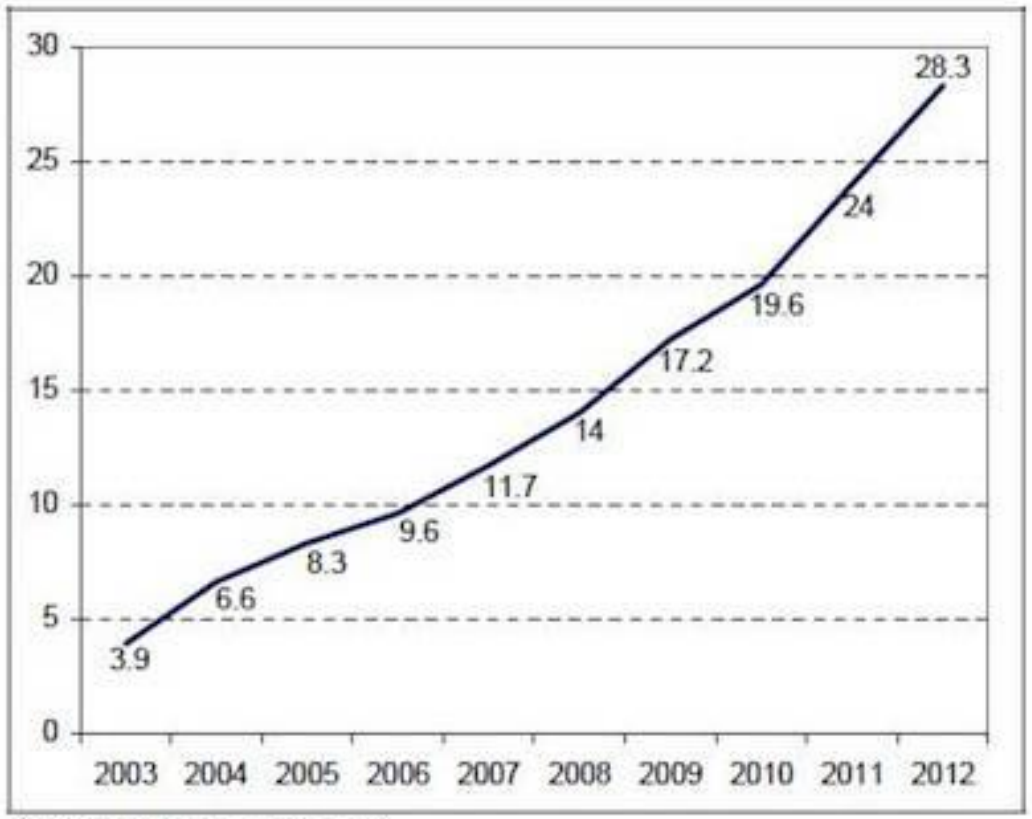
Airbus wing brackets: the organic foreground part is 3d printed. In the background is the existing machined part. EADS Innovation Works

According to EADS, reducing the weight of an airplane by just one kilogram can result in fuel savings of $3,000 per year, or $100,000 over 30 years—the typical life of an airplane.

http://newlaunches.com/archives/nasa-uses-3d-printing-to-make-rocket-engine-injectors-massively-reduces-cost-and-manufacturing-time.php

Direct Digital Manufacturing

Percentage of revenue from 3D printed parts



Source: Wohlers Report 2013

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New Businesses …

"Although we agree that 3D Printing is not yet being used by everyone around the world, the awareness and use is growing incredibly fast, and we are betting with all of our time and energy that it will reach the 'Plateau of Productivity' in WAY under the 5-10 years that Gartner predicts. Looking at the growth of Desktop 3D Printing over the past 3 years we have seen an incredible improvement in the quality of the 3D Printers, a considerable drop in price and massive variation (on a theme/patent)"

