Additive Manufacturing for Biomedical Applications

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Overview

- Why is additive manufacture interesting for medical applications?
- A (very brief) history of AM for biomedical applications
- Future of biomedical AM and AM more generally

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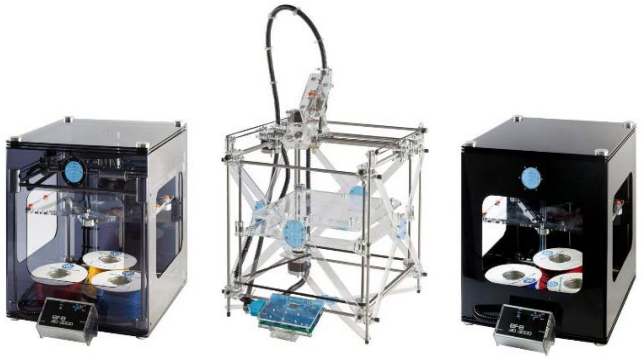
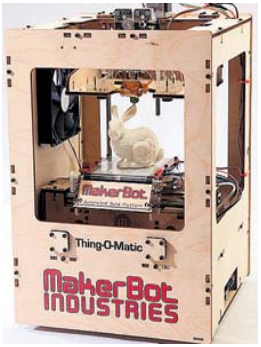
Additive Manufacture Machines

- **High end**
  > $200k

- **Mid-moderate**
  $20k – $200k

- **Low cost**
  $1k - $20k





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Additive Manufacture

- Features of additive manufacture:
  - “rapid” – direct from CAD to machine control, so no significant planning step
  - Cost is about volume, not geometric complexity
    - Cost models generally favour low volume geometrically complex components
    - Lot size of 1
  - Wide range of materials and material combinations possible, but:
    - not many currently “commercial-off-the-shelf”
    - materials not normally “swapable” between machines
  - Digital supply chain

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What does Additive Manufacture enable?

- Mass Customisation
- Manufacture at Point of Sale or Use
- New Material/Structure Combinations
- All of these are of interest for biomedical applications

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Medical Applications

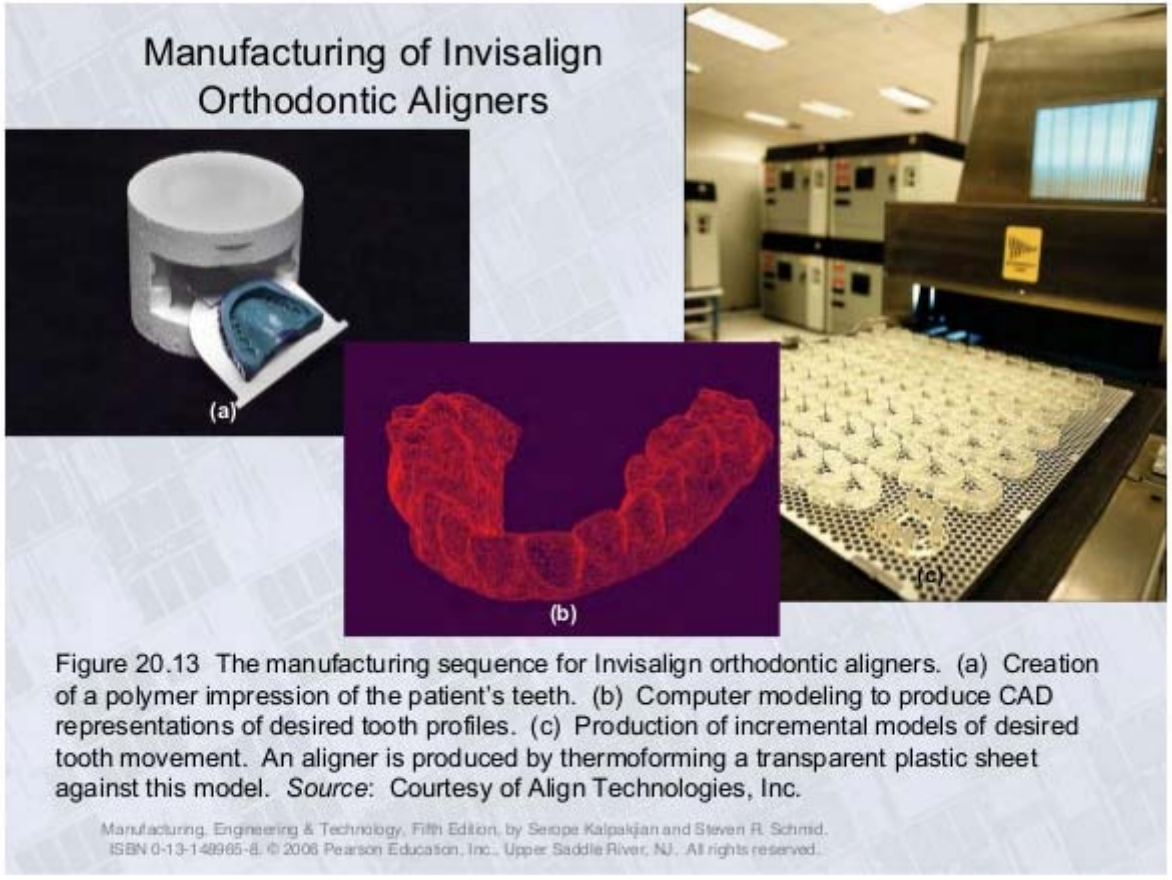
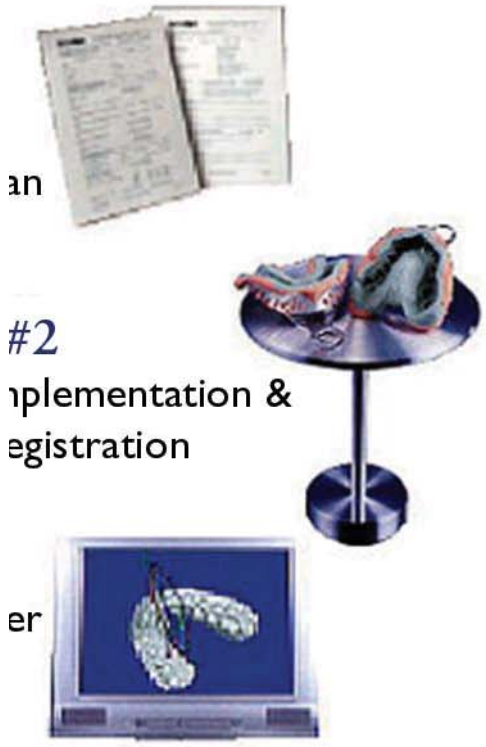


