Wirtschaftliche Auswirkungen von 3D-Druck
Economic Implications of 3D printing

-

Robin Kleer

10. Kölner Medienkongress

17. November 2014, Wolkenburg

RWTH Technology & Innovation Management Group, Aachen

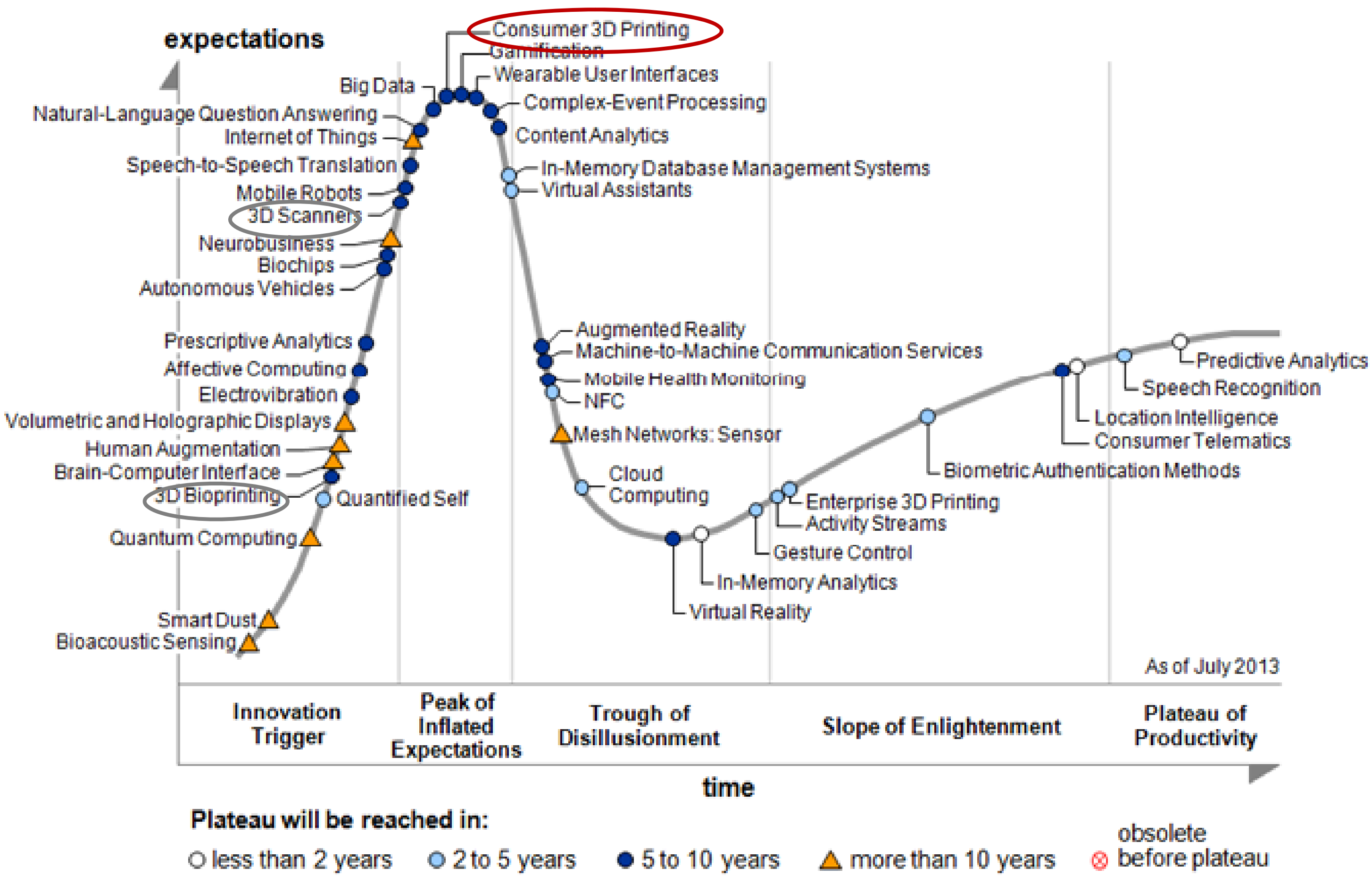
We are at the advent of a new industrial revolution*

* The Economist says (13 Feb 2011)

Really?

3D printing is currently being hyped...

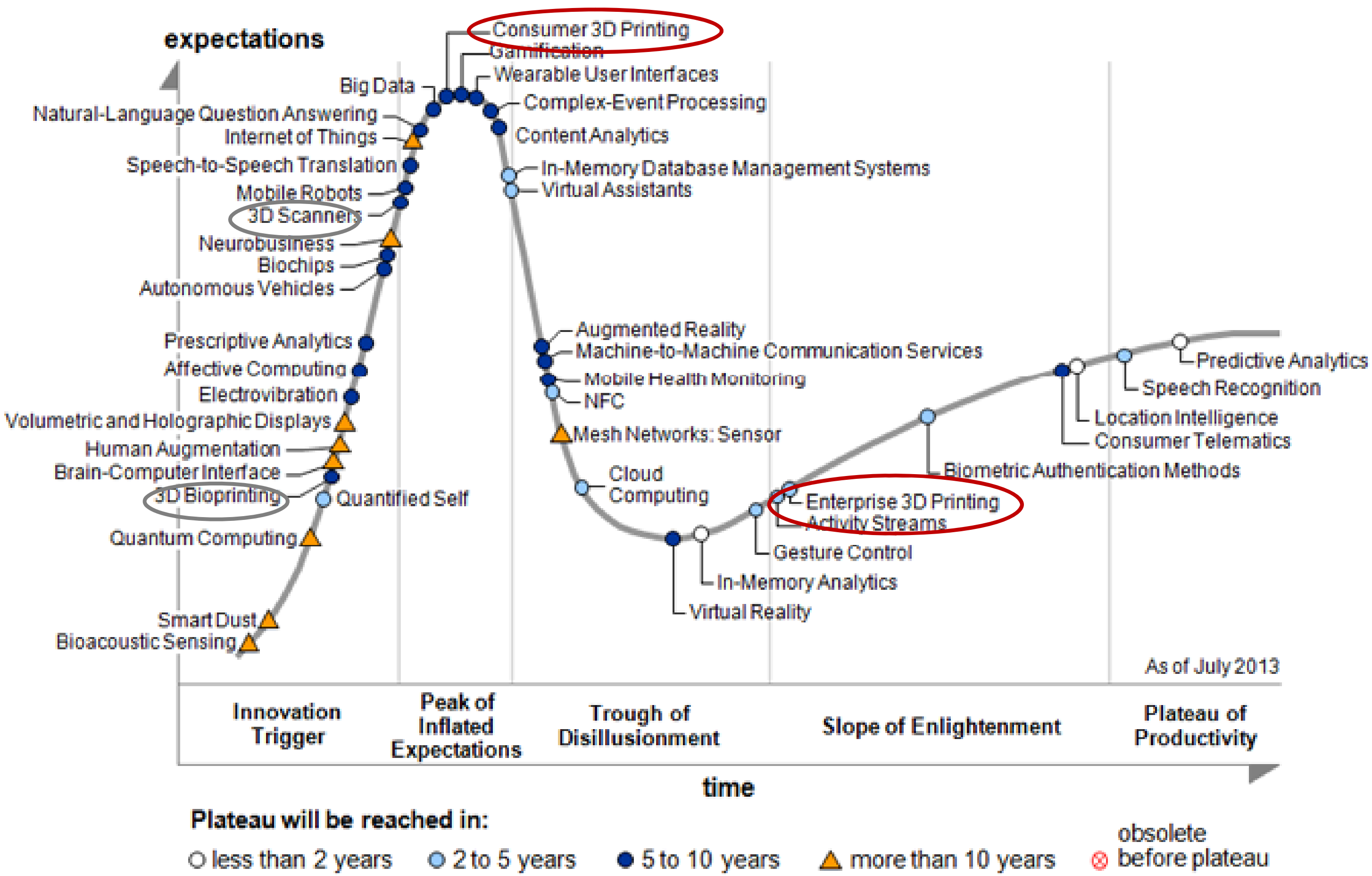
Gartner's Hype Cycle for Emerging Technologies 2013



Source:Gartner (2013), http://www.gartner.com/newsroom/id/2575515

… with “enlightenment” being reached for industrial applications

Gartner’s Hype Cycle for Emerging Technologies 2013



Source:Gartner (2013), http://www.gartner.com/newsroom/id/2575515

What is additive manufacturing?
(3DPrinting)

3D Printing ("Additive Manufacturing"): A Whole Bunch of Technologies for Digital Production

- **Fused deposition modeling (FDM)**
  - **Technology:** Extrusion-based printing of filaments through a heated nozzle (similar to inkjet printing but with additional z-axis)
  - **Used for:** Low-volume rapid manufacturing of parts / components (Maker-Bot)
  - **Mainly used material:** Polymers (e.g., ABS, PLA, polyethylene), edible substances
- **Selective Laser Sintering (SLS)**
  - **Technology**: Layer of powder deposited on build platform, laser fuses powder layer in the desired shape, new powder added
  - **Used for:** Prototyping, small-run rapid manufacturing
  - **Mainly used material:** Thermoplastics, metal & ceramic powders
- **Selective Laser Melting, Stereo-Lithography, Laminated Object Manufacturing,…**

AM means digital production, i.e. transferring a digital model directly (mold-less) into a tangible product.

AM technology is not new, but its diffusion and applications are!

