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additive manufacturing academy
TO BOOST Trainers' competences in industry

Summary

Design for Additive Manufacturing (DfAM)

Project Number: 2021-1-IT01-KA220-VET-000033365

UNIT 2 – STEPS IN ADDITIVE MANUFACTURING

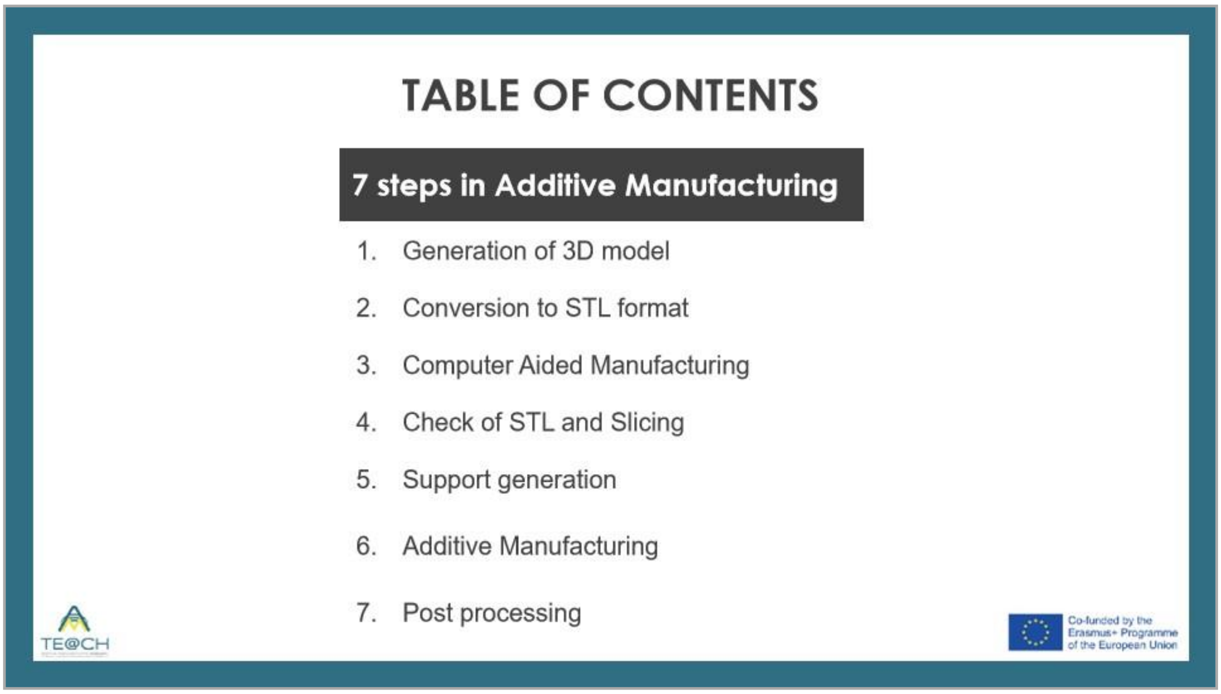
Course Content

The second unit of module two is about the seven steps in Additive Manufacturing.