Shapeways Inc

http://www.shapeways.com/blog/archives/1582-3d-printing-hits-the-peak-of

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Enterprise Printing: New factories

http://www.youtube.com/watch?v=AhuQPif90oU

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Challenges …

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3D Printing … Summary

UNIQUE ADVANTAGES

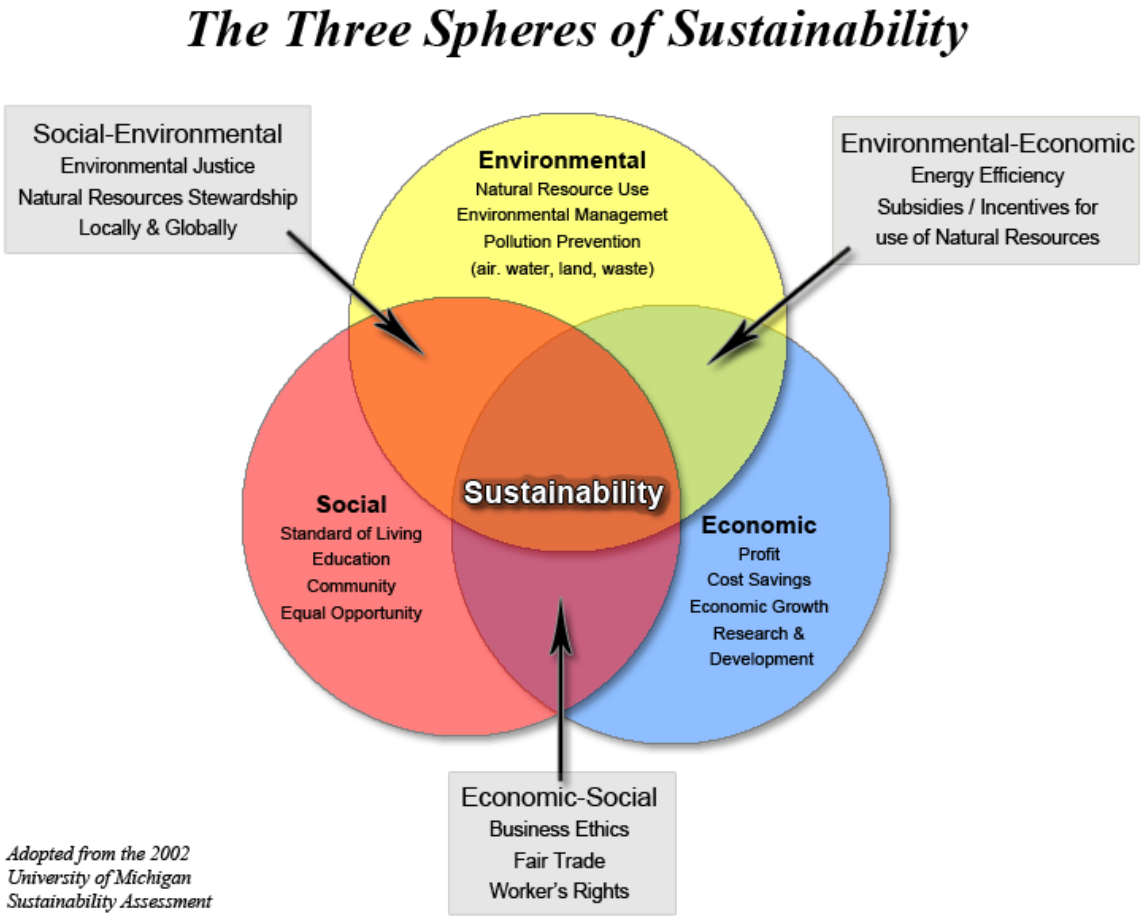
- Affordable customization
- Allows manufacture of more efficient designs — lighter, stronger, less assembly required
- One machine, unlimited product lines
- Very small objects (nano)
- Efficient use of raw materials (less waste)
- Pay by weight — complexity is free
- Batches of one, created on demand
- Print at point of assembly/consumption
- Manufacturing accessible to all — lower entry barriers
- New supply chain and retail opportunities

AREAS OF FURTHER DEVELOPMENT

- Printing large volumes economically
- Expanding the range of printable materials
- Reducing the cost of printable materials
- Using multiple materials in the same printer, including those for printing electronics
- Printing very large objects
- Improving durability and quality

