



# M.Tech Digital Manufacturing

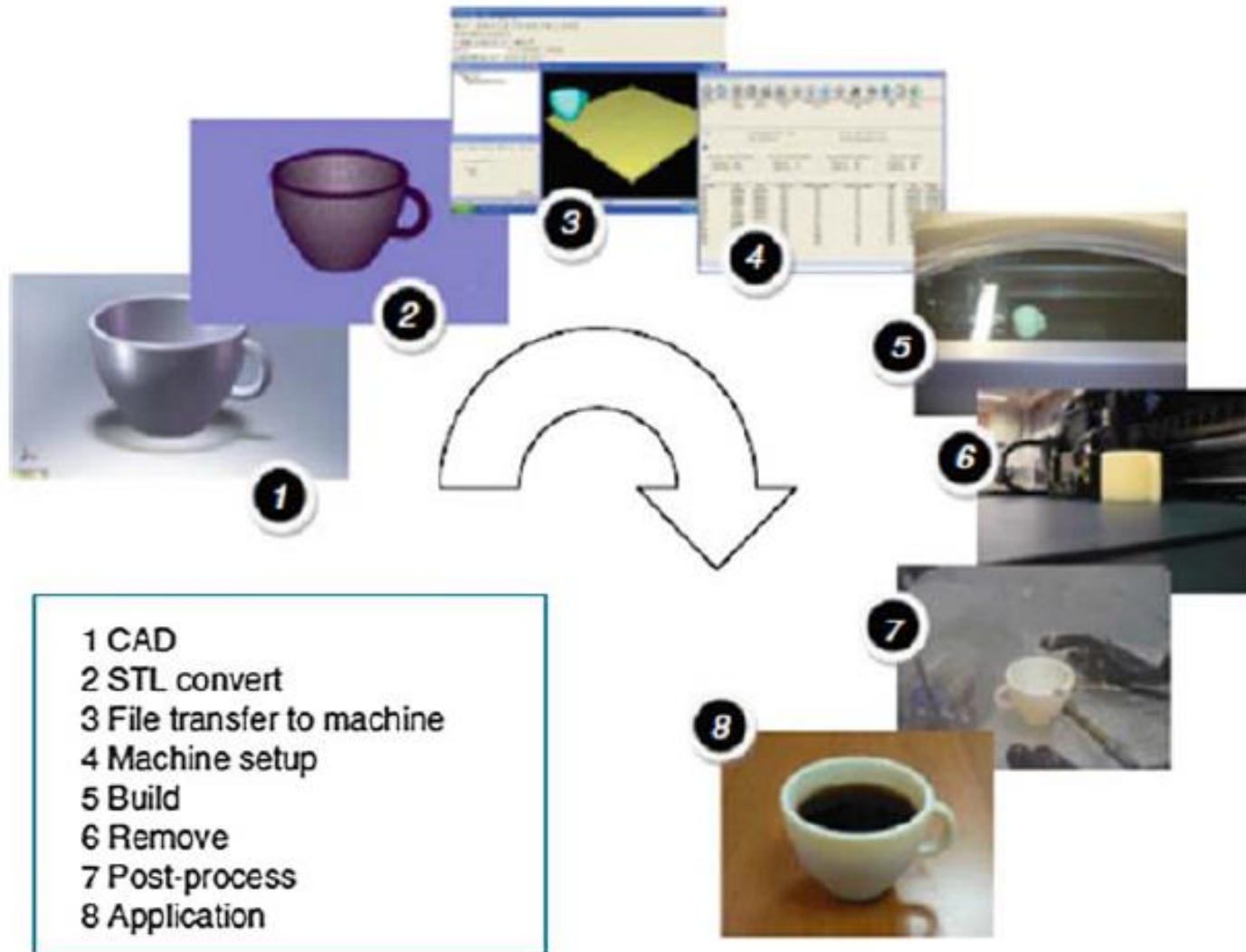
**BITS Pilani**  
Pilani Campus

Jayakrishnan J  
Guest Faculty



# **DMZG521- Design for Additive Manufacturing Session 5 Lecture 9-10**

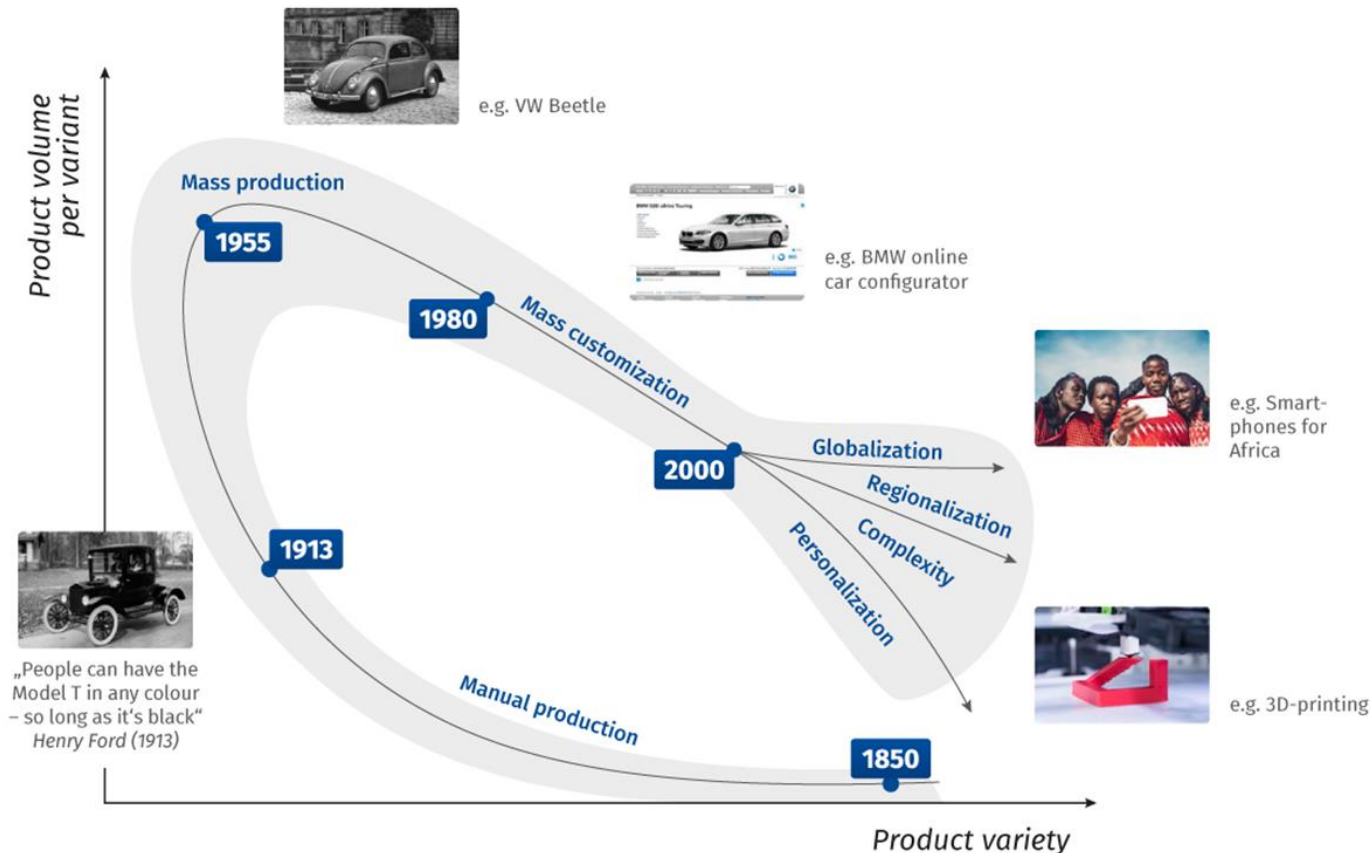
# AM Process Chain



# Mass customization



- Mass customization aim to achieve customized product at a rate similar to mass production rate



# Mass Customization



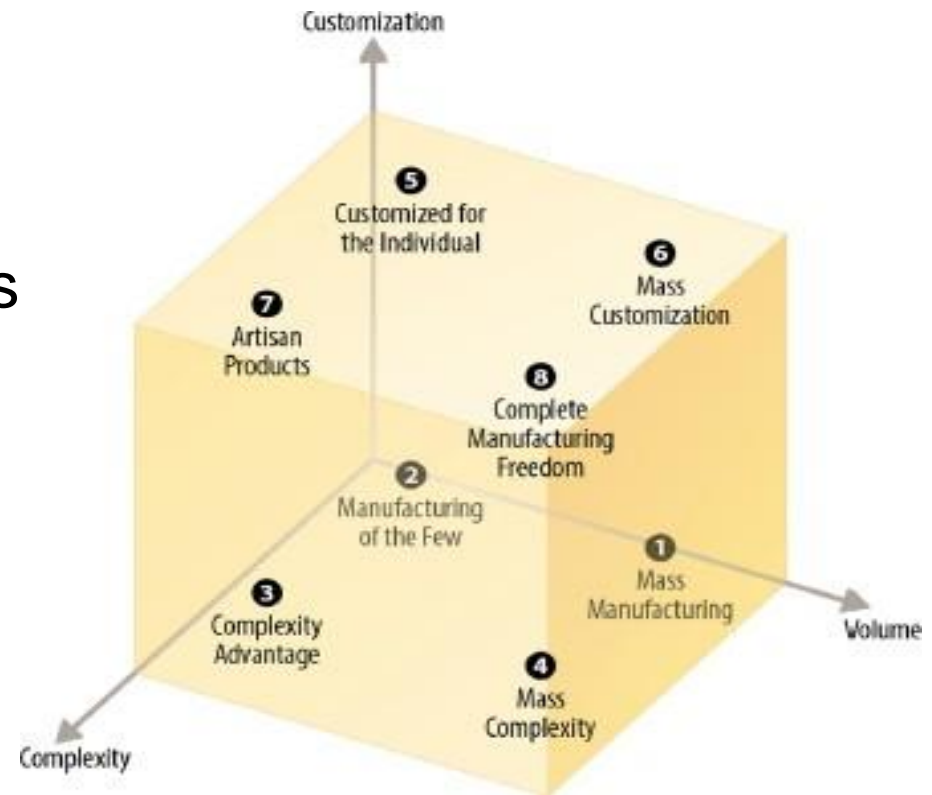
First Coined by Davis (1987)

“Mass Customization as the ability to provide individually designed products and services to every customer through high process agility, flexibility and integration, thus Mass Customization systems may reach customers as in the mass market economy but treat them individually as in the pre-industrial economies.”

