

# Modular Course B: Creative Design in shoe Industry

## Unit B2 – Computational tools and prototyping

### Lecture LB2.1 – Computational tools and prototyping



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DISHOLEA | Improving the digital  
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T2.2 – Development of modular  
courses and training  
material.

D2.2 – Modular Course in <sup>1</sup>  
Creative Design

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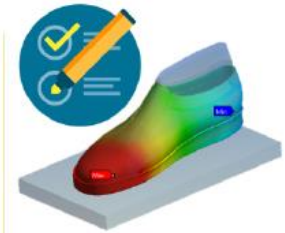
- Introduction
- Product Manufacturing
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- Current computer-aided modelling practices in footwear industry
- CAD/CAE/CAM hardware/software
- 3D Printing Technology in Footwear Design and Manufacture
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# Introduction

- Existing methods and technologies for footwear design and manufacture can be divided into two categories:
  - (a) Methods and technologies to support the design process in terms of general functional properties.
  - (b) Methods and technologies for supporting the design process in relation to specific, usually anthropocentric, biomechanical properties.
- Modern proposals use Computer-Aided Engineering (CAE) technologies with three-dimensional foot models to study the foot behavior and in some cases to improve parameters related to shoe design.
  - Finite Element Method (FEM)

# Prototyping

- Prototyping, Testing and Analysis are essential components of the footwear design process.
- Creating physical or digital models of the product to test and refine its design, functionality, and performance before moving to the production stage.
- A physical prototype is a tangible, three-dimensional representation or model of a product, design, or concept. Constructed using materials similar to those that will be used in the actual product.
- A **digital prototype** is a virtual representation or simulation of a product, design, or concept that is created using digital tools and



Prototyping, testing and analysis



*Physical prototype of a footwear product designed with adherence to circular economy principles. Credit: TUIASI-Alexandru Urma, Marin Cojocari and Diana Misiru*



*Digital prototype of a footwear product designed with adherence to circular economy principles. Credit: TUIASI- Maria Popa*

# Product Manufacturing

- TECHNOLOGIES
  - Computer-Aided Design (CAD)
  - Computer-Aided Engineering (CAE)
  - Computer-Aided Manufacturing (CAM)
  - Computer-Integrated Manufacturing (CIM)

