Centro de Tecnologia da Informação Renato Archer

# *Industry 4.0 and Additive Manufacturing (AM)*


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CTI Renato Archer - Brazil

3D Technologies Division


Santiago – May, 3rd 2016

NACIONES UNIDAS
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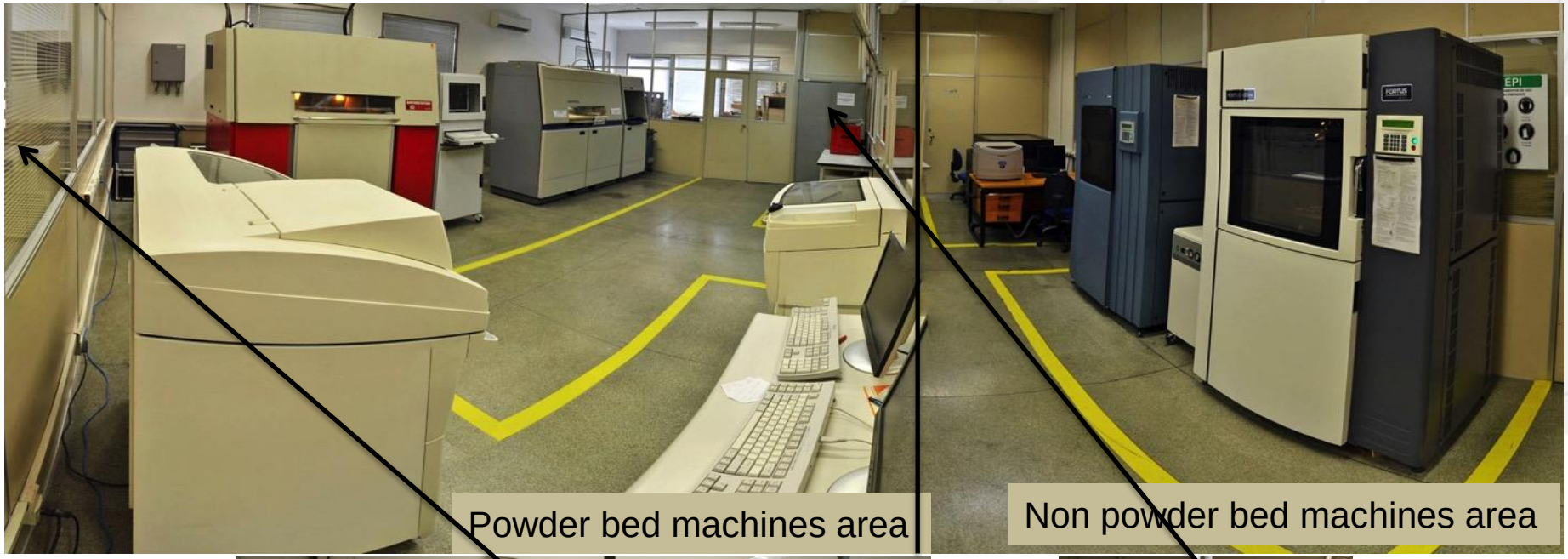
# CTI Renato Archer - AM infrastructure



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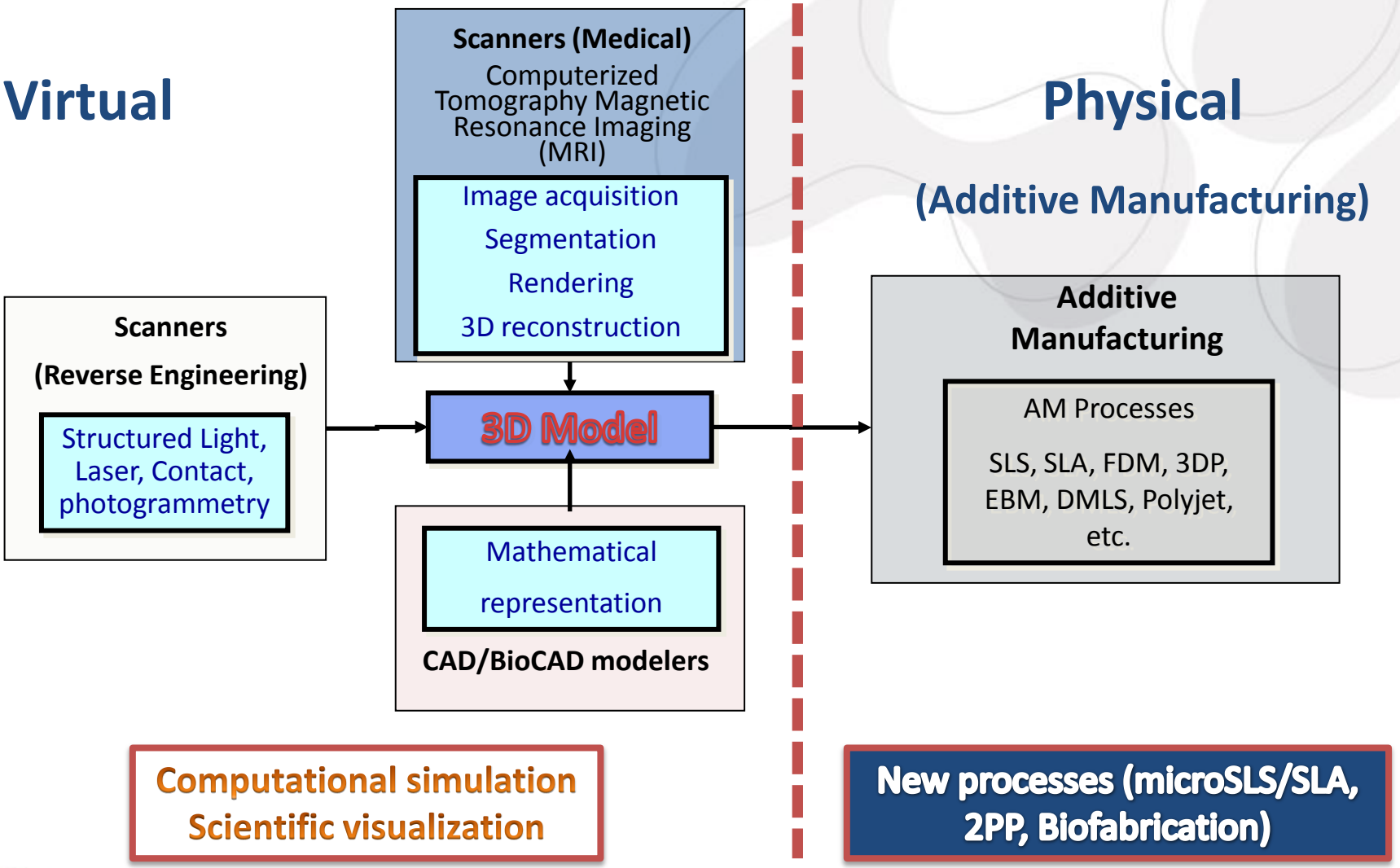
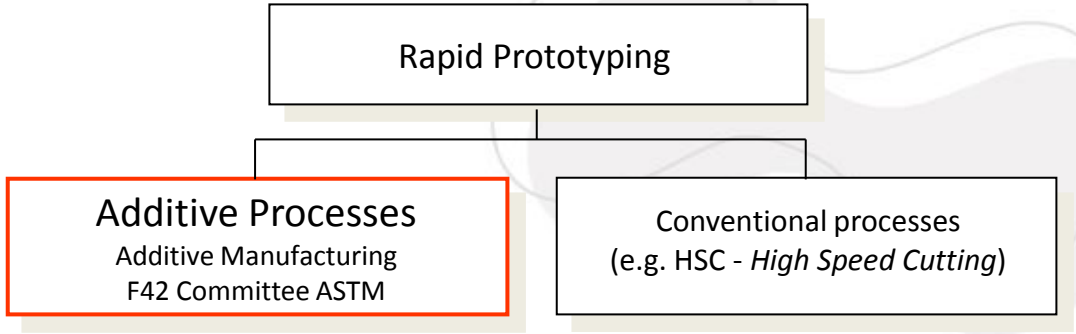
# 3D Technologies