Source: Pham and Gault (1998); Gibson et al. (2010); McKinsey (2013)

This is not a new concept … original principle goes back to 1902, core patent filed in 1984

1902 - Peacock patent for laminated horse shoes

1952 - Kojima demonstrated layer manufacturing benefits

1967 - Swainson files US patent for dual light-source resin system

1981 - Kodama publishes 3 solid holography methods

1982 - Chuck Hull experiments with SLA

1984 - Chuck files US patent 4,575,330

1986 - 3D Systems formed, others follow

1987 - Rapid Prototyping became a commercial reality

1990 - Layer manufactured parts used as casting patterns

1995 - Layer manufactured parts used as tools

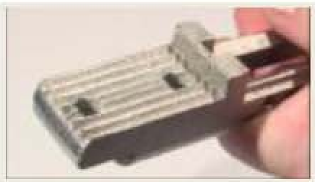
2000 - Layer manufactured parts used as production parts

2011 – 45,000 ALM machines globally (40 variations)

2012 – 45,000 new machines expected to be sold

Source: Econolyst (2013)

What can we print today? Almost everything …

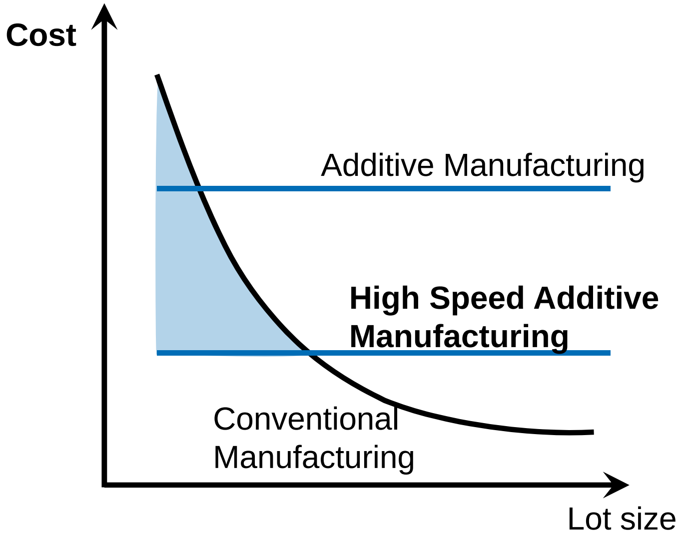
Organic materials	Ceramic materials	Polymeric materials	Metallic materials
Waxes	Alumina	ABS	Aluminium
Tissue / cells	Mullite	Polyamide (nylon)	Tool Steel
	Zirconia	Filled PA	Titanium
	Silicon Carbide	PEEK	Inconel
Beta-Tri calcium Phosphate		Thermosetting epoxies	Cobalt Chrome
	Ceramic (nano) loaded epoxies		Copper
	Silica (sand)	PMMA	Stainless steel
	Plaster	Polycarbonate	Gold / platinum
	Graphite	Polyphenylsulfone	Hastelloy
		ULTEM	
		Aluminium loaded polyamide	

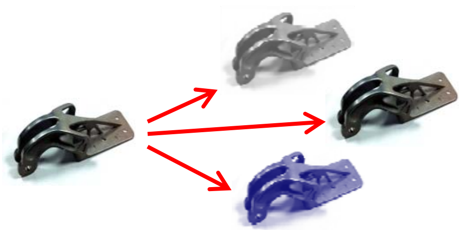
Source: Econolyst (2013)

Why do we need AM?

Digital Production

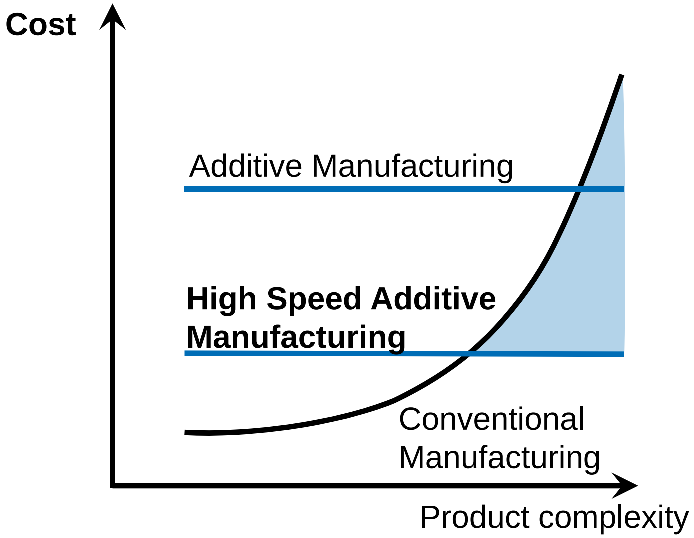
Individualization without cost penalty





***Product architectures** optimized for function, resource and manufacturing efficiency*

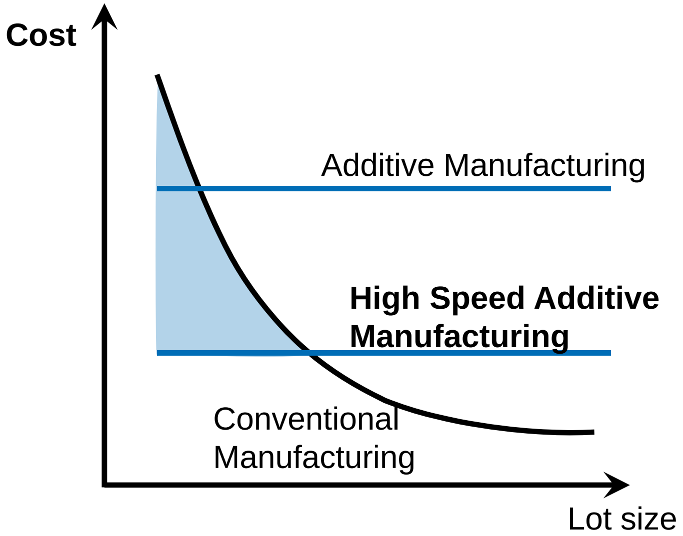
Complexity without cost penalty



***Product designs** optimized for function, resource and manufacturing efficiency*

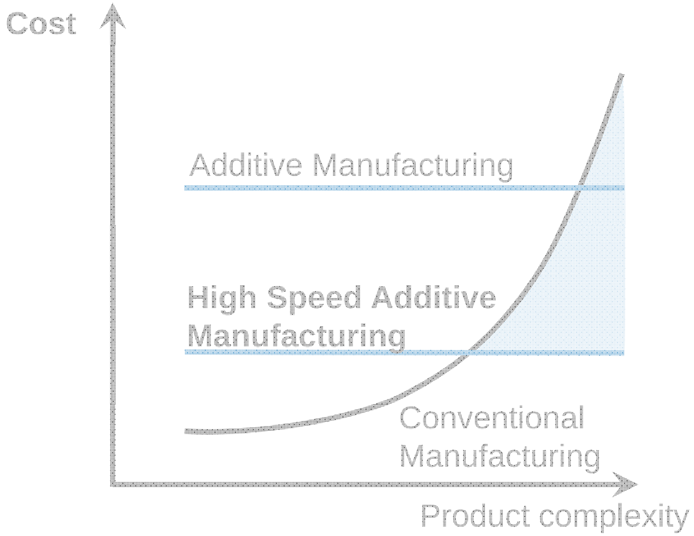
Digital Production

Individualization without cost penalty



***Product architectures** optimized for function, resource and manufacturing efficiency*

Complexity without cost penalty



***Product designs** optimized for function, resource and manufacturing efficiency*

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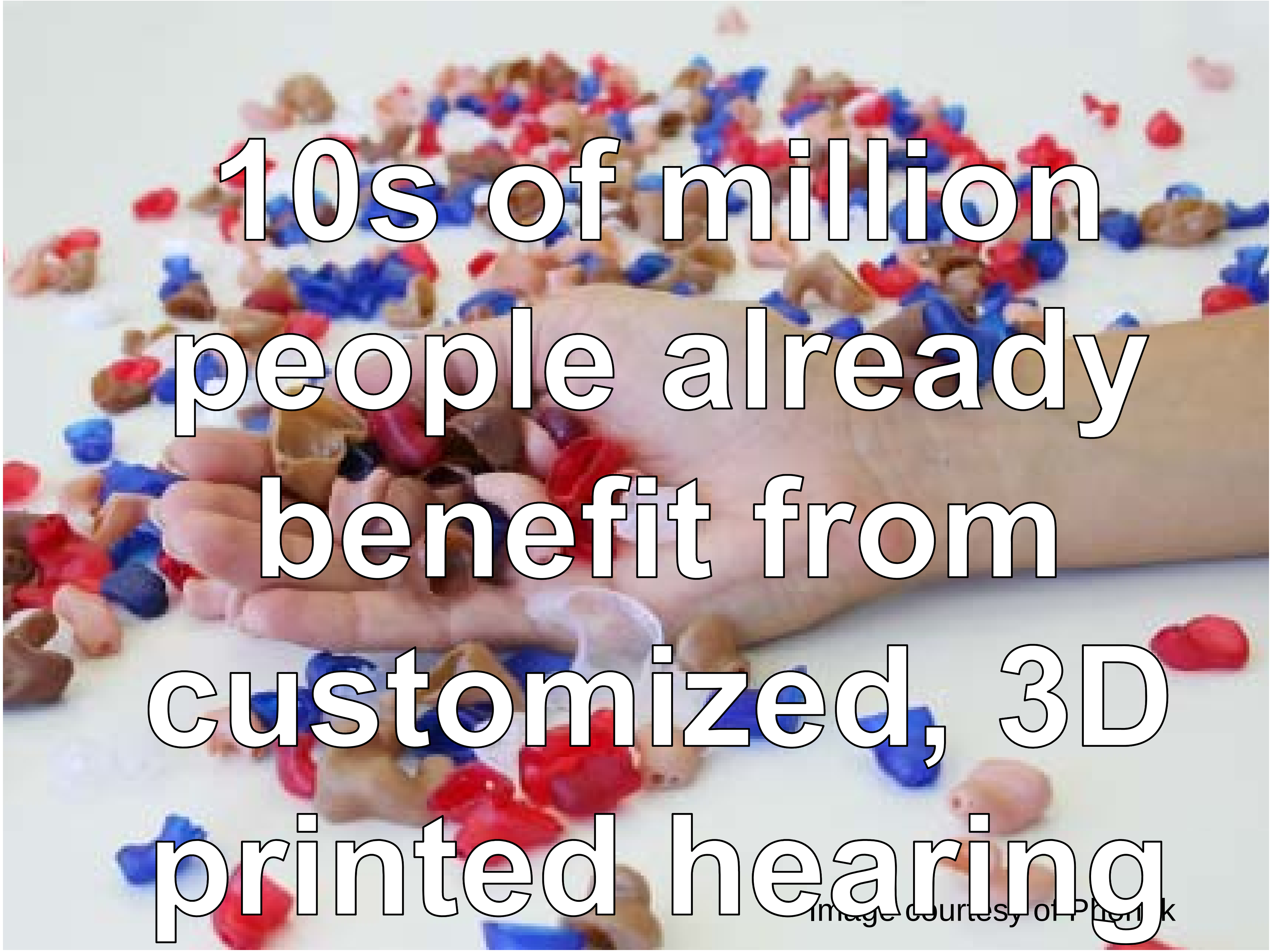
Do we really need / want this?