# Current computer-aided modelling practices in footwear industry

- **CAD/CAM/CAE benefits**



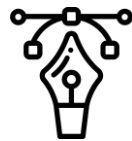
TIMING



COST



PERFORMANCE

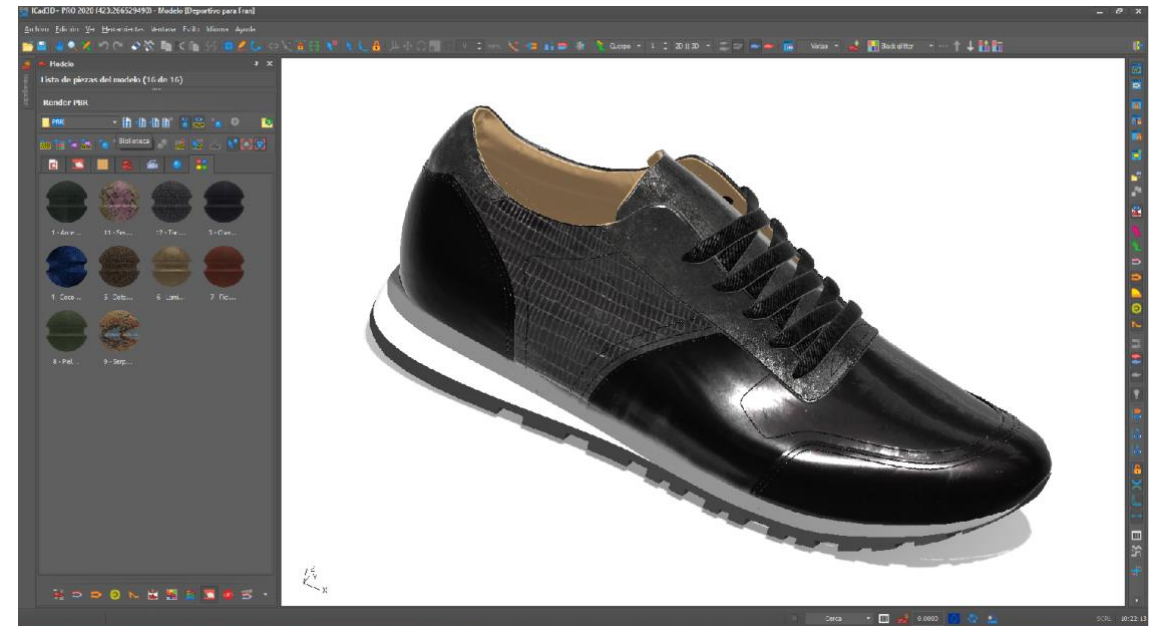


CREATIVITY



FAST CHANGES

## Shoe 3D model



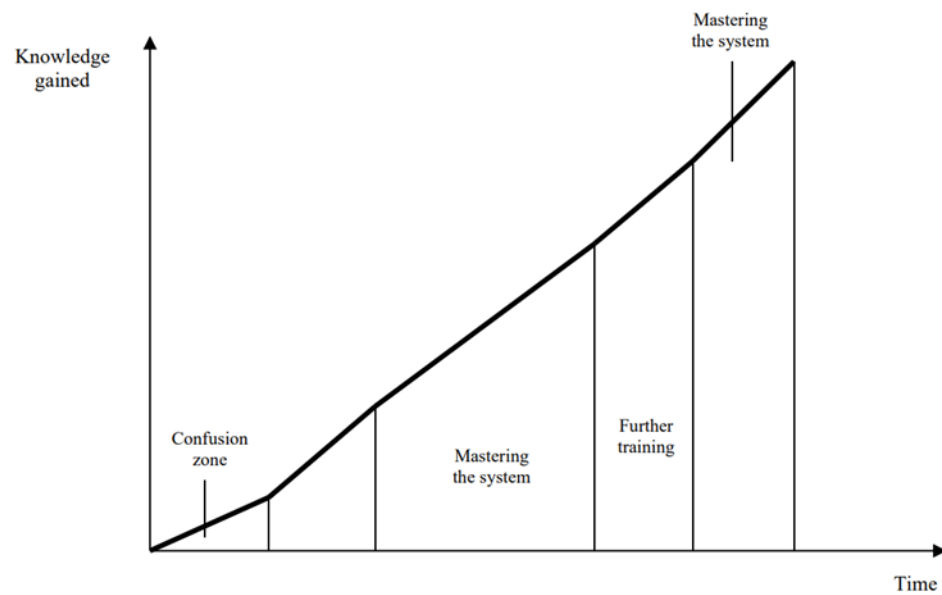
Source: INESCOP. Icad3D+

# CAD/CAE/CAM hardware

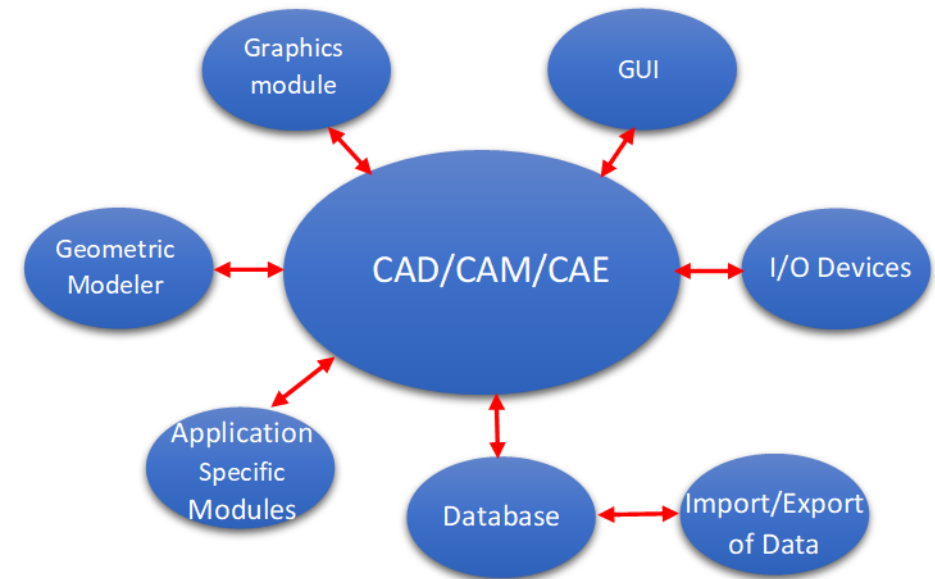
Differences between a CAD/CAM/CAE system and a standard computer system:

- Hardware: High computing power, graphics information processing, fast user interaction, large storage space, special input and output devices
- Software: Special applications that require a lot of computing power and graphics processing.

# CAD/CAE/CAM software

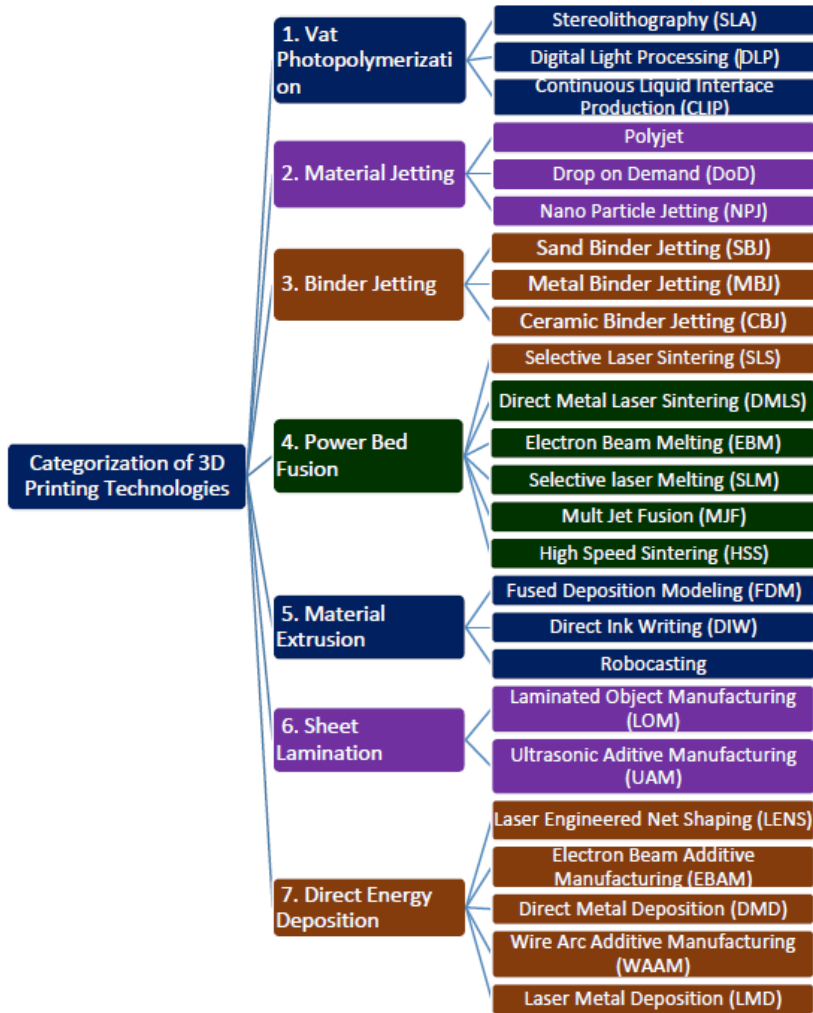


*Typical CAD / CAM / CAE system learning curve*



*The basic architecture of a CAD/CAM/CAE system*

# 3D Printing Technology in Footwear Design and Manufacture



Adidas' 4DFWD shoes with 3D printed midsole



Sneaker with haptic coating effect



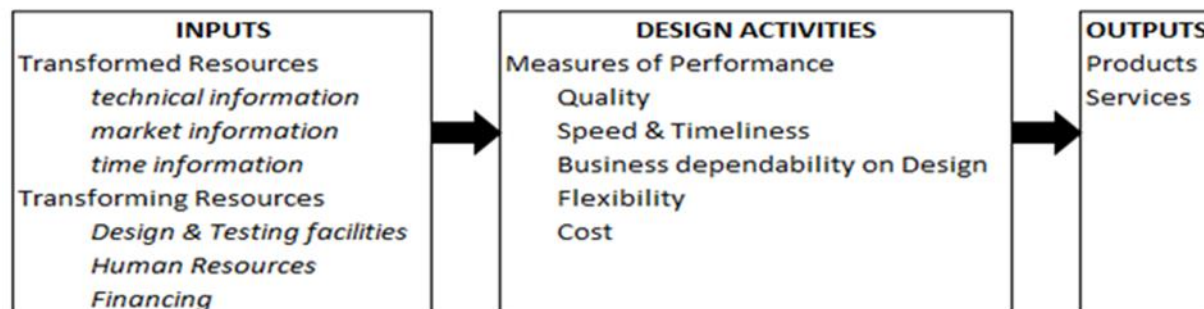
Earth Moc, the 3D printed biomimetic shoe



