Additive Manufacturing in Pakistan: Current Penetration and Key Challenges

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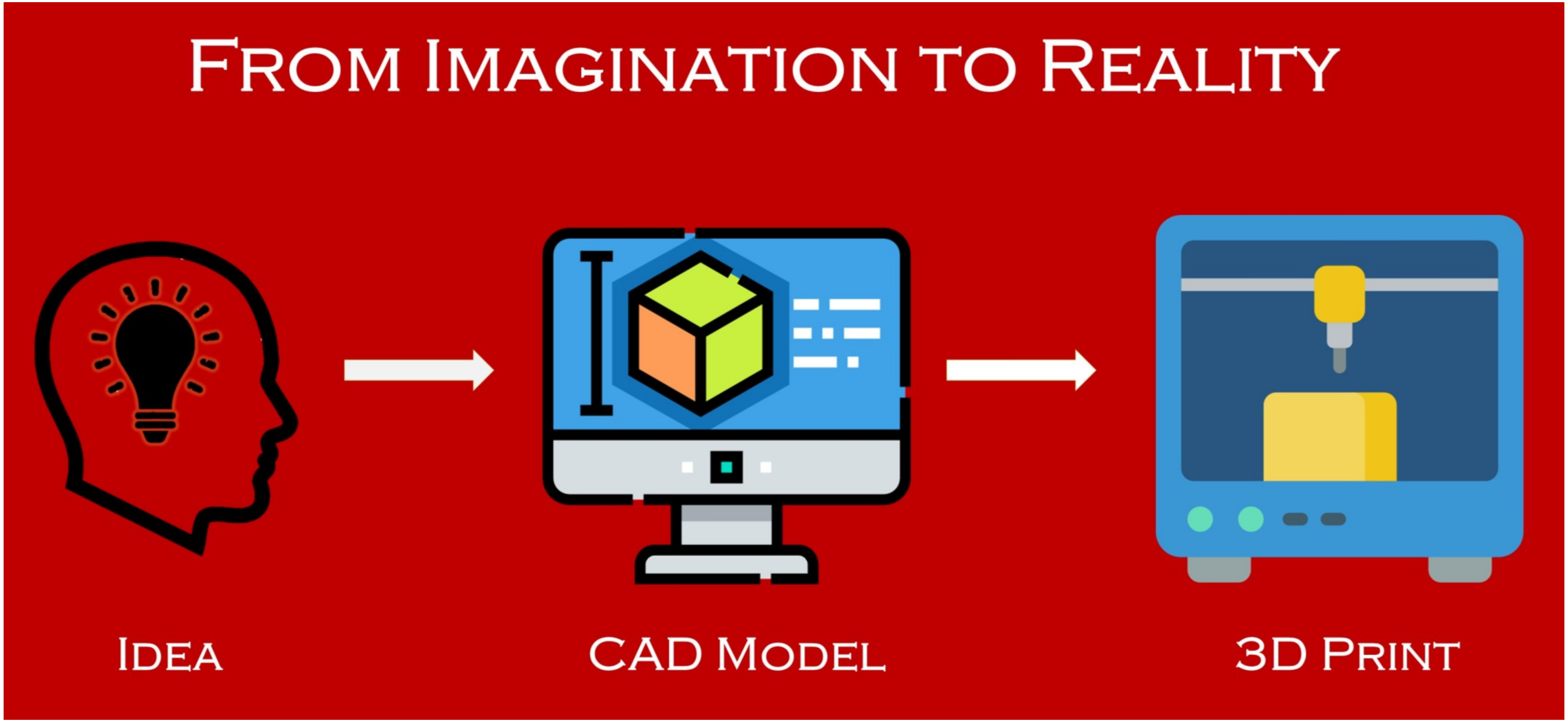
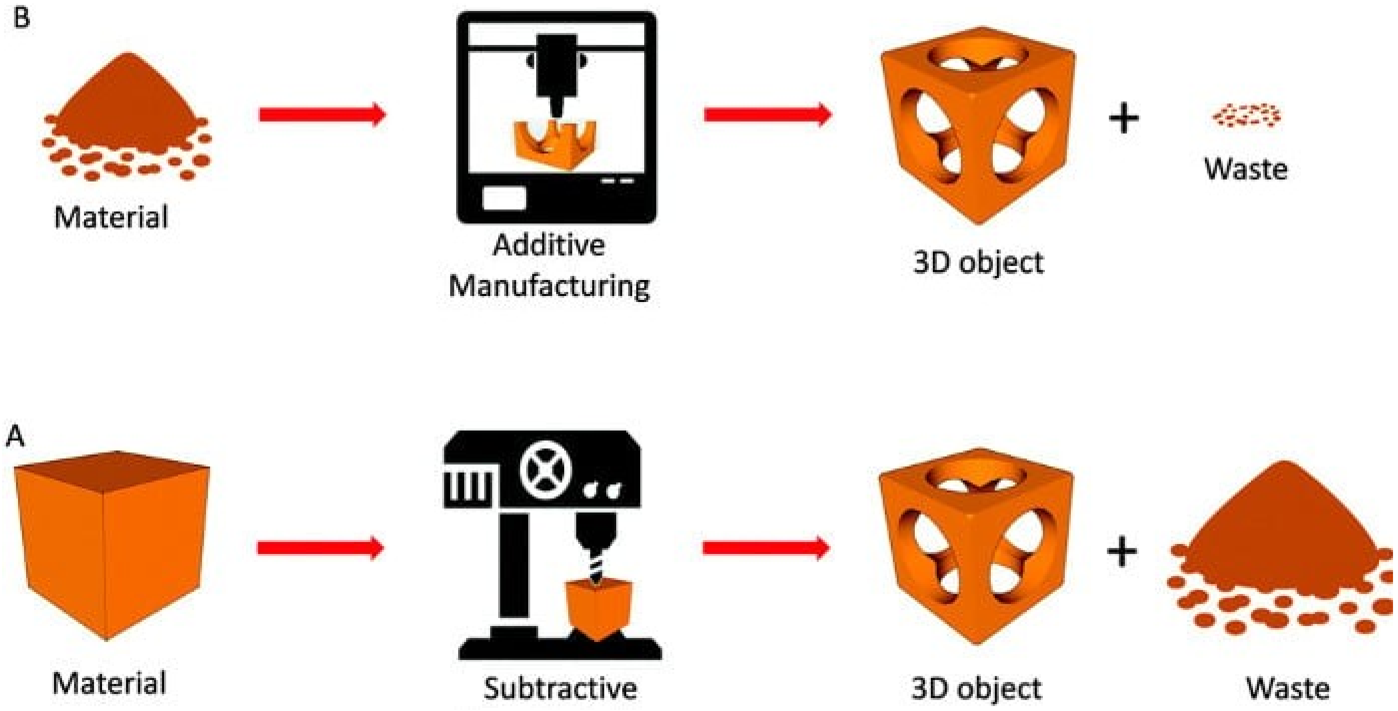
Additive Manufacturing