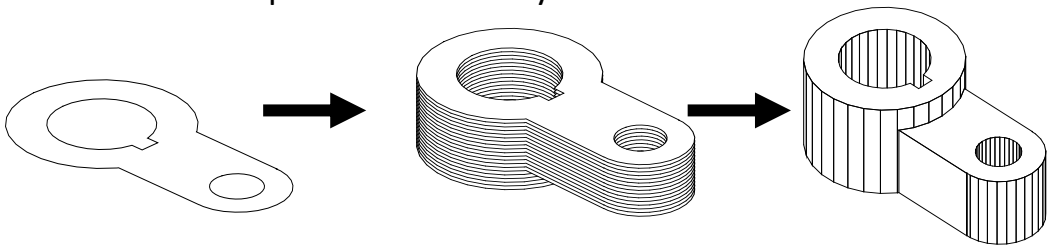


# Additive Manufacturing (AM) concepts

## Rapid prototyping, Solid Free-form fabrication, 3D printing




Controlled deposition of thin layers of material to build a solid



Originally a tool for product development

- Aeronautics industry
- Automobile industry
- Goods industry

Modeling and Process planning for RP

- Virtual model generation (CAD/Reverse engineering/MIP systems)
- Process planning
- Processing (RP process)
- Post processing

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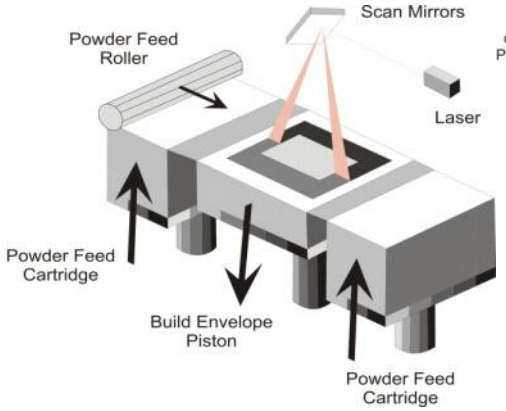
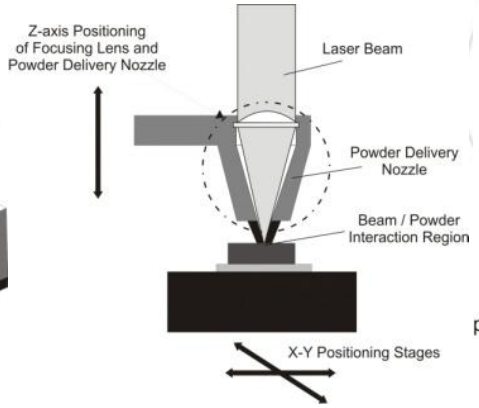
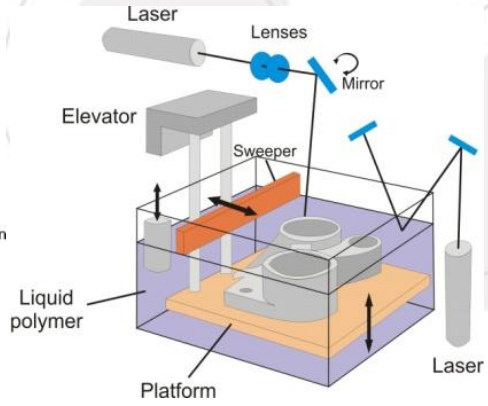
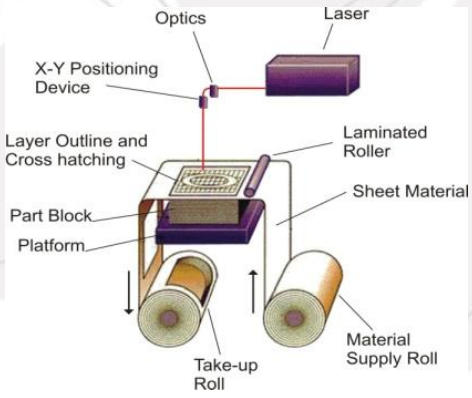
# ASTM/ISO Standard – 7 Classes of AM processes