3D-printed Cryptide sneakers

# Footwear Design

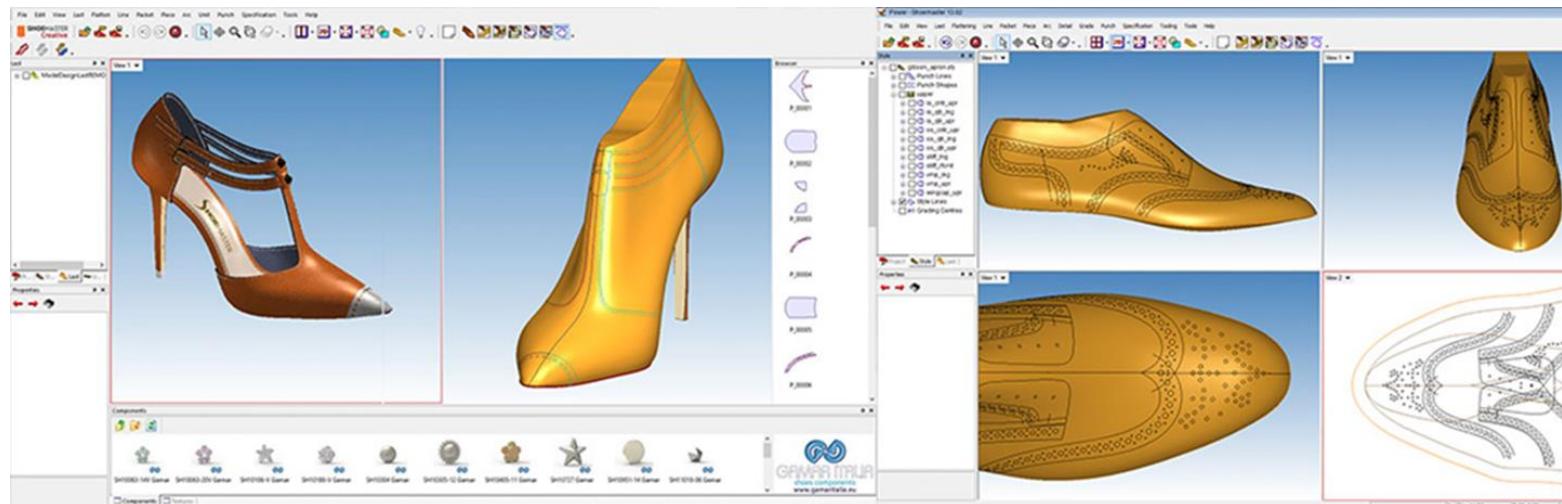
- The Product Design process consists of five stages:
  - conceptualization,
  - concept screening,
  - preliminary design,
  - evaluation and improvement,
  - prototyping
- Result: final/detail design.



# Software Tools for Footwear Development

- **Shoemaster**

- CAD/CAM system
- Design, development, and engineering of footwear prototypes.
- <https://atom-shoemaster.com/en/>



*Interface of Shoemaster. Source: Atom S.p.A., Shoemaster*

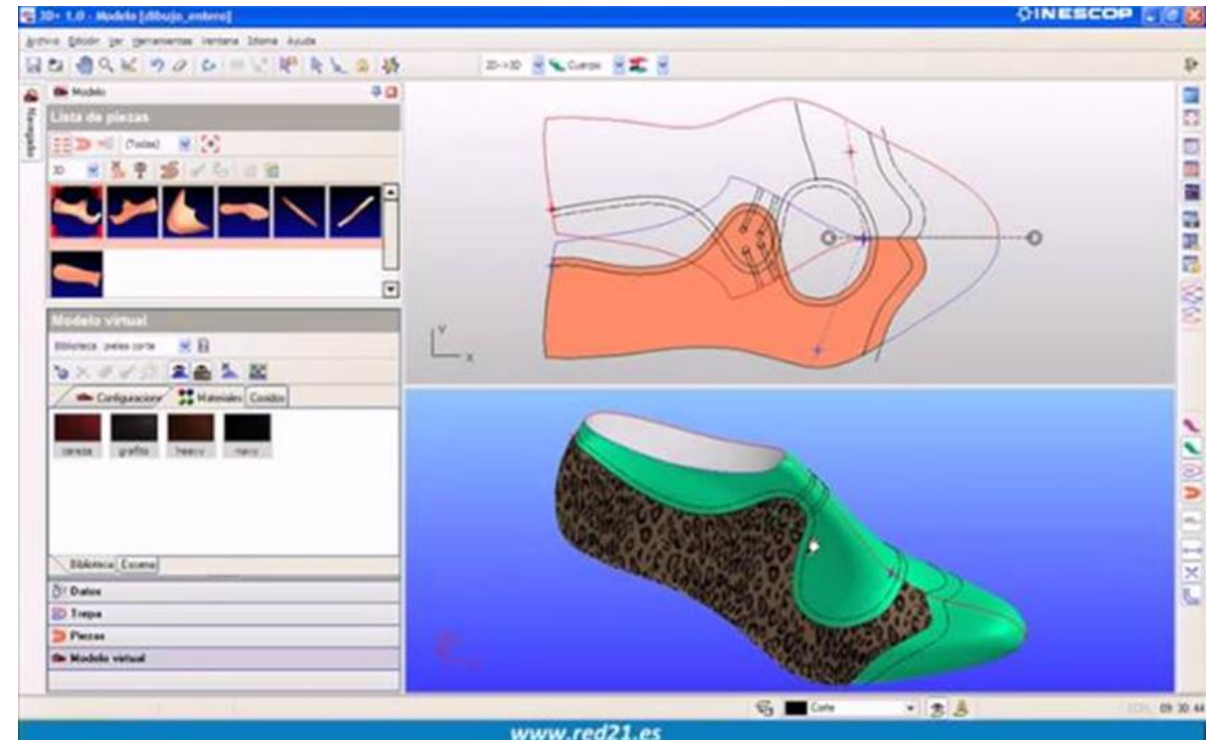
# Software Tools for Footwear Development

- **ICad3D+**

- CAD system
- Footwear (3D) design and (2D) pattern engineering.