Additive Manufacturing

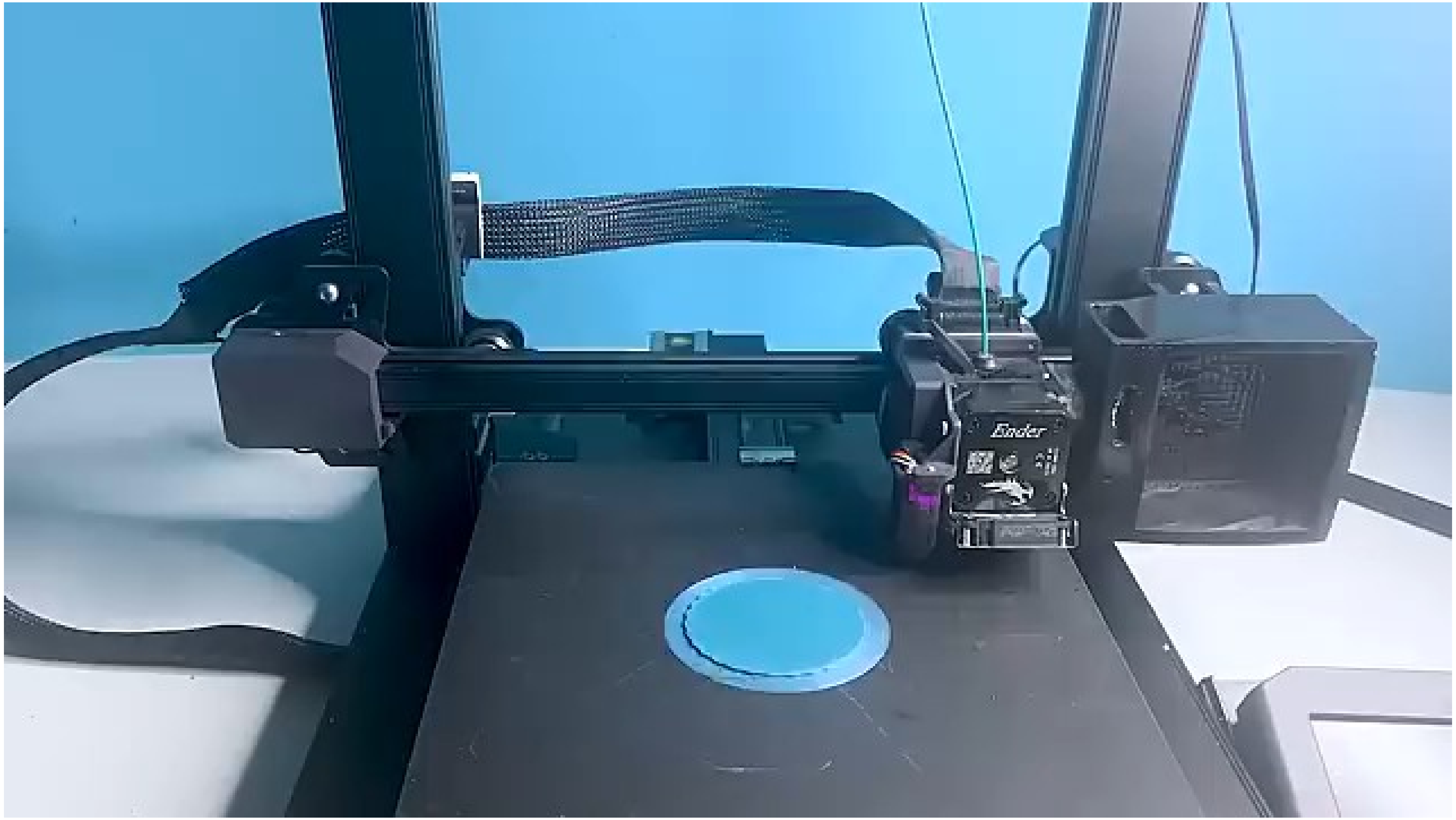
Additive Manufacturing is a process of creating **three-dimensional objects** by building them **layer by layer** from a **digital model**, typically using materials such as plastics, metals, or composites.

Unlike traditional **subtractive methods** that remove material from a solid block, **additive manufacturing adds material only where needed**, enabling **complex geometries**, reduced waste, and rapid prototyping.