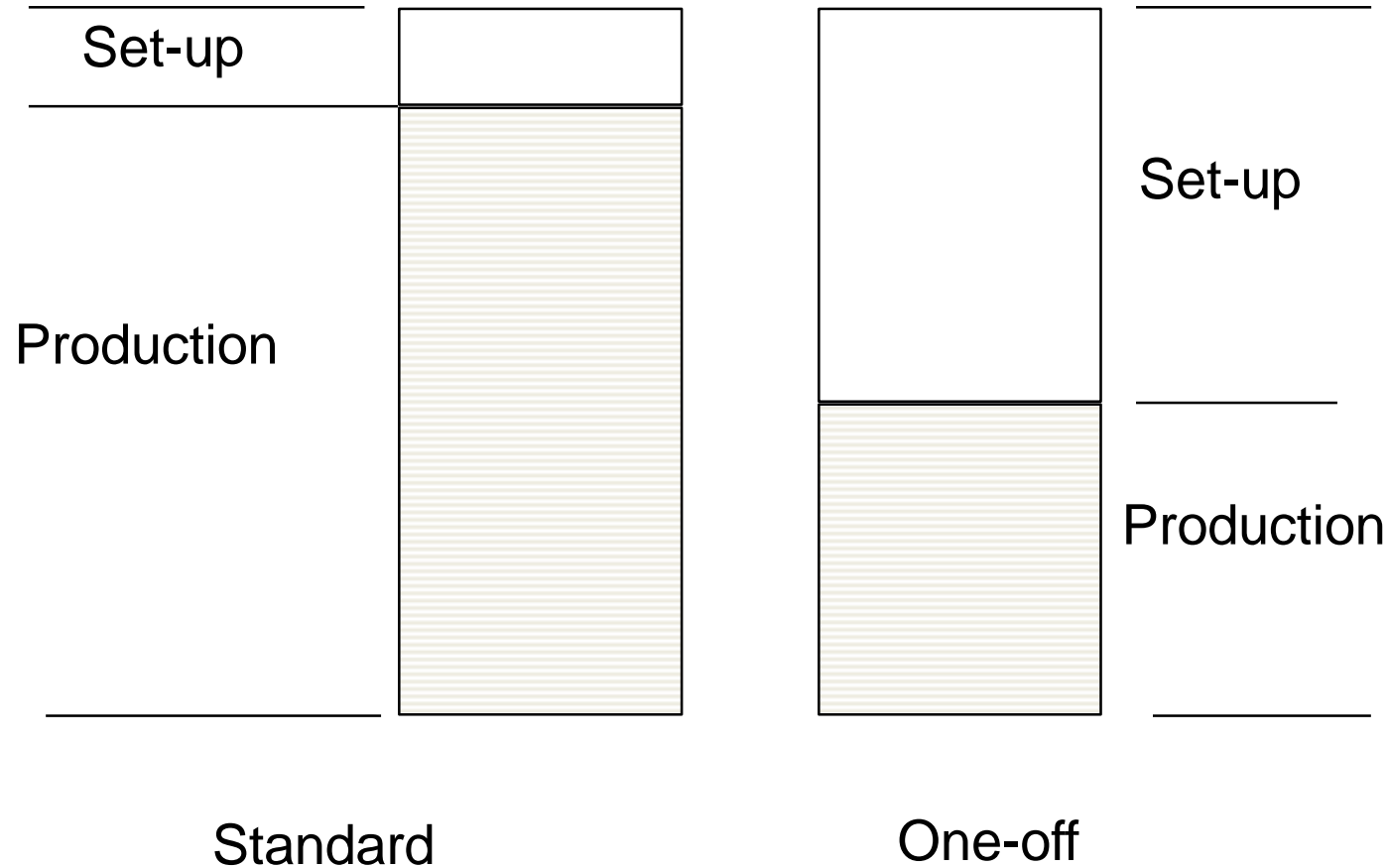
# Mass Customization in present industry



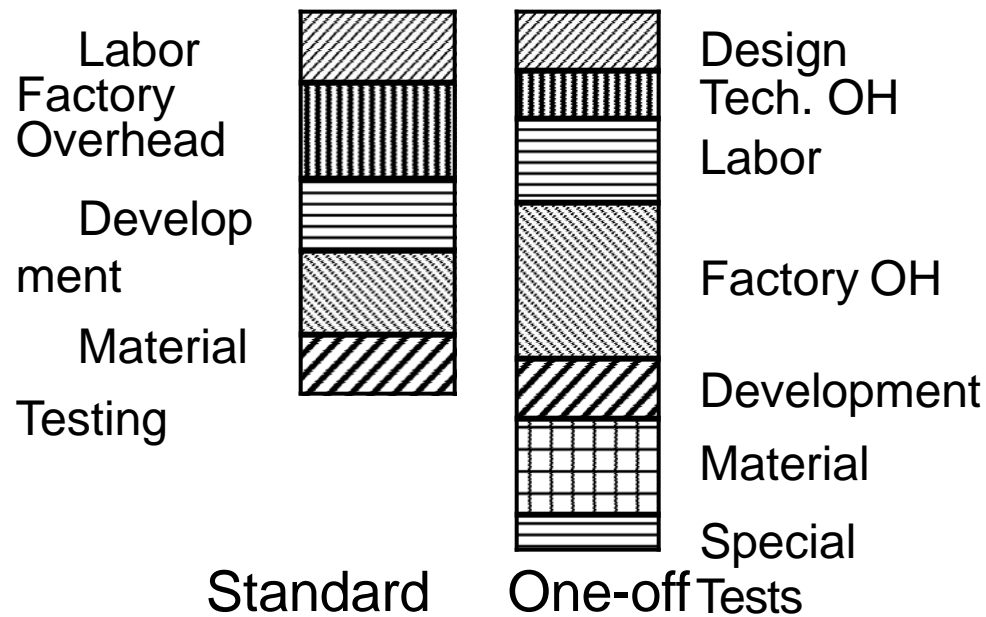
- MC uses innovative supply chain concepts to produce customized products from a range of existing parts
- Tooling cost of existing parts
- Suppress the innovative product development
- AM as toolless manufacturing



