Additive Manufacturing
16ME420

Development of AM & Process Chain

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Introduction

Need - Development of AM systems – Challenges in AM - AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM - Classification of AM processes - Benefits Applications

Figure 1

The Generic Product Development Process

	Concept Development	System-Level Design	Detail Design	Testing and Refinement	Production Ramp-Up
Marketing	• Define market segments • Identify lead users • Identify competitive products	• Develop plan for product options and extended product family	• Develop marketing plan	• Dev. promotion and launch materials • Facilitate field tests	• Place early production with key customers
Design	• Study feasibility of product concepts • Develop industrial design concepts • Build and test experimental prototypes	• Generate alternative architectures • Define systems and interfaces • Refine industrial design	• Define part geometry • Spec materials • Spec tolerances • Industrial design control	• Reliability, performance and life tests • Get regulatory approvals • Impliment design changes	• Evaluate early production output
Manufacturing	• Estimate manufacturing cost • Assess production feasibility	• Identify suppliers • Make/buy study • Define final assembly scheme	• Define processes • Design tooling • Begin tooling procurement	• Begin supplier ramp-up • Refine mfg. processes	• Begin operation of production system

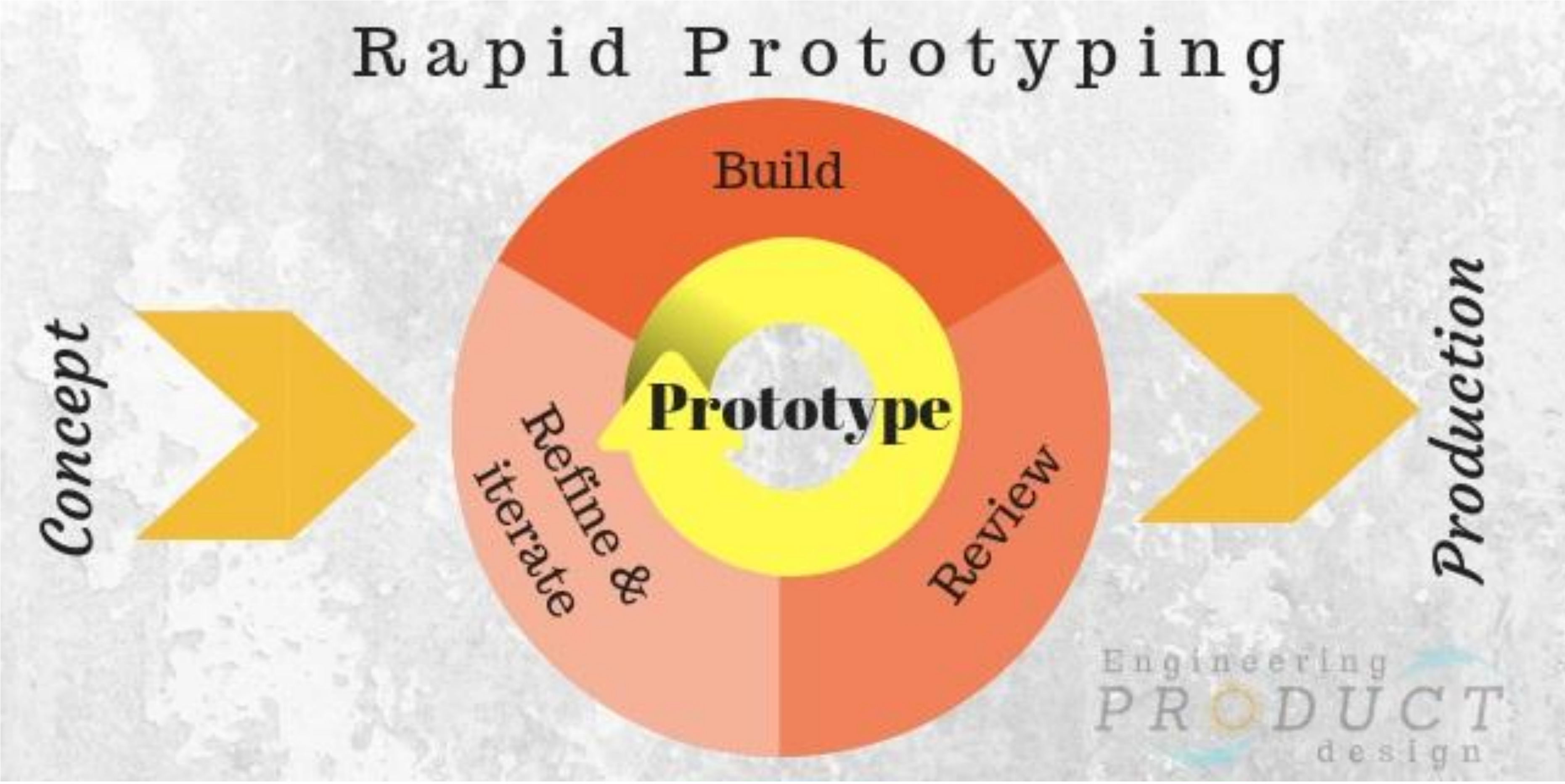
Rapid Prototyping 101

1. What is Rapid Prototyping?
2. What do you need to prototype?
3. The Rapid Prototyping process
4. How much should you include in your prototype?
5. What is meant by fidelity of a prototype?
6. How do you select which fidelity level to prototype on?
7. How do you choose a prototyping tool?
8. Prototyping best practices: do's and don'ts

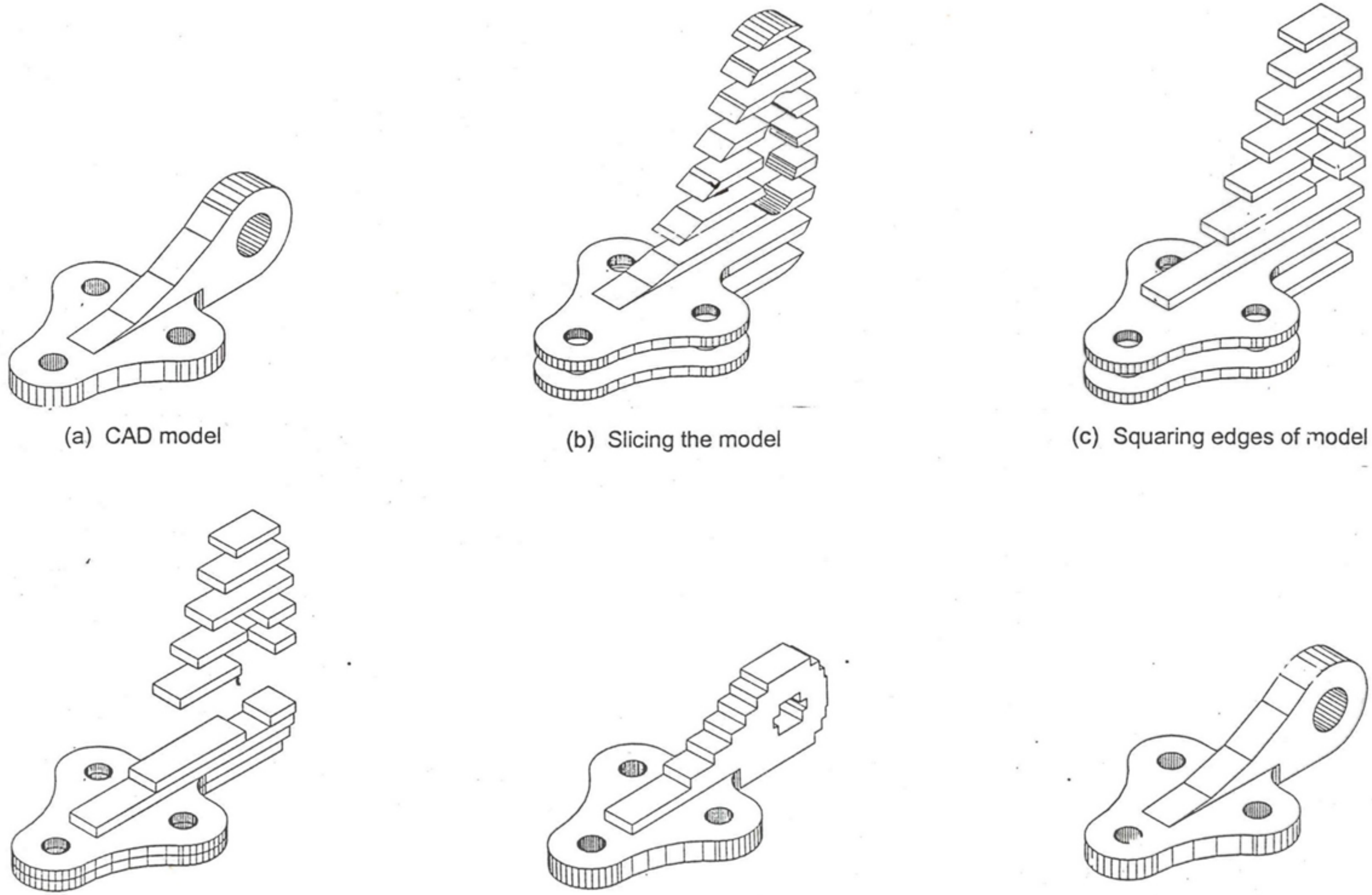
Need for Rapid prototyping

Rapid prototyping helps to reduce the costs of product development. There is no **need** to develop special tools for each new product.