- <https://icad.inescopolutions.com/>

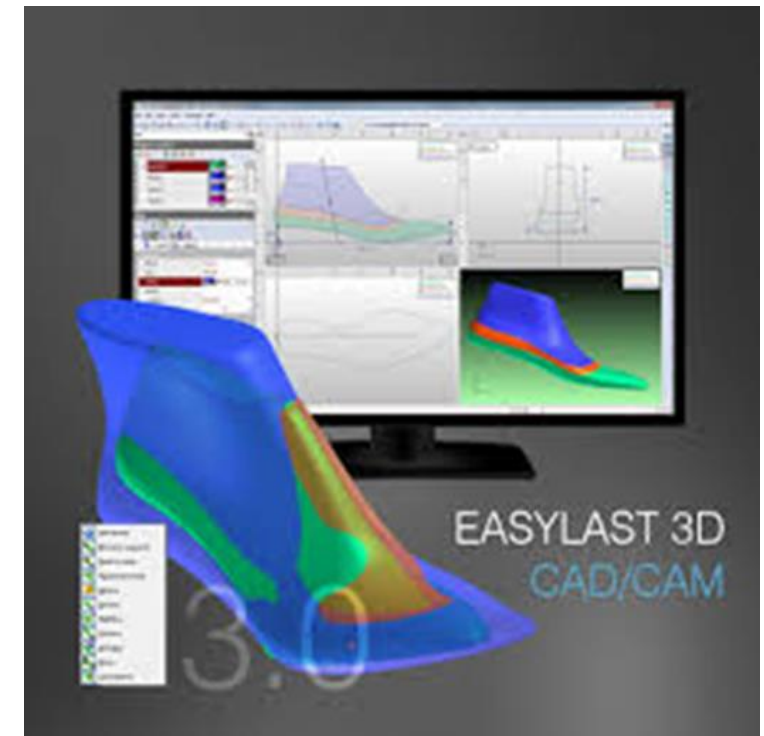


*Interface of ICad3D+. Source: ICad3D+ Design - 3D Shoe Design software (lady shoes sample).*

# Software Tools for Footwear Development

- **EasyLast 3D**

- CAD/CAM system
- Design and development of 3D shoe last models.
- <https://wpquality.newlast.com/prodotto/easy-last-3d-cad-cam/?lang=en>

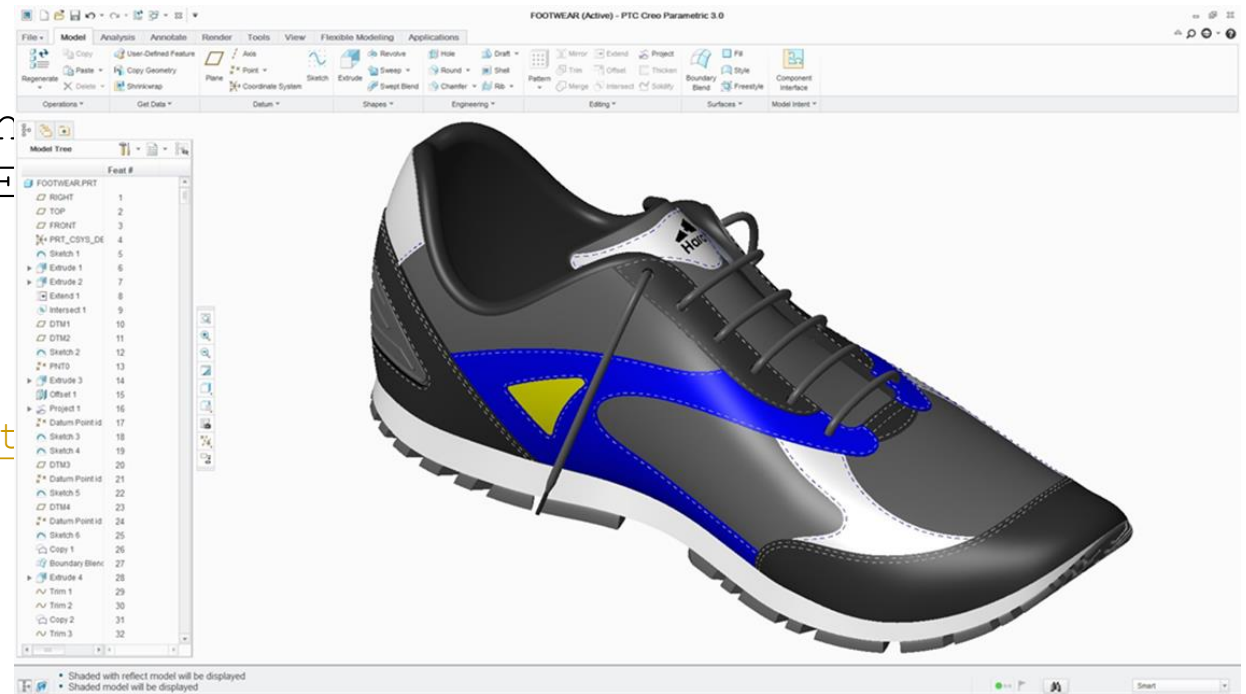


*Interface of EasyLast 3D  
CAD/CAM source: Newlast group,  
EasyLast 3D CAD/CAM*

# Software Tools for Footwear Development

- **PTC Creo**

- Design, manufacturing and engineering (CAD/CAM/CAE)
- Solid-modeling and surface-modeling
- <https://www.ptc.com/en/product/creo>