# Standard v. One-off Design (Time Comparison)

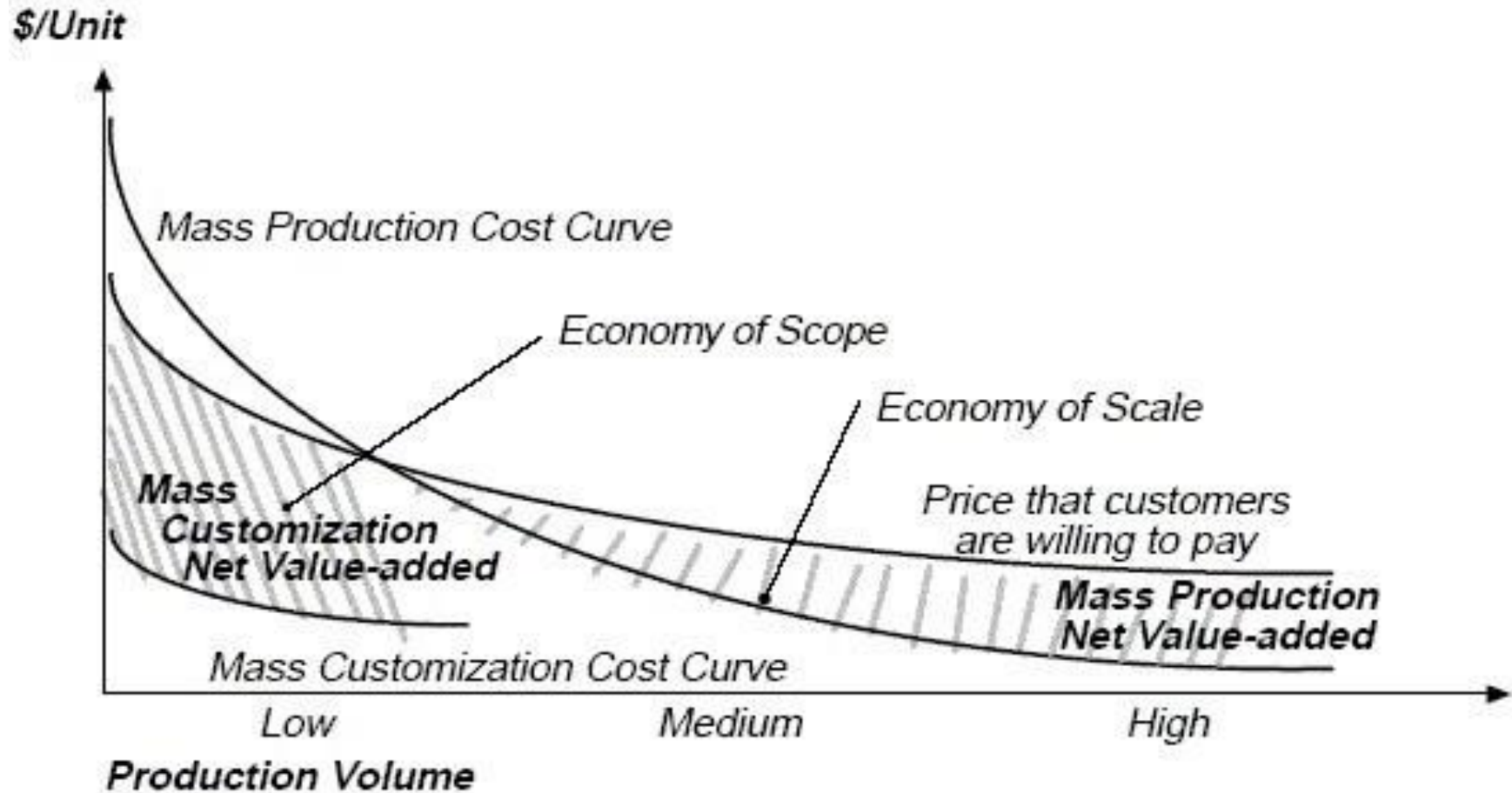


# Standard v. One-off Design (Cost Comparison)

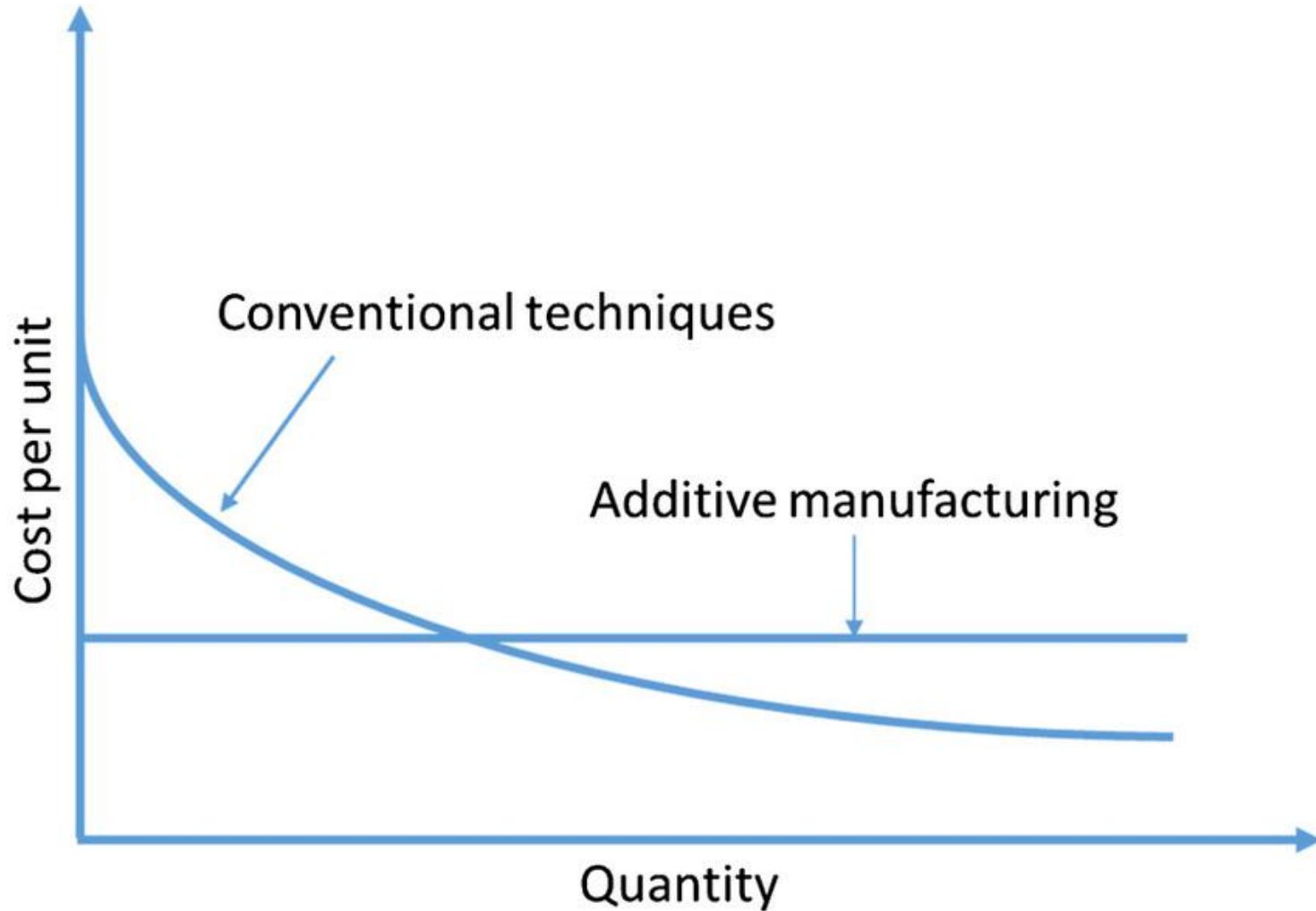




# Mass Production Vs Mass customization



# Cost Benefits



# Mass Customization Enablers

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- Group technology
- Part standardization
- Product modularization
- Process modularity
- Product platform development
- Concurrent product-process-supply chain engineering

# HOW DOES ADDITIVE MANUFACTURING ENABLE CUSTOMIZATION?

Additive manufacturing uses a digital workflow for production, mass customization becomes more possible. Here's an example of a digital workflow using a customized bike seat.

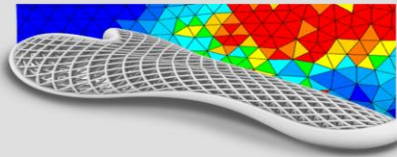
1



## CUSTOMER INPUT

User pressure profiles can be measured in local bike shop during fitting session

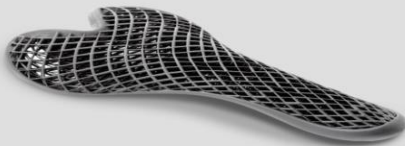
2



## GENERATE CONFIGURATION

Optimization models provide local maps of the density of the lattice

3



## MANUFACTURE

Customized design is manufactured without additional tooling costs using HP MJF technology

4



## FULFILL

A logistics provider will deliver your customized product to your doorstep

Courtesy:

<https://www.fastradius.com/resources/making-mass-customization-of-products-possible-with-additive-manufacturing/>