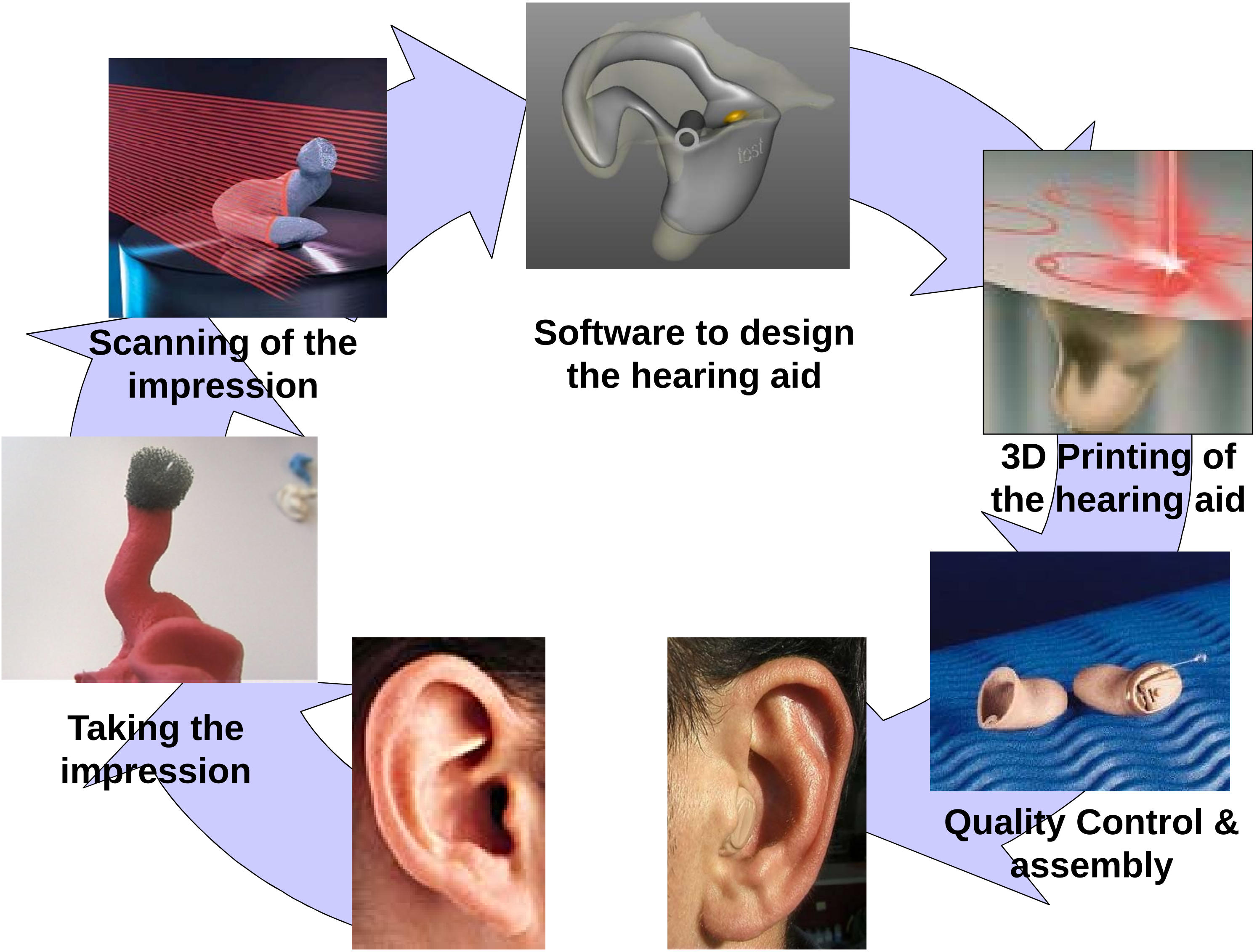
Unfulfilled heterogeneity of demand



10s of million people already benefit from customized, 3D printed hearing

Image courtesy of Pho[illegible]k

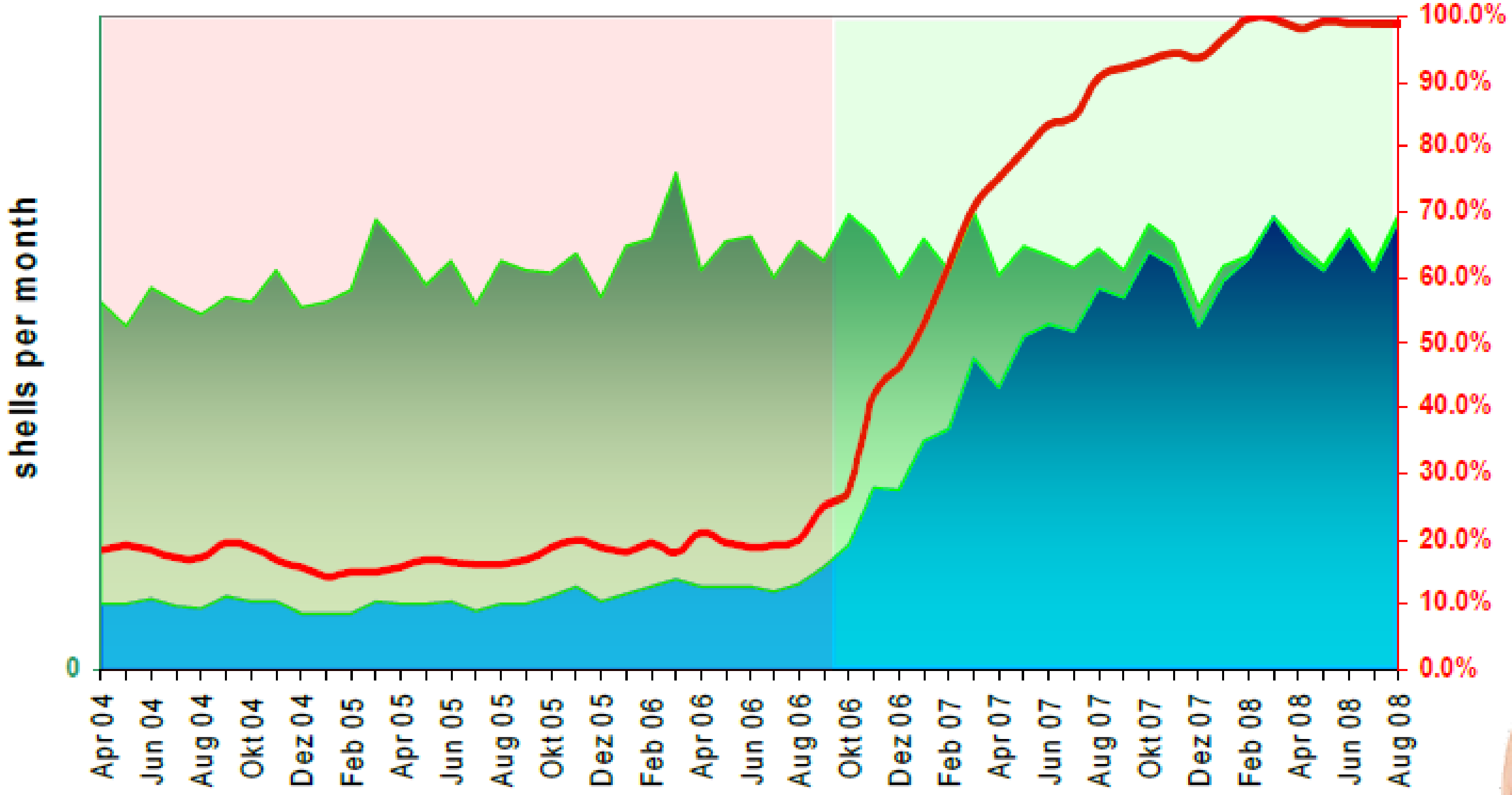
Hearing aids (outer shells) -- an application made for additive manufacturing …

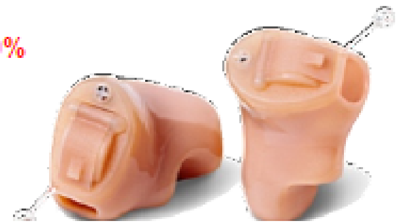


Source: Mazerialise (2014)