PROCESS PLANNING

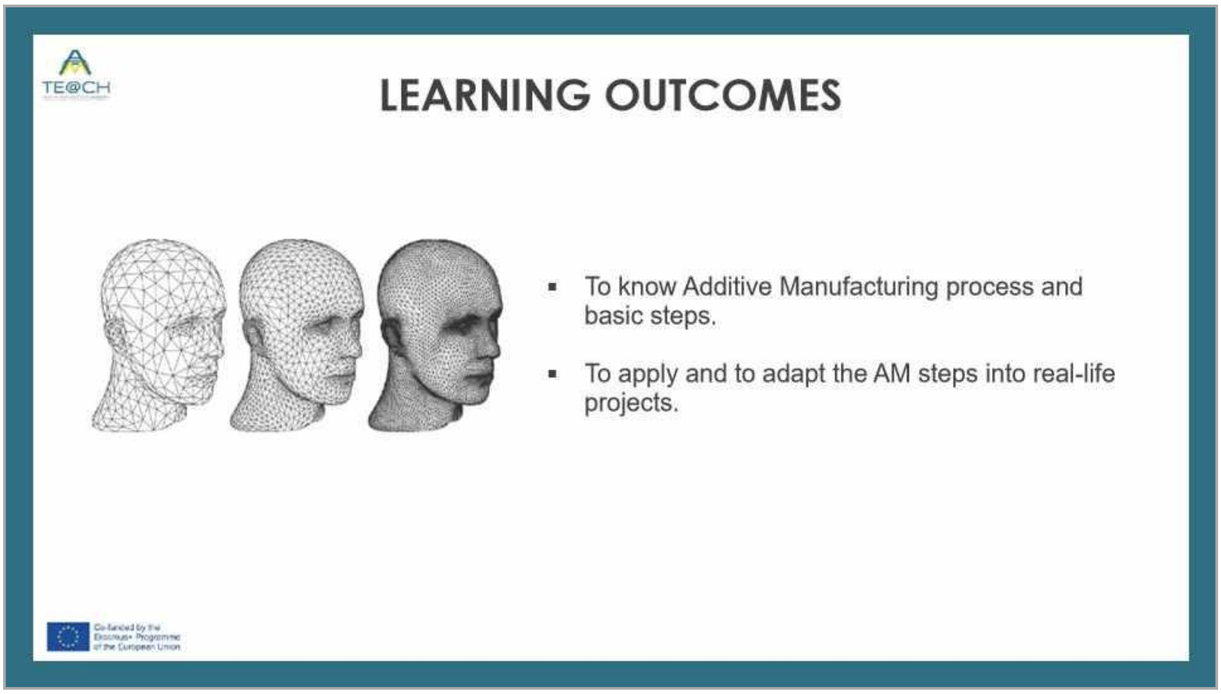
The sequence of operations required to move from design to realization is known as Process Planning. A typical process planning is depicted in this slide and includes:

1. Generation of 3D model.
2. Conversion to STL format.
3. Computer Aided Manufacturing.
4. Check of STL and Slicing.
5. Support generation.
6. Additive Manufacturing.
7. Post processing.



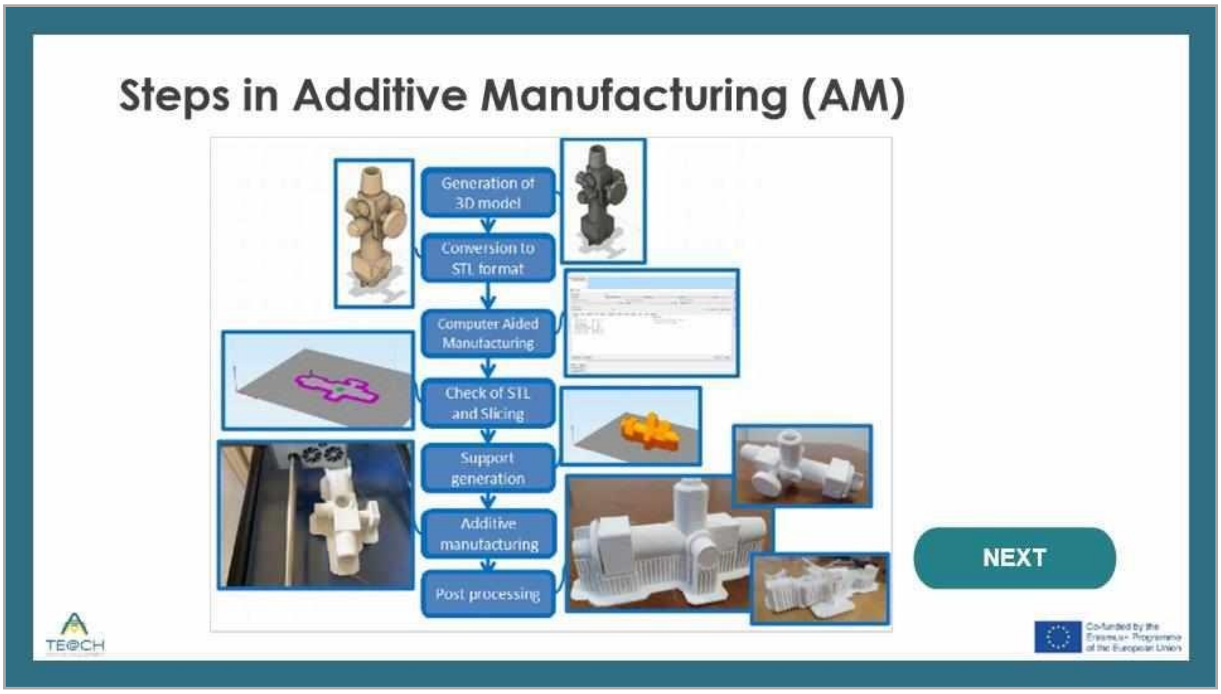
An industrial product has a typical lifecycle constituted of the four successive phases of conception, design, realization and service.

