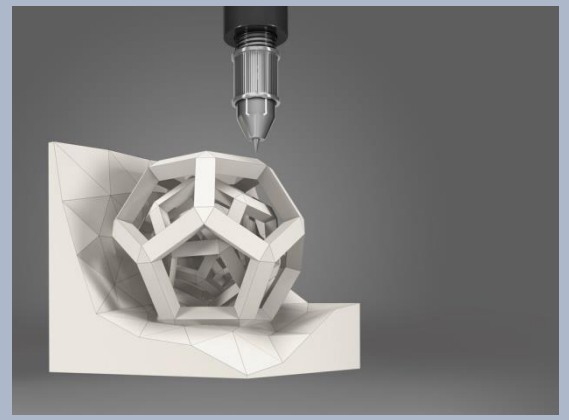
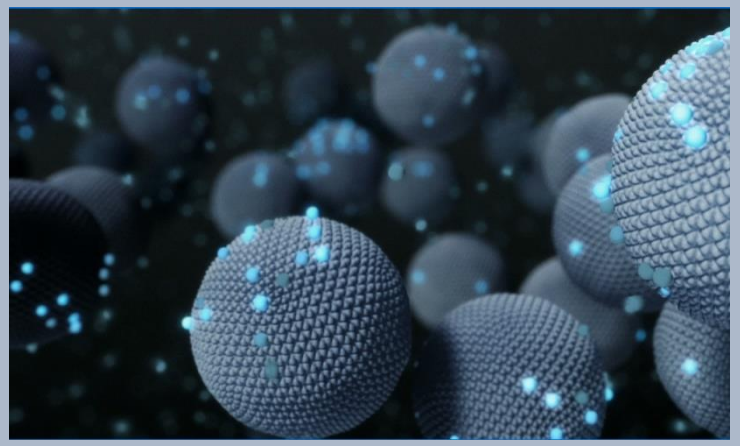
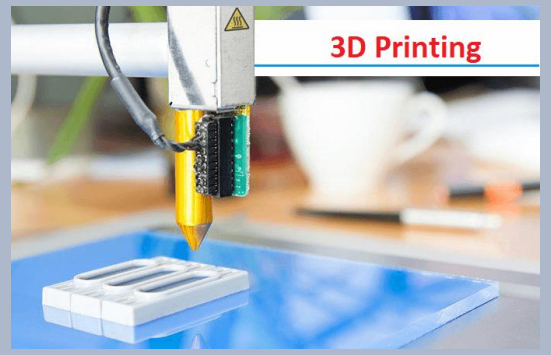
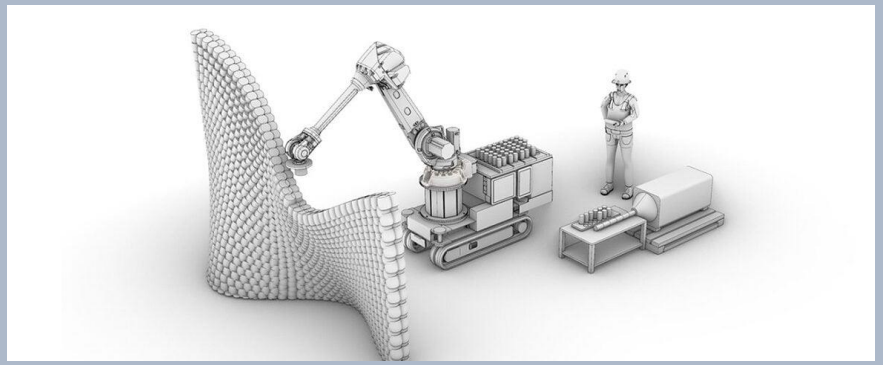
Unit-5