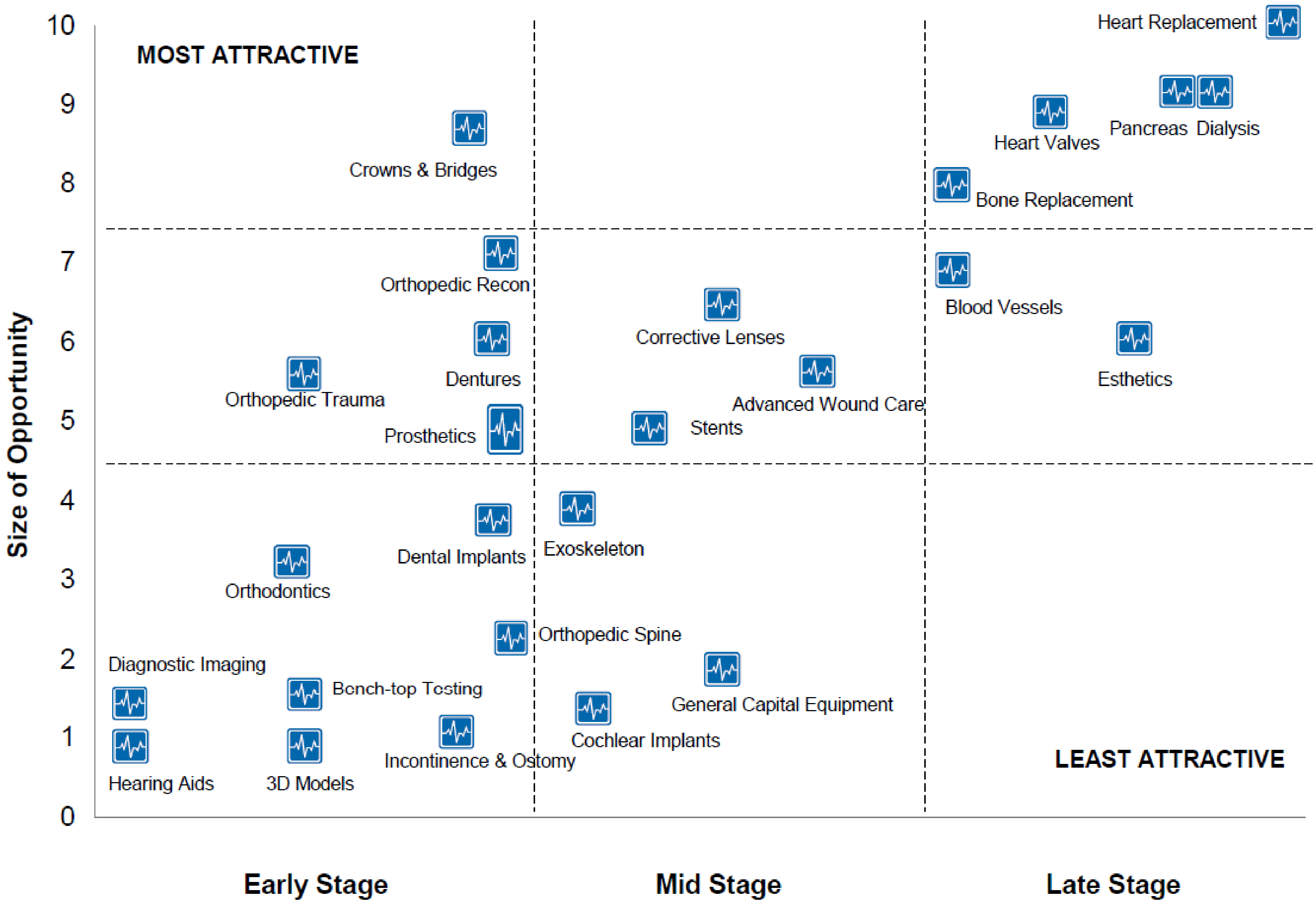
… reaching full market penetration already in 2008

Digital manufacturing of shells to nearly 100% in 2 years – **in 2008**



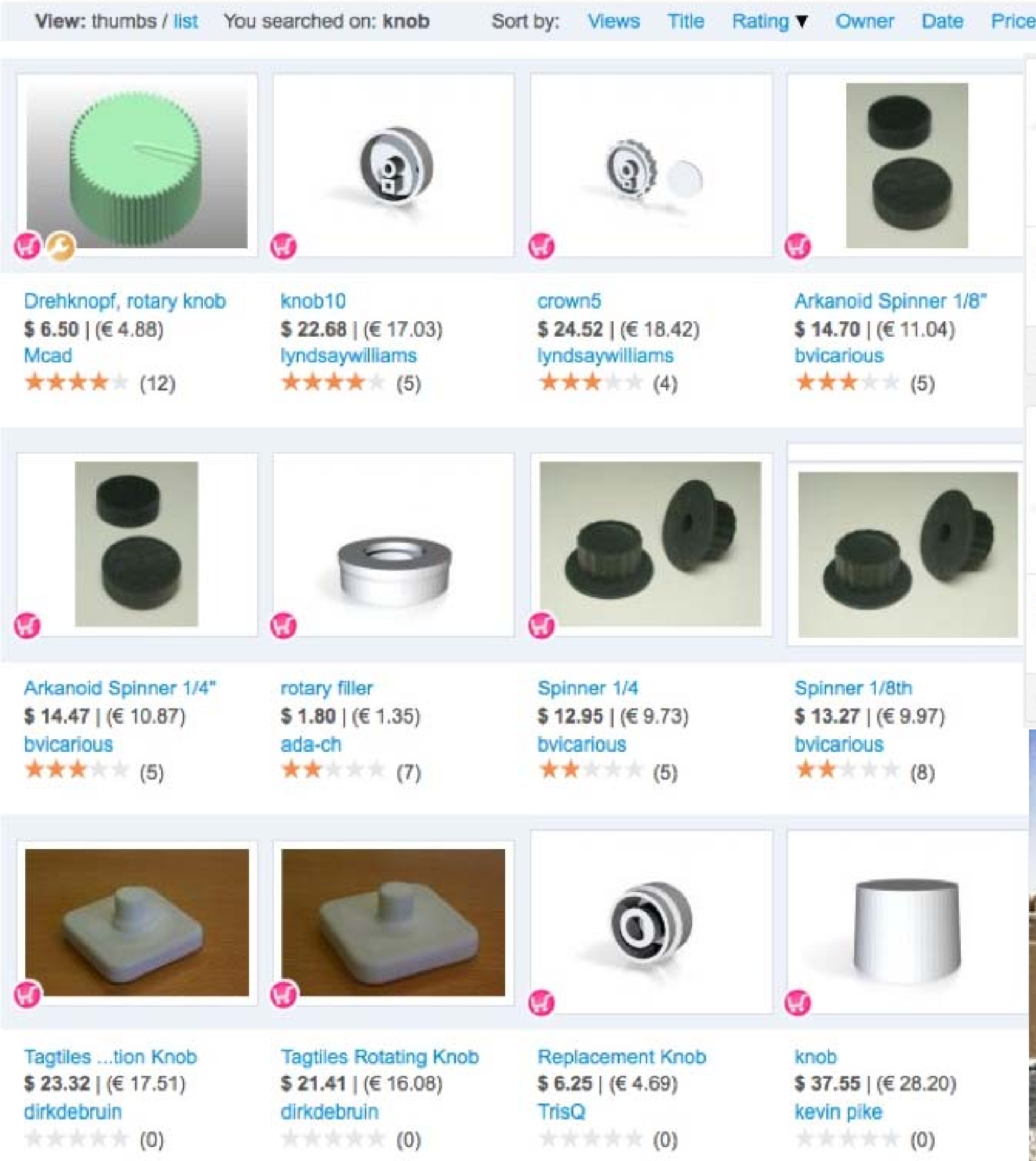


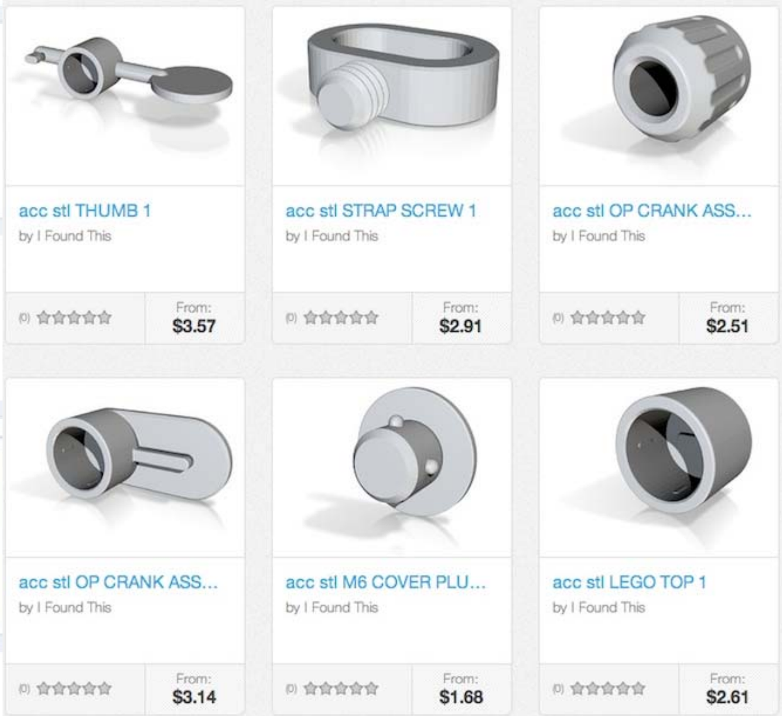
MorganStanley expects many more medical (device) applications of AM – driver is customization!