*Interface of PTC Creo parametric. Source: GRABCAD COMMUNITY.*

# Software Tools for Footwear Development

- **Autodesk Fusion 360**

- Design, manufacturing and engineering (CAD/CAM/CAE)
- Solid-modeling and surface-modeling
- <https://www.autodesk.com/products/fusion-360/overview>



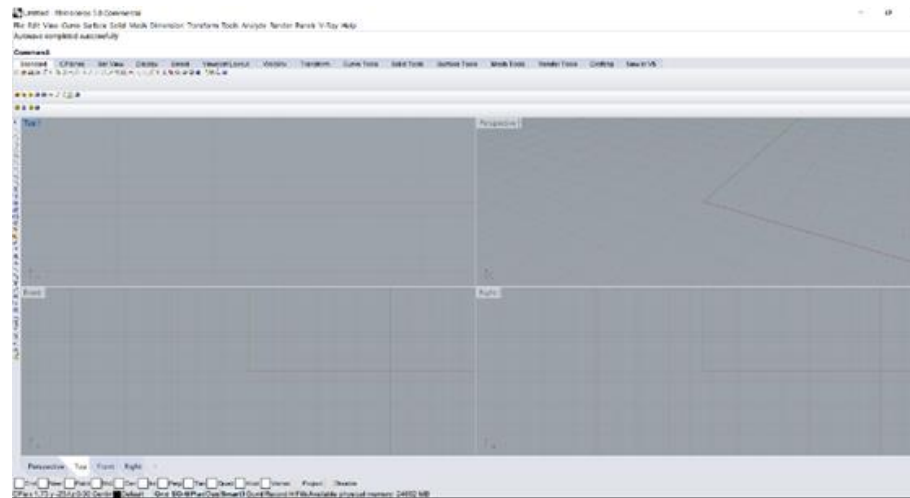
*Interface of Fusion 360. Source: Autodesk Fusion 360*

# Software Tools for Footwear Development

- **Rhinoceros 3D**

- CAD/CAM
- rapid prototyping
- 3D printing
- Reverse engineering

- <https://www.rhino3d.com/it/>



*Rinoceros Interface. Source: POLIMI*

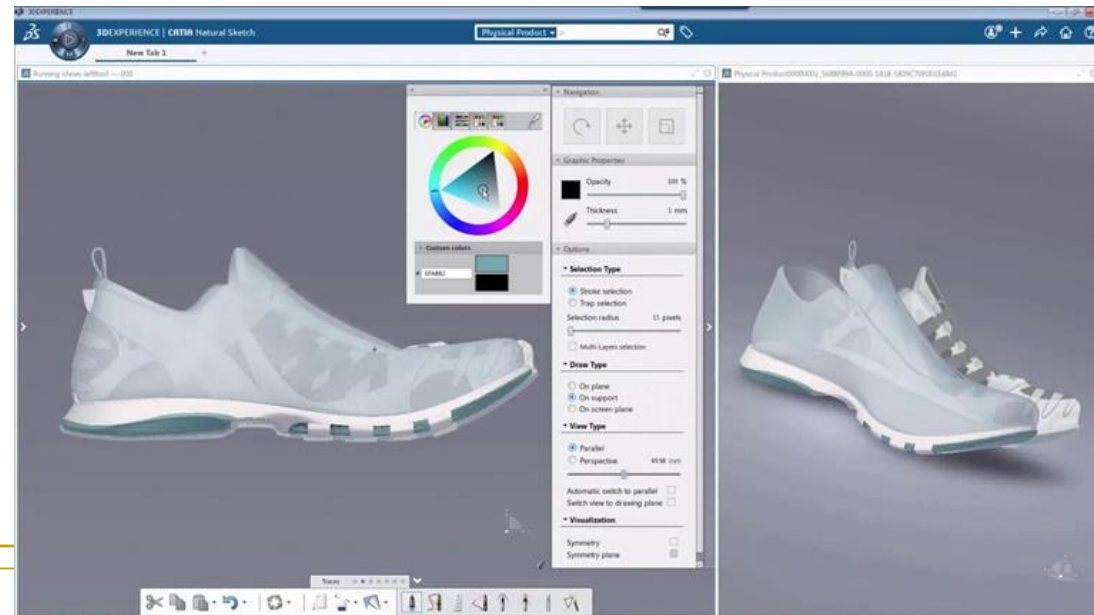


*ICAD3DP, an INESCOP sole design plugin for Rhinoceros. Source: INESCOP*

# Software Tools for Footwear Development

- **3DS CATIA**

- CAD system
- 3D sketching
- 3D printing
- Reverse engineering
- Rendering
- <https://www.3ds.com/it/prodotti-e-servizi/catia/>