Figure 20.13 The manufacturing sequence for Invisalign orthodontic aligners. (a) Creation of a polymer impression of the patient's teeth. (b) Computer modeling to produce CAD representations of desired tooth profiles. (c) Production of incremental models of desired tooth movement. An aligner is produced by thermoforming a transparent plastic sheet against this model. *Source*: Courtesy of Align Technologies, Inc.



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The InvisAlign Process

- Automated near net shape manufacture, then material of choice, then a finishing process
- Semi-automated, CAD driven design process, with geometry capture and scanning to establish initial CAD files
- Shape, structure and mechanical properties important
- ~60 million parts shipped to date

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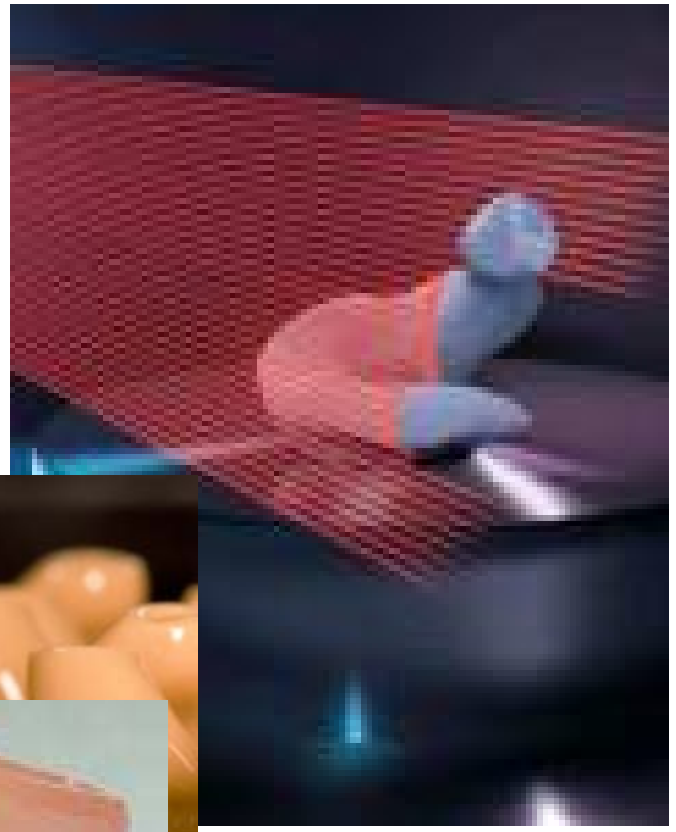
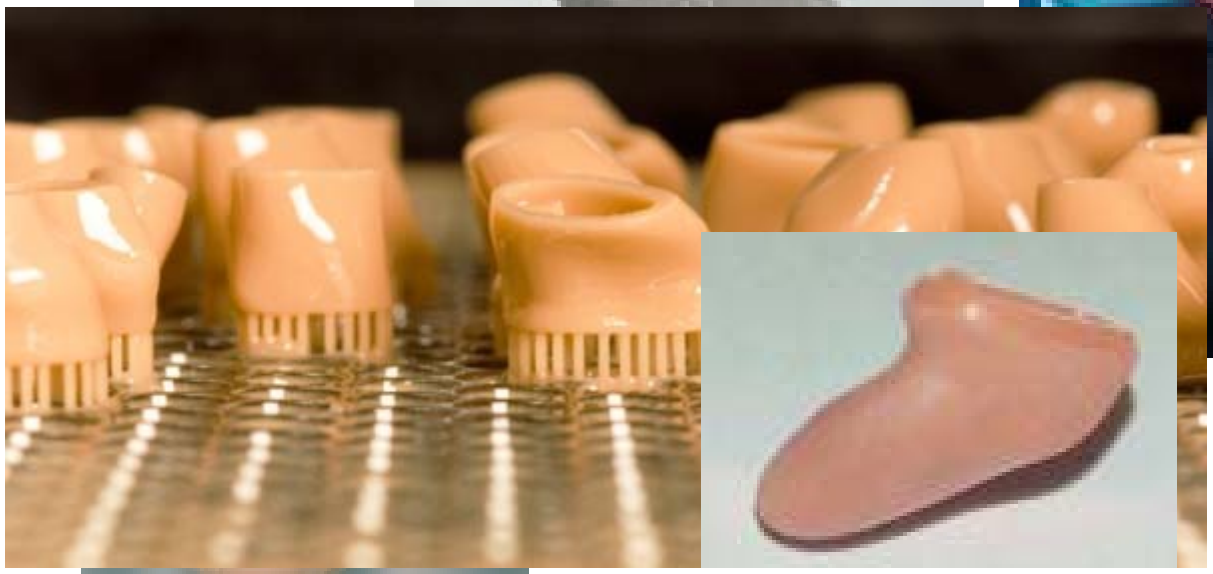
In-The-Ear Hearing Aid



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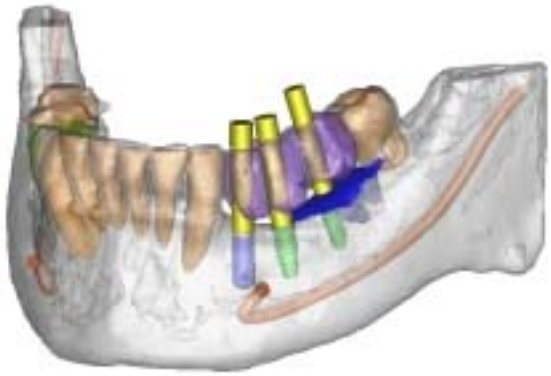
Surgical Devices – SimPlant and SurgiGuide from Materialise