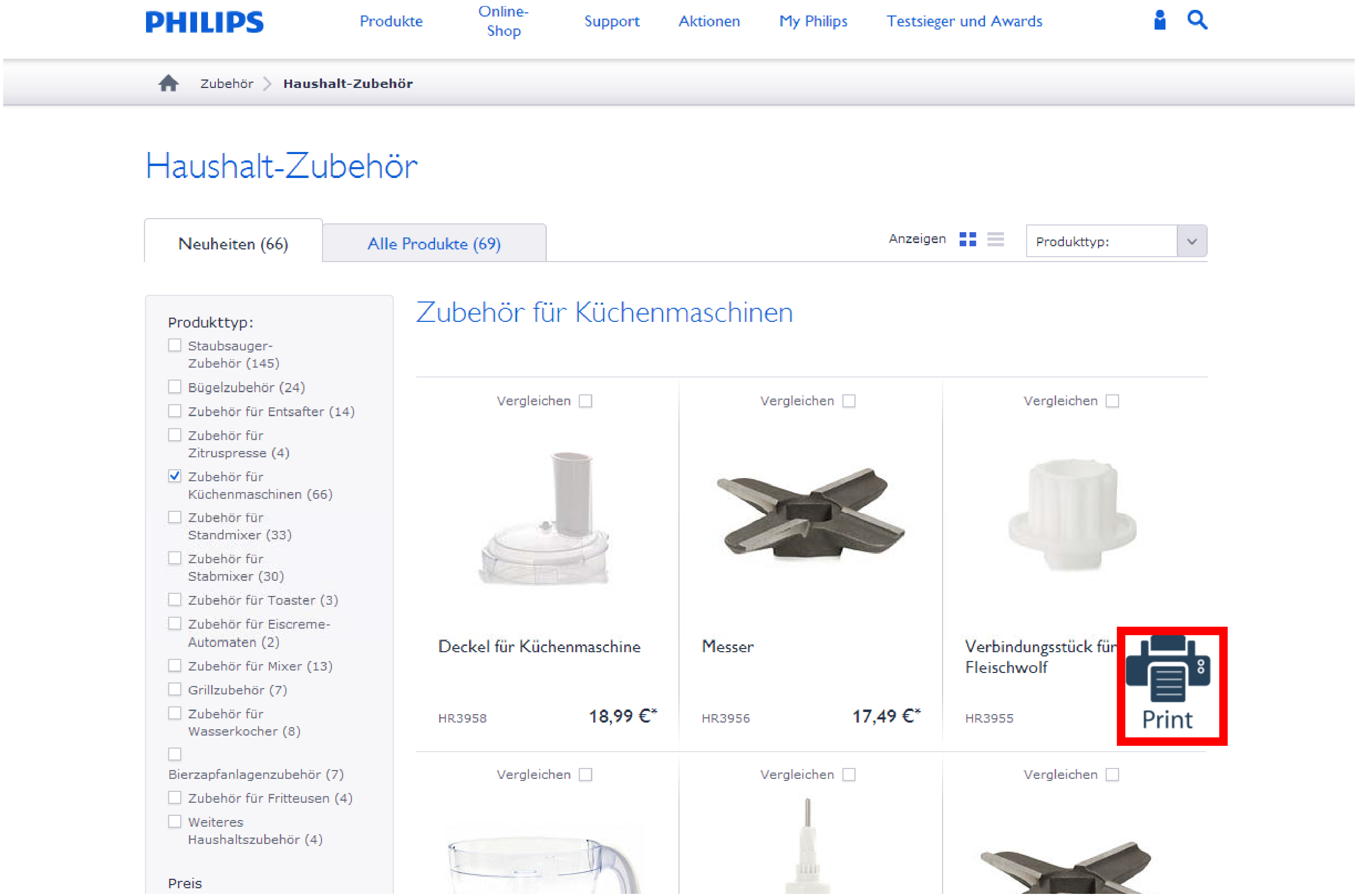
Source: MorganStanley (2013)

One of the central applications for AM are spare parts on demand – both in consumer as well as in industrial markets

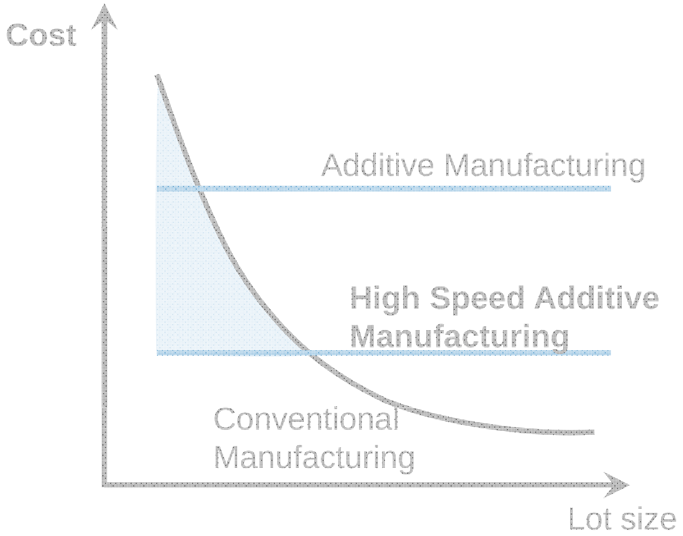


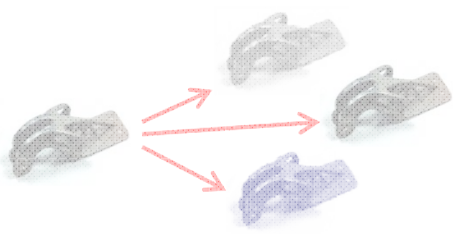


This demands a new integration into existing value chains – several startups are working on this



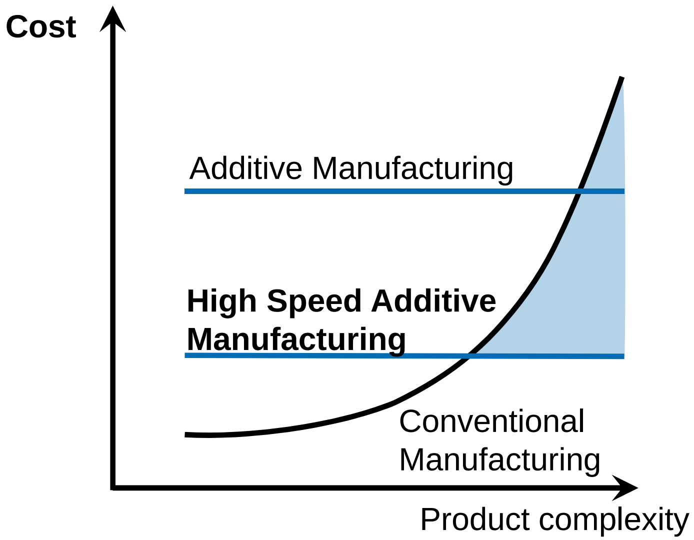
Individualization without cost penalty





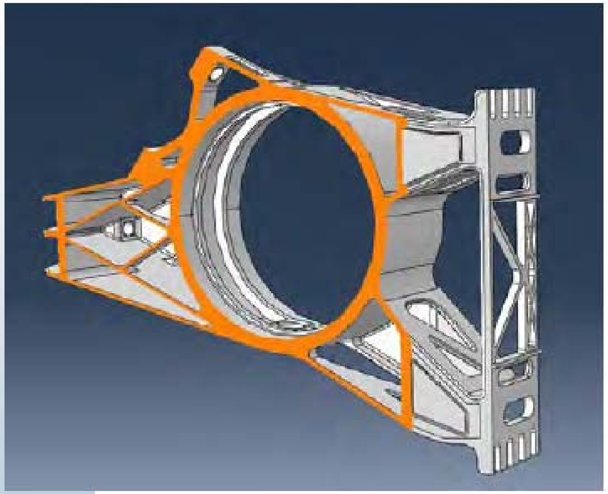
***Product architectures** optimized for function, resource and manufacturing efficiency*

Complexity without cost penalty



***Product designs** optimized for function, resource and manufacturing efficiency*

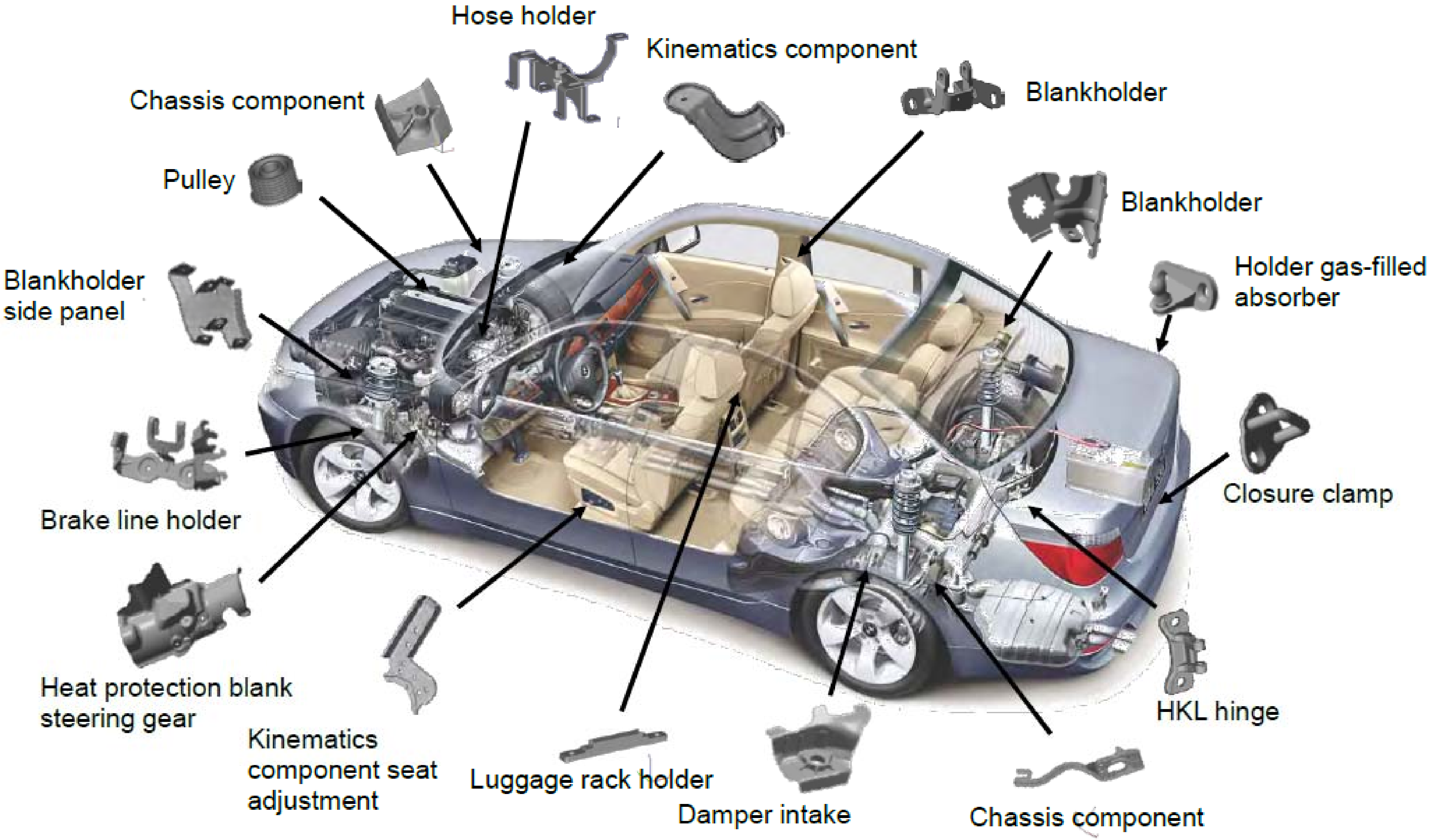
SLM-manufactured upright with hollow structures