Introduction to Digital Fabrication



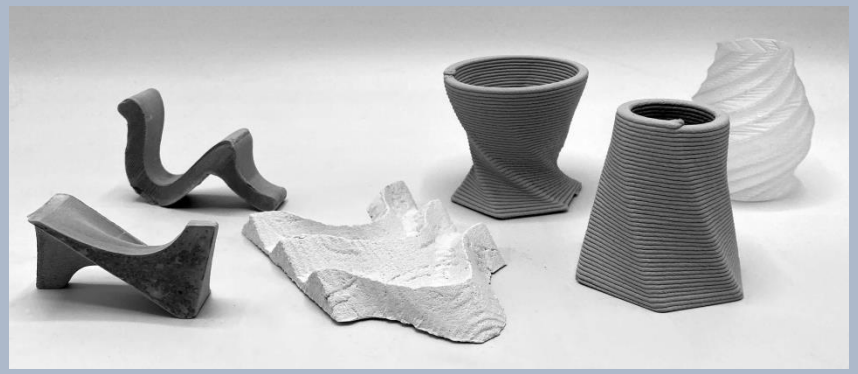


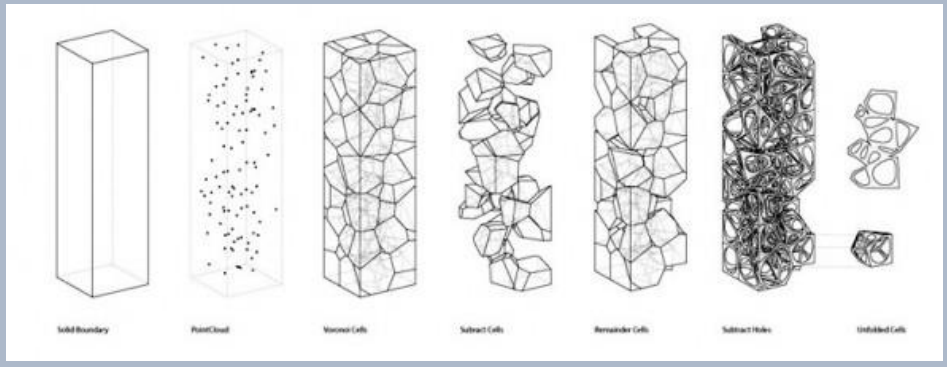




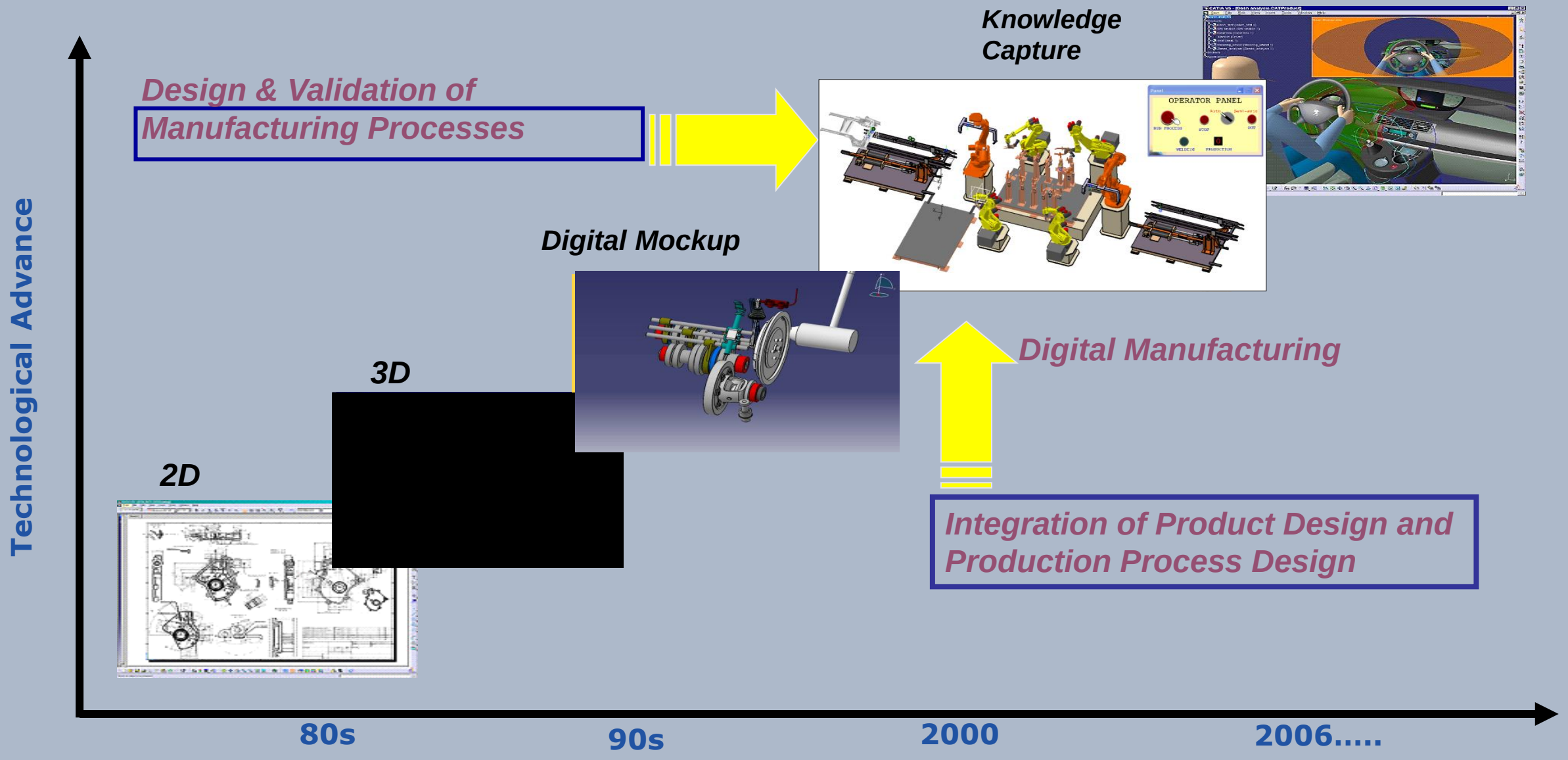
CONTENTS:

1. Need of digital manufacturing,
2. Prototype,
3. Types and roles of prototypes,
4. Rapid prototyping (RPT),
5. Phases of RPT,
6. Fundamentals of RPT and advantages



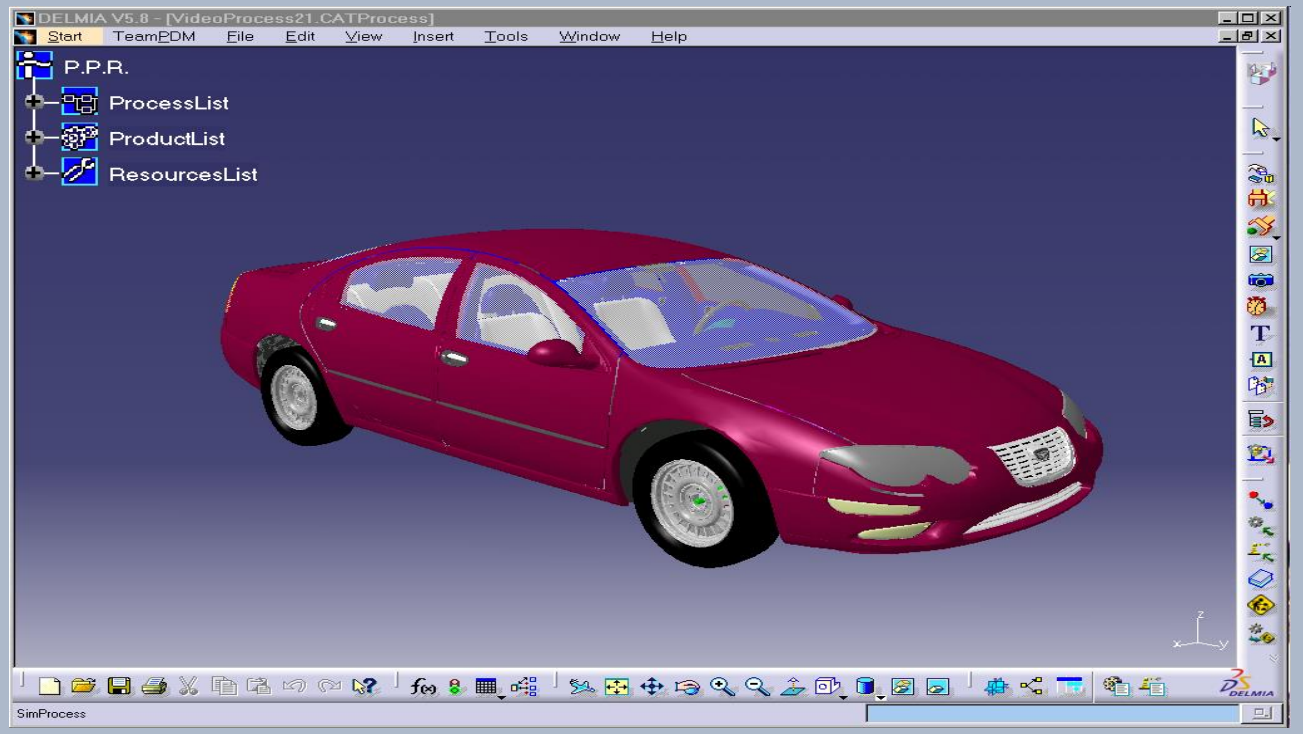


Evolution of the Design/Build Process



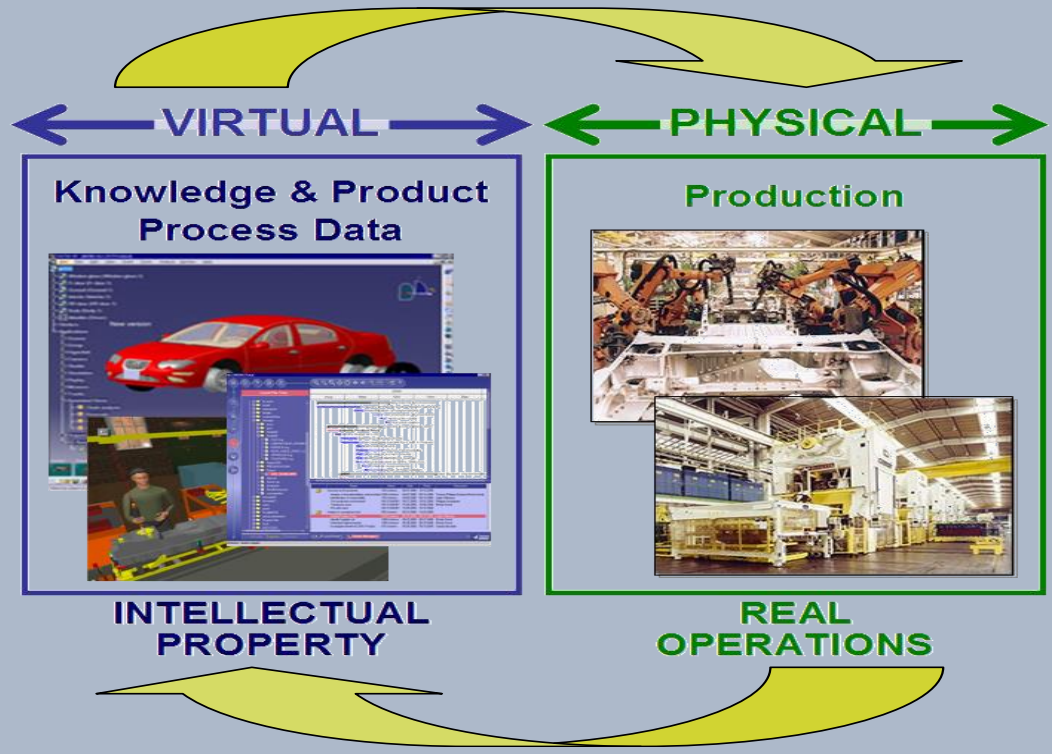
What is Digital Fabrication?