Bone supported & mucosa supported drill guides

www.materialise.com

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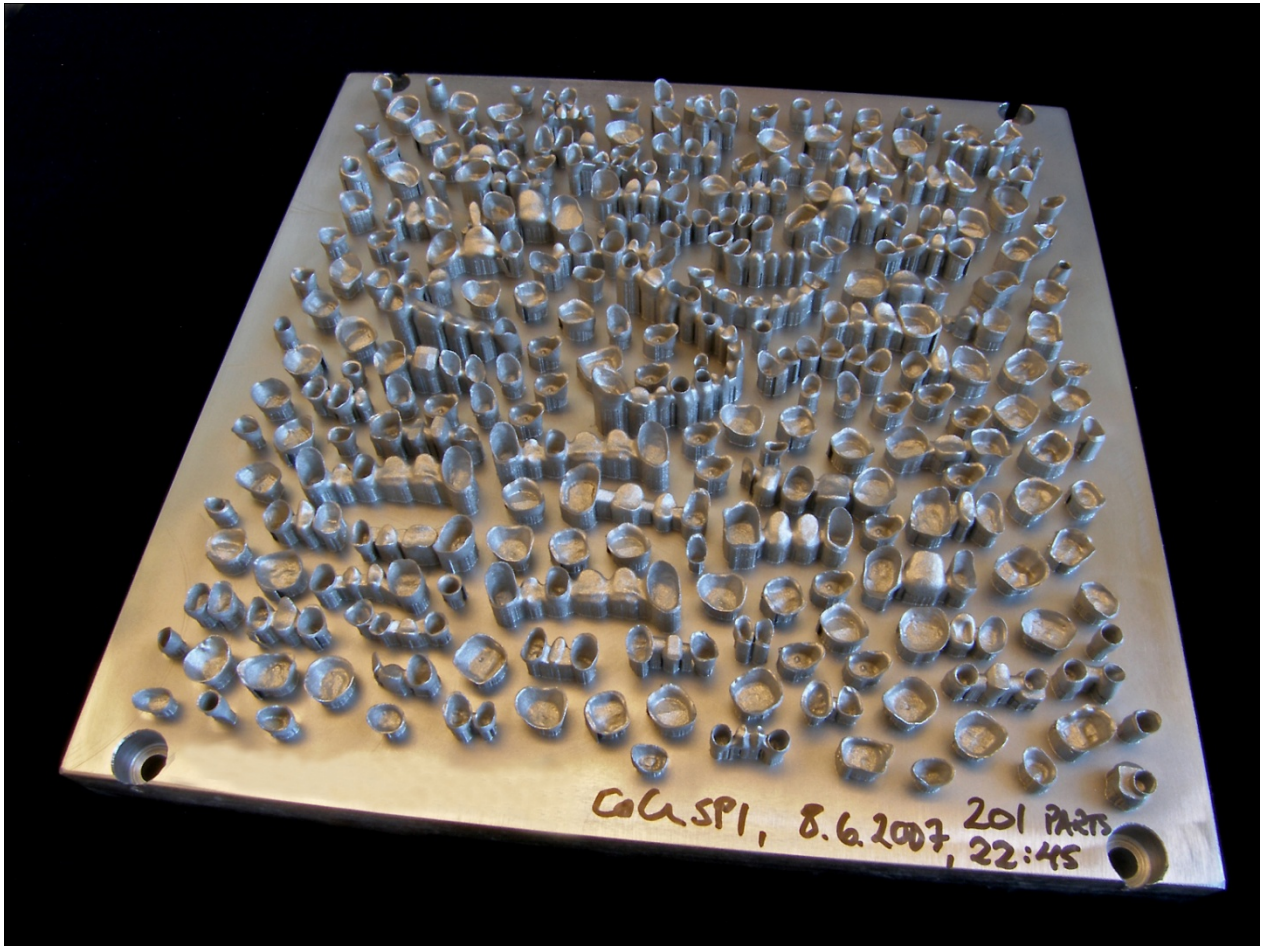
201 EOS CobaltChrome SP1 Dental Cores