- First AlMgSc (Scalmalloy®) part manufactured by HP-SLM
- Weight saving: approx. 20 %

Design for Manufacturing → Manufacturing for Design

Selective Laser Melting SLM – Automotive Examples

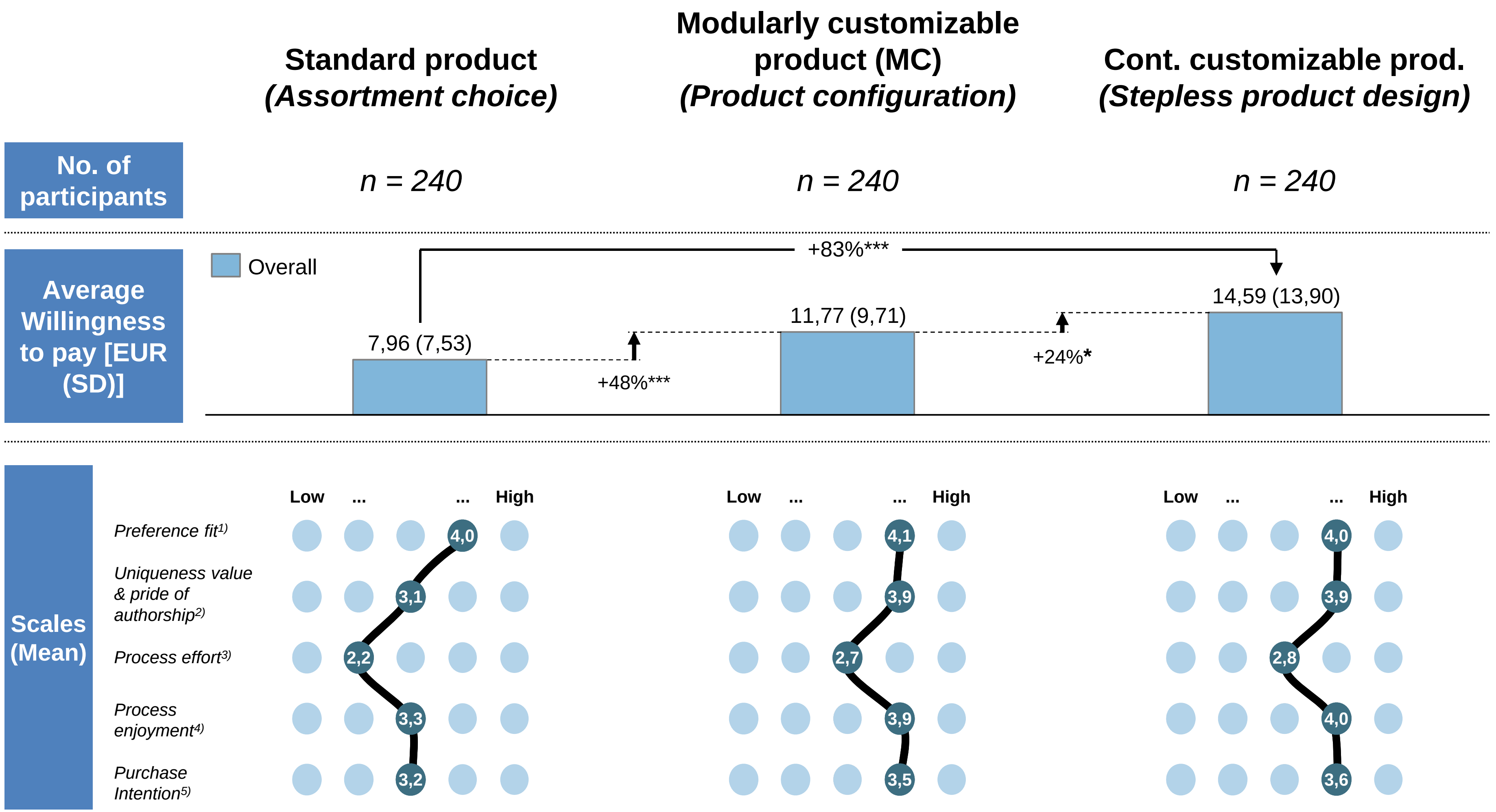


Source: N. Skrynecki, Kundenorientierte Optimierung des generativen Strahlschmelzprozesses, 2010

What are “they” willing to pay for this?

How do we communicate the additional value?

RWTH-TIM Study (2014): Highly customizable product yield a +83% higher WTP compared to standard products



* p < 0,05; ** p < 0,01; *** p < 0,001; WTP values not normally distributed: square root transformation of variable leads to same levels of significance

1) Differences n.s.; For 2), 3), 4) and 5) differences significant** between assortment choice and product configuration as well as assortment choice and stepless product design but n.s. between product configuration and stepless product design

Reality check / Current issues

There is a variety of issues holding back industry from wide scale use of additive manufacturing technologies

Speed – Conventional processes are still significantly faster.

Repeatability – Still little process prediction or closed loop feedback. Therefore, no reliable process.

Poor materials data – Few comprehensive information on material properties. Standardized testing protocols and certifications just under development.

Lack of trained designers/engineers – No one can design for the complex geometries AM offers. Also lack of trained engineers and technicians to optimize the processes and run them.

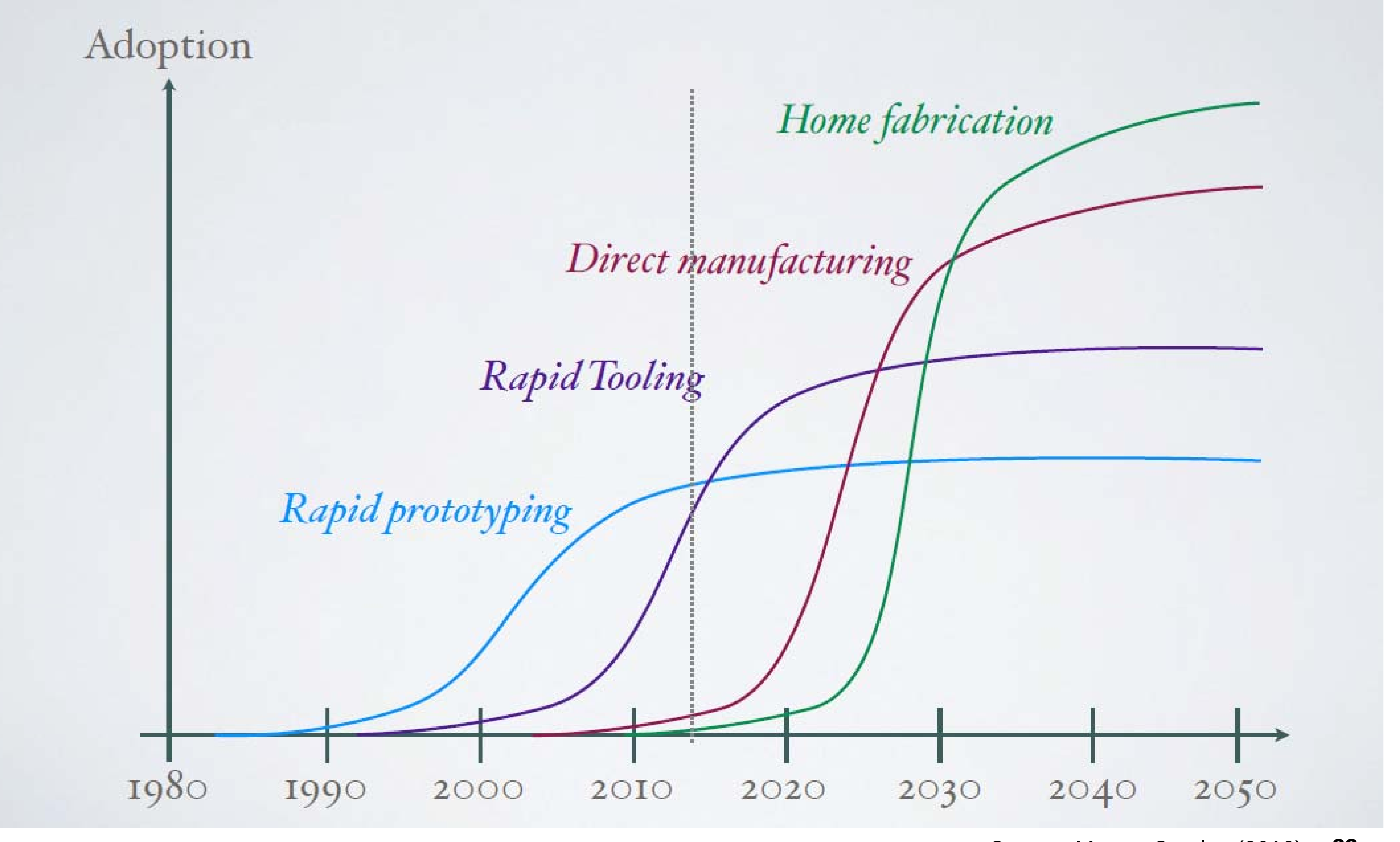
Design Software – Existing CAD does not work well for complex geometries (e.g. internal lattices and surface textures). No CAD solution for geometry optimization and representation of mixed or graded materials etc.

Business Models – AM enables lots sizes of one, customized products and remote manufacturing. This will require companies to design business in a very different way to exploit this technology.

Source: UK Government Report, Technology Panel (2013), Econolyst (2014)

An interesting development: Industrial applications (adoption) is being outpaced (leapfrogged) by “makers”

Home use of 3D printers (home fabrication, “fabbing”) seems to demonstrate the same steep adoption curve like other recent digital consumer technologies /



Source: MorganStanley (2013)

"There is no reason for any individual to have a computer in their home."