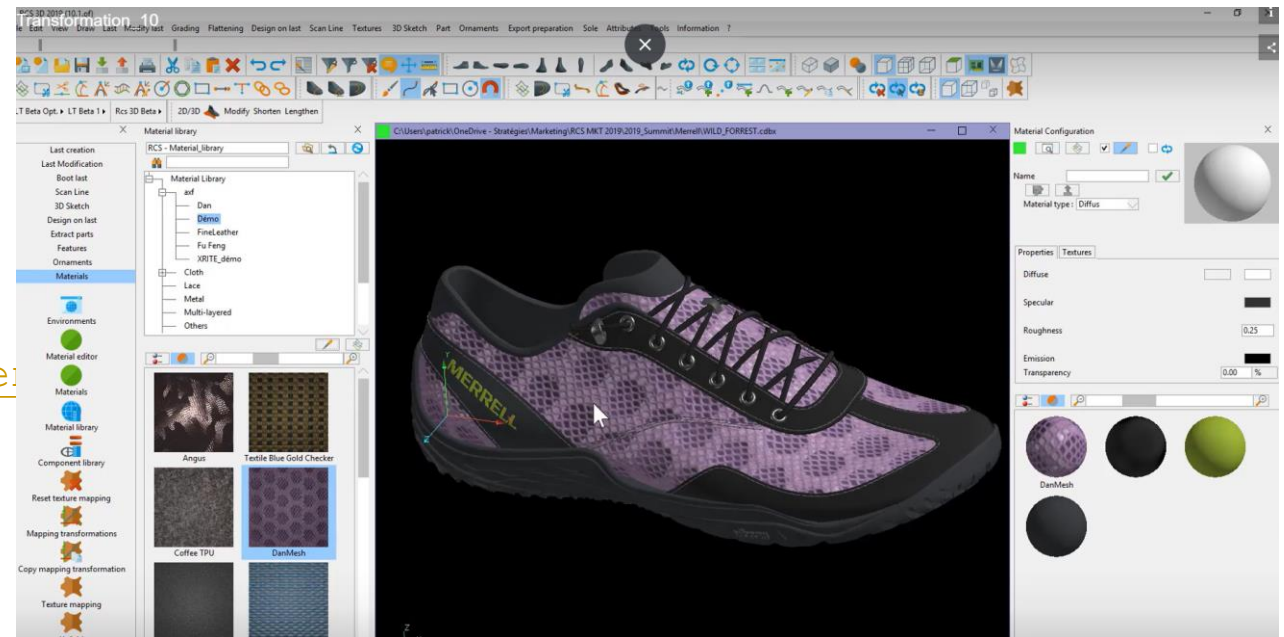


*Catia Interface. Source: <https://www.youtube.com/watch?v=cXpUGvMsbSo>*

# Software Tools for Footwear Development

- **Romans CAD 3D**

- CAD software
- 2D/3D/ PDM
- Last/ Footwear/ Bag
- <https://www.romans-cad.com/en>

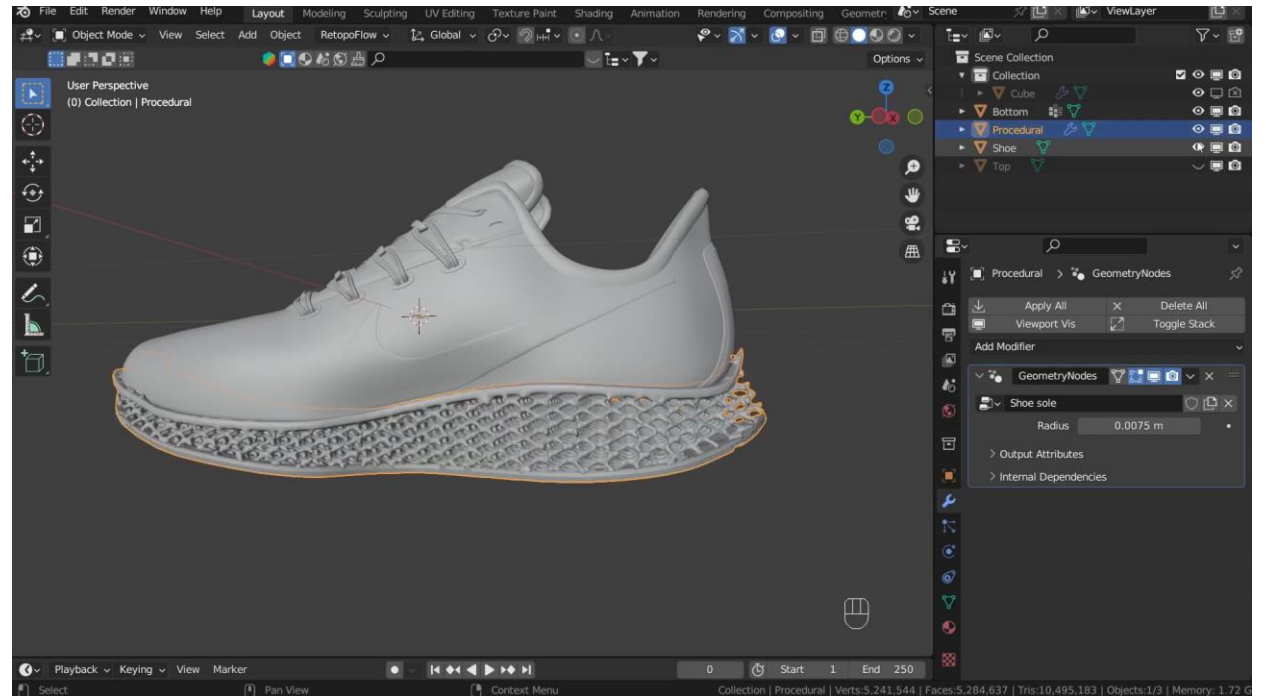


*Romans Interface. Source: Romans*

# Software Tools for Footwear Development

- **Blender**

- Blender software is not CAD software
- Polygon modelling
- Modeling/rendering/simulation
- Generate 3D models for visualization and prototyping
- <https://www.blender.org/>



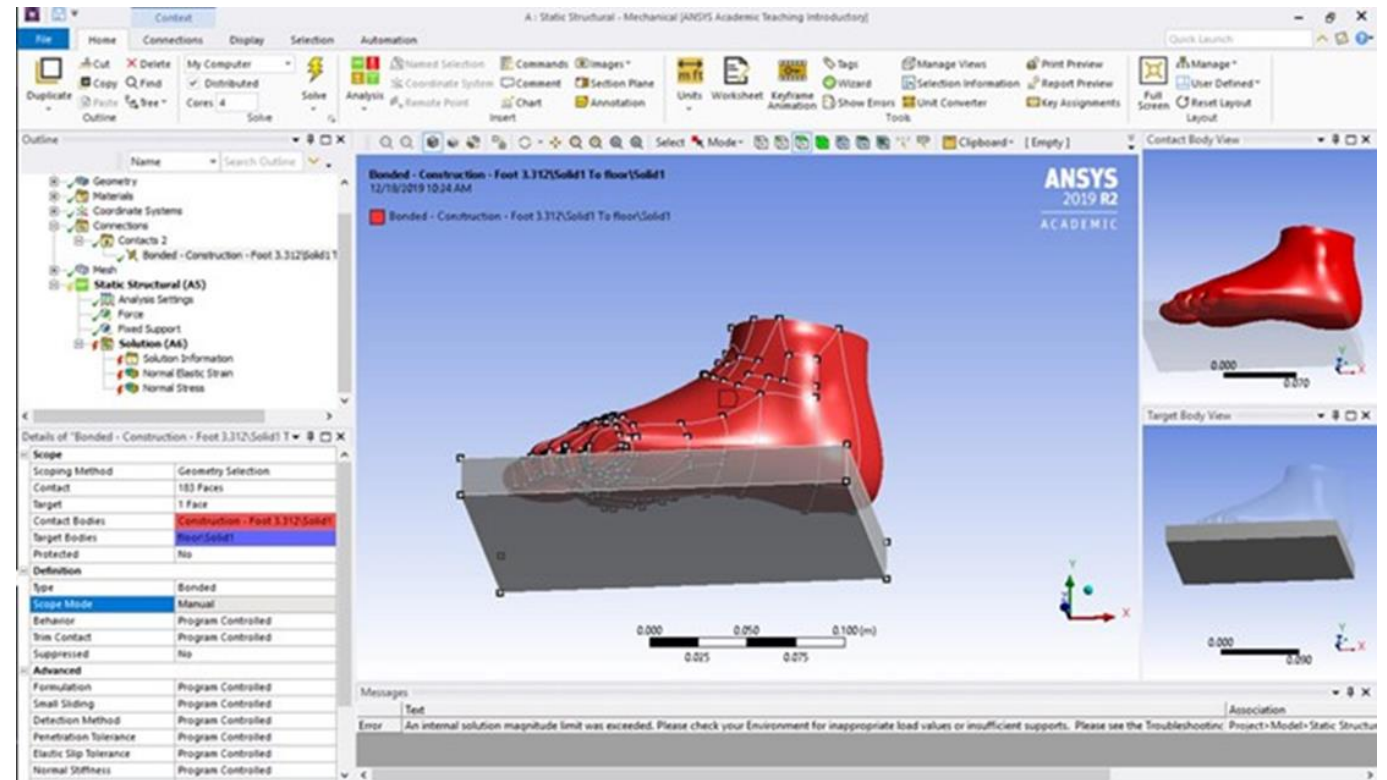
*Blender Interface. Source:  
<https://www.youtube.com/watch?v=VNYZ2SQ3ukQ>*