In this unit we can learn the steps of the typical lifecycle of an industrial product. In particular we learn to know additive manufacturing processe and the basic steps and to apply, to adapt these steps into real-life projects.



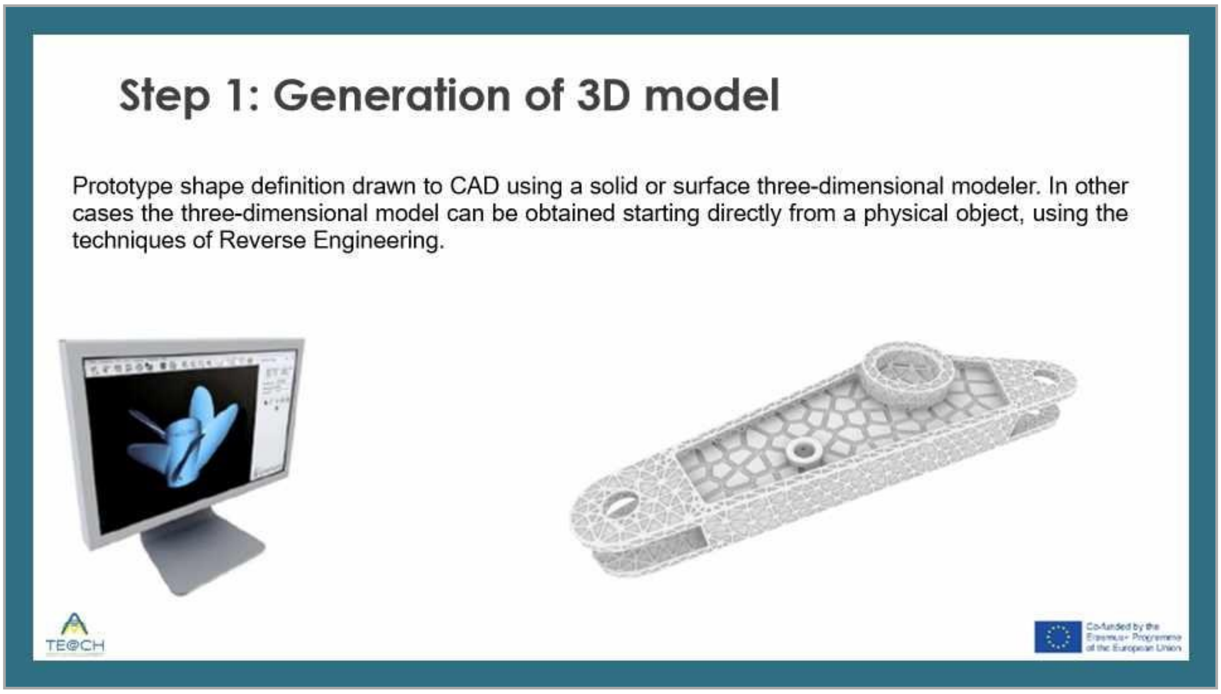
STEPS DESCRIPTION

In this slide, general workflow in Additive Manufacturing process is shown, from generation of 3D model that include preparing appropriate CAD model, selecting required STL file resolution, up to setting processing parameters for AM process.