Source: https://bitfab.io/blog/additive-manufacturing/

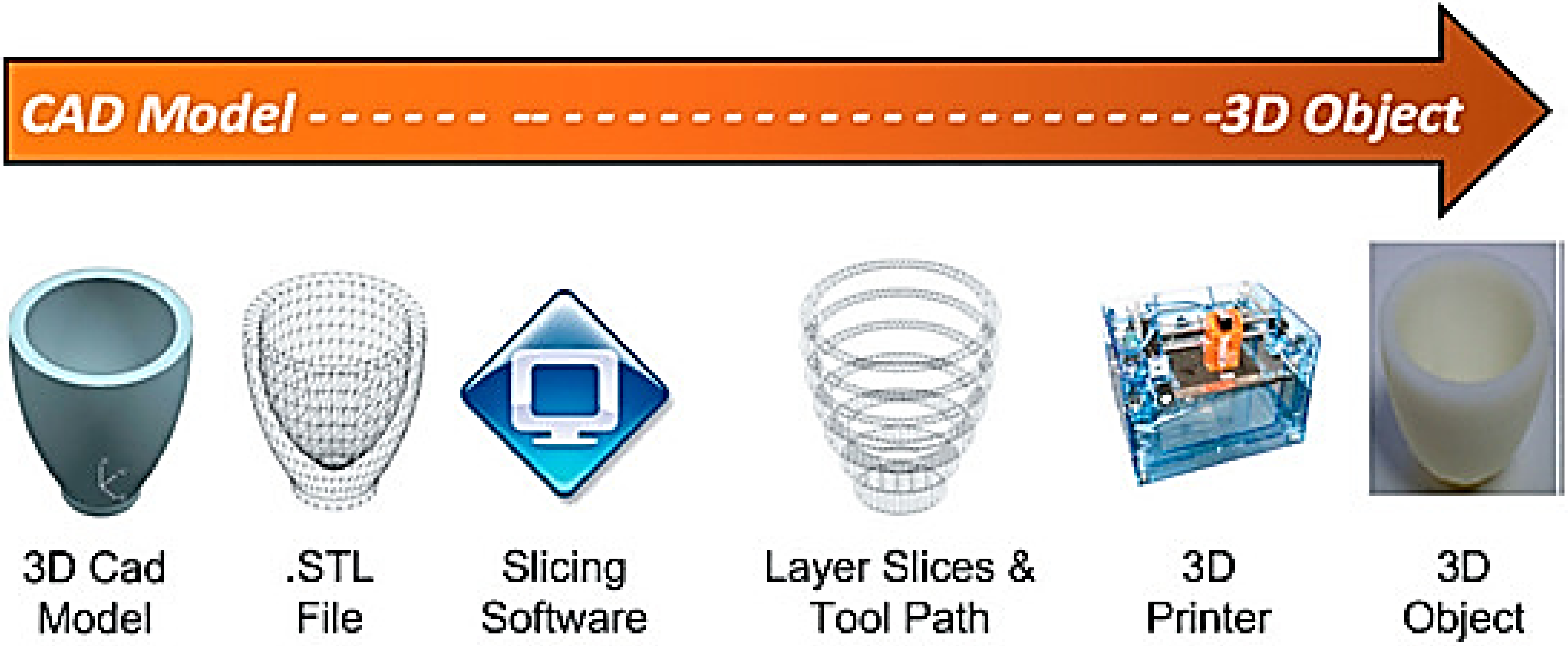
Additive Manufacturing



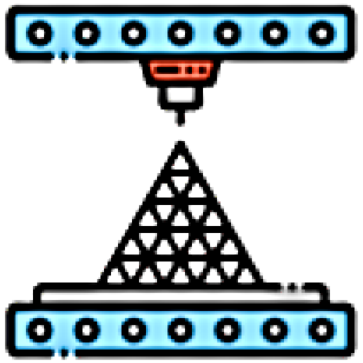
Additive Manufacturing

ADVANCED STRUCTURES &
composites center

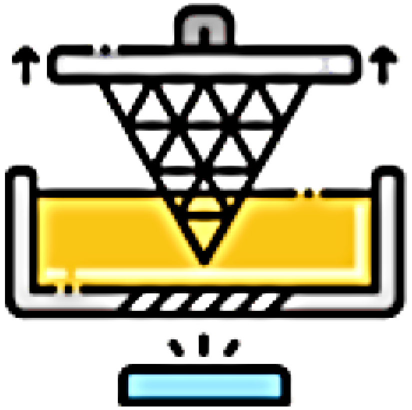
Additive Manufacturing



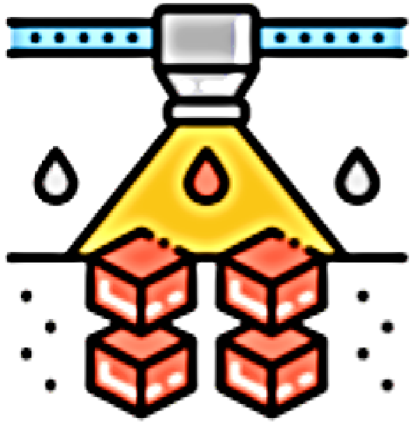
Type of Additive Manufacturing Technologies