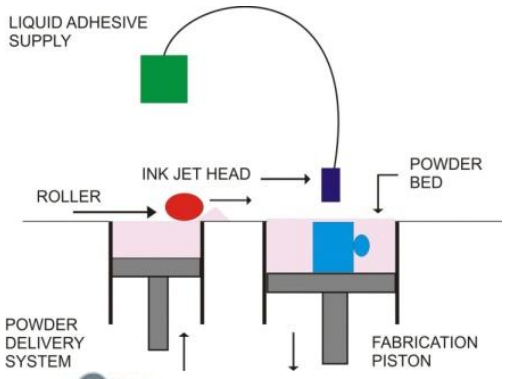
| laser | | | |
|---|---|---|---|
| Metallic or polymeric Powder (SLS/DMLS) | Metallic powder (LENS) | Liquid Resin (SLA) | Sheet (LOM) |
| ink-jet head | electron beam | extrusion head | UV lamp/ink-jet head |
| Ceramic Powder (3DP) | Metallic Powder (EBM) | Polymeric Filaments (FDM) | Liquid Resin (Objet) |

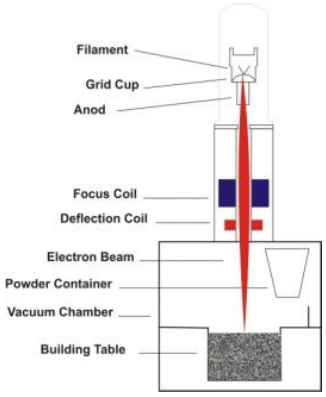


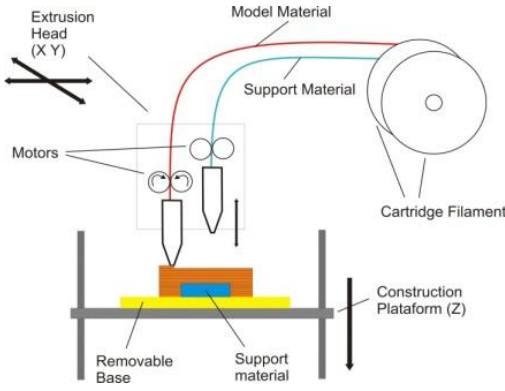



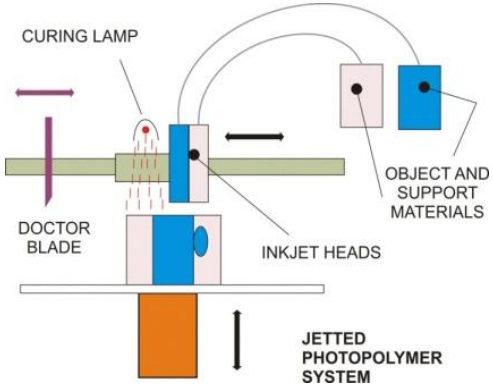

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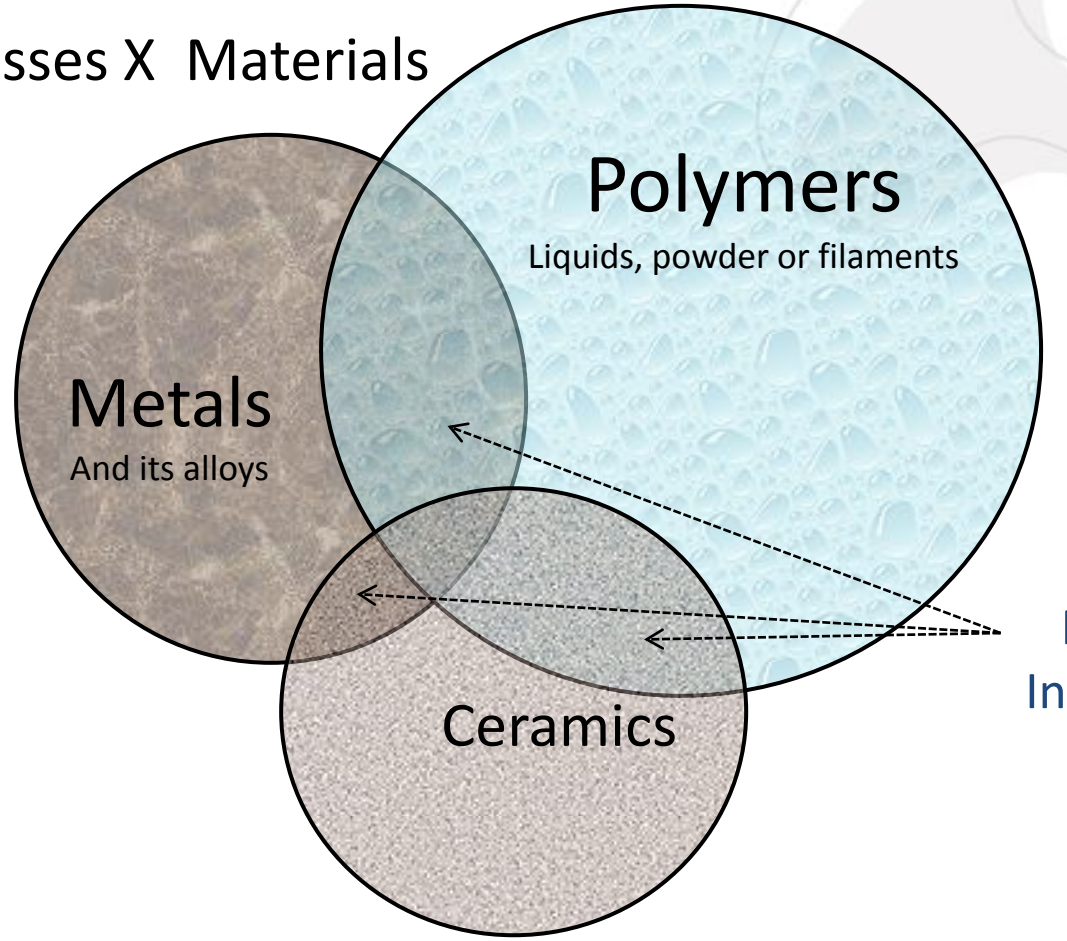
# Materials for AM