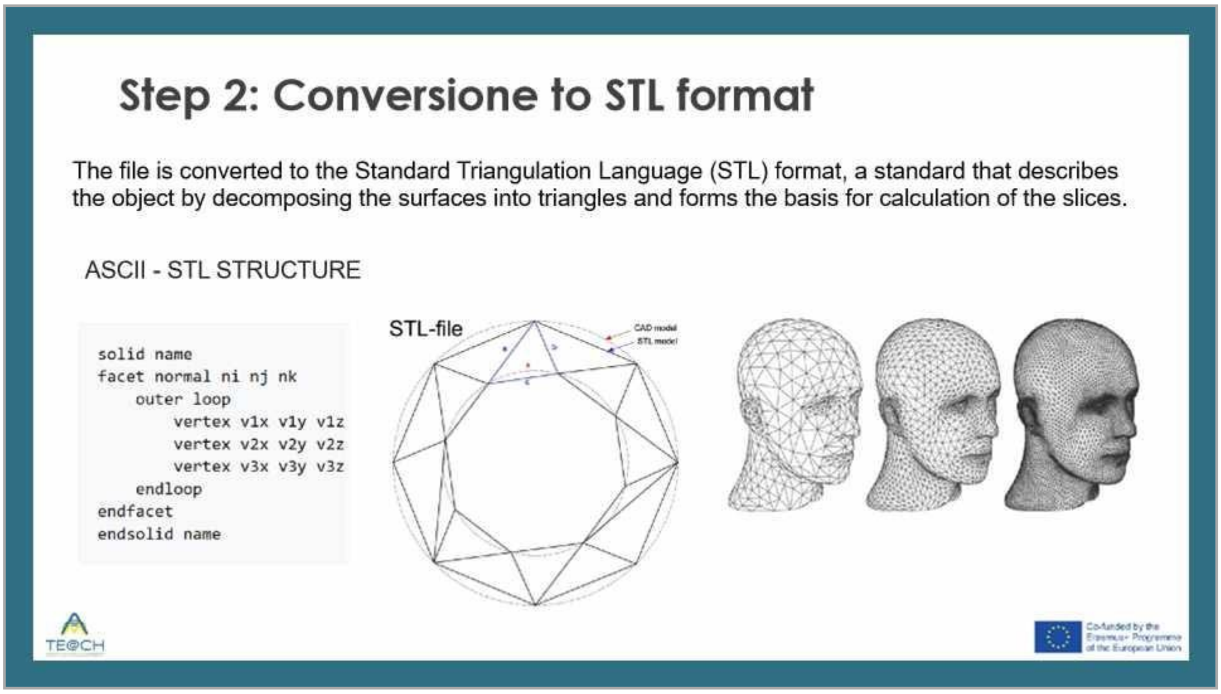
GENERATION OF 3D MODEL

Prototype shape definition drawn to CAD using a solid or surface three-dimensional modeler. In other cases the three-dimensional model can be obtained starting directly from a physical object, using the techniques of Reverse Engineering.