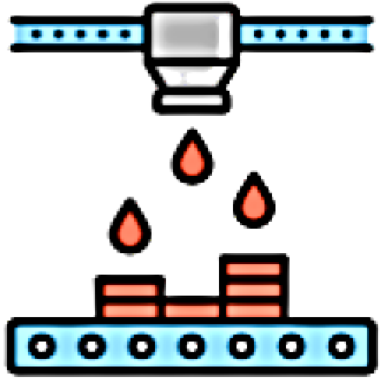
Material Extrusion



Vat Polymerization

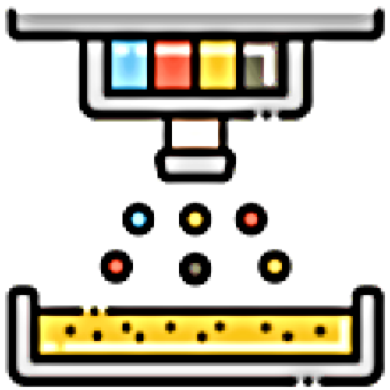


Powder Bed Fusion

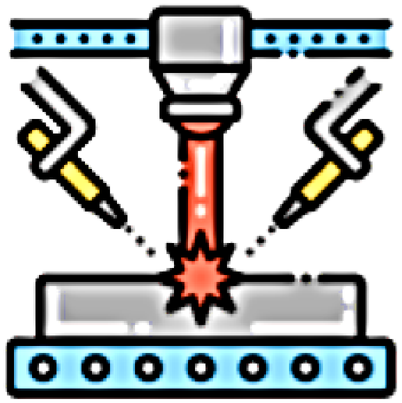


Material Jetting

Type of Additive Manufacturing Technologies



Binder Jetting



Directed Energy Deposition

Sheet Lamination

From Prototyping to Smart Manufacturing

- **1980s – The Birth of AM**
  - ***Charles Hull*** *invented* ***Stereolithography (SLA)*** *and filed a patent* ***– 1984***
  - *The first commercial 3D printer, the* ***SLA-1****, was released by 3D Systems* ***– 1988***
- **1990s – Technology Diversification**
  - ***Fused Deposition Modeling (FDM)*** *was developed and patented by* ***Scott Crump****, who co-founded* ***Stratasys – 1990***
  - *3D printing remained mainly in* ***prototyping and R&D*** *sectors during this period*
- **2000s – Wider Adoption and Research**
  - *Additive manufacturing began moving from* ***rapid prototyping to functional parts***
  - *The open-source* ***RepRap Project*** *was launched, enabling users to build low-cost 3D printers* ***– 2005***
  - *The first* ***self-replicating 3D printer*** *was created, significantly reducing the entry cost* ***– 2008***

From Prototyping to Smart Manufacturing

- **2010s – Industrial and Consumer Growth**
  - ***Metal 3D printing*** *technologies like* ***Direct Metal Laser Sintering (DMLS)*** *and* ***Electron Beam Melting (EBM)*** *gained traction*
  - *Major industries (aerospace, automotive, healthcare) started using AM for* ***end-use parts***
  - *Additively Manufactured* ***LEAP Fuel Nozzle*** *made its first flight* ***– 2016***
  - *Custom medical devices (e.g., implants, prosthetics) and* ***bioprinting*** *saw rapid growth*
- **2020s – Integration into Smart Manufacturing**
  - *AM is now a key part of* ***Industry 4.0****, integrated with* ***IoT****,* ***AI****, and* ***digital twins***
  - *Advances in* ***multi-material****,* ***multi-axis****, and* ***large-scale printing*** *have emerged*
  - *Applications have expanded to construction (3D printed houses), food (3D printed meals), and space (NASA printing tools on ISS)*