Processes X Materials

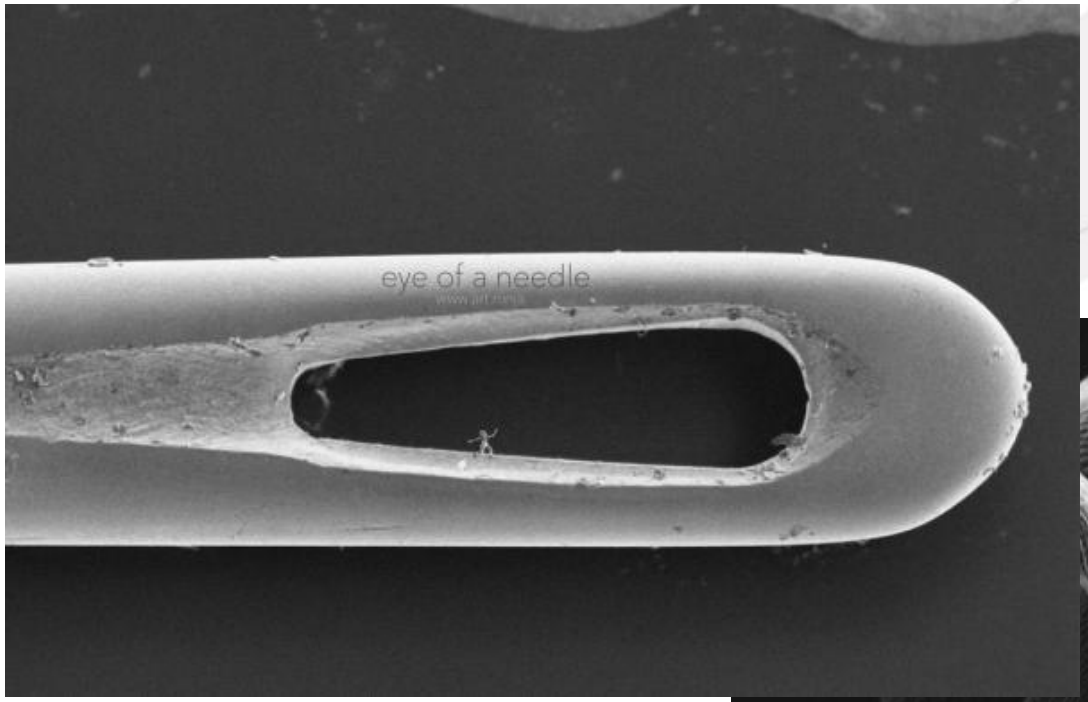


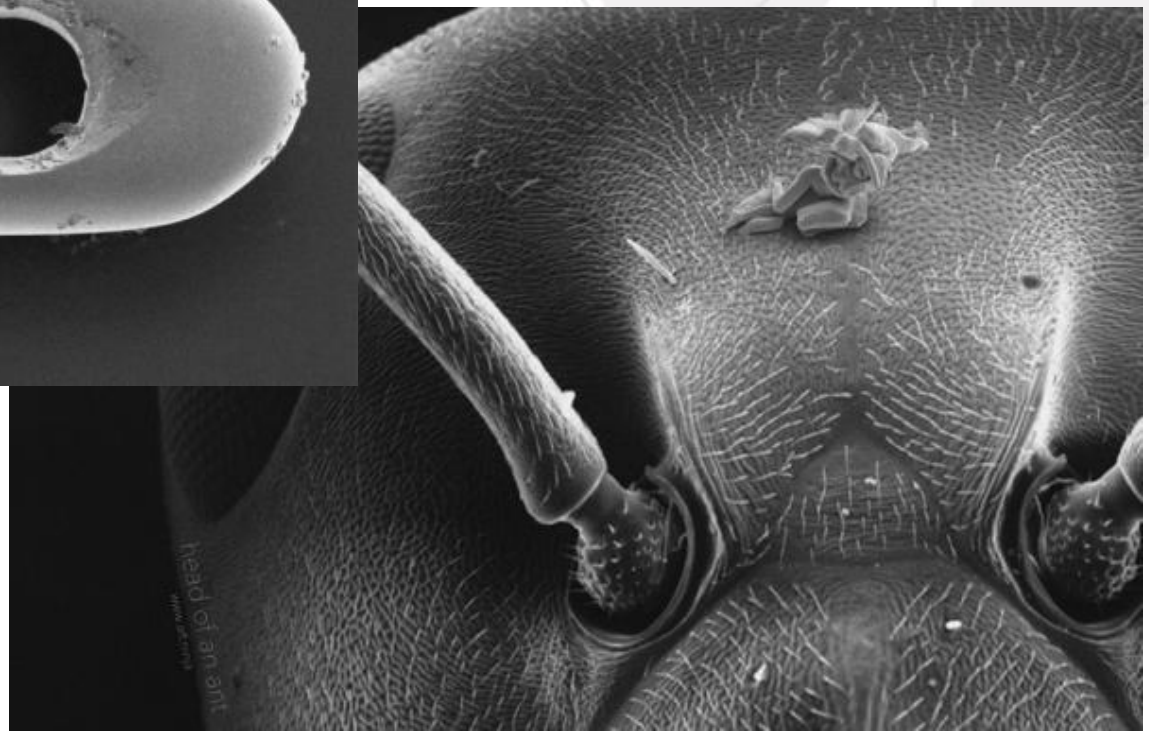

Composite
Functional graded materials
Incorporation of nanomaterials

Biomaterials
(synthetic and biological)

A very restricted class of materials for AM can be implanted in to the human body

# Two Photon Polymerization

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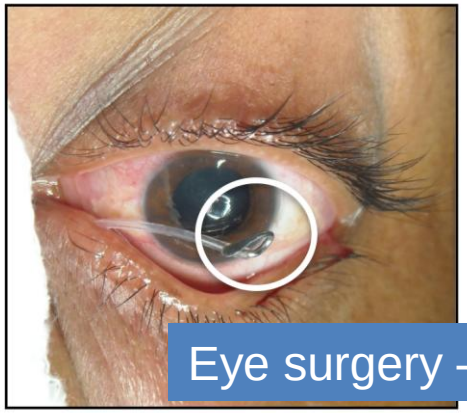
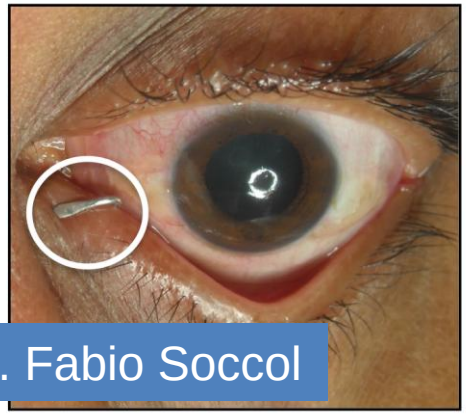
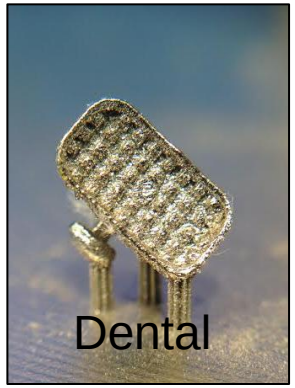
Source: http://www.3ders.org/articles/20141115-jonty-hurwitz-3d-printed-nano-sculptures-at-the-same-scale-as-a-human-sperm.html