"Digital Manufacturing represents an integrated suite of PLM tools that supports manufacturing process design, tool design, plant layout, and visualization through powerful virtual simulation tools that allow the manufacturing engineer to validate and optimize the manufacturing processes. "



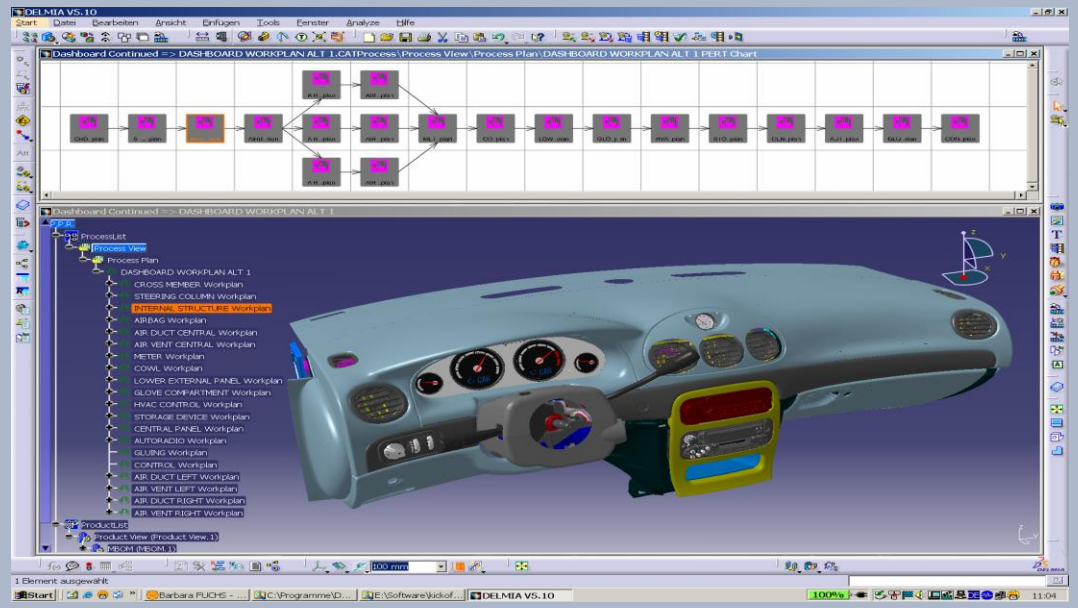
What Does Digital Fabrication Do?

- **Manufacturing Planning**
  - Define Manufacturing Processes
  - Process Planning (Assembly & Installation)
  - Define Work Instructions & Work Flow
- **Detailed Process Design & Analysis**
  - Detailed Resource Modeling & Simulation
  - Process Definition and Validation
  - 3-D Factory Layout
  - Equipment, Tool & Fixture Simulation
  - Ergonomic Simulation
- **Validation & Virtual Commissioning**
  - Control Logic Validation
  - Kinematic (Robotic) Validation
  - Quality Assurance/Process Improvement Validation
  - Sensor/Metrology Placement Validation
  - Virtual Commissioning/Validation of Automation Systems
  - Knowing that the Production System Works Prior to Launch: Priceless.



Digital Fabrication Redefines Concurrent Engineering

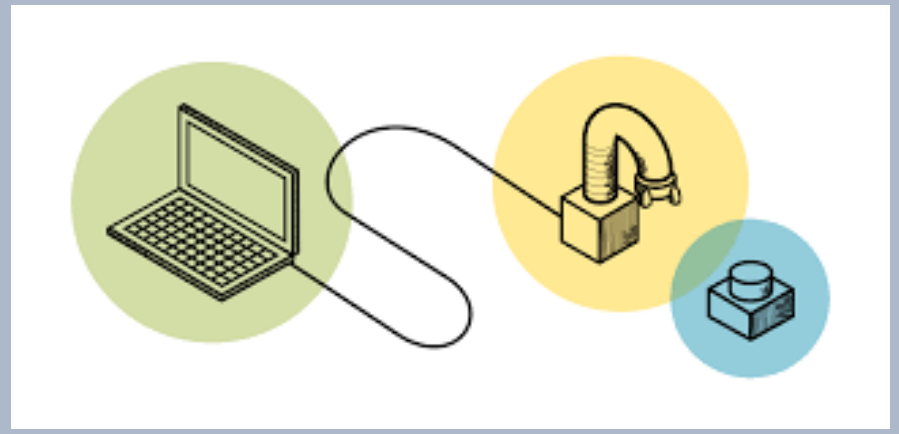
- Product Design (CAD) tools are employed to define “What" is to be built,
- Manufacturing Process design tools are used to define “How" it is to be built.
- Integration of Product & Process Design directly supports the concept of Concurrent Engineering

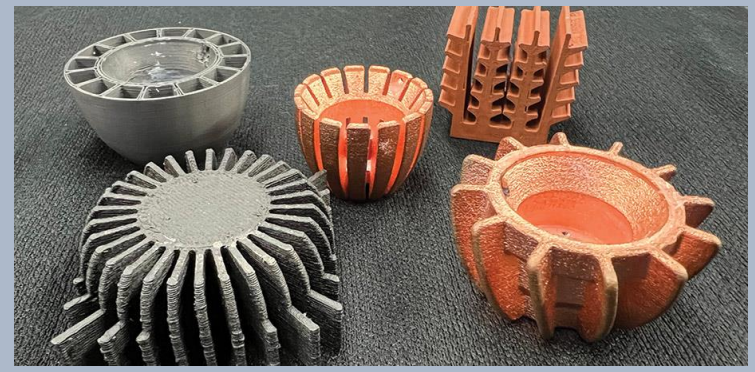


Digital Manufacturing facilitates the Holistic view of Product and Process Design as integral components of the overall product life cycle

Introduction- DIGITAL FABRICATION

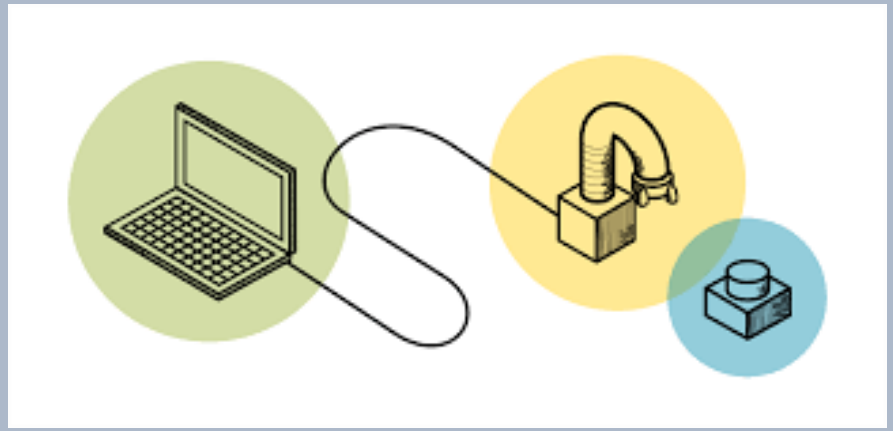
- Digital fabrication is a **design** and **manufacturing workflow**, where **digital data** directly drives manufacturing equipment to form various part geometries,
- This data most often comes from **CAD** (**Computer-Aided Design**), which is then transferred to CAM (**Computer-Aided Manufacturing**) software,
- The output of CAM software is data that directs a specific **additive and subtractive** manufacturing tool, such as a 3D printer or CNC milling machine.
- https://www.youtube.com/watch?v=ptDJw98Ds9M