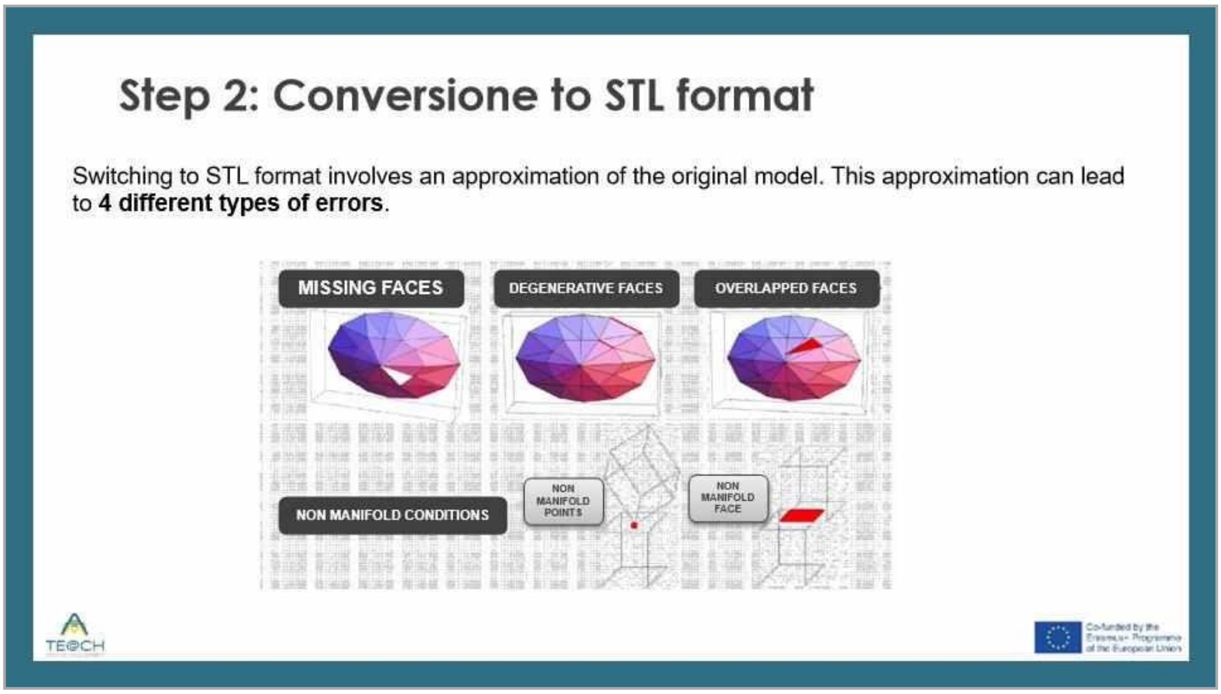
CONVERSION TO STL FORMAT

The file is converted to the Standard Triangulation Language (STL) format, a standard that describes the object by decomposing the surfaces into triangles and forms the basis for calculation of the slices.



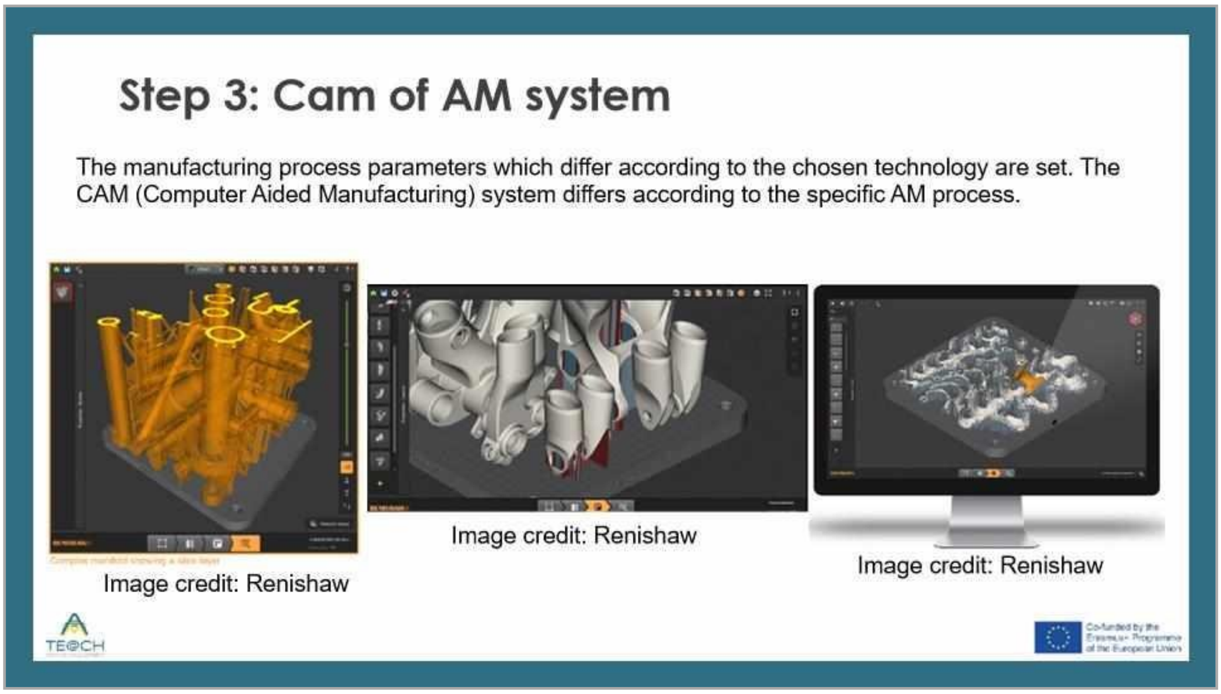
Switching to STL format involves an approximation of the original model. This approximation can lead to 4 different types of errors:

1. MISSING FACES
2. DEGENERATIVE FACES
3. OVERLAPPED FACES
4. NON MANIFOLD CONDITIONS



CAM OF AM SYSTEM

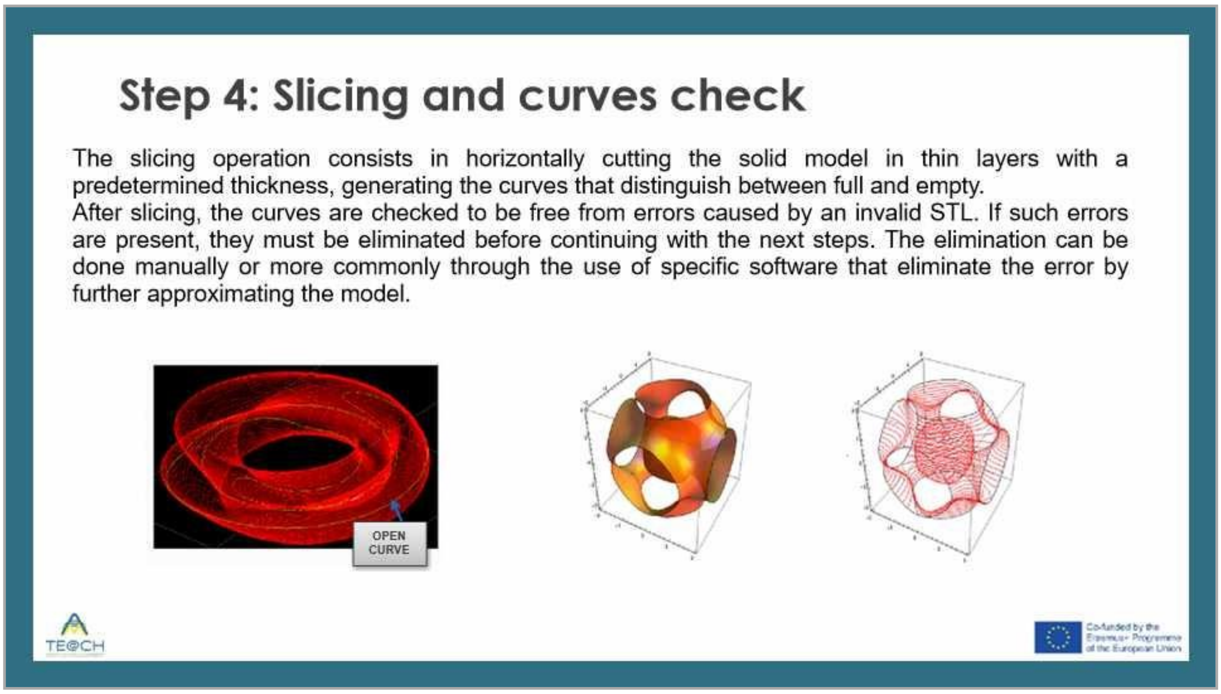
The manufacturing process parameters which differ according to the chosen technology are set. The CAM (Computer Aided Manufacturing) system differs according to the specific AM process.



SLICING AND CURVES CHECK

The slicing operation consists in horizontally cutting the solid model in thin layers with a predetermined thickness, generating the curves that distinguish between full and empty.

After slicing, the curves are checked to be free from errors caused by an invalid STL. If such errors are present, they must be eliminated before continuing with the next steps. The elimination can be done manually or more commonly through the use of specific software that eliminate the error by further approximating the model.