Source: CSC

Sustainability



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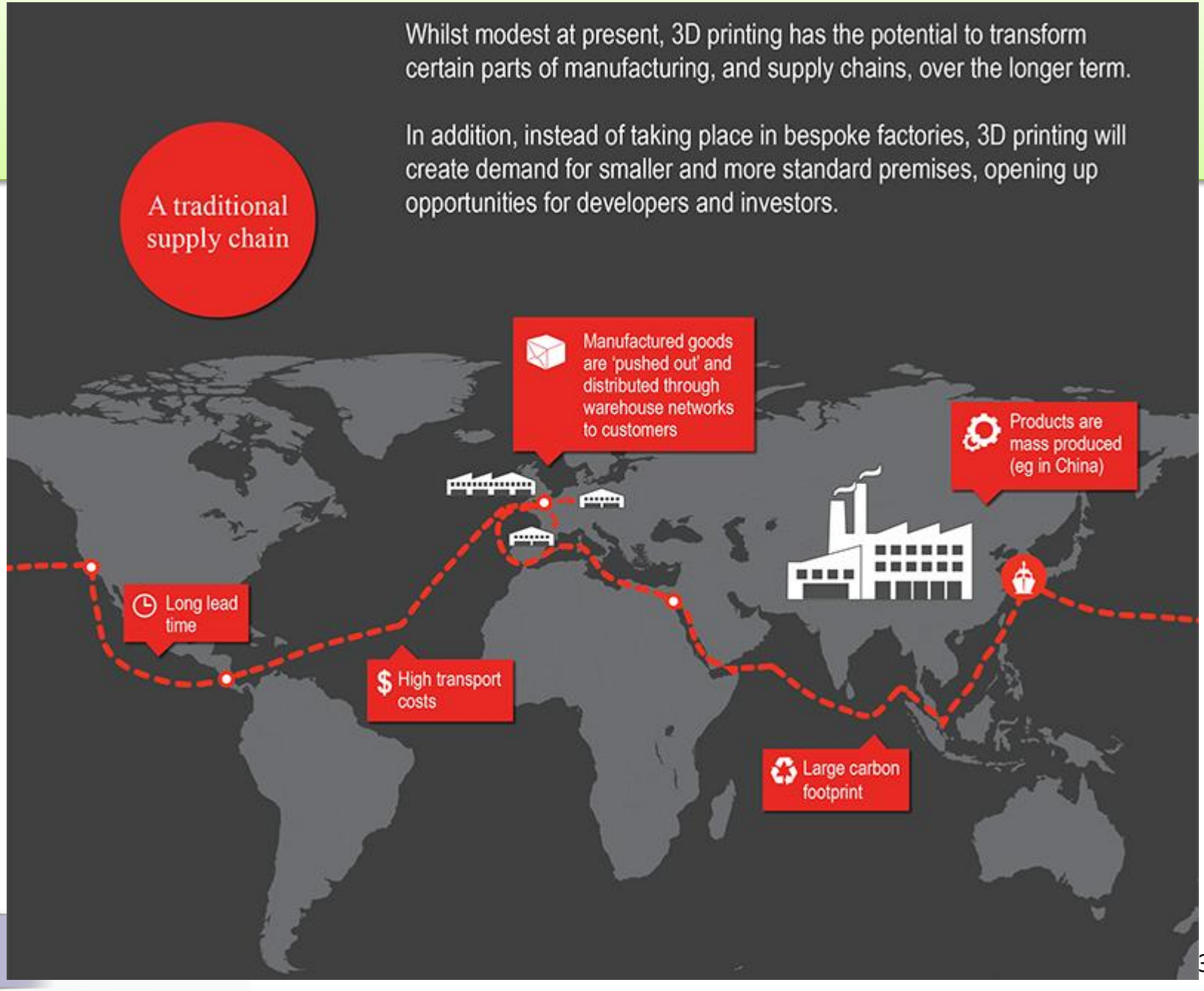
http://www.joneslanglasalle.eu/EMEA/EN-GB/Pages/the-impact-of-3D-printing-on-supply-chains-infographic.aspx