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Jaw Reconstruction

Made by Layerwise in Belgium, implanted in the Netherlands

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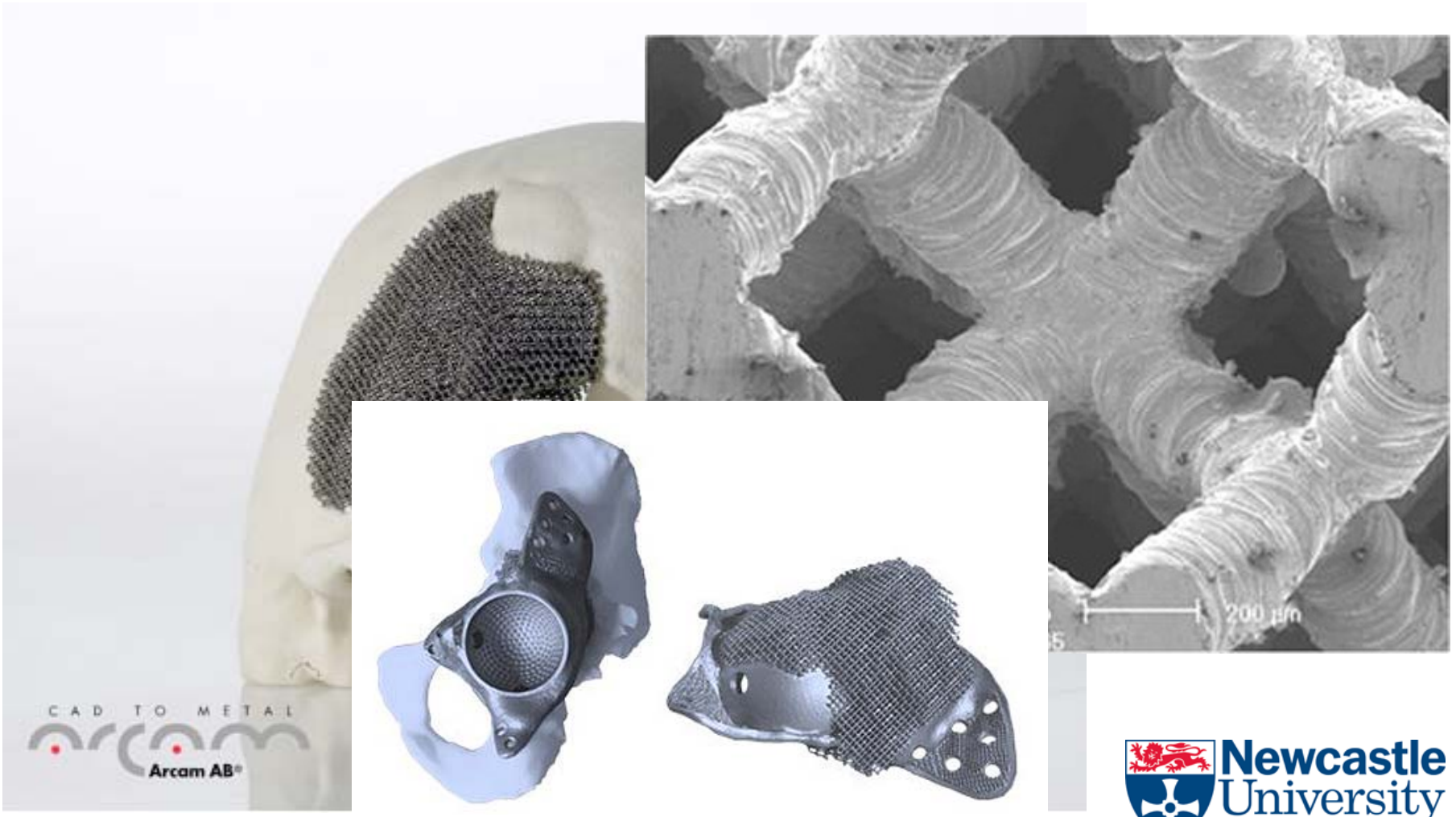
Personalised AM