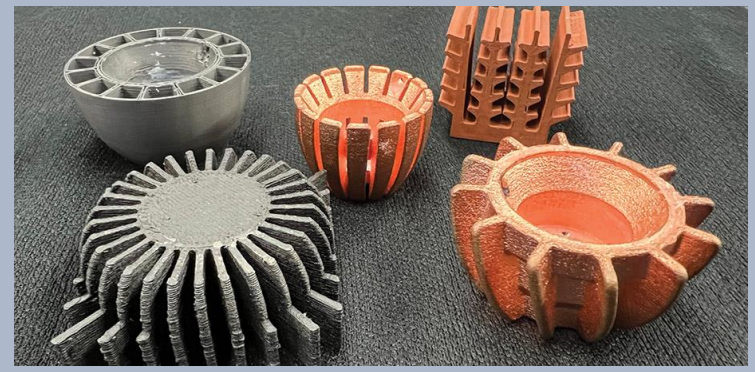
Introduction- DIGITAL FABRICATION

- Digital fabrication is a **design** and **manufacturing workflow**, where **digital data** directly drives manufacturing equipment to form various part geometries,



- This data most often comes from **CAD** (**Computer-Aided Design**), which is then transferred to CAM (**Computer-Aided Manufacturing**) software,

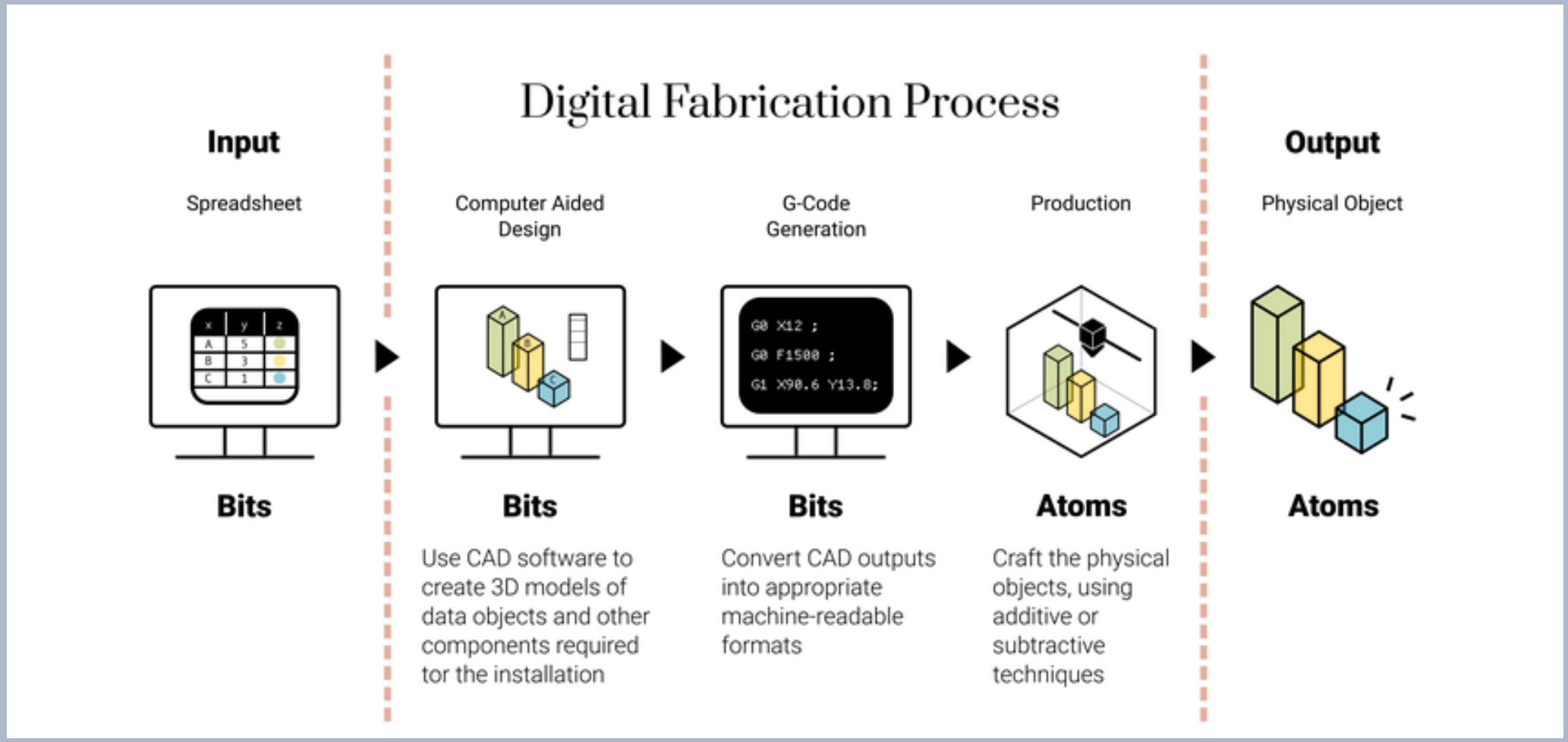
- The output of CAM software is data that directs a specific **additive and subtractive** manufacturing tool, such as a 3D printer or CNC milling machine.



Need of Digital Manufacturing

- **Market Competition**- The competition in the world market for new manufactured products has intensified tremendously,
- **Swift Production**- For fast production, the processes involved in the **design, test, manufacture** have been squeezed, both in terms of time and material resources,
- **Keep it in-house** – With a 3D printer and the right software, you can **produce** small batches of products on your own premises without the need for external vendors,
- **Save money** – Because you're only making **prototypes or small batches** of a product, you won't need much **storage space**. You can also save money on materials by using lower-grade supplies or even recycled plastic,
- **Save time** – Digital fabrication **accelerates** the process of product development as you can create prototypes much more quickly than traditional manufacturing methods, with no need to outsource
- **Spot errors early** – Engineers like digital fabrication because it helps them spot any issues that exist within days rather than months,

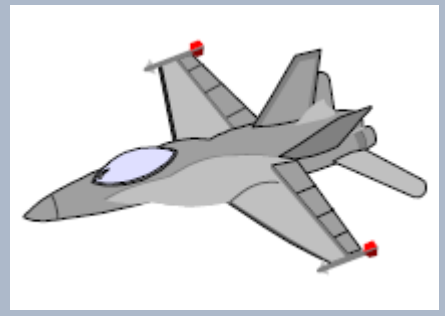
DIGITAL FABRICATION PROCESS



Video

Prototype

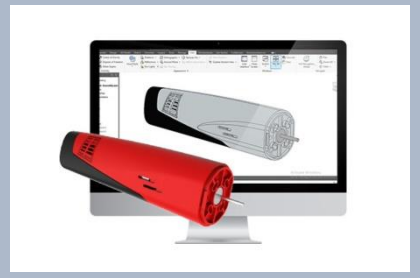
- According to Oxford Dictionary, *a '**prototype**' is the **first or original example** of something that has been or will be copied or developed; it is a **model** or **preliminary version**;*



- *e.g.: A prototype supersonic aircraft.*

- **Another definition**- An **approximation** of a product (or system) or its **components** in some form for a definite purpose in its implementation,

https://www.youtube.com/watch?v=8Ome0BKLgqQ&t=47s
https://www.youtube.com/watch?v=WZpv4eBcHik



Prototyping is the process of realizing these prototypes.