LEAP Fuel Nozzle a Breakthrough

- The **LEAP (Leading Edge Aviation Propulsion)** engine is a high-bypass turbofan developed by **CFM International**, a joint venture between **GE Aviation** and **Safran Aircraft Engines**.
- GE Aviation redesigned the **traditional 20-part nozzle** as a **single-piece component** using **Direct Metal Laser Melting (DMLM)**, a form of metal 3D printing. 25% lighter and 500% more dureable

Source: https://www.geaerospace.com/

LEAP71 AI Designed Rocket Engine

- **LEAP 71**, a Dubai-based company, developed an **AI system Noyron** that autonomously **generates** the full **3D geometry** of the **rocket engine**, performs thermal and thrust models based on the input thrust, propellant type, chamber pressure as inputs.
- The 3d model is then additively manufactured
- They designed and produced a 5 kN liquid-fuel **rocket engine** and it was **hot-fire tested in 2024**

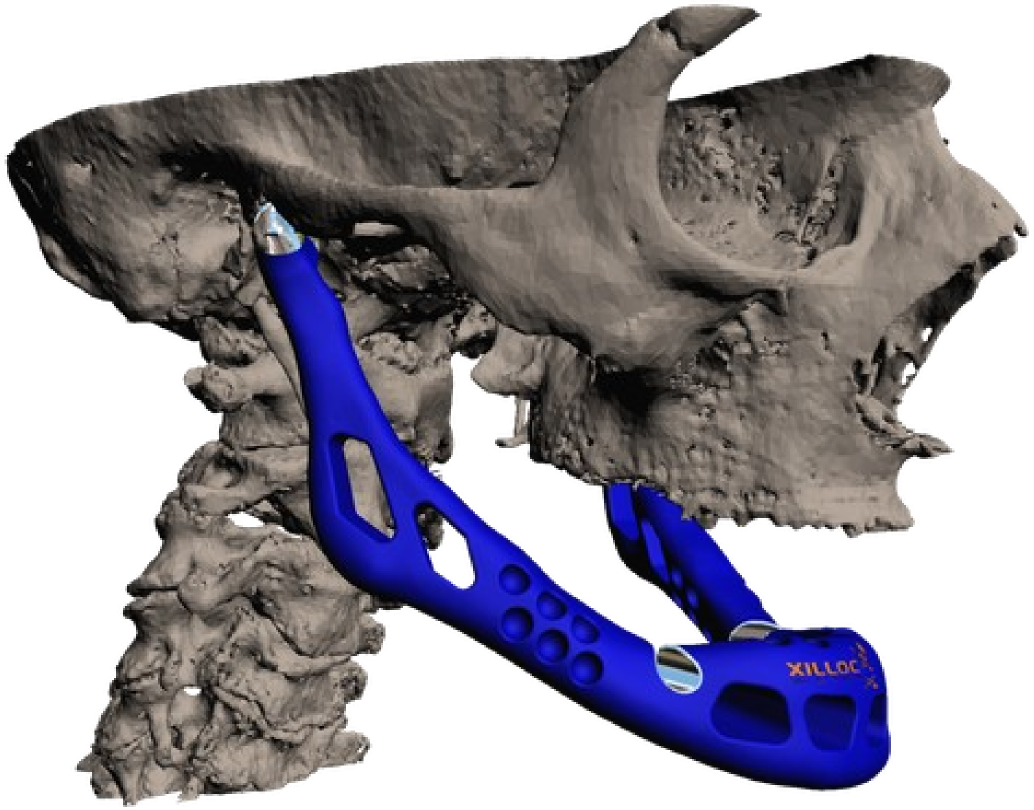
Source: https://www.leap71.com/

LEAP71 AI Designed Rocket Engine

Source: https://www.leap71.com/

Additively Manufactured Implants

- **LayerWise**, a **KU Leuven** spin-off, additively manufactures the world's first **patient-specific lower jaw** which was implanted to treat a senior patient's progressive osteomyelitis of almost the entire lower jawbone, medical specialists and surgeons opted for such a complete patient-specific implant the first time ever.