innovate

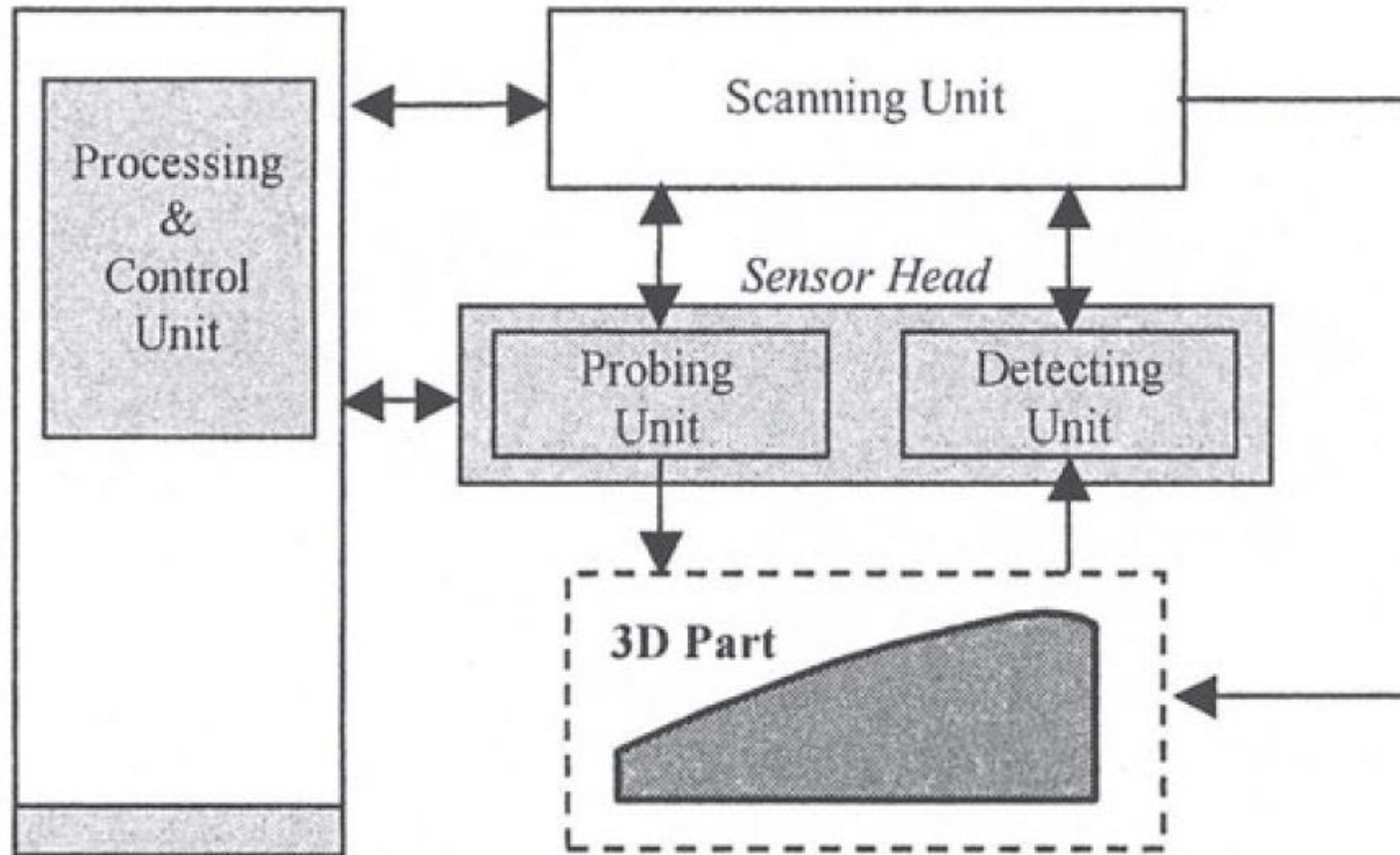
achieve

lead

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# Reverse engineering





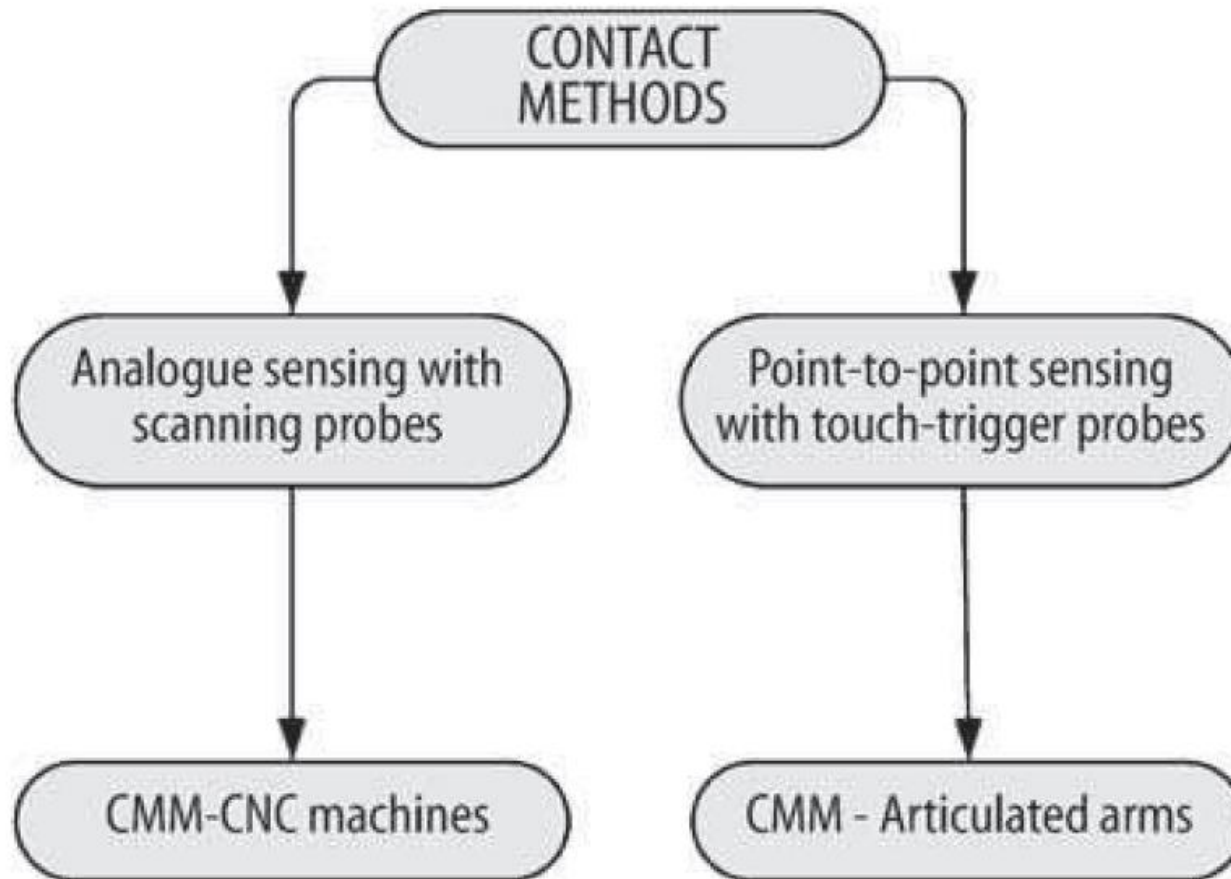
# Classification



- Contact Methods
- Non-contact Methods

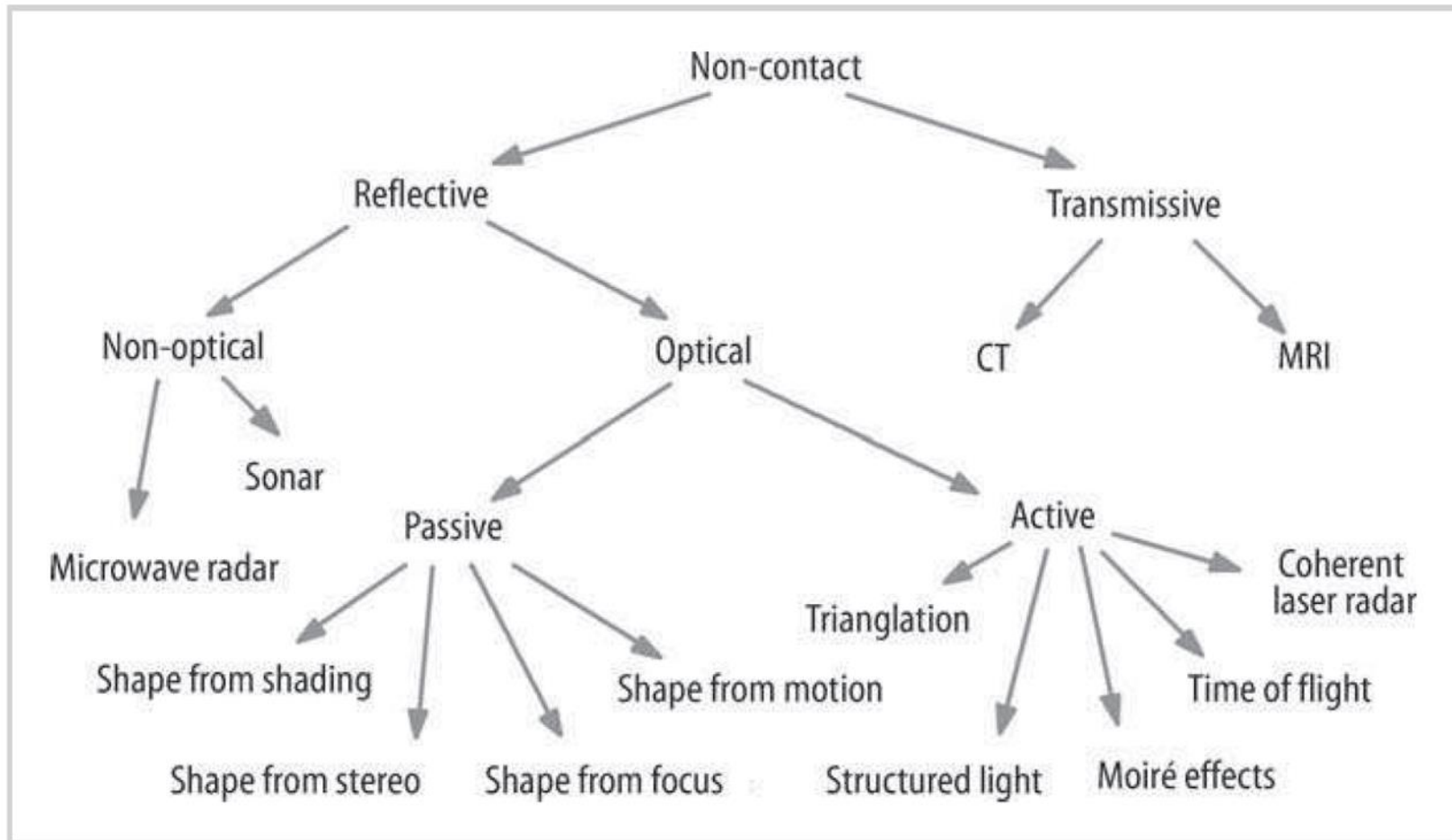


# Contact Type





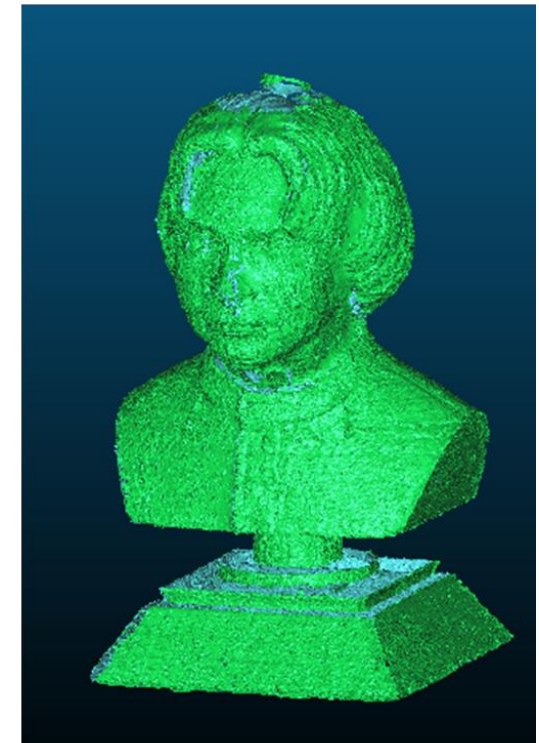
# Non-Contact methods



# 3D Scanners



Cloud compare



Photogrammetry –  
Autodesk recap