Prototype

- A prototype is the first or original example of something that has been or will be copied or developed; it is a model or preliminary version.

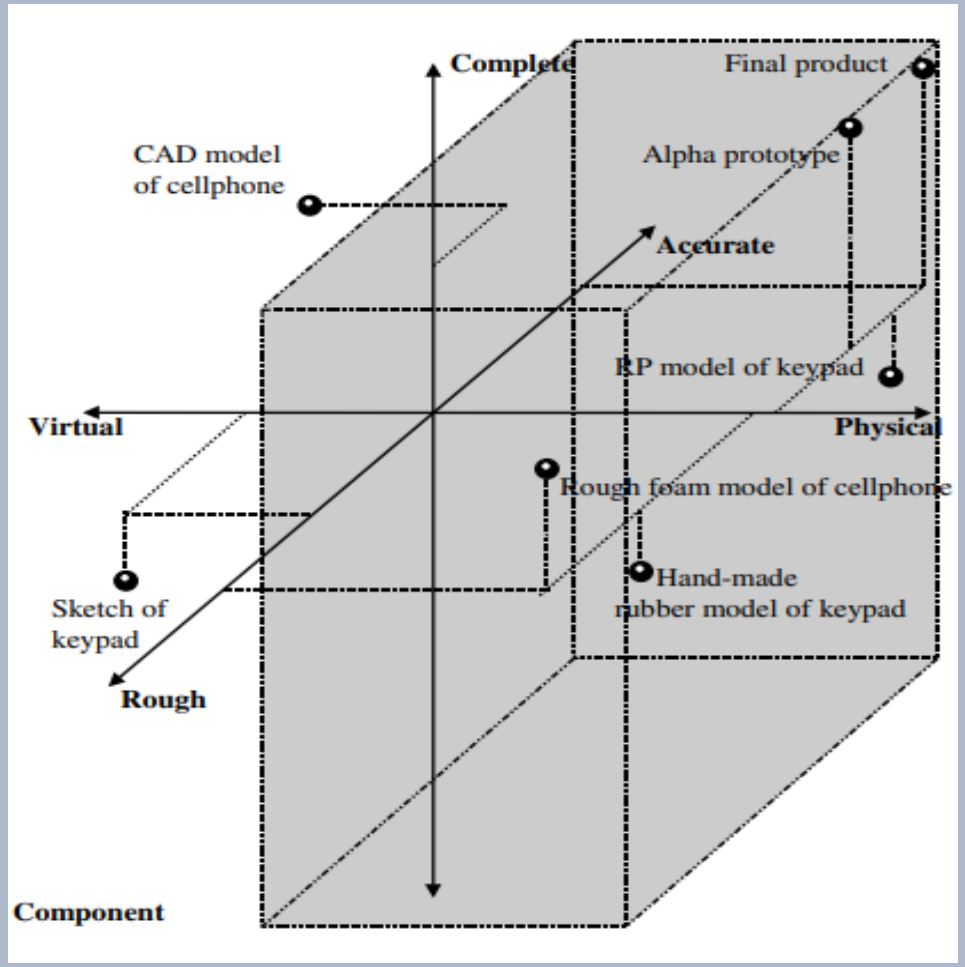
Types of Prototypes

- There are three aspects of interests:

1. **Implementation** of the prototype- from the **entire product** to its **sub-assemblies**/ **components**,
2. **Form** of the prototype- from a **virtual (nontangible)** prototype to a **physical (tangible**) prototype, and
3. **Degree** of the approximation- from a very **rough representation** to an **exact replication** of the product.

Examples:

- **Virtual prototypes:** Mathematical models, control systems, visualization of airflow over an aircraft wing to ascertain lift and drag on the wing during supersonic flight. **Drawbacks-** Couldn't predict any unexpected phenomena,
- **Physical prototypes:** Mock-up of cellular mobiles,
- **Rough prototypes:** Foam models- to see the dimensions and general forms,
- **Exact replication:** Pre-production models

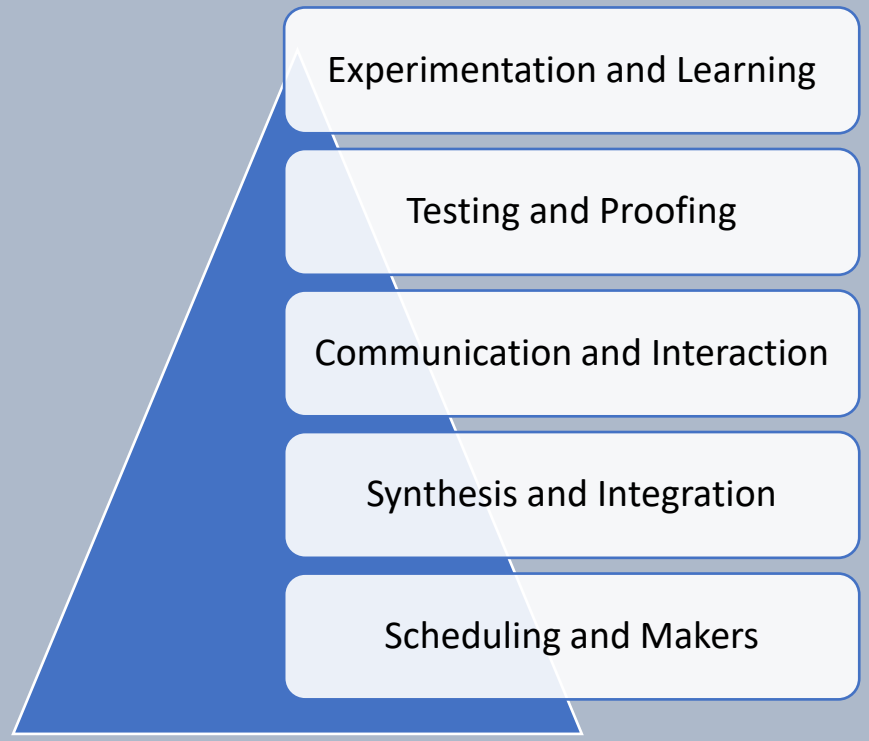


Types of prototypes described along the three aspects of implementation, form and approximation

Roles of the Prototypes

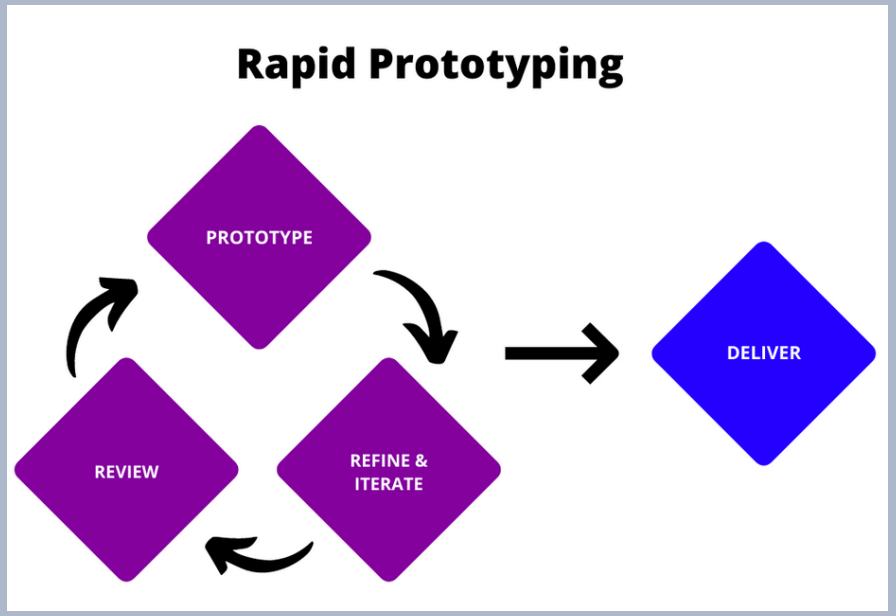
The roles of prototypes in the product development process are shown in Figure:

- **Experimentation and Learning**- Prototypes can be used to help the thinking, planning, experimenting and learning processes whilst designing the product.
- **Testing and Proofing-** Eg., in the early design of folding reading glasses for the elderly, concepts and ideas of folding mechanism can be tested by building rough physical prototypes,
- **Communication and Interaction-** Protypes not just convey the information within the product development team, but also to management and clients,
- **Synthesis and Integration-** A prototype can also be used to synthesize the entire product concept by bringing the various components and sub-assemblies together to ensure that they will work together,
- **Scheduling and Makers-** Prototyping helps in the scheduling of the product development process and is usually used as markers for the end or start of the various phases of the development effort.



Rapid Prototyping

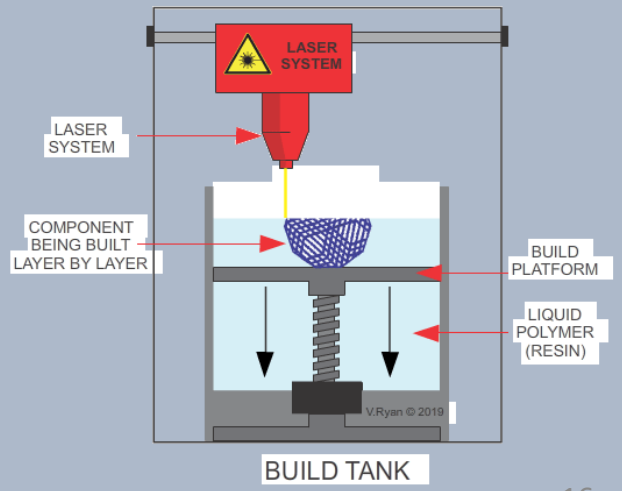
- Rapid prototyping is a **group of techniques** used to **quickly** fabricate a scale **model** of a physical part or assembly using three-dimensional computer aided design data,
- "As the name implies, rapid prototyping is a process of creating a prototype rapidly to evaluate the features or some part of the product."
- https://www.youtube.com/watch?v=OhNnKTaciVI
- https://www.youtube.com/watch?v=3KcK_-fY_OI&t=22s



- The **first Rapid prototyping method**, called ***stereolithography***, was developed in the late 1980s, but more sophisticated techniques are available these days,

https://www.youtube.com/watch?v=faGyF81LadA

- The term '**rapid**' is **relative**. Some prototypes may take hours or days to build,



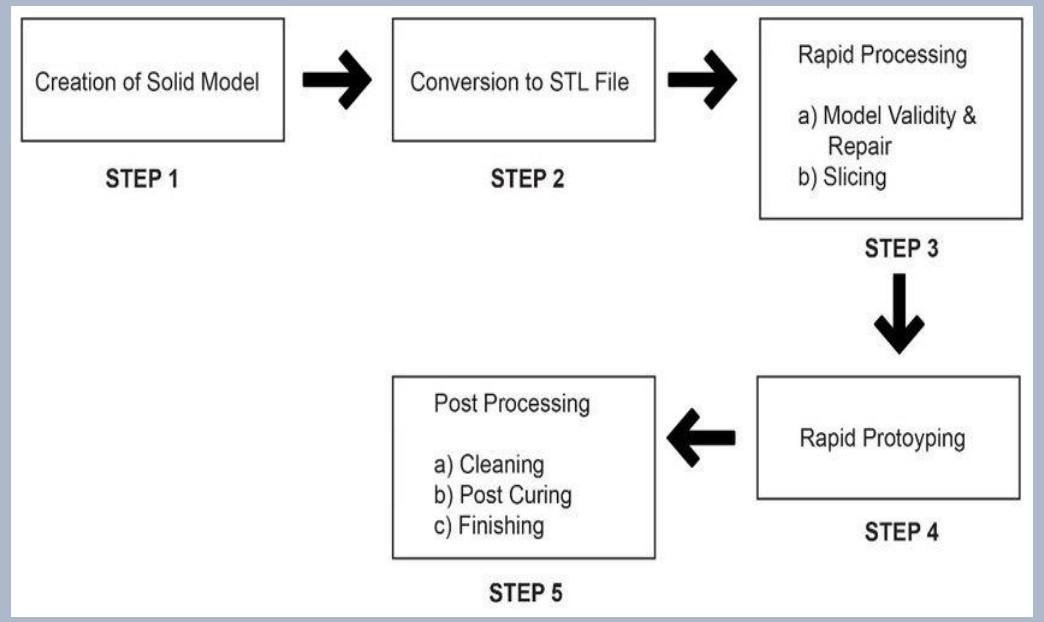
Rapid Prototyping

- Rapid prototyping is a **additive manufacturing** process, that works on the basic principle of producing a 3D part by **building and stacking 2D layers** together,

- Most common types of Rapid Prototyping systems are:

  (a) SLA – Stereolithography,
  (b) SLS – Selective Laser Sintering,
  (c) LOM – Laminated Object Manufacturing,
  (d) FDM – Fused Deposition Modeling

- Although these are different techniques, but their basic principles are same.