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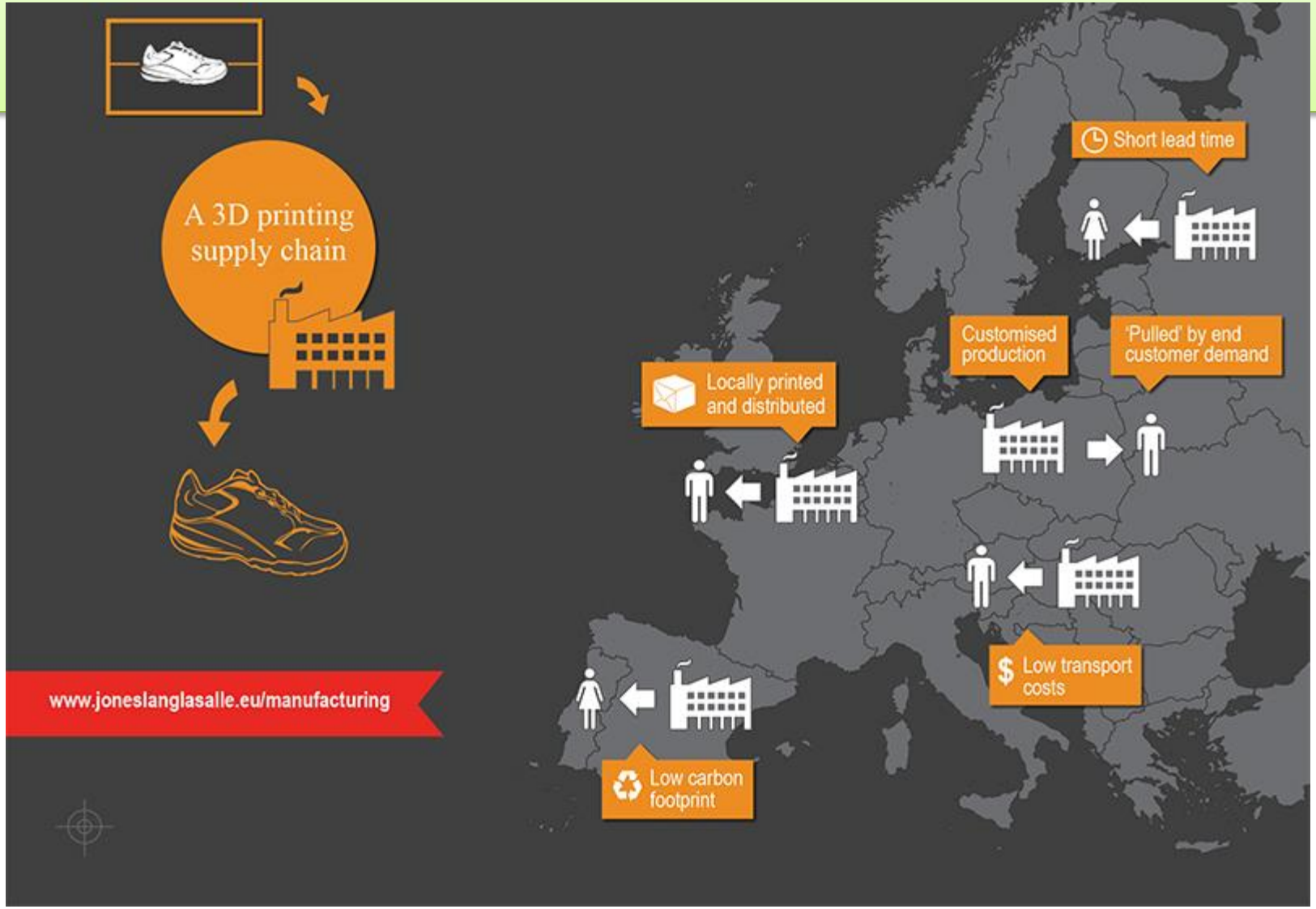
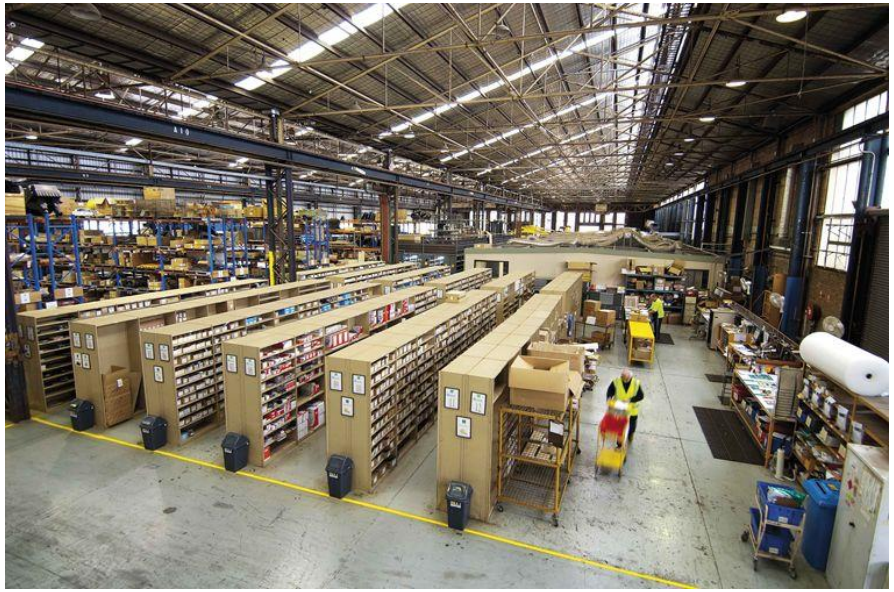
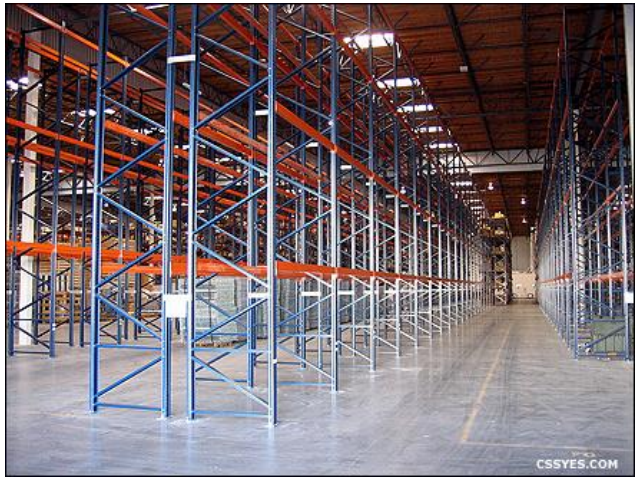