Designed by Mobelife

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Foot and ankle-foot orthoses

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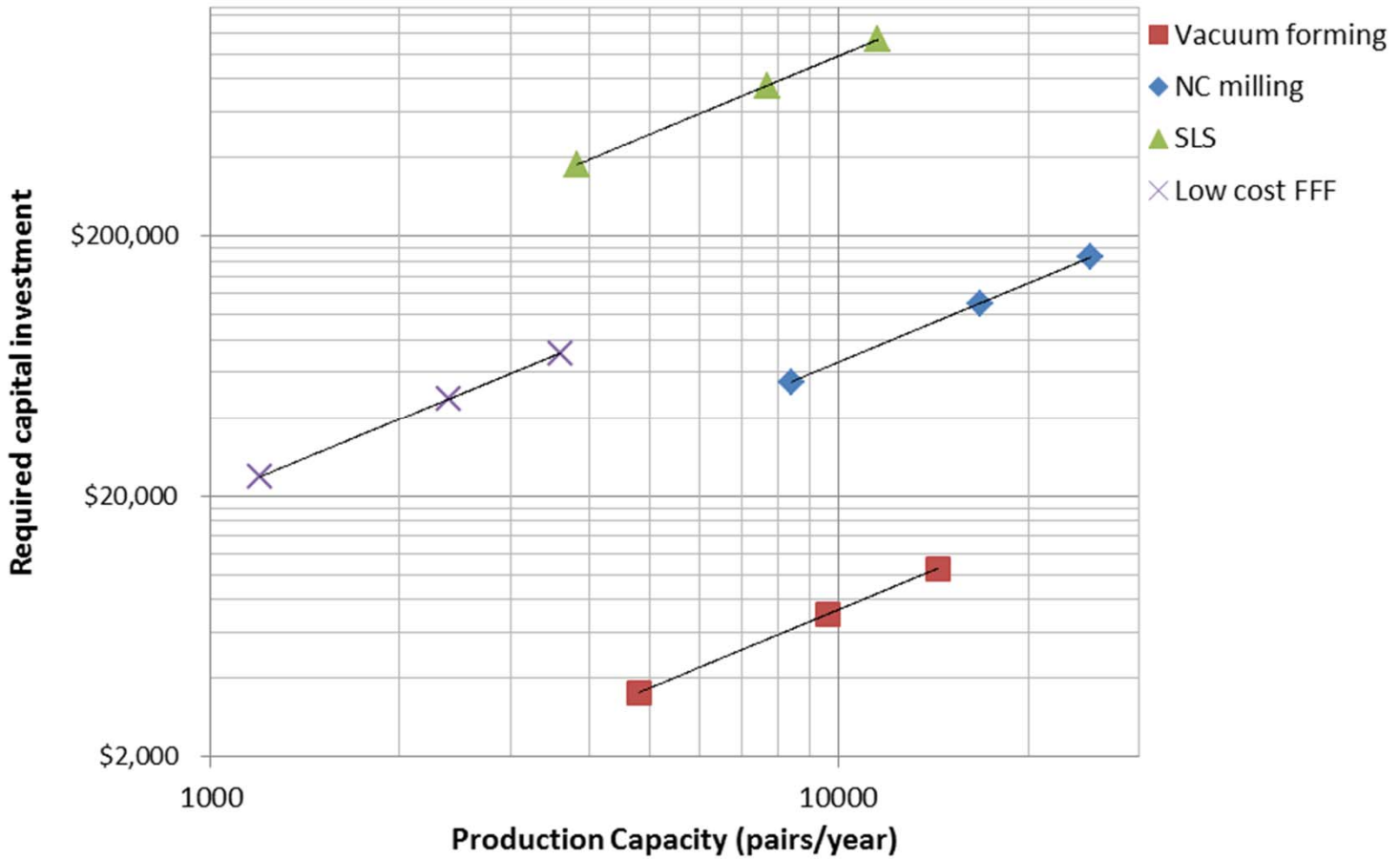
Capital Investment and Productivity v's Traditional Processes