Source: https://www.kuleuven.be/

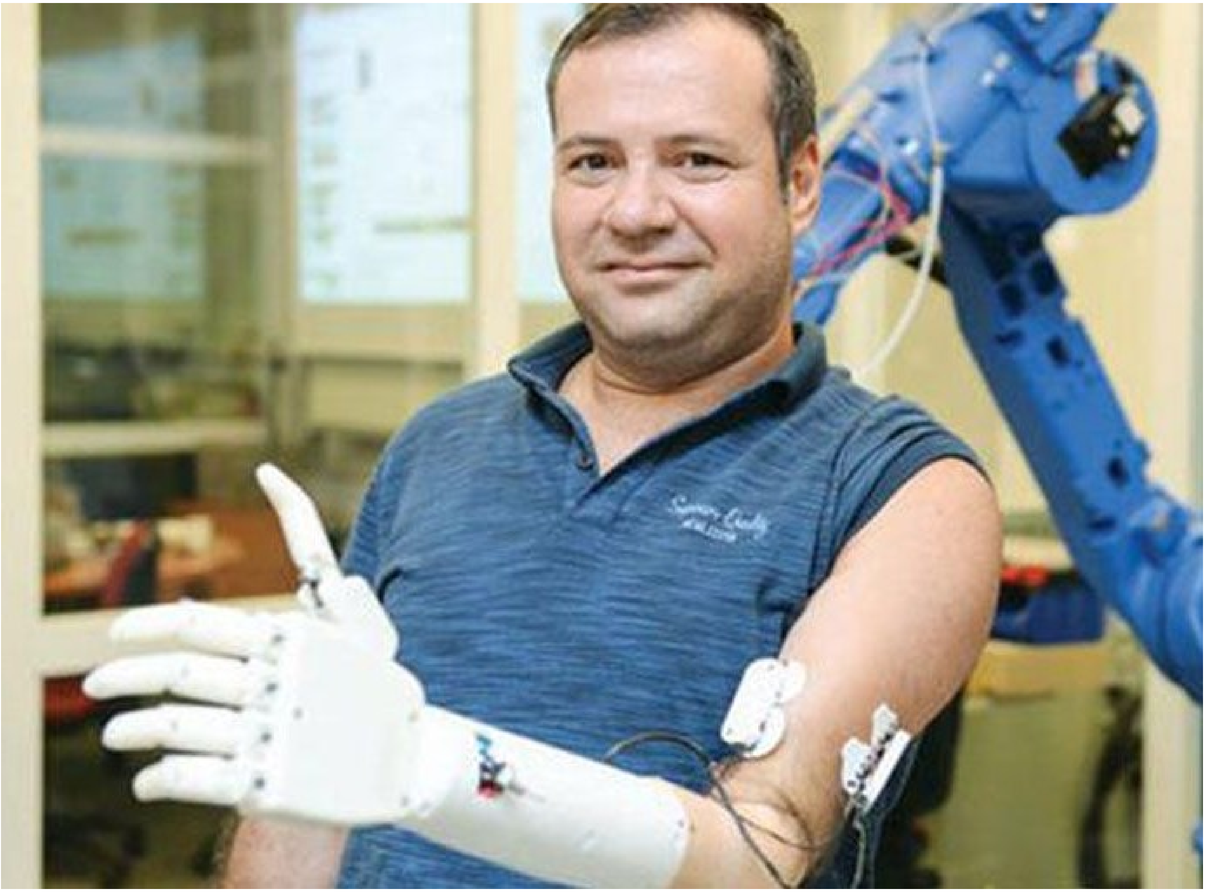
Additively Manufactured Prosthesis

- **Hero Arm** is a **clinically approved** myoelectric prosthetic for children (8+) and adults with below-elbow limb differences
- Additively Manufactured using Nylon 12, it's custom-fit via 3D scanning.