# Metallic Additive Manufacturing


Orthopedic



Eye surgery – Dr. Fabio Soccol


Immediate Load – Dr. Giovanni Giacomo


Dental

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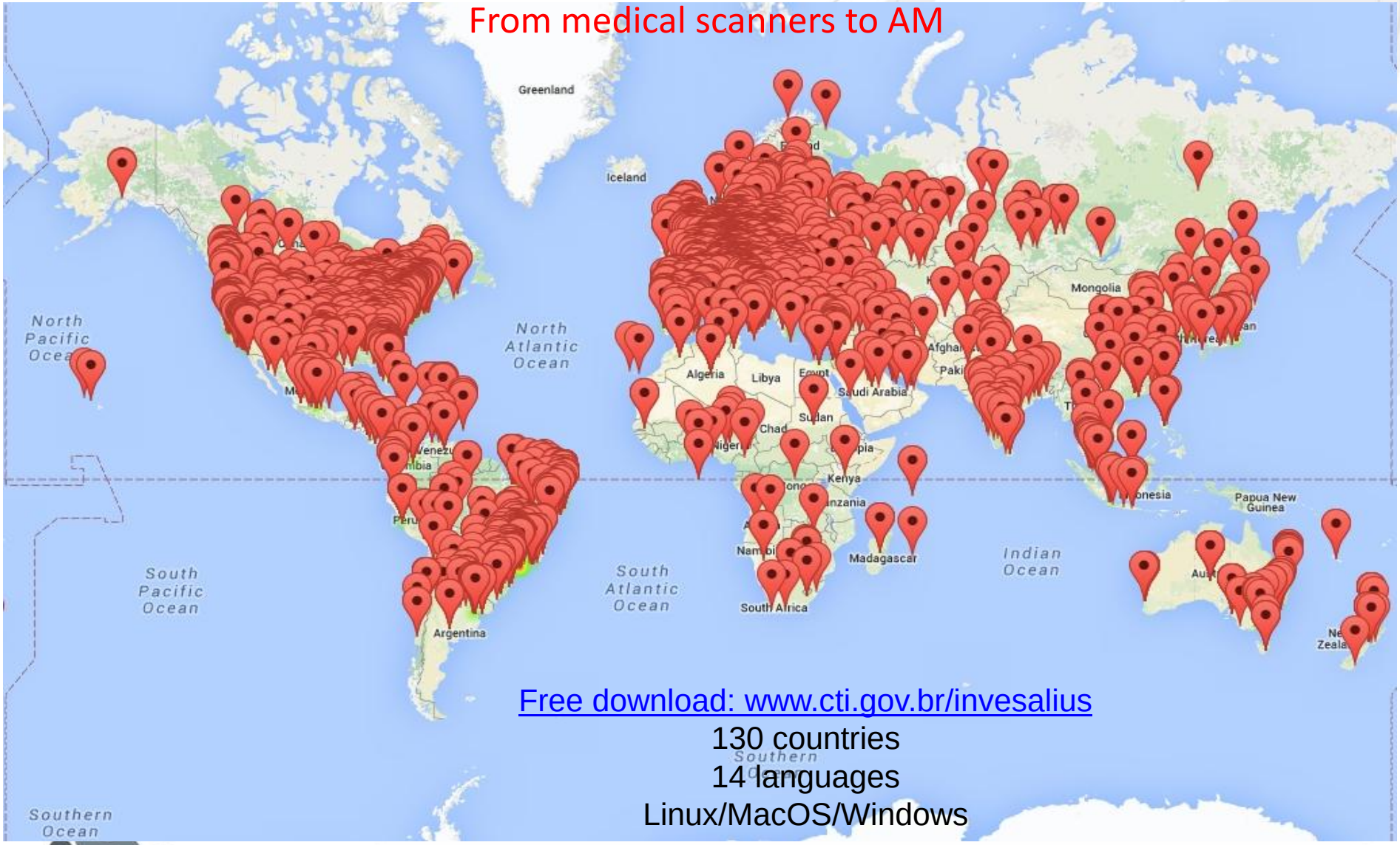
Thanks to Techno How and Concept Laser

# CTI Renato Archer - InVesalius

From medical scanners to AM




[Free download: www.cti.gov.br/invesalius](www.cti.gov.br/invesalius)

130 countries

14 languages

Linux/MacOS/Windows

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# Logistics


Home Press Releases Current Press Releases The UPS Store Makes 3D Printing Accessible to Start-Ups and Small Business Owners

## The UPS Store Makes 3D Printing Accessible to Start-Ups and Small Business Owners

San Diego, July 31, 2013

***The UPS Store®*** **today announced it is the first nationwide retailer to test 3D printing services in-store. Select *UPS Store* locations will be offering the services to start-ups, small businesses and retail customers, beginning in the San Diego area with locations in additional cities across the United States in the near future.**

## Stratasys, UPS Team up to Bring 3DP to 100 Stores in the US

The Engineer posted on September 30, 2014 | Comment | 1633 views

## Industrial Scale 3D Printing Factory at UPS Announces another First, Same-Day Shipping

Article Comments (0)

June 30, 2015 11:01 AM EDT Tweet 0 Like 0 Send to a Friend

LOUISVILLE, KY (PRWEB) June 30, 2015

CloudDDM, LLC, a company focused on delivering direct digital manufacturing, DDM, services, announced today their new same-day shipping service for 3D printed parts out of their 3D printing factory operating at UPS Worldport®, the world's largest packaging handling facility.