‘Eliminate’ Stocks / Inventories





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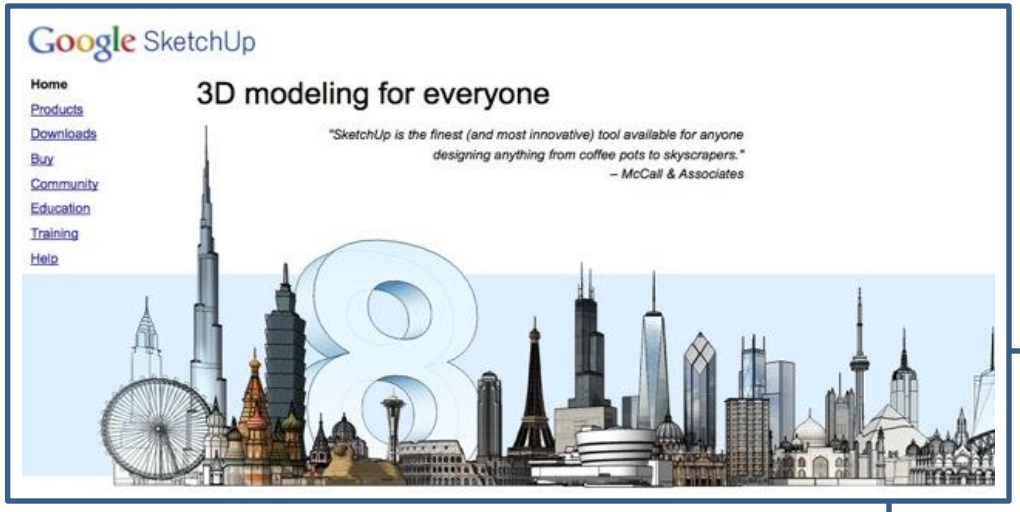