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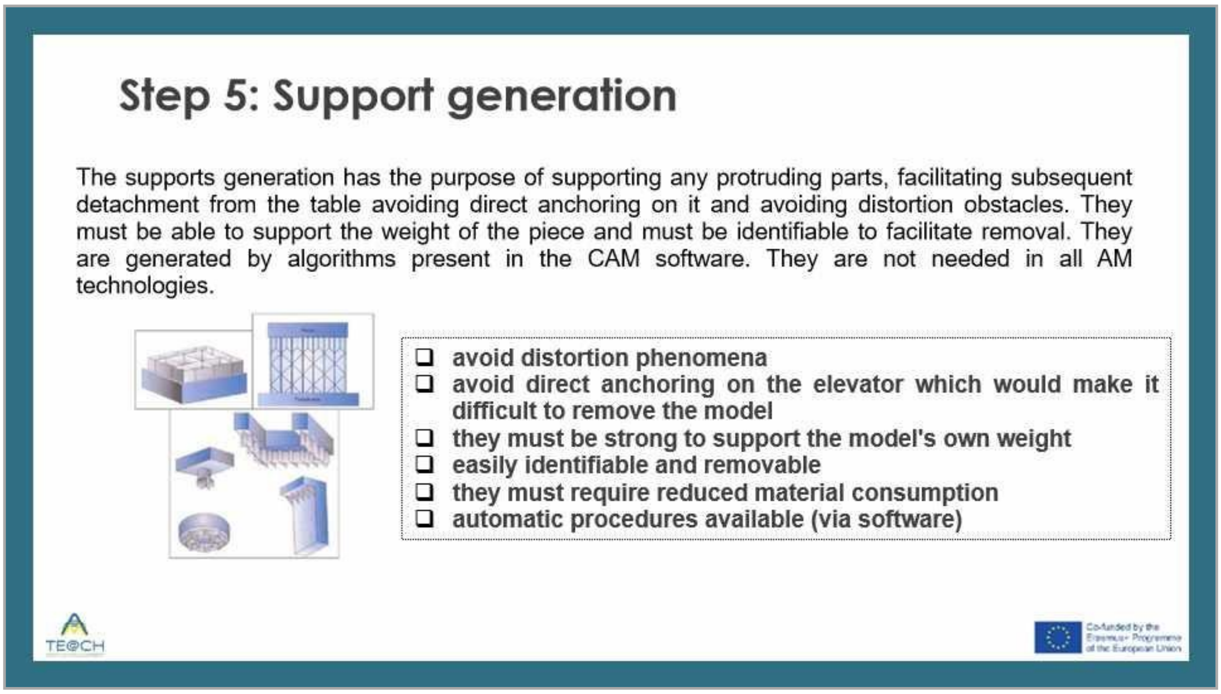
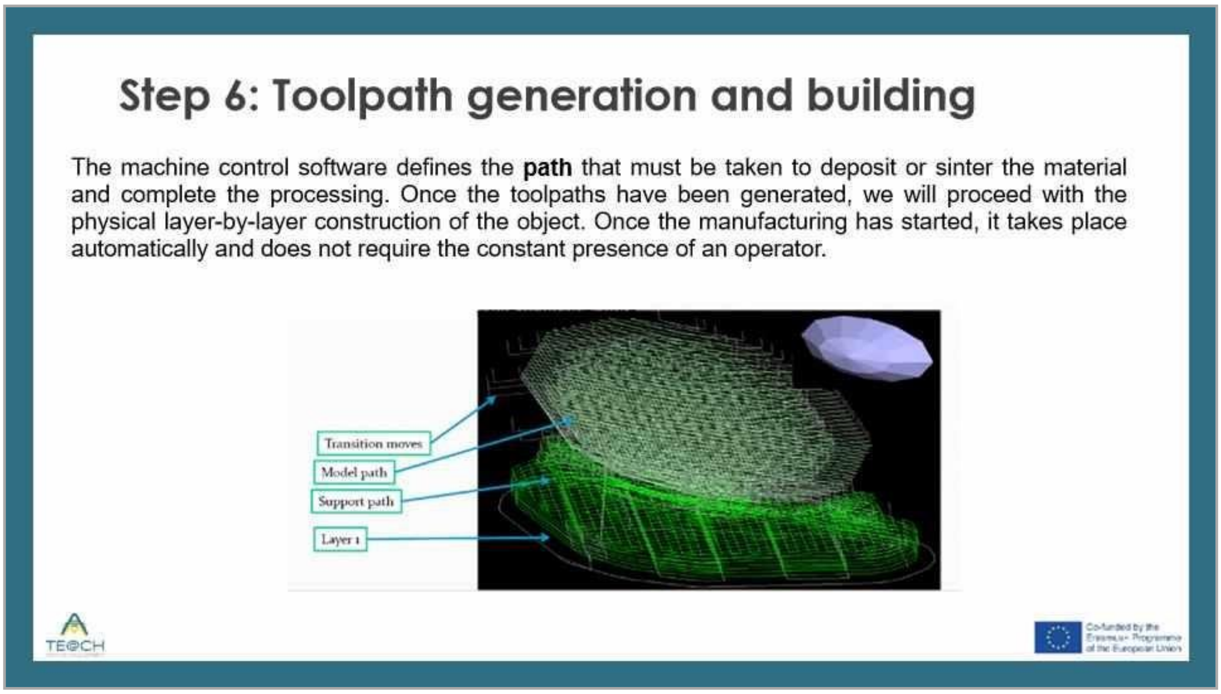
SUPPORT GENERATION

The supports generation has the purpose of supporting any protruding parts, facilitating subsequent detachment from the table avoiding direct anchoring on it and avoiding distortion obstacles. They must be able to support the weight of the piece and must be identifiable to facilitate removal. They are generated by algorithms present in the CAM software. They are not needed in all AM technologies.