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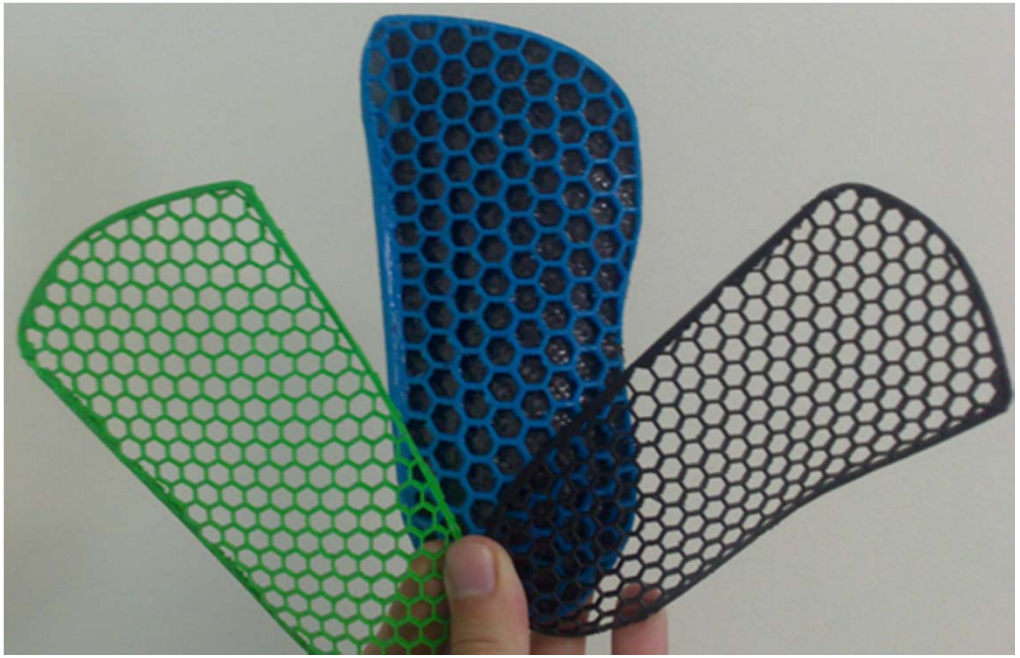
Innovative FOs



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Future of AM for Biomedical Applications

- Mainstream
  - Lower cost
- Upstream
  - Added value
- For ***mass*** healthcare applications this isn't either/or, it's both

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Future of AM for Biomedical Applications

- Clinical drivers: lower overall treatment cost and better clinical outcome
  - minimally invasive
  - treat problems early
- To date nearly always hybrid approaches
- Design automation
- For mass scale applications scalability within a clinical context and affordability both important