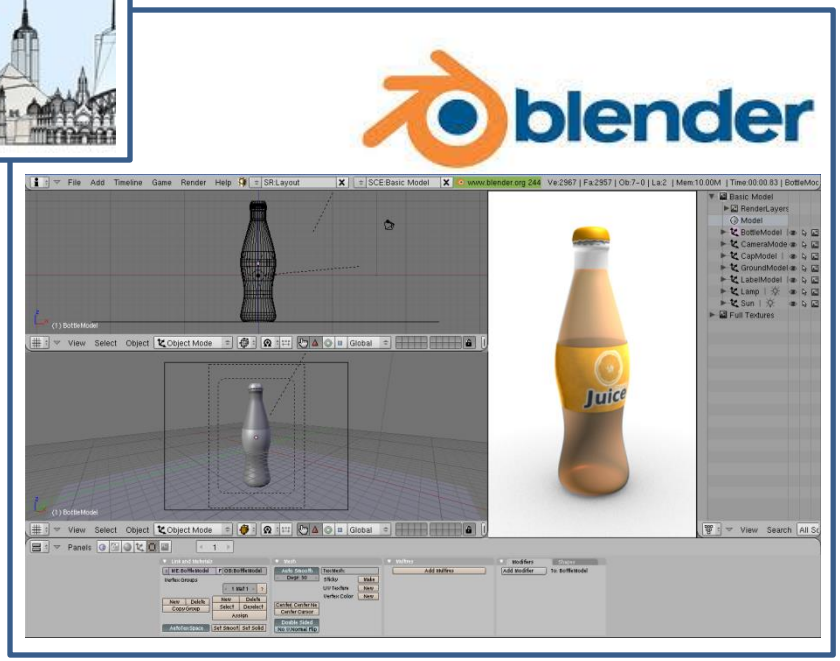
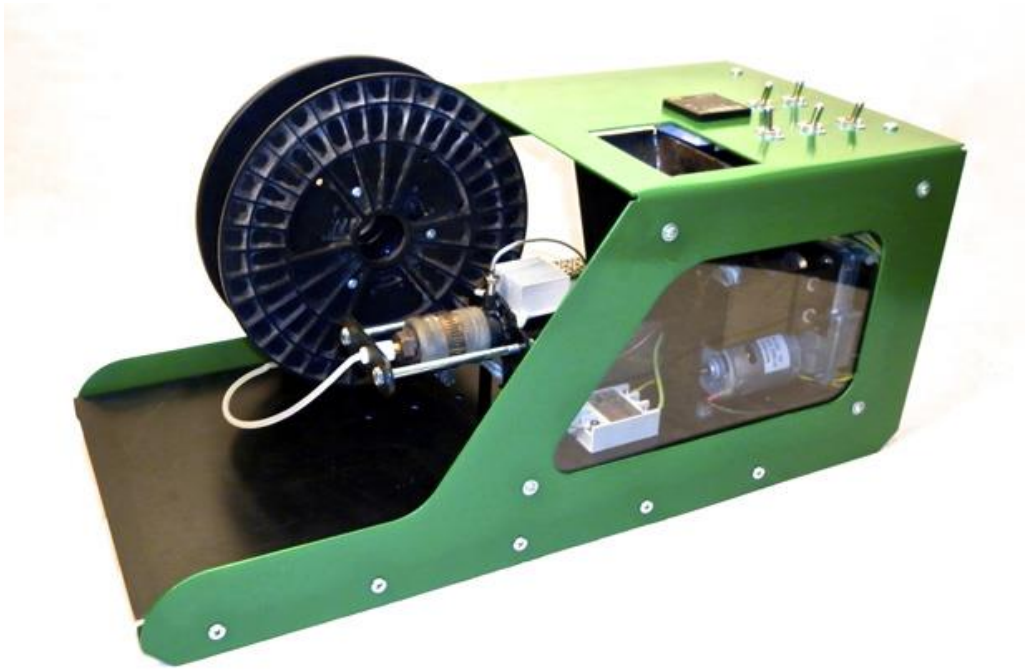
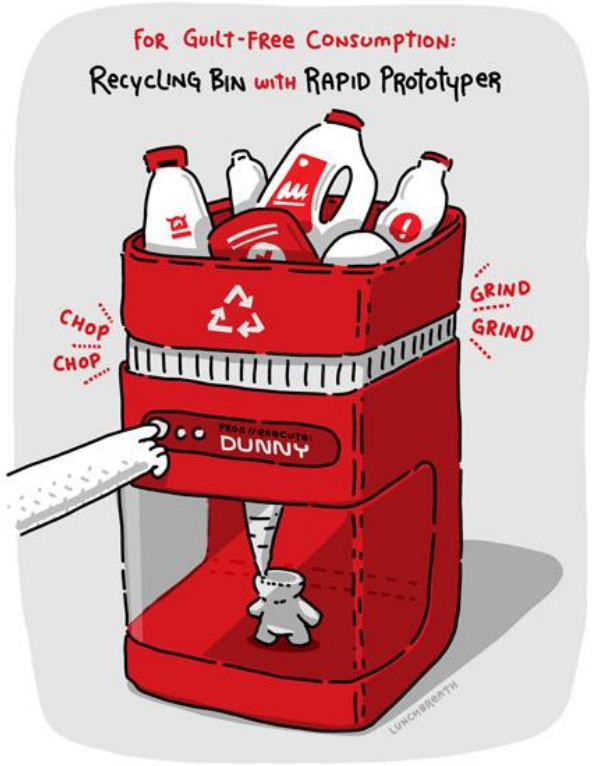
Democratization of 3D Modeling