# 3D Foot Scanners



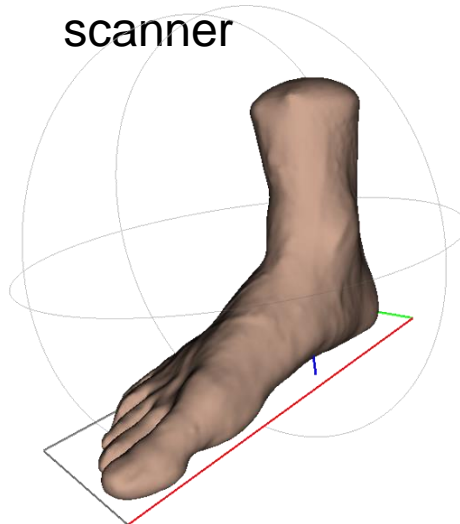
Footscan® plates



Tiger® 3D foot scanner



iQube® 3D foot scanner E500

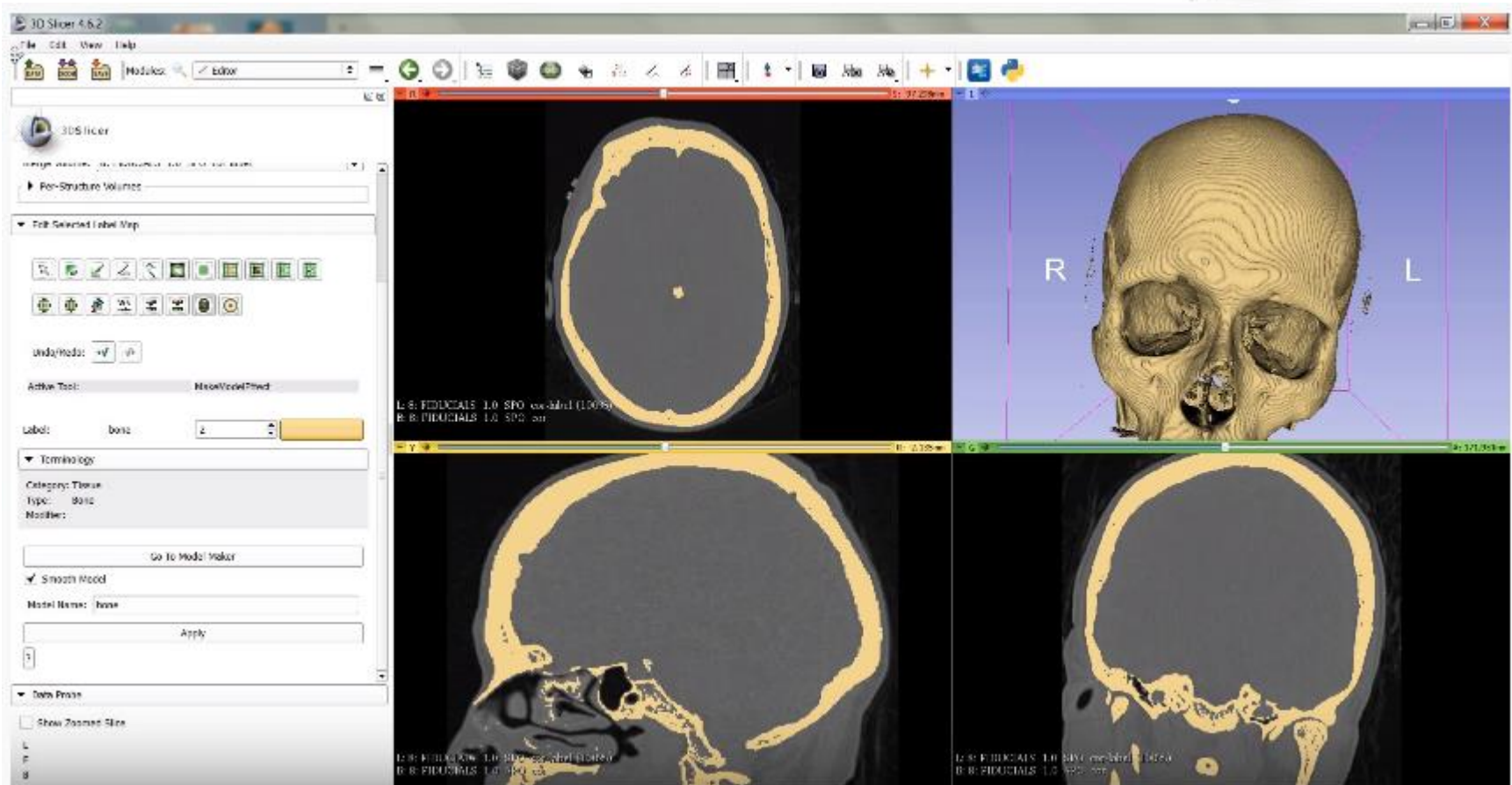


*Courtesy: GO4D*

# Processing of CT Scan Data



- DICOM to STL

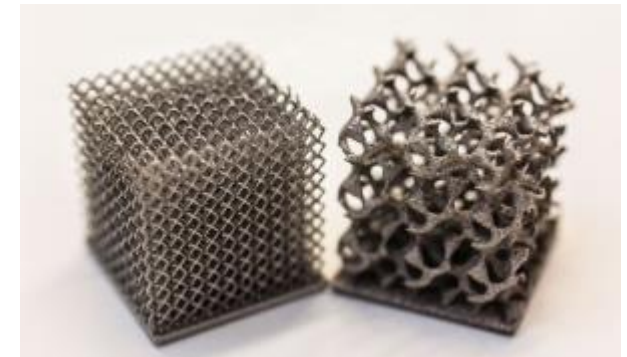
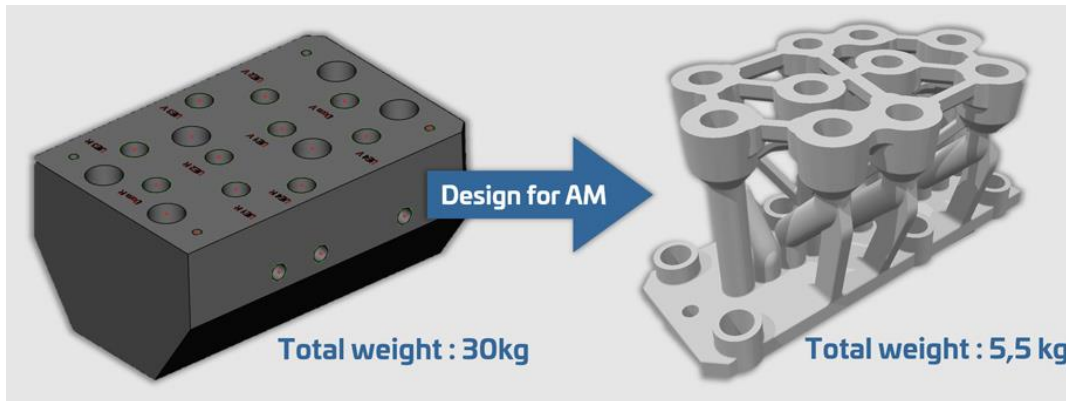
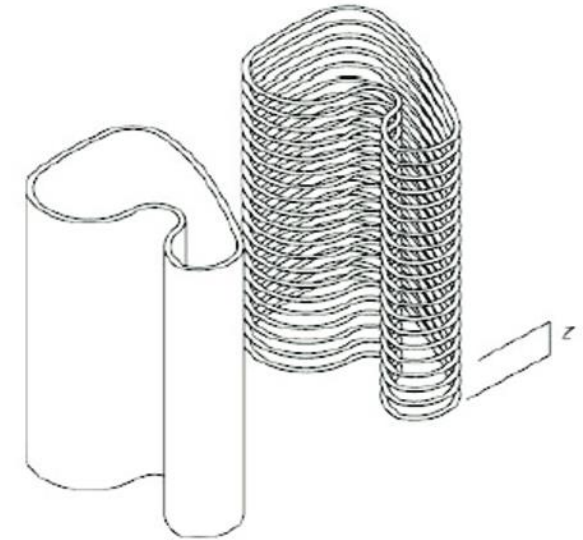




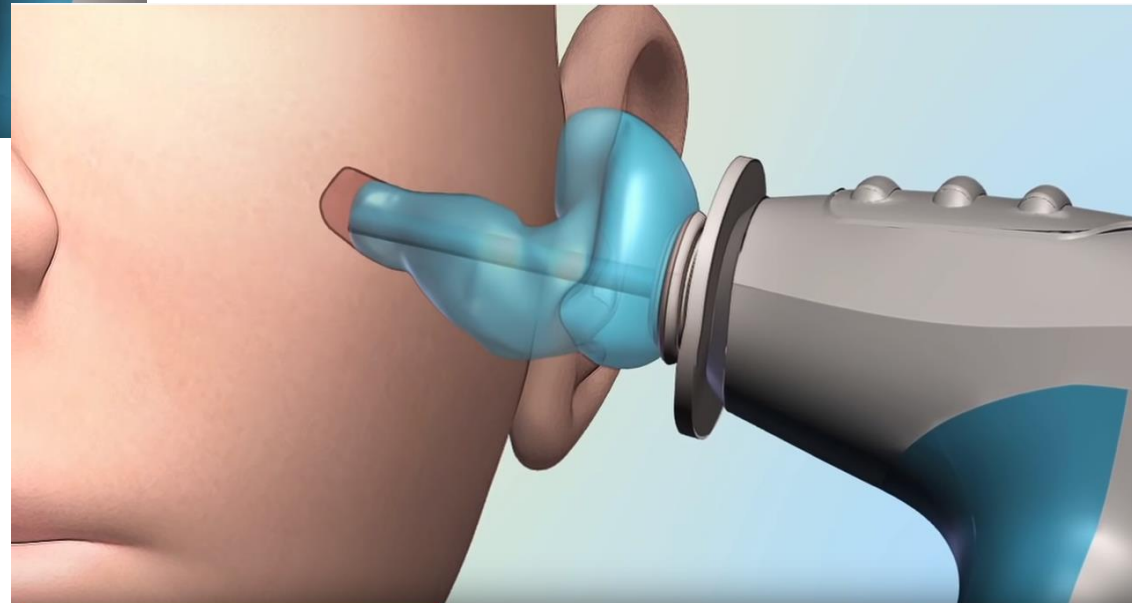
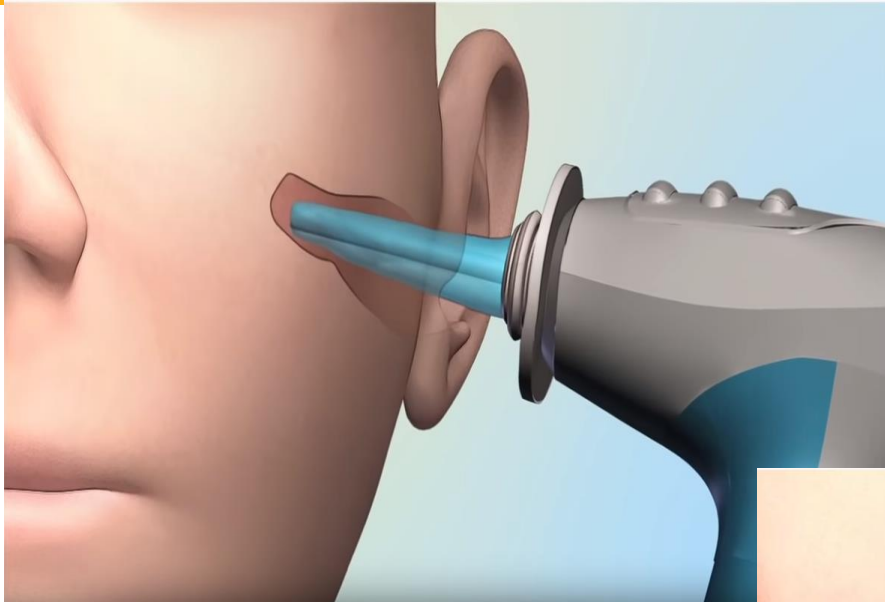
# AM Process Capabilities for Mass Customization