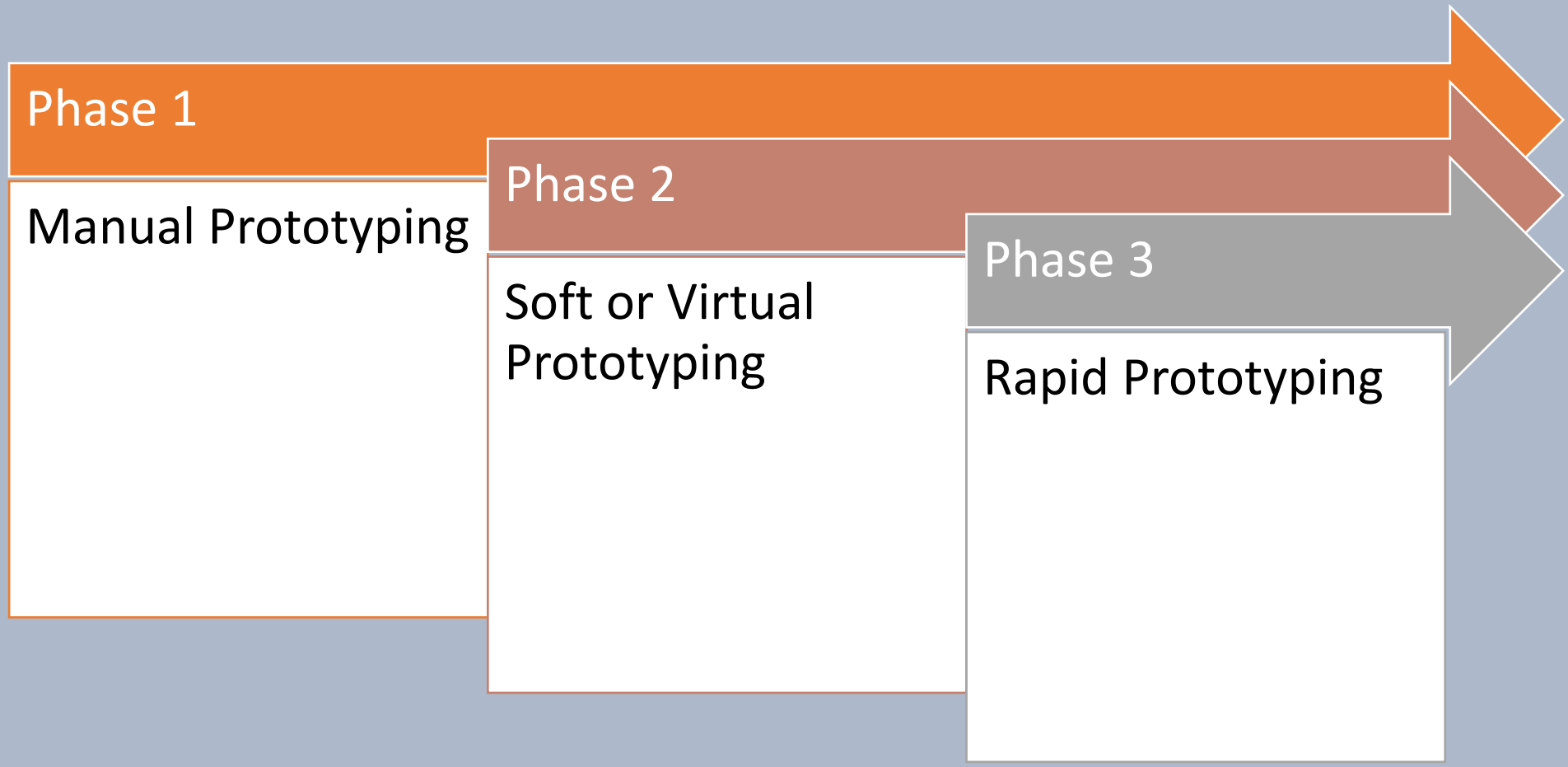
Rapid Prototyping Process

- Fabricate the model
  - Building the model layer by layer
  - Forming a 3D model by solidification of liquid/ powder

- Removing support structure and cleaning
  - After building, drain out extra material,
  - Cut out the prototype,
  - Cut out unnecessary support material

- Post Processing
  - Includes surface finishing and other processes

Phases of Rapid Prototyping



Phases of Rapid Prototyping

Prototyping processes have gone through three phases of development:

➢ **First Phase: Manual Prototyping-**

- In this early phase, prototypes are **not very sophisticated**,
- Fabrication of prototypes takes on average about **four weeks**, depending on the level of **complexity**,
- The techniques used in making these prototypes tend to be craft-based and are usually **extremely labor intensive**.

➢ **Second Phase: Soft or Virtual Prototyping-**

- Computer models can be stressed, tested, analyzed and modified as if they were physical prototypes,
- Eg., analysis of stress and strain can be accurately predicted on the product,
- With such tools on the computer, several iterations of designs can be easily carried out by changing the parameters of the computer models.

➢ **Third Phase: Rapid Prototyping-**

- It includes tremendous time savings, especially for complicated models.