# Software Tools for Footwear Development

- **Ansys**

- Finite element analysis software
- Strength, toughness, elasticity, temperature distribution, electromagneticism, fluid flow, and other attributes.

- <https://studentcommunity.ansys.com/thread/simulation-of-foot-standing-6174/>

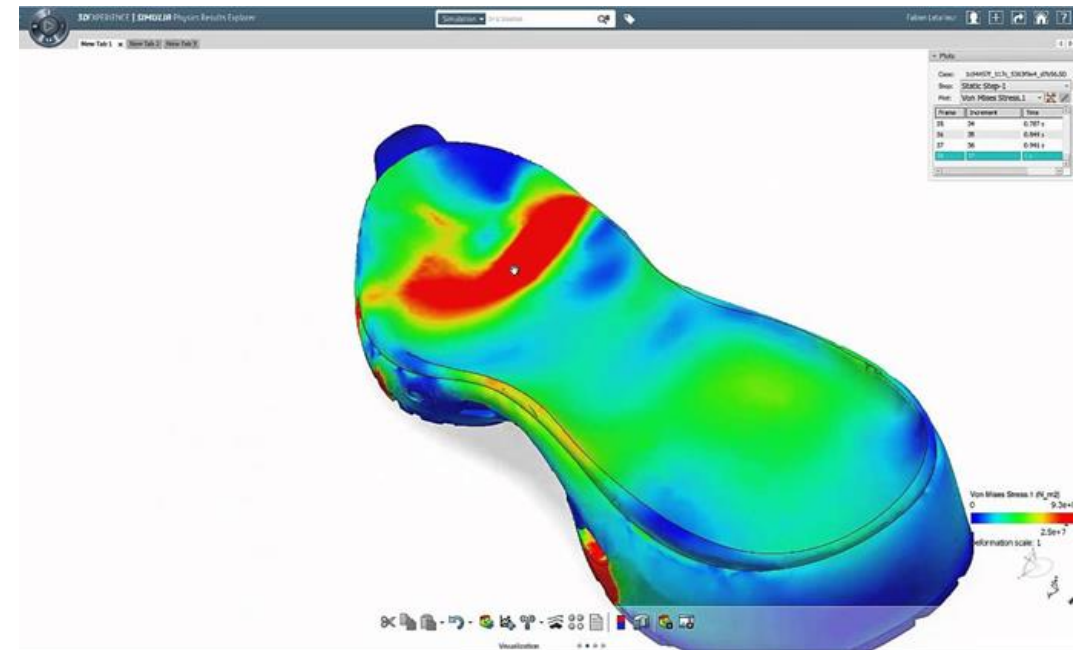


*Interface of Ansys. Source: Ansys, Student community)*

# Software Tools for Footwear Development

- **ABAQUS**

- Finite Element Analysis
- Complex real-world problems, large simulation models, nonlinear Simulation, conductive and convective heat transfer, mass diffusion, acoustics, piezoelectricity and electrochemistry independently, sequentially coupled, or fully coupled with stress analyses.
- <https://www.3ds.com/products/simulia/abaqus>



*ABAQUS Simulations.*

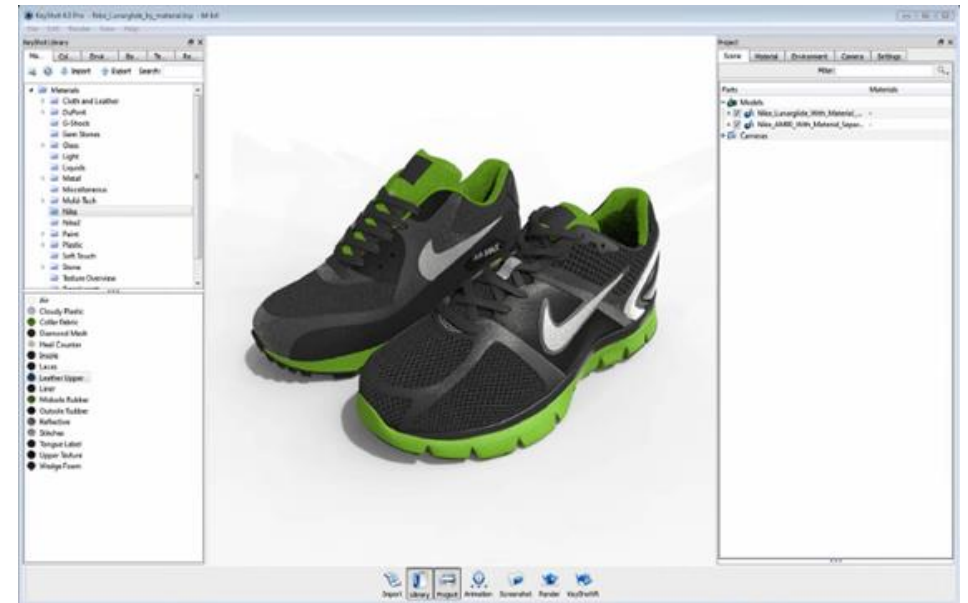
*Source:*

*<https://www.youtube.com/watch?v=4pbyjYdFwhw>*

# Software Tools for Footwear Development

## • Rendering Software

The photorealistic rendering helps designers and all the stakeholders involved in the development of a shoe to visualize the product without a physical model. Through software such as **KeyShot** and **V-Ray** it is also possible to make quick changes and customize the materials to be applied.