- Layer by layer manufacturing
- Processing of biocompatible materials
- Lattice structures
- Lightweighting



# Mass Customization in Hearing aids

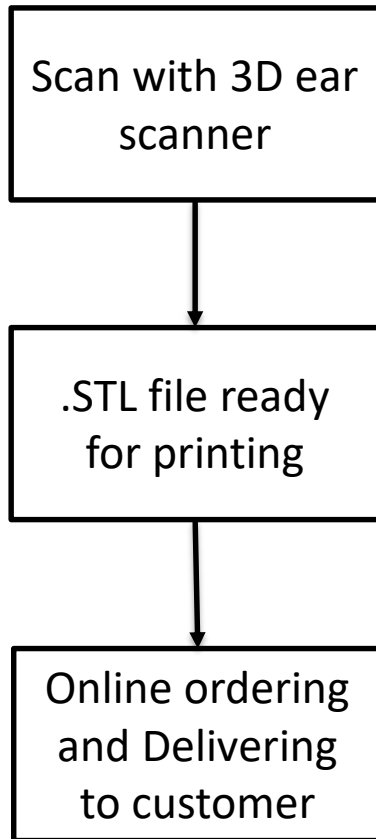


*Courtesy: Lantos technologies*

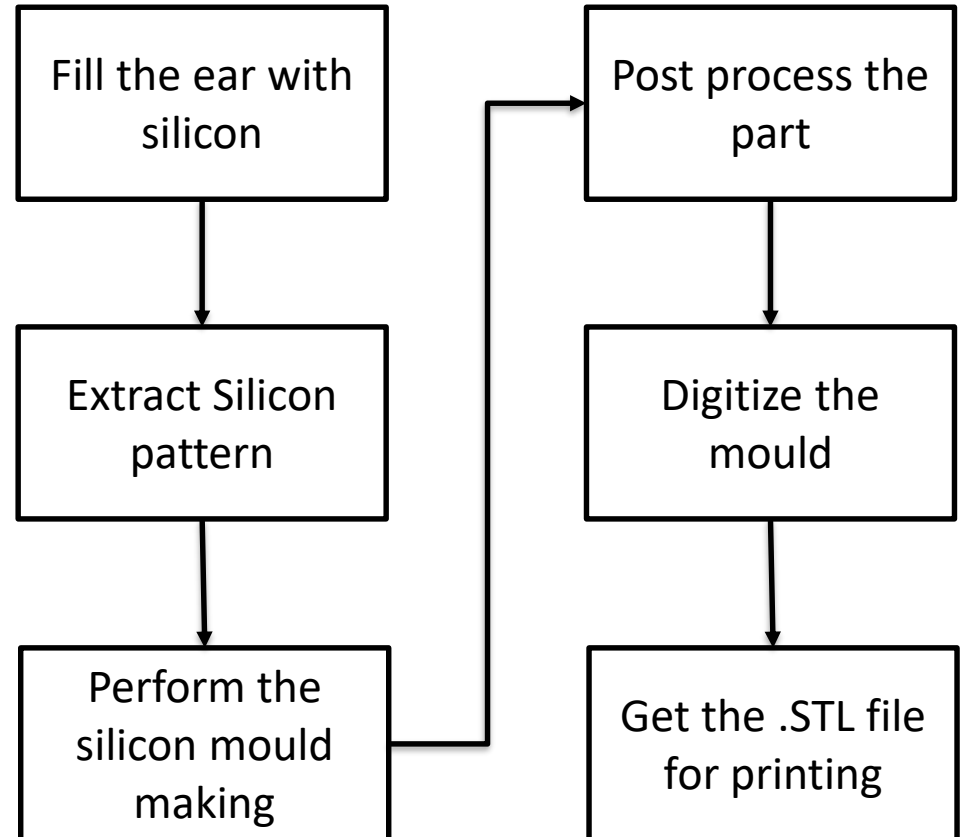
# Hearing aid manufacturing



## With AM process



## With Traditional process



# Application of Customization



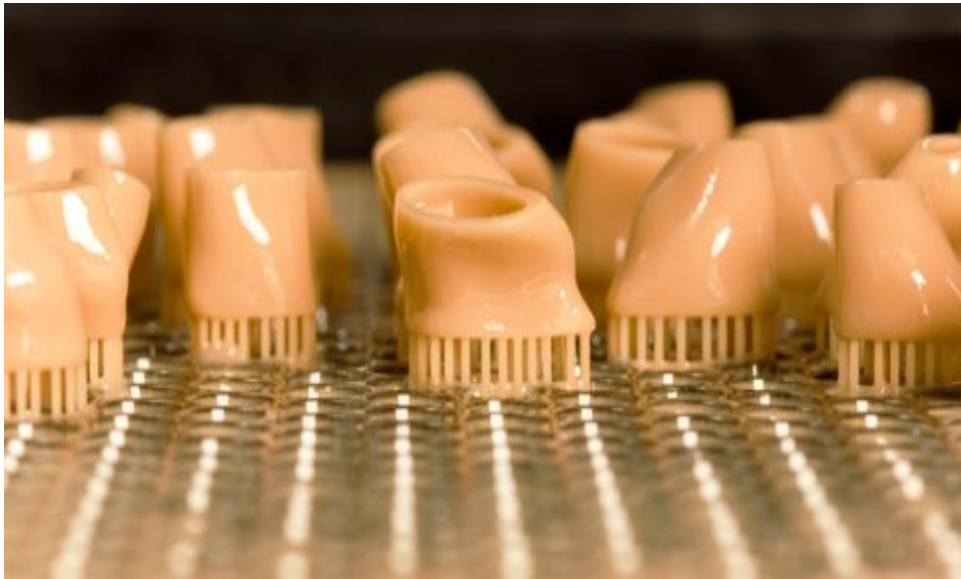
- Dentistry
- Fashion
- Implants
- Hearing Aids
- Automobiles