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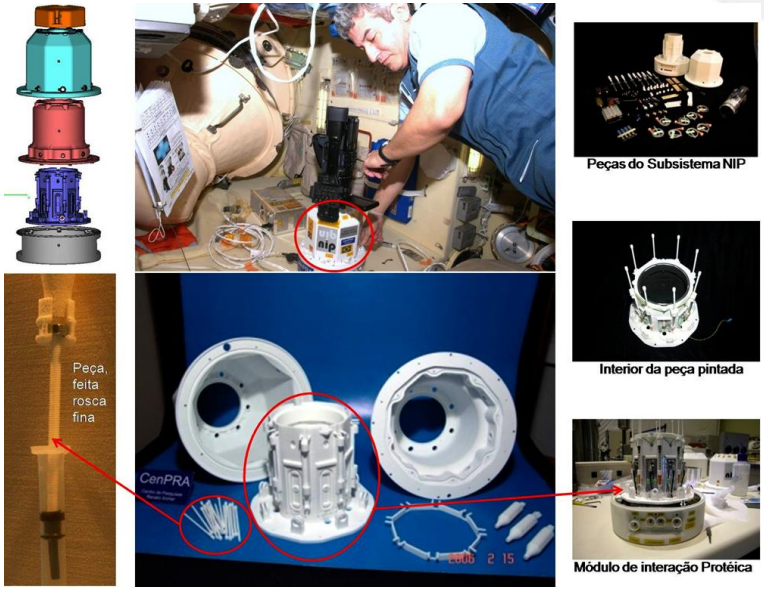
# Aerospace

Many parts already certified for flying (Airbus / Boeing).
Non mission critical (yet)

International Space Station
“Made in Space” Program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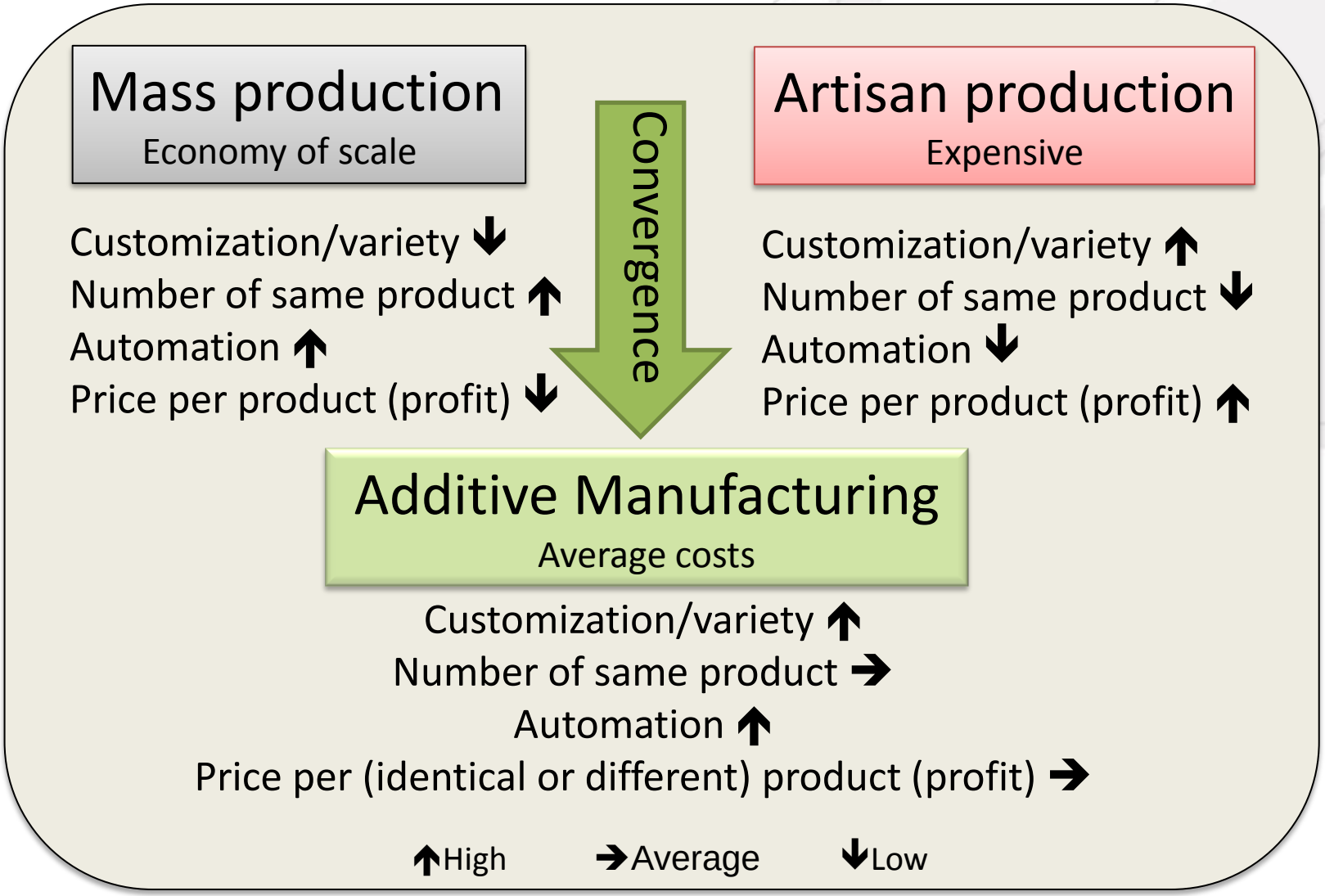
Maia et al (2008) Maia, I.A., M.F. Oliveira, P.Y. Noritomi, J.V.L. Silva. Application of Rapid Manufacturing to build artifacts for using in microgravity environment. An International Space Station case. Virtual and Rapid Manufacturing. (Bártolo (Ed)), 559-562, Taylor and Francis Group, London.

# Additive Manufacturing

- Additive Manufacturing is a strategic area;
- AM is multiuse and taking-off as a serious manufacturing process;
- Energy optimization (green technology);
- Mass customization;
- Highly flexible / less investments (SME);
- Reduce supply chain (from jus-in-time logistics to “just-in-place“ manufacturing);
- Stable growing of 60-70% yearly (metal AM);
- New regulations and testing for processes and materials are on the way.

# Additive Manufacturing

- Quality control “on-the-fly”;
- Pay by weight - complexity is for free;
- Open-source software -> open-source hardware -> open design;
- Comply with Industry 4.0 (is mainly IT);
- To be cheaper, faster and higher quality;
- Needs improvements in processes (stability and repeatability);
- Needs improvement in materials for final use;
- Disconnection between software and hardware;
- New design process for AM (CAD/CAM/CAE) is necessary.