Rapid prototyping uses the same CAD and printing equipment each time. The automated **prototyping** process also reduces staff costs



Rapid Prototyping
Build
Prototype
Review
Refine & iterate
Concept
Production
Engineering PRODUCT design

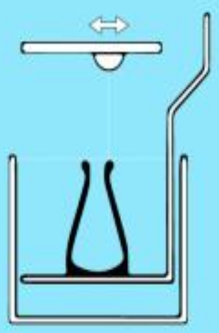


(a) CAD model
(b) Slicing the model
(c) Squaring edges of model
(d) Stacking and pasting layers
(e) Physical prototype
(f) Finished physical prototype

From the 1970s to today, key 3-D printing moments

1977

Wyn Kelly Swainson patents directing a laser onto a tray submerged in liquid plastic, fusing a layer of solid plastic on top.



1986

Chuck Hull patents stereolithography, focusing UV light at a liquid photopolymer surface, creating crosslinked layers.

1999

Scientists at the Wake Forest Institute for Regenerative Medicine 3-D print a bladder — the first 3-D printed organ.

2005

The first functional furniture is 3-D printed by French artist Patrick Jouin.

2013

A baby's life is saved by a 3-D printed splint created by the University of Michigan.

2017

Boeing debuts FAA-approved 3-D printed titanium parts for the 787 Dreamliner.

Sources: Madmuseum.org, The Guardian

Stereolithography Invention

United States Patent [19]

Hull

[11] **Patent Number:** **4,575,330**

[45] **Date of Patent:** **Mar. 11, 1986**

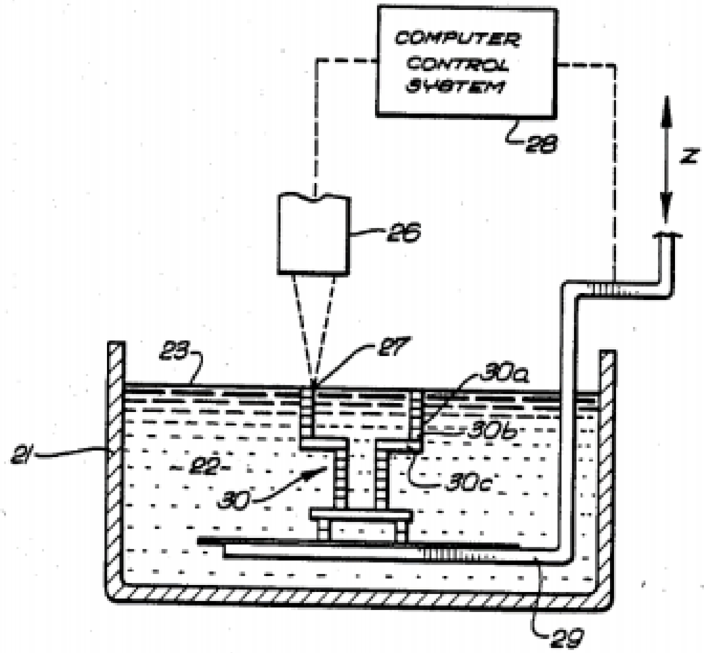
[54] **APPARATUS FOR PRODUCTION OF THREE-DIMENSIONAL OBJECTS BY STEREOLITHOGRAPHY**

[75] Inventor: **Charles W. Hull**, Arcadia, Calif.

[73] Assignee: **UVP, Inc.**, San Gabriel, Calif.

[21] Appl. No.: **638,905**

[22] Filed: **Aug. 8, 1984**



- 3D Systems was founded 1987
- First commercial product
  SLA-1 (1988)

Different names for 3D-Printing

- Rapid Prototyping (& Manufacturing)
- Automated Fabrication (Autofab)
- (Solid) Free Form Fabrication
- Layer-based Manufacturing
- Rapid Manufacturing
- Additive Manufacturing

ASTM-approved AM process terms

- Vat Photopolymerization
- Powder Bed Fusion
- Material Extrusion
- Material Jetting
- Binder Jetting
- Sheet Lamination
- Directed Energy Deposition

Challenges with additive manufacturing

- **Challenge #1:** Size limitations. ...
- **Challenge #2**: Quality consistency. ...
- **Challenge #3**: Scalability limitations. ...
- **Challenge #4**: A narrow range of materials and high material cost. ...
- **Challenge #5**: Limited multi-material capabilities.

Virtual Design