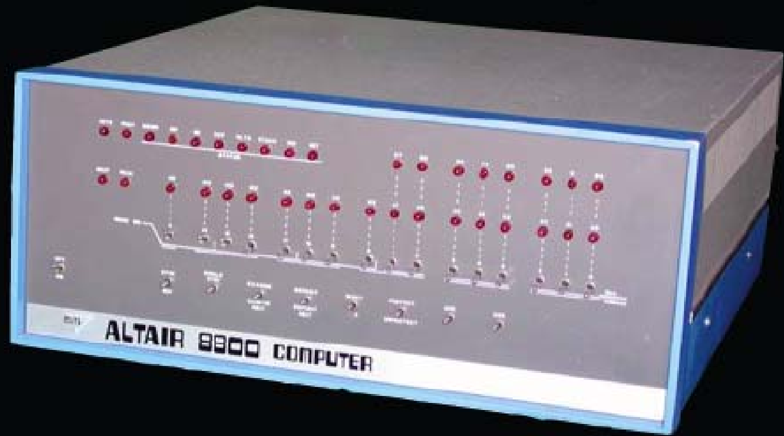
Ken Olsen, President DEC, 1977

While being traditionally a field of large companies (EOS, 3D Systems …), AM hardware is one of the areas where user-generated hardware is becoming an alternative:

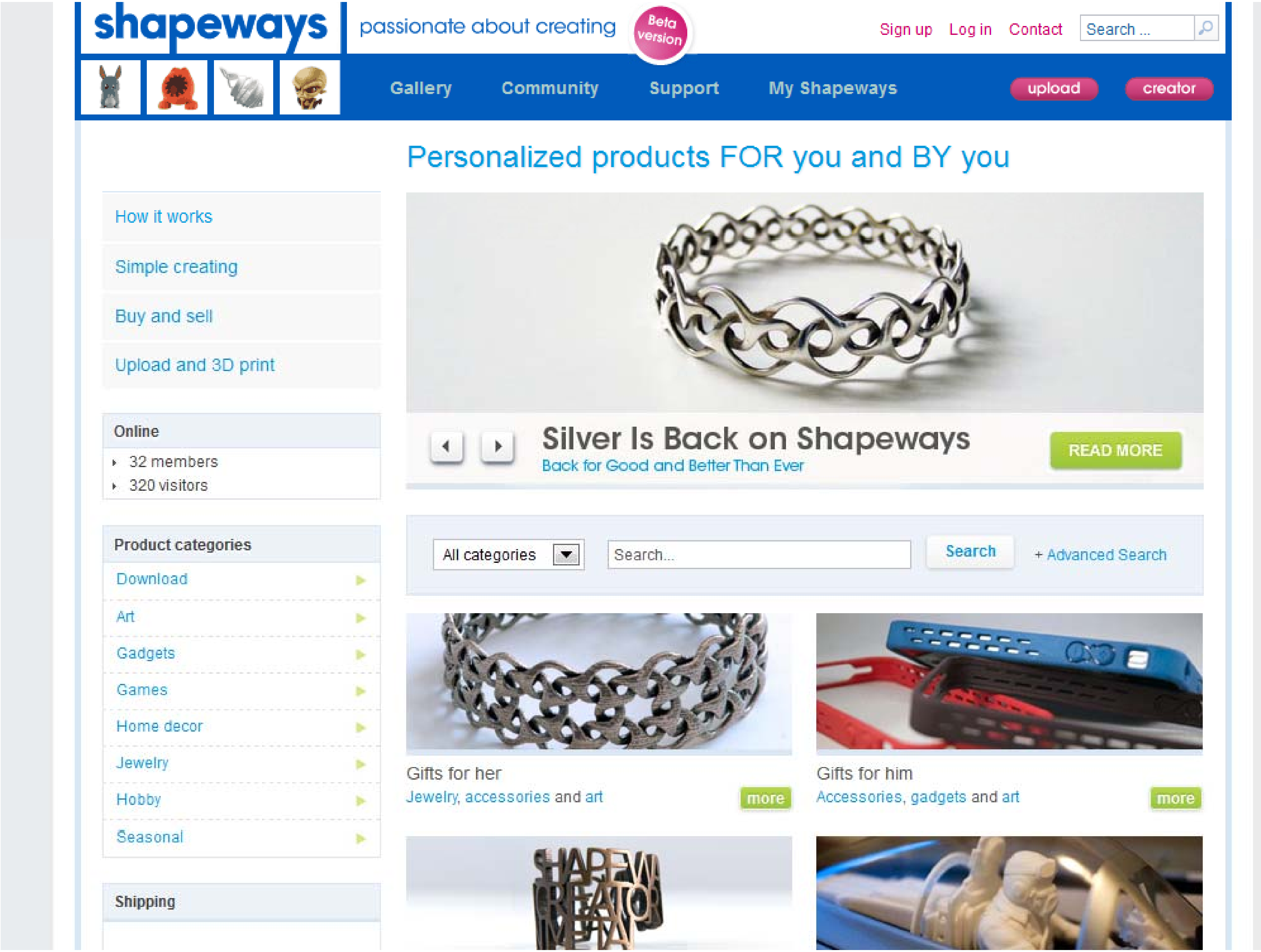
Consumerization of Manufacturing Hardware

(similar to present status quo in IT!)

MakerBot = Altair ?



And why own it when you can share it?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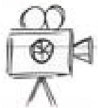

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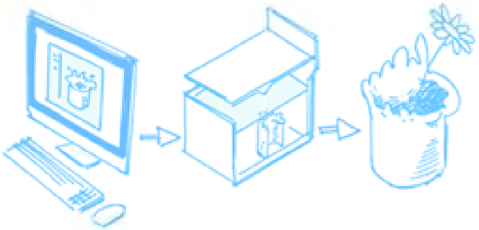

TRY IT OUT NOW or upload your 3D model

Creation corner

Design tools that allow everyone to create unique products.

EXPLORE

This is where perhaps the most serious implications of AM will be

"Digitization in manufacturing will have a disruptive effect every bit as big as in other industries that have gone digital, such as office equipment, telecoms, photography, music, publishing and films."

—The Economist, 4/21/12

Digital assets are made for sharing

An anouncement

Fri

18 Jan 2013

18 January 2013 Last updated at 08:22 ET

4.9K Share

Nokia backs 3D printing for mobile phone cases

Nokia is releasing design files that will let owners use 3D printers to make their own cases for its Lumia phones

The design files will let people produce their own cases for their Lumia 820

Files containing mechanical drawings, case measurements and recommended materials have already been released by the phone maker.

Those using the files will be able to create a custom-designed case for the flagship Lumia 820 handset.

The project makes Nokia one of the first big electronics firms to seriously back 3D printing.

In a blogpost, John Kneeland, one of Nokia's community managers, revealed the Finnish phone maker's decision to release the 3D drawings.

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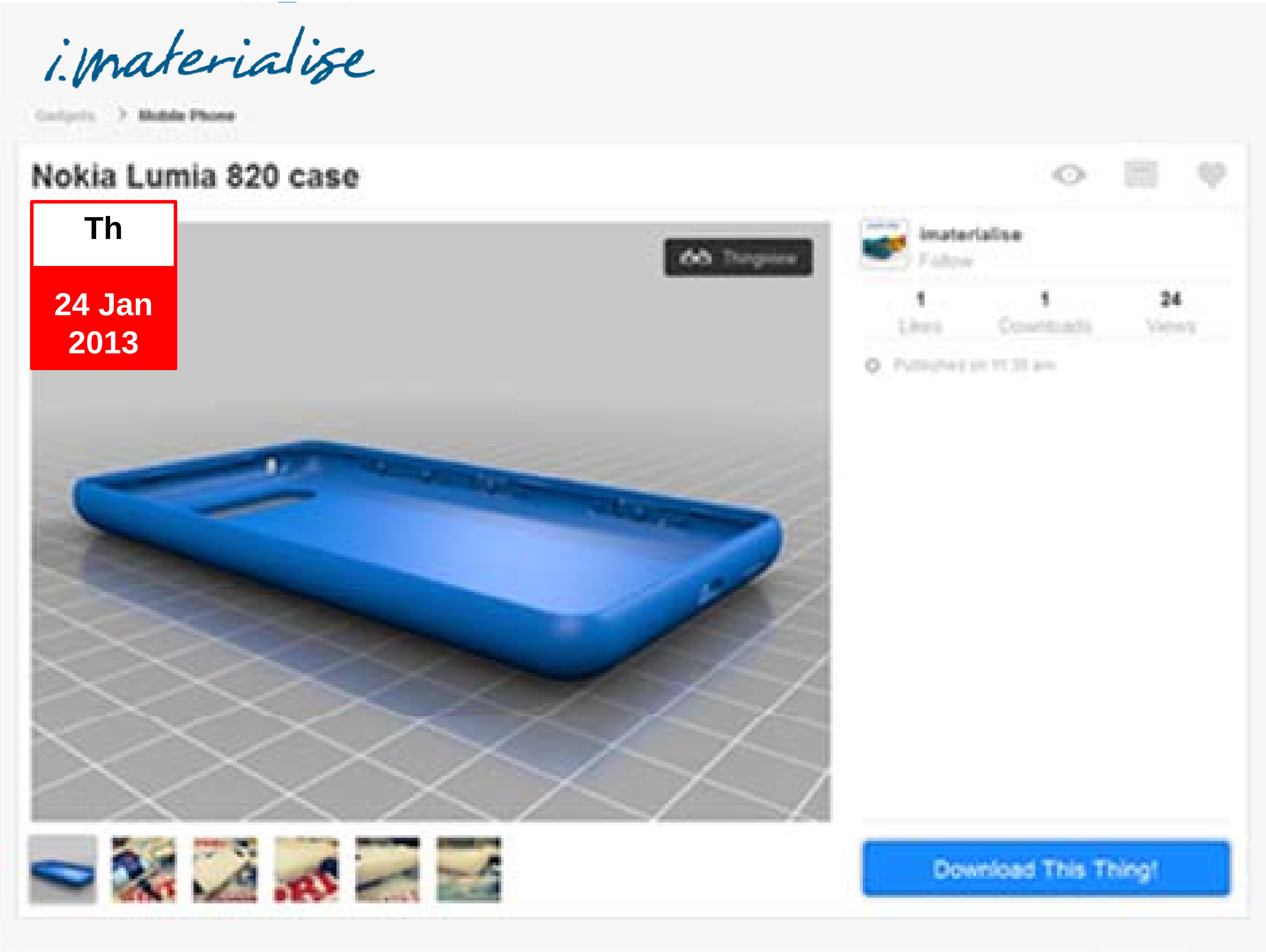