Recycling





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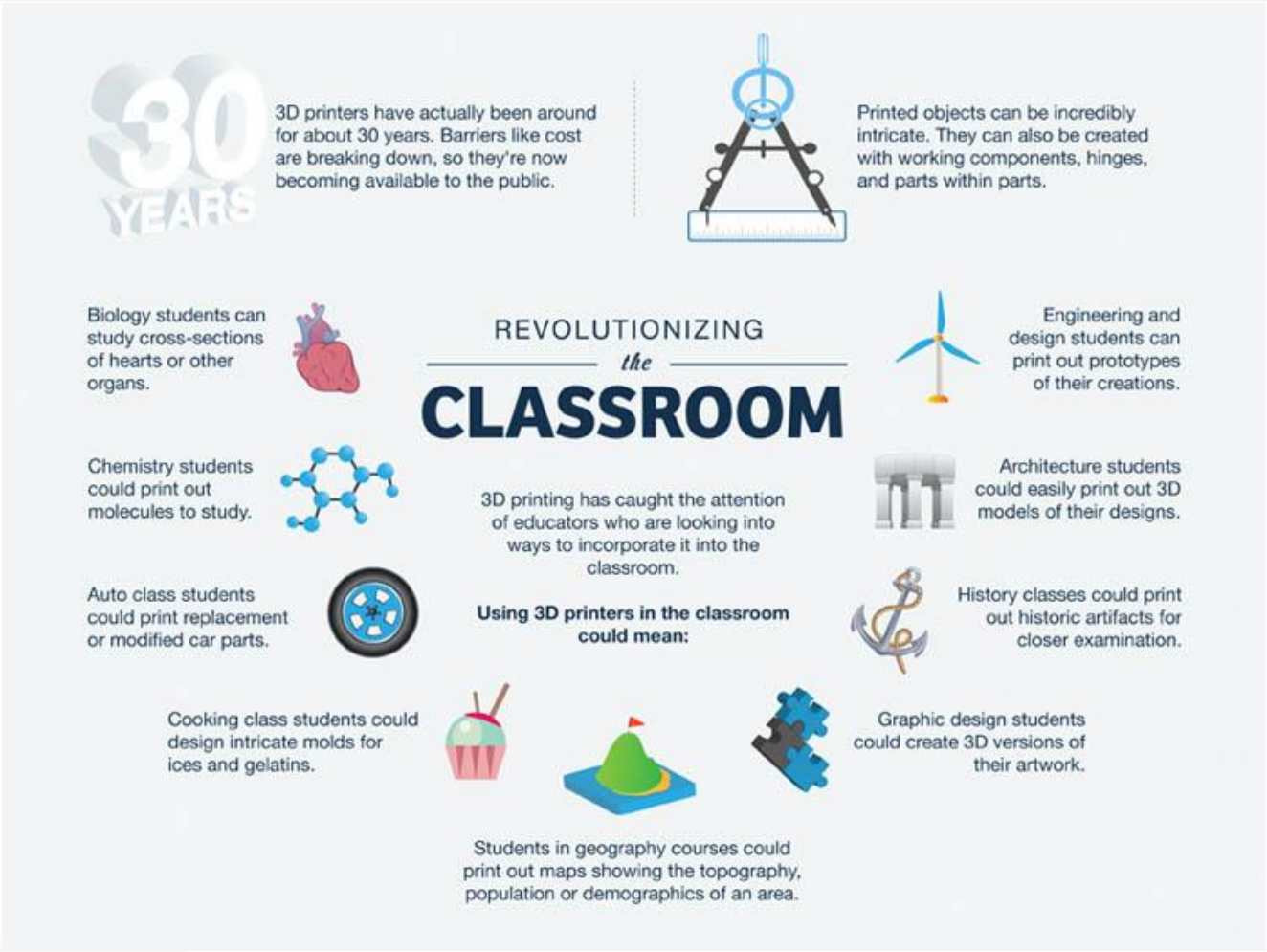
Education