KeyShot Render. Source:

<https://www.youtube.com/watch?v=ViVxWFRQV34>

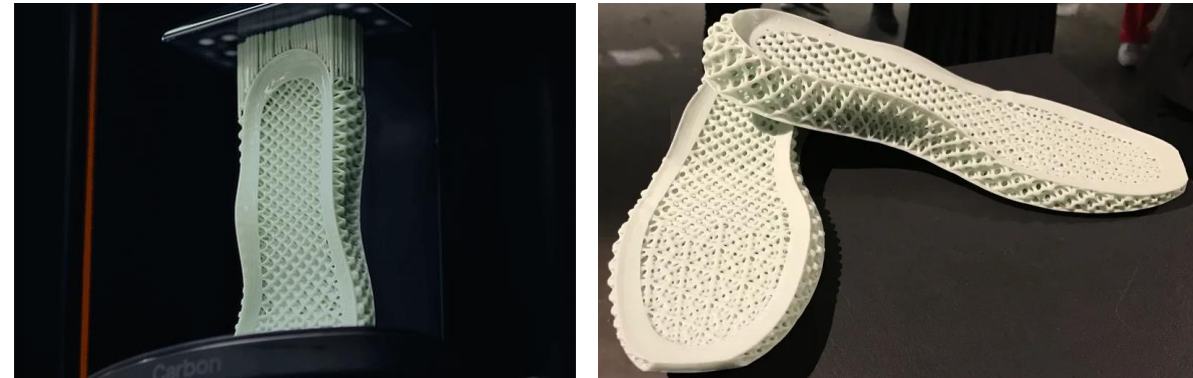
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- <https://www.keyshot.com/>
- <https://www.chaosgroup.com/>

# Software Tools for Footwear Development

- **Rapid prototyping software**

- 3D printing technology is becoming increasingly widespread, also in the world of footwear. The Adidas Futurecraft 4D made in collaboration with Carbon use the innovative Digital Light Synthesis technology, an evolution of the stereolithography 3D printing method (SLA).



*Adidas Futurecraft 4D. Source :*  
<https://d3.harvard.edu/platform-rctom/submission/adidass-race-to-be-1-in-3d-printing/>  
<https://techcrunch.com/2017/04/07/adidas-latest-3d-printed-shoe-puts-mass-production-within-sight/>

- <https://ultimaker.com/software/ul>

# Academic/Research Software

- **Opt-Shoes**

- A Design Support Tool for Comfort Footw
- <https://opt-shoes.aegean.gr/>

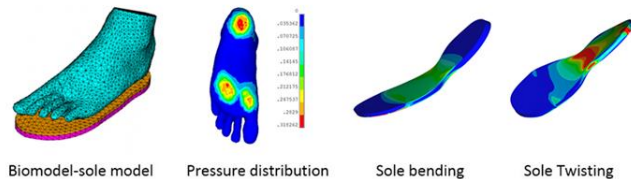


## OPT-SHOES A Design Support Tool for Comfort Footwear

Footwear is one of the most widely and intensively used products influencing human comfort. OPT-Shoes is a simulation and computational "Computer-Aided Engineering" tool for the evaluation of footwear performance in terms of plantar mechanical comfort.

The tool is based on analytical finite element models (FEM) of shoe structures combined with a detailed biomodel of the human lower foot. OPT-Shoes can be used to simulate and compute:

- Plantar pressures distribution on human foot in different gait stances
- Bending & Torsional properties of the sole structure
- Optimum sole structure (materials & thicknesses)



Footwear Layers	
Insole:	Enabled
Insole Material:	EVA
Insole layer thickness:	5mm
Midsole:	Enabled
Midsole Material:	Cork
Midsole layer thickness:	5mm
Outsole:	Enabled
Outsole Material:	Polysoprene
Outsole layer thickness:	5mm

Comfort Level	Strain Energy Density Range ( $10^{-3}$ mj/mm <sup>2</sup> )	Middle Point of Interval ( $10^{-3}$ mj/mm <sup>2</sup> )
Very Flexible	0 - 5	2.50
Relatively Flexible	5 - 15	10.00
Moderately Flexible	15 - 200	107.50
Relatively Rigid	200 - 1000	600.00
Very Rigid	More than 1000	5000.00

Mechanical Comfort Levels for bending deformation of the sole

Comfort Level	Strain Energy Density Range ( $10^{-3}$ mj/mm <sup>2</sup> )	Middle Point of Interval ( $10^{-3}$ mj/mm <sup>2</sup> )
Very Twistable	0 - 1	0.50
Relatively Twistable	1 - 5	2.50
Moderately Twistable	5 - 20	12.50
Relatively Difficult to Twist	20 - 300	160.00
Very Difficult to Twist	More than 300	1000.00

Mechanical Comfort Levels for torsional deformation of the sole

# Questions

- What are the technologies used in modern computer-aided manufacturing of footwear products?
- What are the stages in the shoe design and manufacturing process?
- Research the Internet and list the most basic capabilities of CAD systems in footwear design.
- The use of CAD/CAM/CAE software offers many advantages in the design and manufacture of footwear, at all stages. **True** OR **False**
- CAD/CAM/CAE software users do not need special training for the smooth and efficient operation of these systems. **True** OR **False**
- 3D printing has been advancing the boundaries of personalized footwear, producing shoes with special characteristics that were not possible using classical shoe-making techniques. **True** OR **False**

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