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The opportunities are endless…

Cody Wilson

ABOUT DEFENSE DISTRIBUTED

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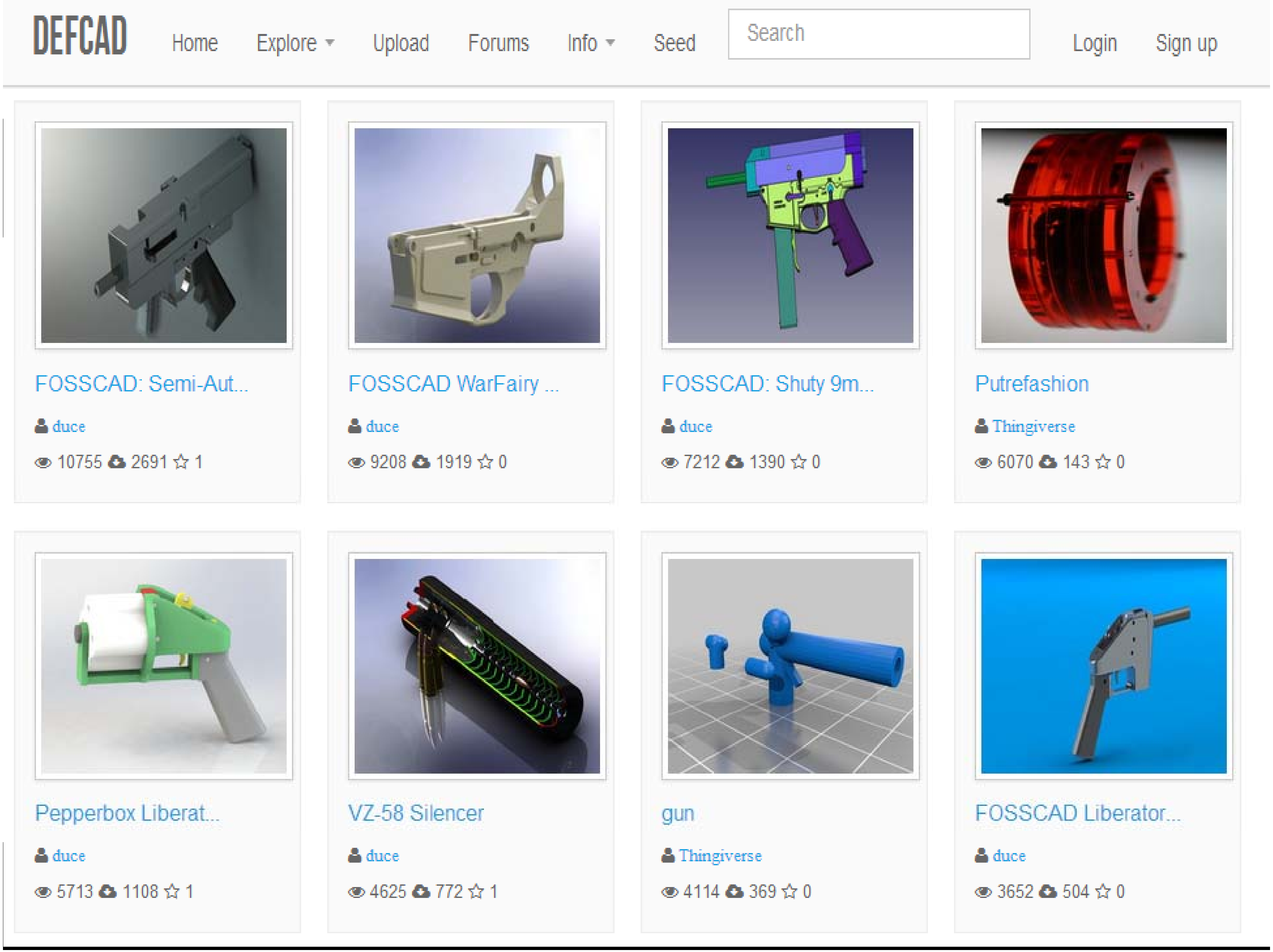
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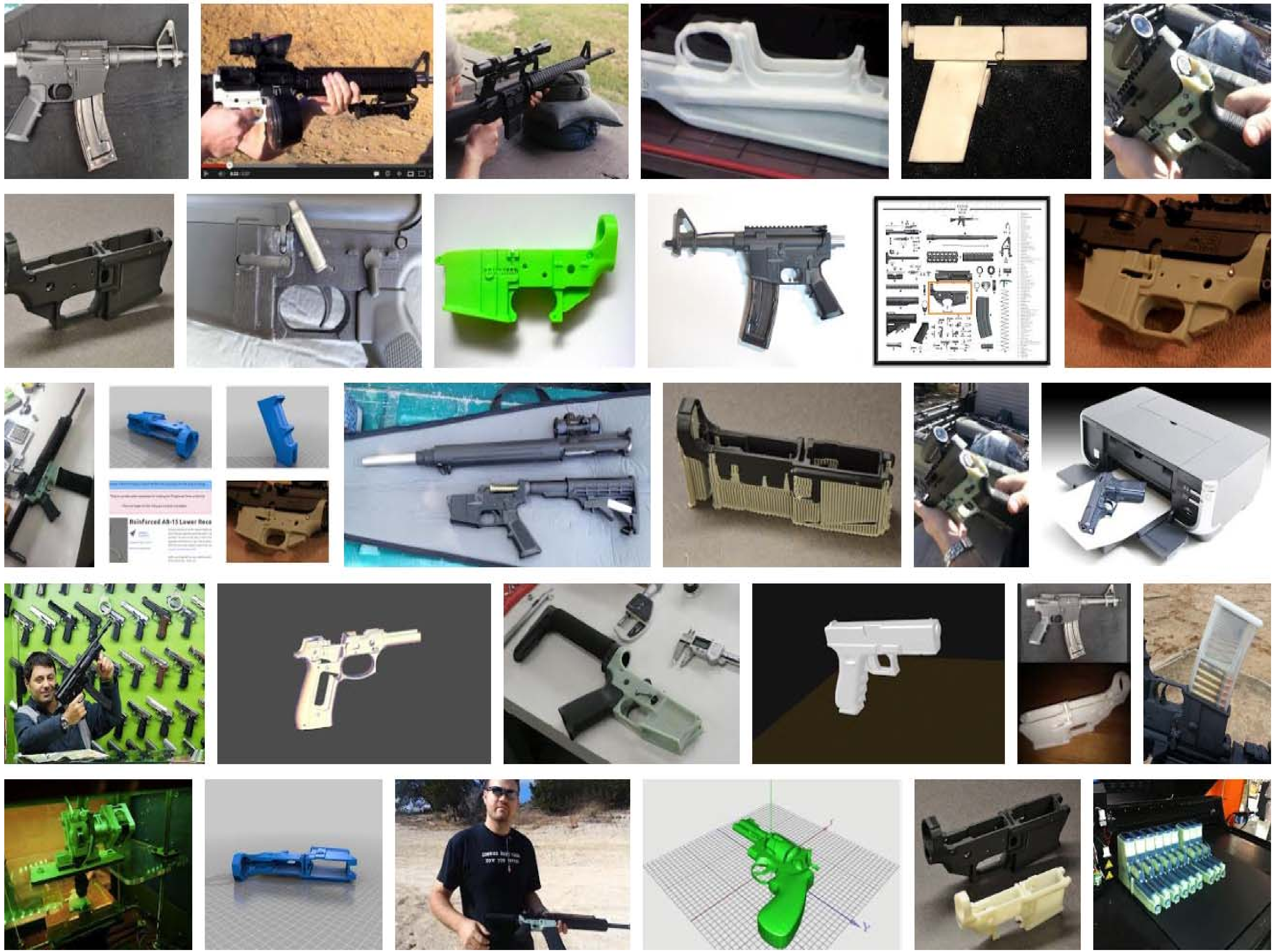
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We urgently need a wider debate on the impact of the maker economy on IP & innovation policy …

… *and especially we have to take care that uneducated speculations are not killing the innovation.*

And manufacturers have to ask themselves: “What is the concert equivalent in our industry?”

Research at RWTH-TIM Concerning AM

- Impact of AM on market structure
  - Effect for incumbents
  - Effect for start-ups
  - Welfare implications

- Impact of AM on the innovation process
  - Cheaper / better Prototyping
  - User innovation → User manufacturing

- New business models with AM
  - Sharing economy
  - How to integrate AM-Technology in existing companies

The central question:

Where can AM provide additional value by fulfilling heterogeneities in your market


TNO innovation for life

TNO innovation for life

MARIJN ROOVERS food design

nxt lvl

400 AD
The Mayans grow cocoa in Yucatán, Mexico.

500
The existence of the first cocoa beverage.

900
King Quetzalcoatl is worshipped as the God of cocoa.

1502
Columbus is given cocoa beans.

1528
Cortés introduces cocoa to the Spanish court.

1615
Chocolate is introduced in France.

1720
Cocoa botanically classified.

1777
The first chocolate factory.

1847
First commercial chocolate bar.

1875
The first milk chocolate.

2013
First complex 3D printed chocolate concept for gastronomy.

Contact:

RWTH Aachen University

TIM Group

kleer@time.rwth-aachen.de

http:\\time.rwth-aachen.de\tim