Mass production
Economy of scale
Customization/variety ↓
Number of same product ↑
Automation ↑
Price per product (profit) ↓
Convergence
Artisan production
Expensive
Customization/variety ↑
Number of same product ↓
Automation ↓
Price per product (profit) ↑
Additive Manufacturing
Average costs
Customization/variety ↑
Number of same product →
Automation ↑
Price per (identical or different) product (profit) →
↑High
→Average
↓Low

# AM in USA

Former NAMII (National Additive Manufacturing Innovation Institute)

"America Makes"
Public-Private Partnership
Industry-Government-Universities

https://www.americamakes.us/membership/membership-listing


160+ members

"Forefront of AM research, technologies, processes, materials, and education"

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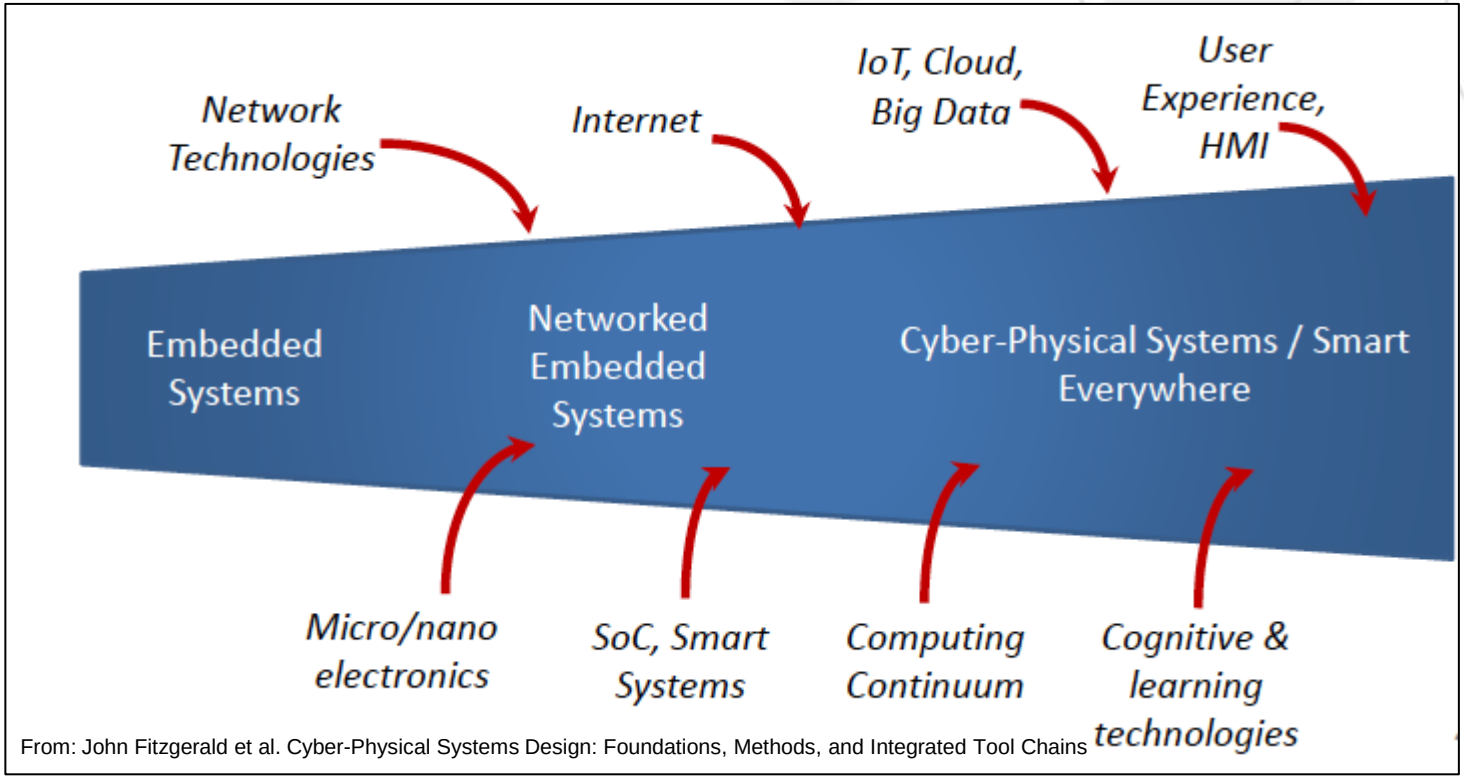
# Cyber-Physical Systems (CPS)

- CPS integrate computing and physical systems (embedded systems, smart sensors/actuators, etc.);
- CPS is the basis for Industry 4.0;
- Involves complex systems modeling.




From: John Fitzgerald et al. Cyber-Physical Systems Design: Foundations, Methods, and Integrated Tool Chains