# Hearing aids printing

## Vat photopolymerization process



# Mass Customization in Dentistry



In PBF processes

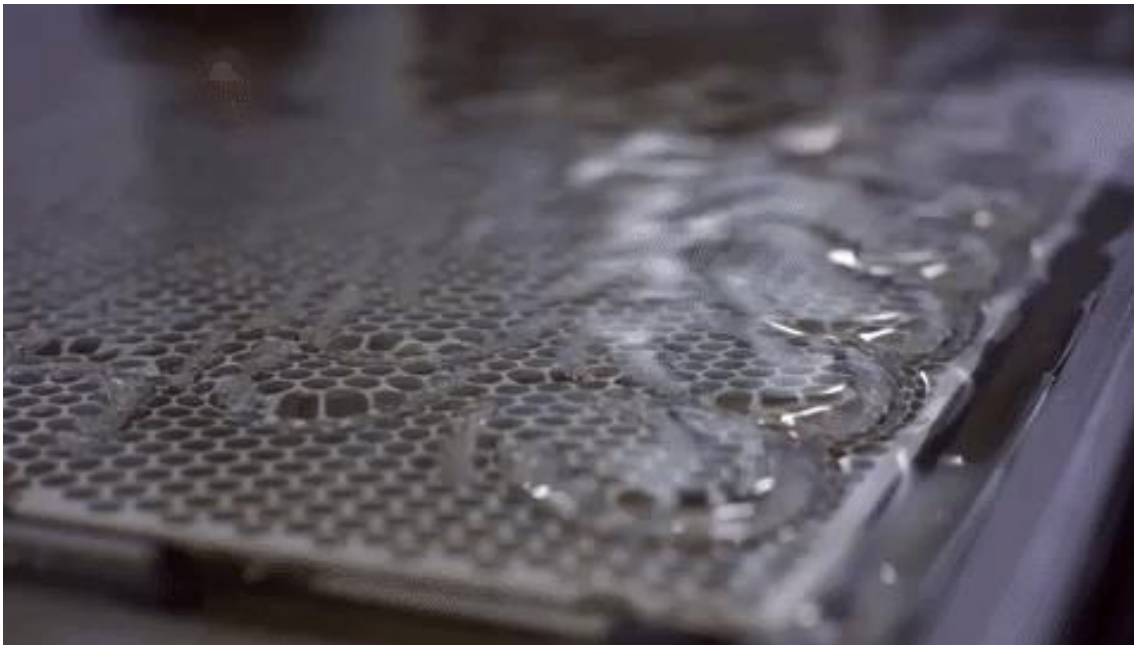


# Customization for braces

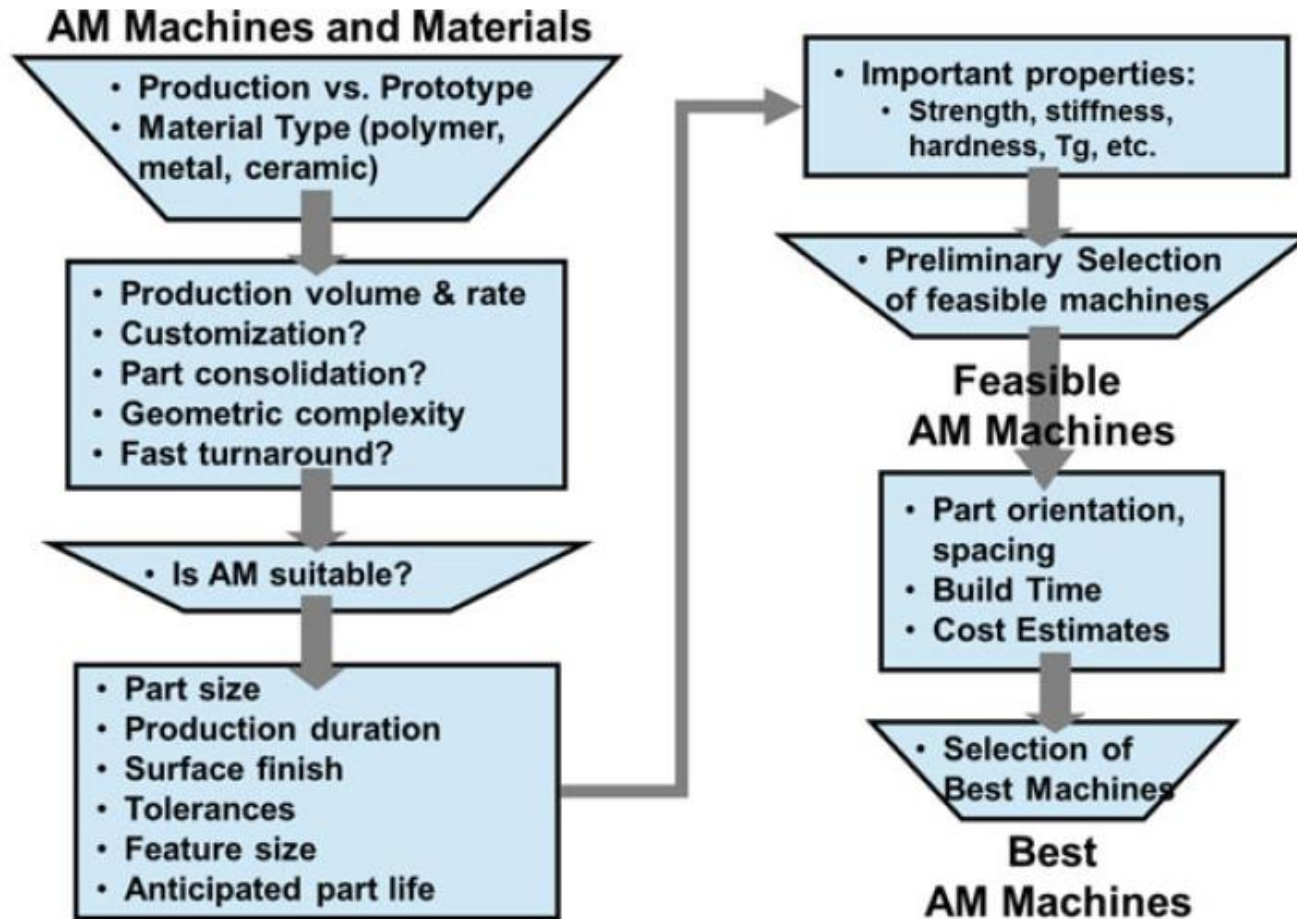


## Invisalign braces

- SLA process
- 3D data from X-ray or CT Scan



# AM Process Selection



# AMSelect: Part Data

A screenshot of the 'RM Selection' software window. The window has a title bar with the text 'RM Selection' and standard window controls. Below the title bar is a menu bar with 'File', 'Database', and 'Help'. The main area contains five tabs: 'Project Data', 'Part Data' (which is selected), 'Qualitative', 'Prelim Select', and 'Assessment'. The 'Part Data' tab contains several input fields: 'Part Size [mm]' with sub-fields for X (100.0), Y (100.0), and Z (100.0); 'Actual Volume [mm^3]' with a value of 100000; 'Material' with a dropdown menu showing 'Polymer'; 'Smoothest Surface Finish, Ra [micron]' with a value of 3.0; 'Tightest Tolerance [micron]' with a value of 20.0; and 'Smallest Feature Size [mm]' with a value of 1.0. At the bottom of the window, there is a copyright notice: 'Copyright Georgia Tech, Dr. David Rosen, 2014'.

# Questions for assessment



RM Selection

File Database Help

Project Data Part Data **Qualitative** Prelim Select Assessment

Qualitative Assessment of Additive Manufacturing Suitability:

For your production volume, how many parts have exactly the same shape?

- ☒ None, all parts have unique shapes
- ☐ Few, <10% have exactly the same shape
- ☐ Some, <50% have exactly the same shape
- ☐ All parts have the same shape

Part Consolidation: Is your part replacing more than 1 other part?

- ☒ Yes, it replaces an assembly of more than 10 parts
- ☐ Yes, it replaces 6-10 parts
- ☐ Yes, it replaces 2-5 parts
- ☐ No, the part replaces 1 other part or this is a unique applicati...

Part Geometry Complexity?

- ☒ part shape is very complex; can fabricate using only AM
- ☐ part shape could be fabricated using 5-axis mill
- ☐ part shape could be injection molded
- ☐ part could be machined on 2.5-axis or 3-axis mill

Fast Turn-Around: How quickly do you have to respond to design changes or customer orders?

- ☒ Overnight
- ☐ 2-4 days
- ☐ 5-10 days
- ☐ more than 10 days

Assess suitability of AM

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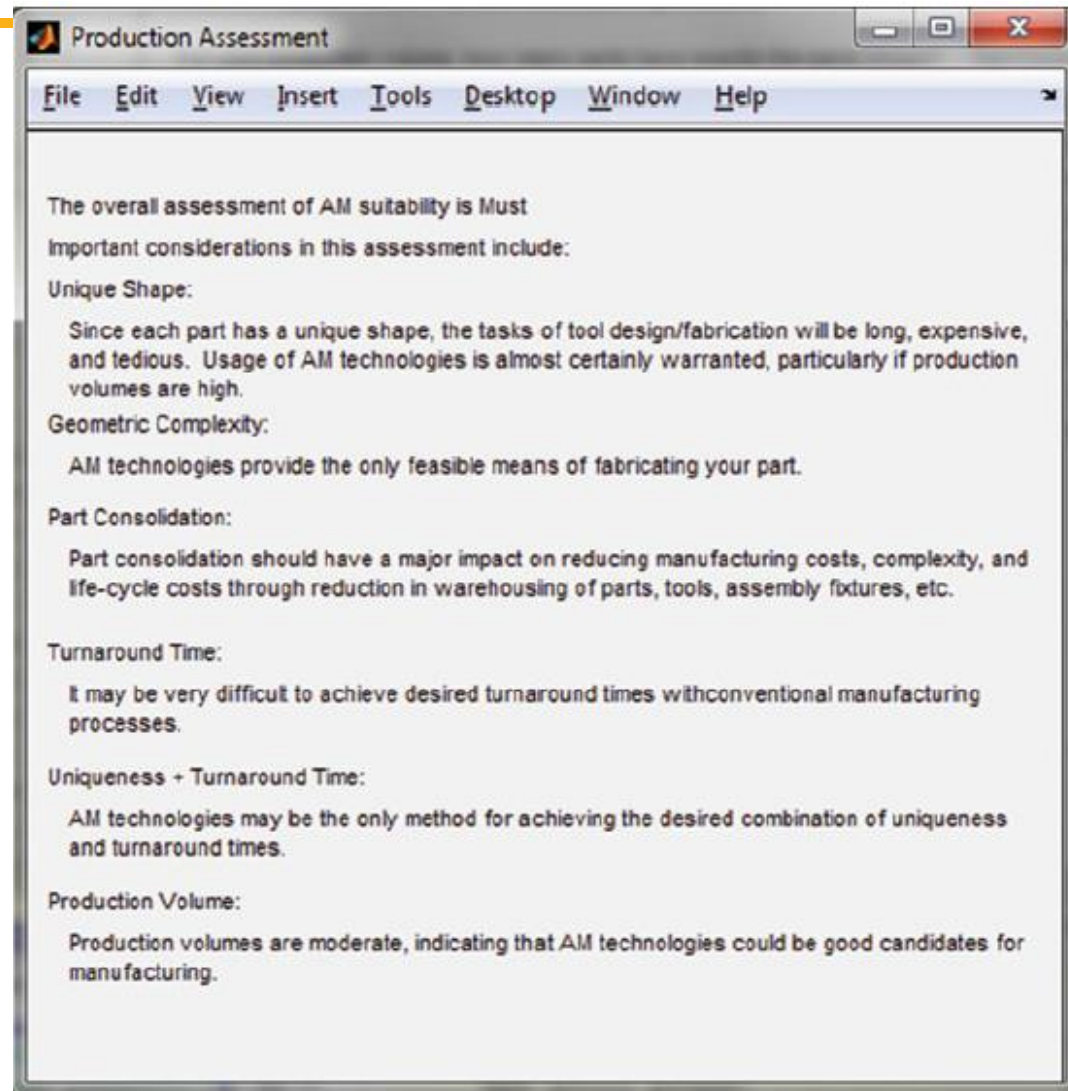