Source: https://openbionics.com/en/hero-arm/

Additively Manufactured Prosthesis

- **MARC Protez** is Turkey's first indigenous, additively manufactured prosthetic arm developed at Koc University.
- Developed by a Pakistani PhD Scholar to aid day-to-day activities of a university employee.



Source: https://www.ku.edu.tr/

Current Penetration in Pakistan

- **Development Phase (2010–2015)**
  - Universities like NUST and NEDUET Commissioned 3D printers
  - 3D printer was developed in 2011 NUST-PNEC as a student final year projects
  - Some tech enthusiasts and hobbyists started **assembling DIY RepRap printers**
  - Participation in exhibitions like *IDEAS* helped showcase 3D-printed models and tools
  - Local dental labs began exploring resin-based SLA/DLP printers for dental crowns and aligners
- **Expansion and Diversification (2015–2020)**
  - Startups such as **Objexyz**, **Browide3D**, **Grit3D,** and **Quantum3D** began offering commercial 3D printing services for prototyping and small-batch production
  - AM was adopted by defense R&D institutes (NESCOM, NDC) for prototyping UAV and weapon parts
  - Bioniks 3D in collaboration with NEDUET started making opensource prosthesis
  - CoE-PIAM3D established at NCP Islamabad

Current Penetration in Pakistan

- **Healthcare Focus (2020–2024)**
  - NGOs and university teams used AM to build low-cost prosthetics, especially for child amputees and war victims
  - Aga Khan University Hospital (AKUH) led innovation in 2023–24 by Developing DRAP approved PEEK cranial and spinal implants and performing successful surgeries
  - 3D scanning + printing orthotic devices became popular in Lahore, Islamabad, and Karachi clinics using FDM and PETG
  - Pakistan's first concrete 3D printer was developed
- **Recent Advances & Institutional Push (2024–2025)**
  - Pakistan Institute of Additive Manufacturing (PIAM) organized an international AM event, highlighting local research in aerospace and biomedicine

Additive Manufacturing in Pakistan

Source: https://bioniks.org/

Key Challenges

- Policy & Regulation: Lack of formal frameworks and incentives
  - **Unclear HS Codes** and the requirement of **NOCs** from **MoI** & **MoD** for importing 3D printers, filaments, powders, and resins often lead to **delays or excessive duties**
  - **No tax exemptions or subsidies** for industrial AM equipment
  - **No AM-specific national strategy**, which leads to **fragmented growth** without targeted investment
- Startups and SMEs hesitate to scale due to high import costs and regulatory ambiguity

Key Challenges

- Infrastructure: Unreliable utilities and high operational costs
  - **Unstable electricity supply** leads to frequent failures during long 3D print jobs.
  - **High costs of quality materials** (filaments, powders, resins) due to import dependency.
- Limited throughput, high part rejection, and discouragement for industrial-scale use.

Key Challenges

- Skills Shortage: Limited expertise in design for AM (DfAM)
  - Engineering curricula in most universities **lack modules on AM**, especially in relation to generative design, topology optimization, or multi-material systems
  - Lack of **cross-disciplinary collaboration** (materials, software, mechanical, electrical).
- AM is used to replicate parts traditionally instead of innovating with new geometries, reducing ROI

Key Challenges

- Market Demand: Low awareness and commercial confidence
  - Industry stakeholders—especially auto part manufacturers—**lack awareness of AM's potential** beyond prototyping
  - **Return on investment (ROI)** is questioned due to perceived low reliability and material strength
  - There's a **disconnect between academia, startups, and industry**.
- Slow adoption, limited industrial projects, and underutilized lab capacities

Conclusion

- Pakistan is on the right track, yes a few years behind the rest of the world
- Just a nudge in terms of Policy, Training, and Synergy between academia and the industry is required

Question and Answers