# AM fits Industry 4.0 purposes

## Industry 4.0

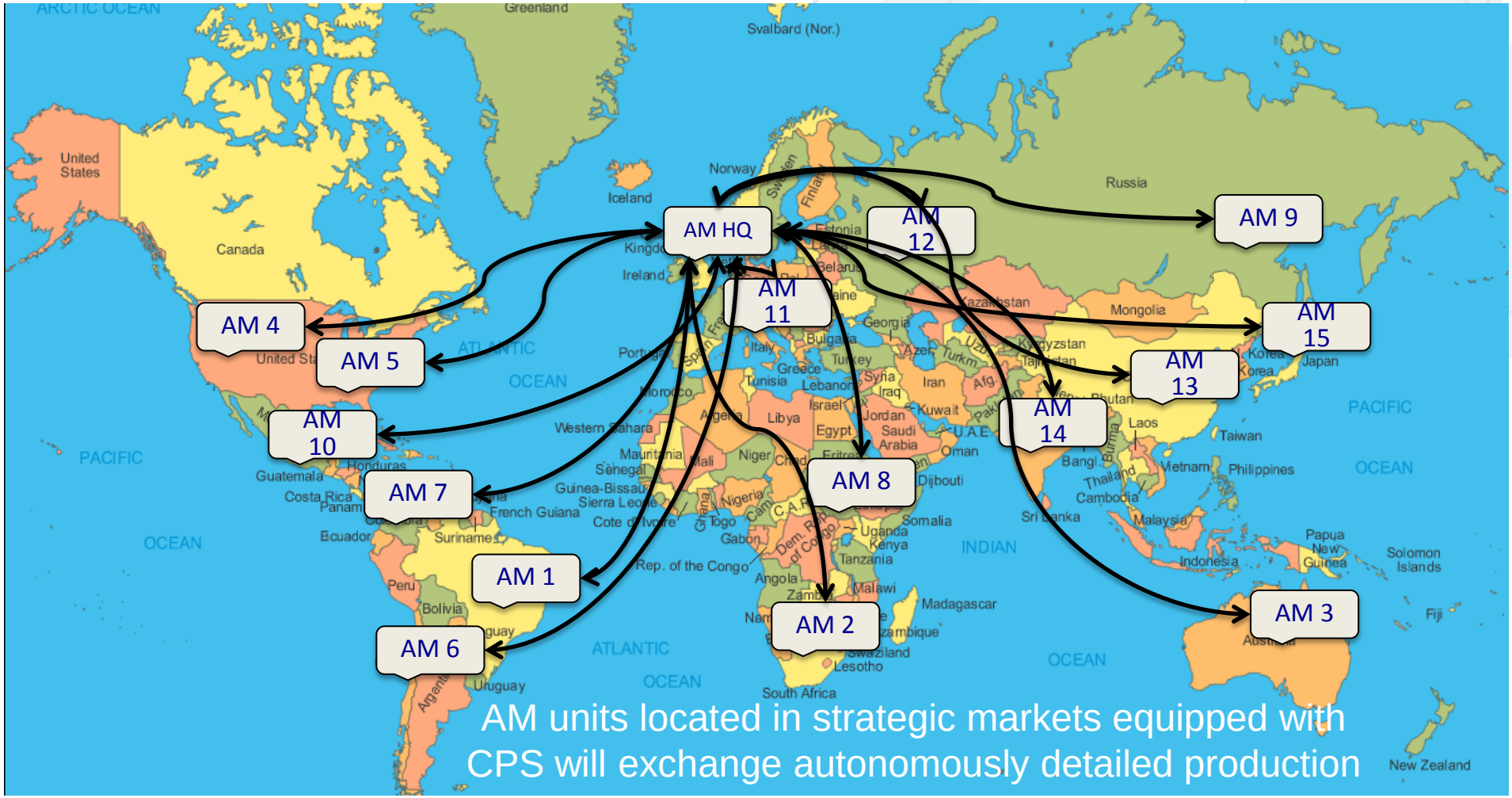
Advanced control systems + Internet technology

Effective communication between people, products and complex systems

- Mass customization;
- High flexibility;
- Decentralized production;
- Resource efficiency (green technology);
- AM can easily incorporates CPS.

# Example of Industry 4.0 and AM Scenario

## Distributed and flexible spare parts production

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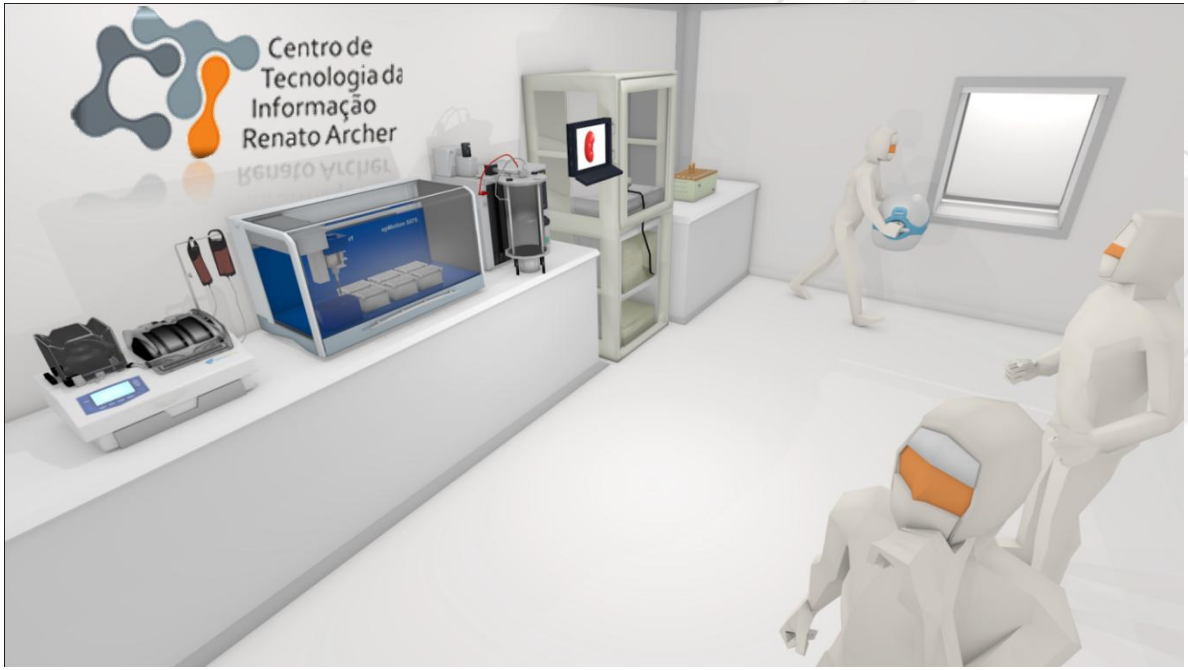
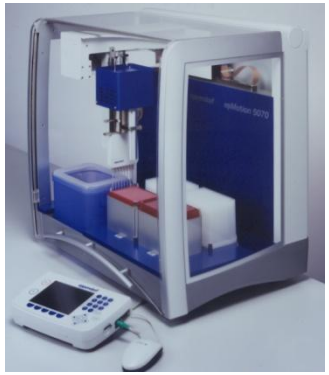
Adapted from: Reiner Anderl. Industrie 4.0 - Advanced Engineering of Smart Products and Smart Production

# Bioprinting - Organ Biofabrication Line





Cell sorter



Robotic tissue spheroids biofabricator

Robotic bioprinter


Perfusion bioreactor

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# AM in LA and Caribbean

- CEPAL proposal for AM centers;
- LA an Caribbean as a global players for innovation and high-added value products;
- Strong and distributed AM infrastructure;
- Education and training;
- Integrated actions like in public (private) healthcare;
- Leverage industry and start-ups.

# Gracias por tu atención!
# Thank you for your kind attention!

Jorge Vicente Lopes da Silva

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