TOOLPATH GENERATION AND BUILDING

The machine control software defines the path that must be taken to deposit or sinter the material and complete the processing. Once the toolpaths have been generated, we will proceed with the physical layer-by-layer construction of the object. Once the manufacturing has started, it takes place automatically and does not require the constant presence of an operator.



POST PROCESSING

During construction, the prototype is fixed to the work surface thanks to the presence of support material or particular fixing structures. Once the fabrication is finished, mechanical operations, manual and non-manual, are necessary to allow detachment from the building plan. In addition, the support structures necessary for the support during the manufacture of the undercut parts are removed by manual or chemical operations.

Step 7: Post processing – Detachment from manufacturing table and supports removal

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Image credit: Materialise

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Step 7: Post processing – Detachment from manufacturing table and supports removal

Post Processing

Build Removal	Part Separation
Removing excess material from the build inside the printer (e.g. in powder bed processes)	Removing parts from the build plate, using EDM, band saw or machining
Removing the build from the printer	Removing parts from each-other if attached for nesting purposes
Inspection for accuracy, potential delamination, surface quality, support attachments, etc.	Removing supports from individual parts, often requiring clippers, EDM, bandsaw or machining (support removal can also be completed in secondary machining steps)

Step 7: Post processing – Detachment from manufacturing table and supports removal

Post Processing

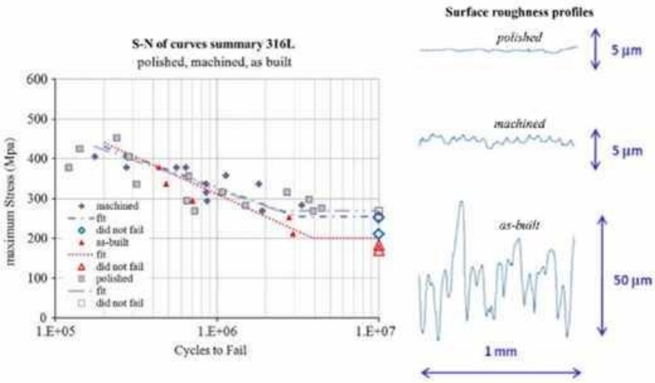
Machining	Surface Finishing
Machining to remove remaining supports, smooth surfaces, add critical features, and hit critical tolerances	Polishing surfaces where surface roughness requirements were not achievable from machining
Custom fixtures may need to be created to hold printed parts for secondary operations. If the part geometry is complex or organic, these fixtures can become resource intensive to design and manufacture	Tumbling or Shot peening to smooth and/or work harden surfaces, or mitigate issues with loose powder on unfinished surfaces

Step 7: Post processing – Detachment from manufacturing table and supports removal

The roughness affects the fatigue life performance.

Indeed, the picture highlights:

- The different order of magnitude for the roughness.
- The wohler curves for stainless steel 316L considering different level of post processing.



Step 7: Post processing – Detachment from manufacturing table and supports removal

Parameters	SLM	DED	EBM
Speed of production	5-20 cm^3/h (40-160 g/h)	until to 70 cm^3/h	until to 60 cm^3/h
Accuracy	from +- 0.02 a +- 0.05 su 25 mm	from +- 0.25 a +-0.5 su 25 mm	from +- 0.1 to +-0.5 su 25 mm
Minimum feature	from 0.04 to 0.2 mm	from 0.5 to 1.0 mm	from 0.3 to 0.6 mm
Surface Quality	from 4 to 10 μm	from 7 a 40 μm	from 10 to 30 μm
Maximum Dimensions	800 x 400 x 500 mm	2000 x 1500 x 750 mmm	Ø350×380 mm
Machining Allowance	0.5 – 1 mm	3-5 mm	2-4 mm
Minimum diameter of hole	Ø 0.25 mm	Ø 1-4 mm	Ø 0.5 mm

Co-funded by the Erasmus+ Programme of the European Union

For further information and contact details, have a look here:

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