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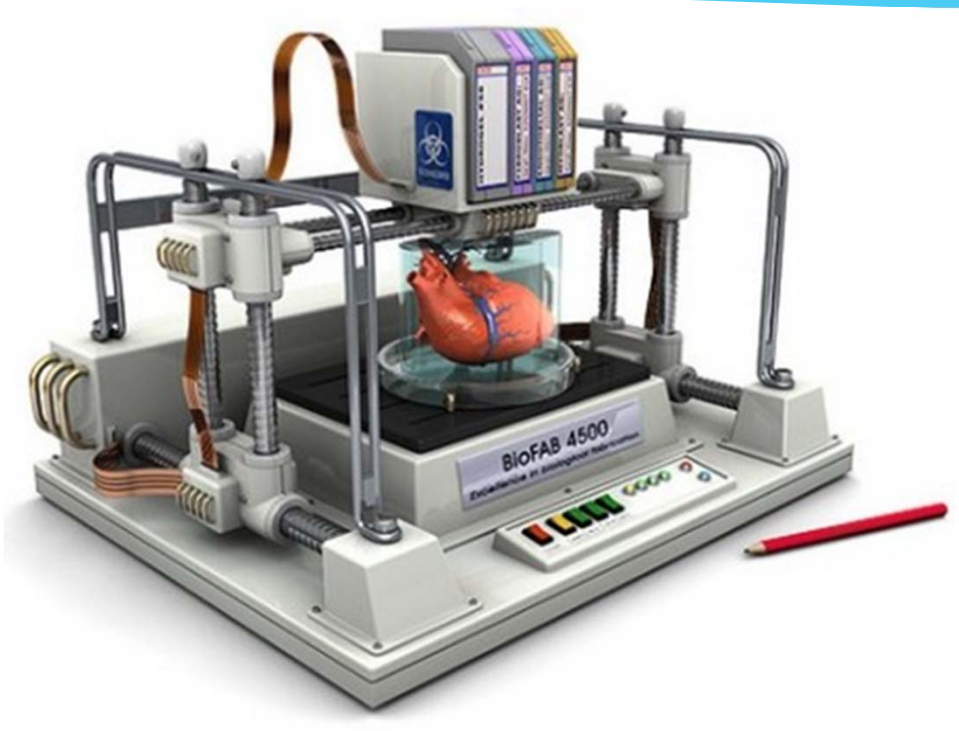
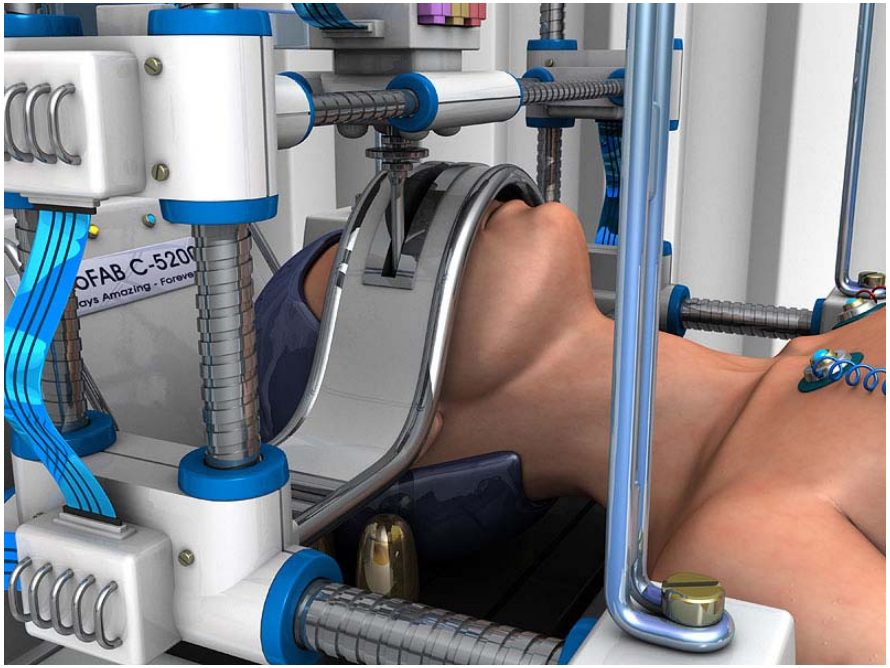
Future possibilities:
cell and material co-processing



C Barnatt. Organ Printing Concept. www.explainingthefuture.com. 2011.