# Assessment report

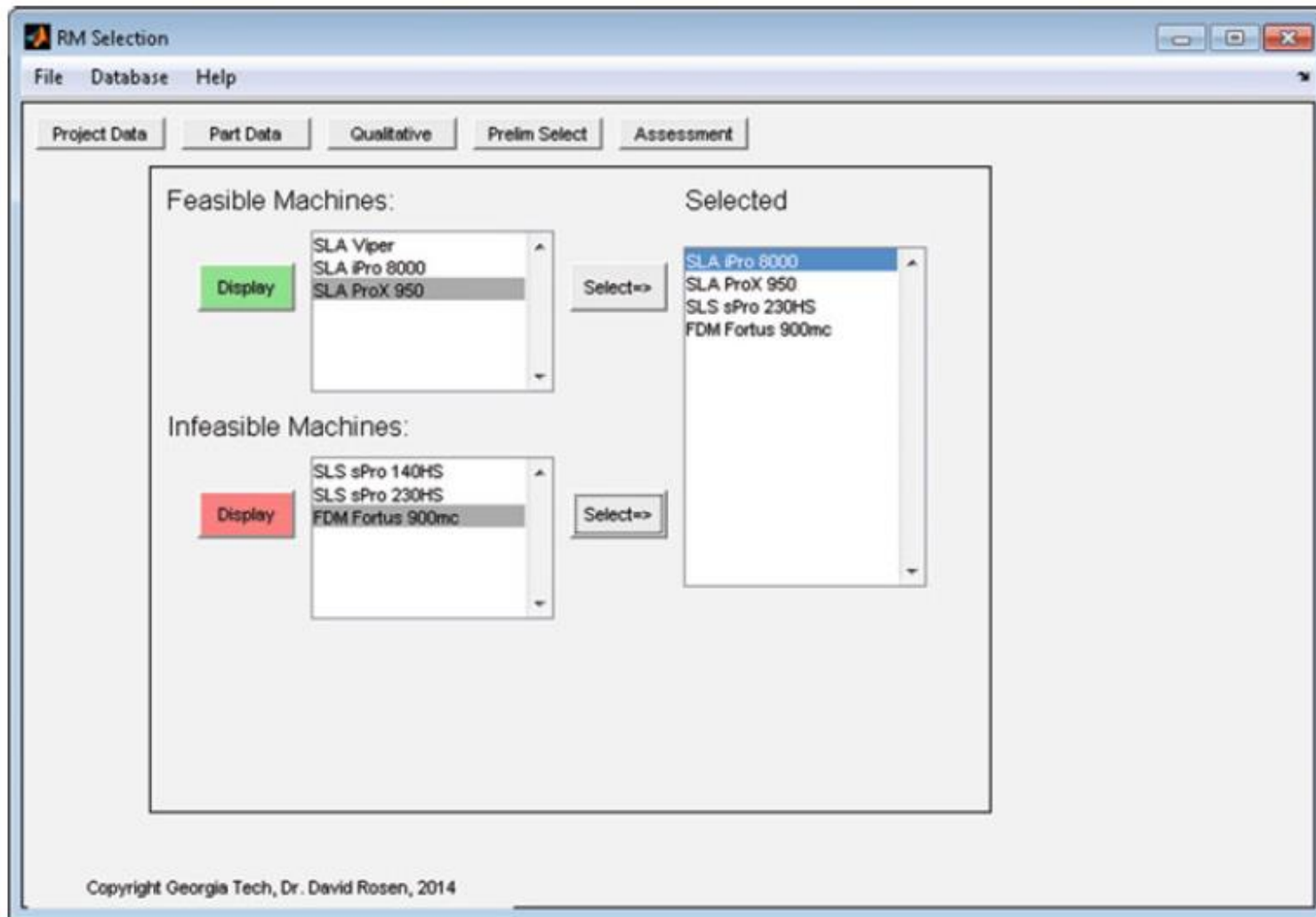
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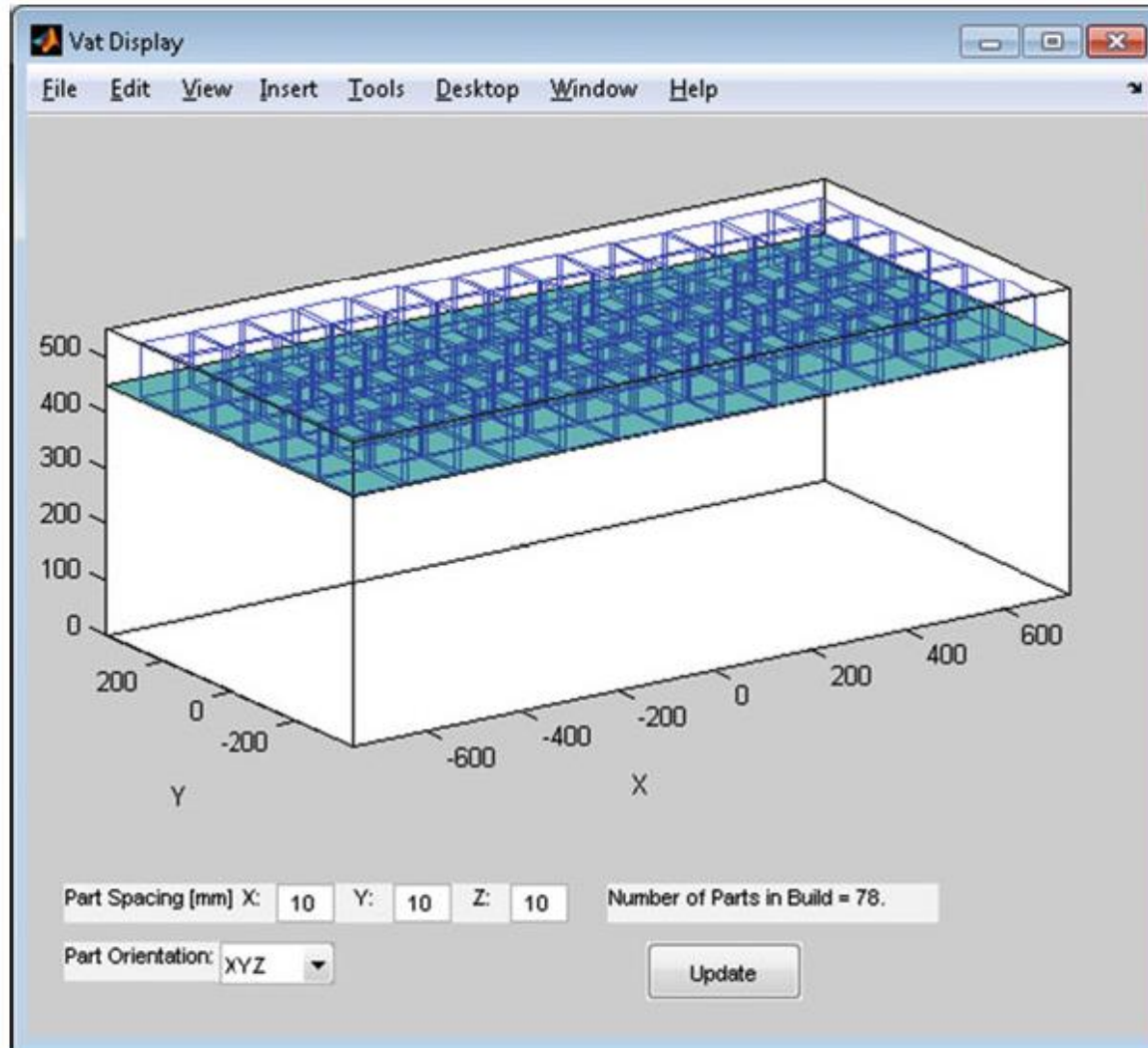


# Feasible Machines

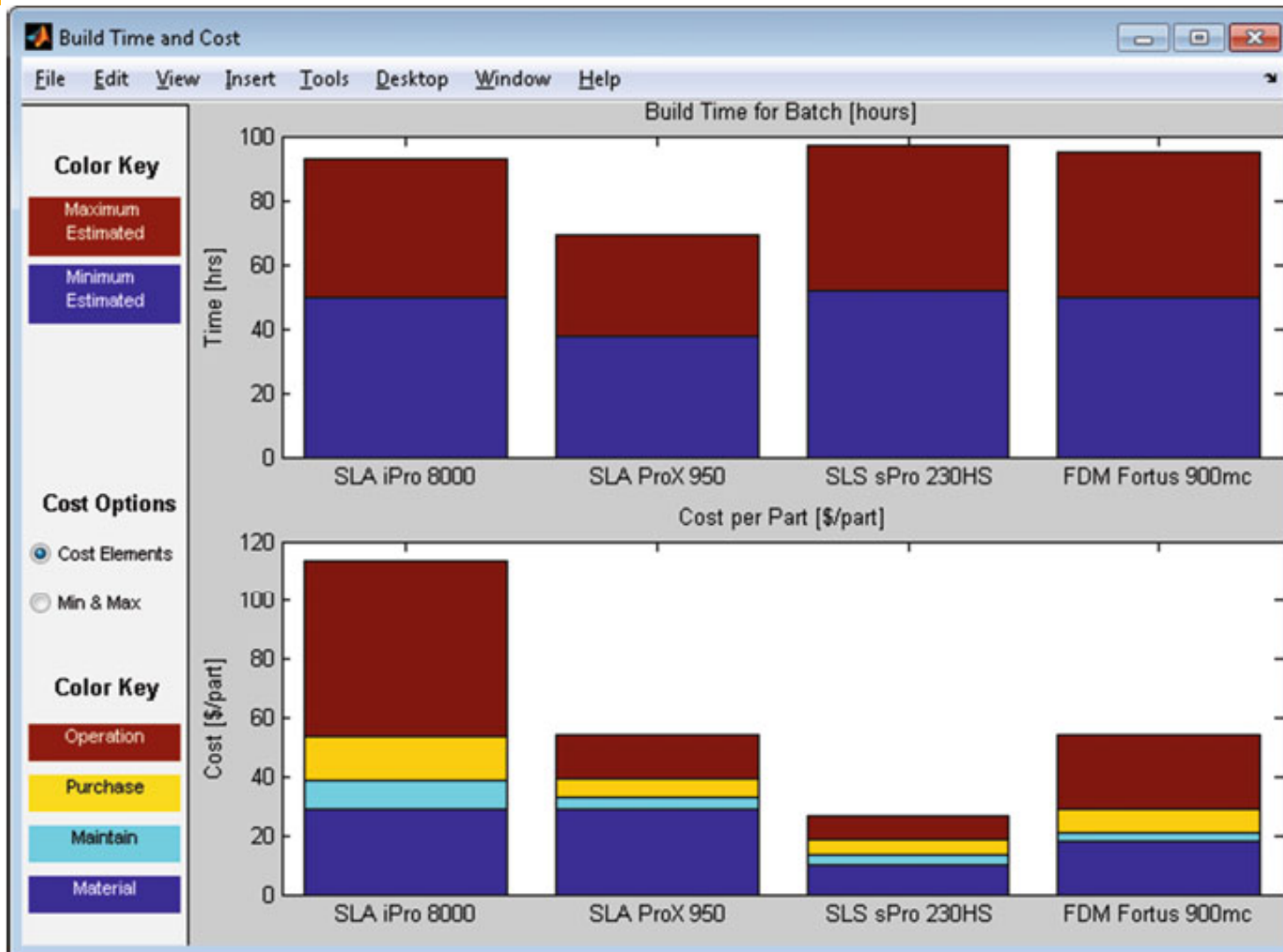




# Layout of parts on the machine platform



# Build time and cost results





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# End of Session 5