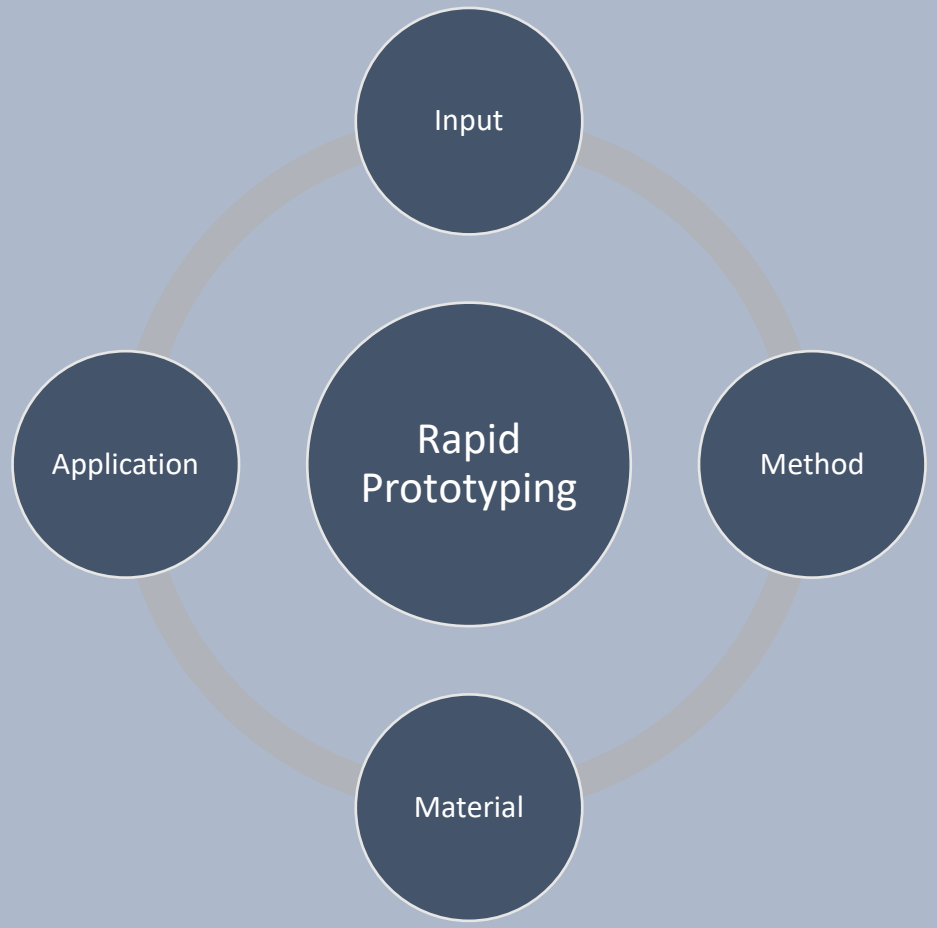
Geometric Modeling and Prototyping

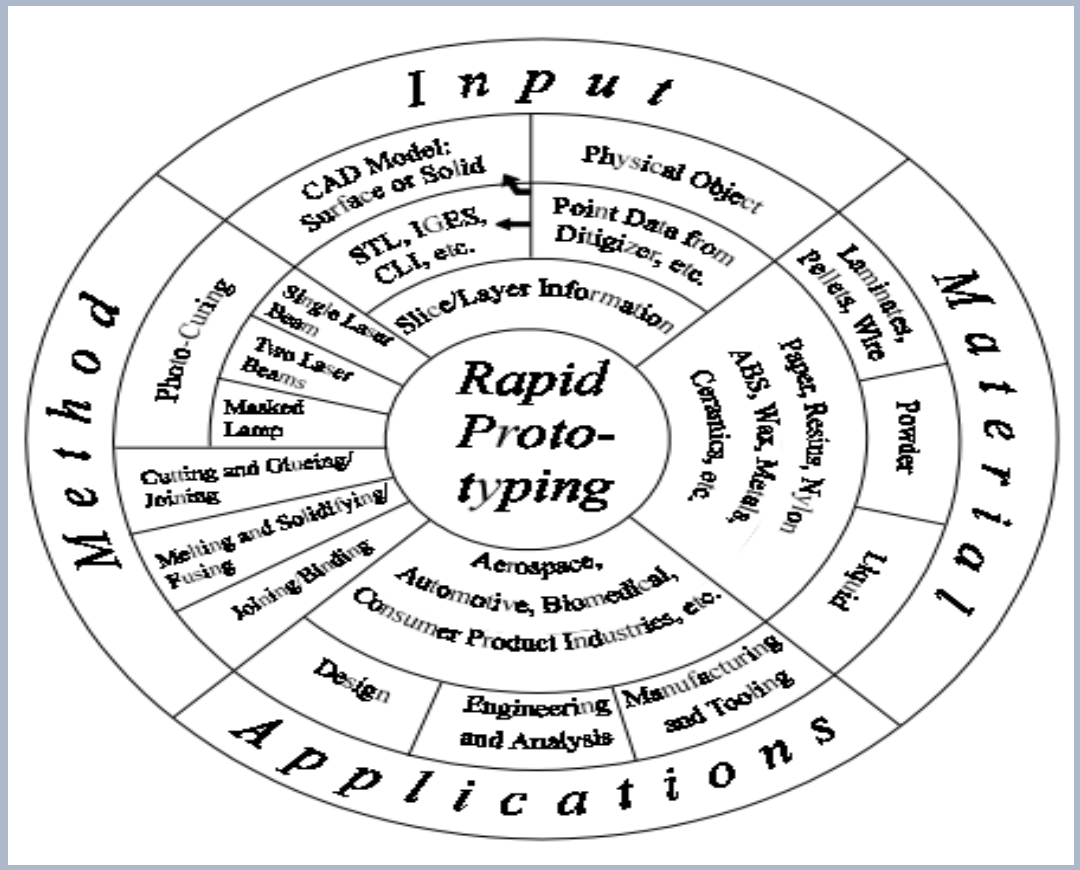
Geometric Modeling	Prototyping

❶ **First Phase: 2D Wireframe**
• Started in mid-1960s
• Few straight lines on display may be:
  • circuit path on a PCB
  • plan view of a mechanical component
• "Natural" drafting technique
	❶ **First Phase: Manual Prototyping**
	• Traditional practice for many centuries
	• Prototyping as a skilled crafts is:
	  • traditional and manual
	  • based on material of prototype
	• "Natural" prototyping technique

❷ **Second Phase: 3D Curve and Surface Modeling** • Mid-1970s • Increasing complexity • Representing more information about precise shape, size and surface contour of parts	❷ **Second Phase: Soft or Virtual Prototyping** • Mid-1970s • Increasing complexity • Virtual prototype can be stressed, simulated and tested, with exact mechanical and other properties
❸ **Third Phase: Solid Modeling** • Early 1980s • Edges, surfaces and holes are knitted together to form a cohesive whole • Computer can determine the inside of an object from the outside. Perhaps, more importantly, it can trace across the object and readily find all intersecting surfaces and edges • No longer ambiguous but exact	❸ **Third Phase: Rapid Prototyping** • Mid-1980s • Benefit of a hard prototype made in a very short turnaround time is its main strong point (relies on CAD modeling) • Hard prototype can also be used for limited testing • Prototype can also assist in the manufacturing of the products

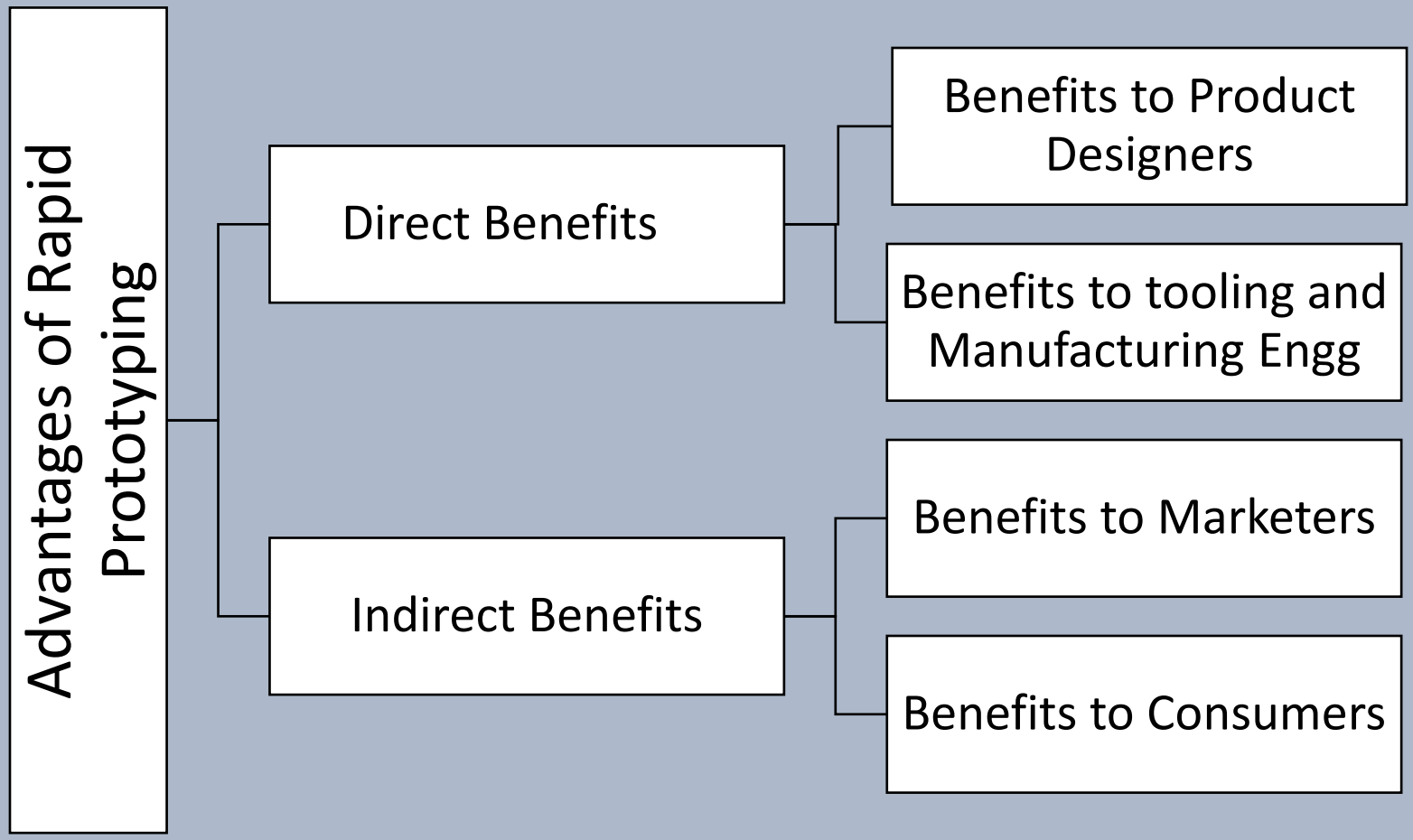
Fundamentals of Rapid Prototyping





The Rapid Prototyping Wheel depicting the four major aspects of RP

Advantages of Rapid Prototyping



Advantages of Rapid Prototyping

➢ Design Applications-

- Designers can **confirm their designs** by building a real physical model in **minimum time** using RP,

Design Benefits-

- Reduced **lead times** to produce prototypes,
- **Improved** ability to **visualize** the part geometry,
- Early detection of **design errors**,

➢ Engineering Analysis and Design-

- Comparison of **different shapes and styles** to determine aesthetic appeal,
- **Stress analysis** of physical models,
- Fabrication of **pre-production parts** for process planning and tool design

Advantages of Rapid Prototyping

- Process is Fast and accurate,
- Superior surface finish,
- Separate materials can be used for components and supports,
- No need to design jigs and fixtures,
- No need of moulds and other tools,
- Harder materials can be easily used,
- Minimum materials wastage,
- Reduces product development cycle time considerably

Limitations of Rapid Prototyping

- Many times component gets distorted,
- Limited range of materials,
- Operation cost

Thanks