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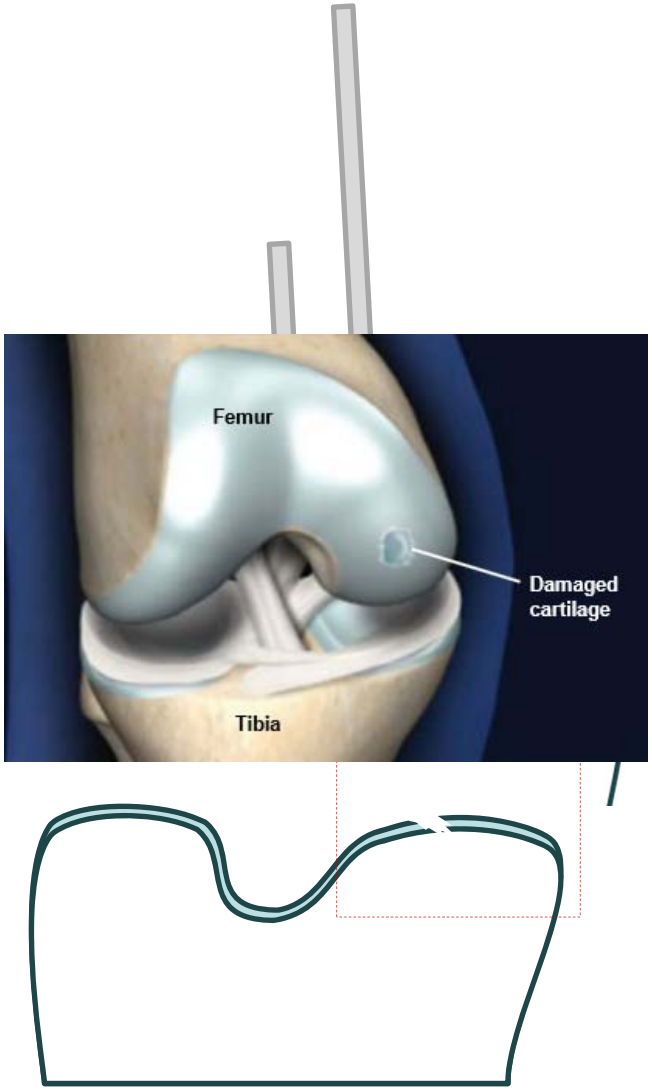
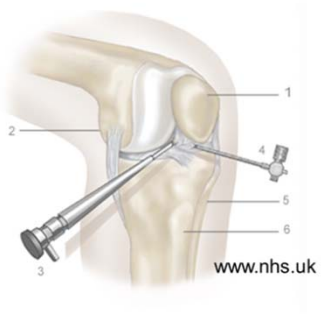
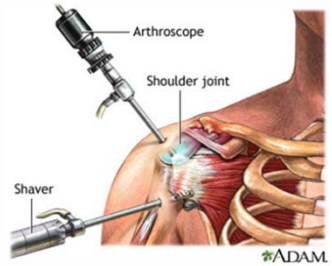
MeDe Innovation



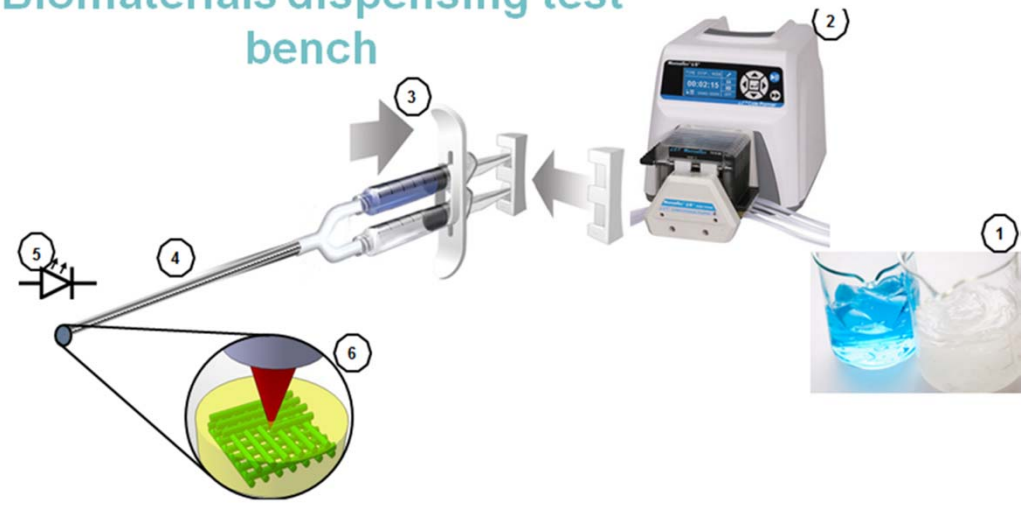


Gileshugo – Creative Commons



orthopaedics.com.sg

Biomaterials dispensing test bench



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Future of AM More Generally

- Also mainstream and upstream
- Cost and value are key to all industries, not just biomedical
- A personal view is that we'll start to see more "product apps" and machines designed for specific applications, as an integrated product delivery system (real "plug and play")

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Questions?