30 YEARS
3D printers have actually been around for about 30 years. Barriers like cost are breaking down, so they're now becoming available to the public.
Printed objects can be incredibly intricate. They can also be created with working components, hinges, and parts within parts.
Biology students can study cross-sections of hearts or other organs.
REVOLUTIONIZING
the
CLASSROOM
Engineering and design students can print out prototypes of their creations.
Chemistry students could print out molecules to study.
3D printing has caught the attention of educators who are looking into ways to incorporate it into the classroom.
Architecture students could easily print out 3D models of their designs.
Auto class students could print replacement or modified car parts.
Using 3D printers in the classroom could mean:
History classes could print out historic artifacts for closer examination.
Cooking class students could design intricate molds for ices and gelatins.
Graphic design students could create 3D versions of their artwork.
Students in geography courses could print out maps showing the topography, population or demographics of an area.

Sustainability

No Waste

Local recycling and reuse

Safe and affordable housing

Global Supply Chain

Educational Projects

Price depends on weight

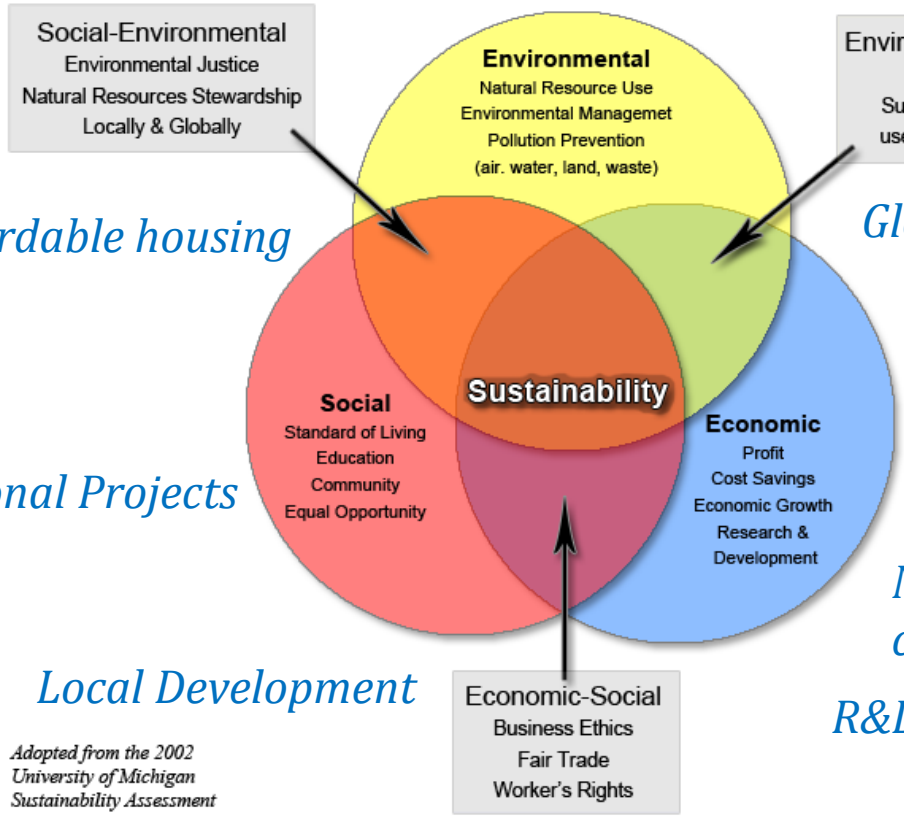
Low Stocks/Inventories

New products: medical, food, construction, etc.

Local Development

R&D Space: Autonomous missions

Increased safety at workplace



Adopted from the 2002 University of Michigan Sustainability Assessment

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Global Sustainable Development

"… Its main enabler is a new paradigm: competitive sustainable manufacturing (CSM), whose high added value (HAV), is knowledge-based (K-b). CSM depends on and affects:

- manufacturing industry, i.e. products and services, processes, business models;
- the related **education, research** and technological development and innovation (E&RTD&I) system"

F. Jovane, H. Yoshikawa, L. Alting , C.R. Boër, E. Westkamper, D. Williams, M. Tseng, G. Seliger, A.M. Paci (2008), "The incoming global technological and industrial revolution towards competitive sustainable manufacturing", CIRP Annals - Manufacturing Technology 57; pp 641–659

Thanks
for your attention!!

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