Co-funded by the European Union

NextGEng

Project title	International Cooperation Framework for Next Generation Engineering Students
Project acronym	NextGEng
Project contract no.	2022-1-RO01-KA220-HED-000088365

NextGEng Project

WP3

International team-teaching pilot program

Deliverable 3.5c

Developed laboratory work, tailored seminars for course C5 and C6

September 2024

WP3	R3.5c - Developed laboratory work, tailored seminars for course C5 and C6
Authors	Ciprian Rad
Short Description	This report presents the results of the laboratory worked, tailored seminars developed for courses C5 and C6 within second round of course and laboratory upgrading process in WP3.
Status	Final
Distribution level	Public
Date of delivery	29/09/2024
Contributions by:	Ciprian Lapusan
Project web site	www.nextgeng.eu

Document History

Version	Date	Author/Reviewer	Description
0.1	22.09.2024	Ciprian Rad	First Draft
0.2	28.09.2024	Ciprian Lapusan	Draft amendments
Final	29.09.2024	Ciprian Rad	Final Version

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Table of Contents

1. Introduction 4

2. Laboratories topics.. 5

1. Introduction

This report presents the outcomes of the course upgrading and team-teaching development carried out within WP3 of the NextGEng project.The implementation process led to the creation of **5 new laboratory activities and tailored seminars** were created in cooperation with industry partners, including ISR (3 labs), Valmet (4 labs), and Bosch (4 labs). These activities strengthen the applied dimension of the curriculum and enhance the connection between academic learning and industrial practice.

The development process was highly collaborative, involving **16 coordination meetings** across the co-teaching teams of courses C5 and C6, with the participation of **12 higher-education teachers** and **5 industry experts**. This joint effort ensured alignment of content, consistent implementation across institutions, and the integration of industry-relevant competencies.

The pedagogical materials developed within this project are released under the Creative Commons CC BY-NC-SA license (Attribution – NonCommercial – ShareAlike). This license permits users to freely access, use, and adapt the materials provided that appropriate credit is given to the authors and the project. The materials may not be used for commercial purposes, and any adaptations or derivative works must be distributed under the same license terms.

In the next Chapters the produced laboratories modules are presented.

2. Laboratories topics

C5 - Computer Aided Design

Laboratory 1 – Design of a Specular Vision System (in collaboration with ISR)

Laboratory 2 – Fit-for-purpose 3D modelling (in collaboration with VALMET)

Laboratory 3 - Design of parametrized parts with applications in logistics (in collaboration with BOSCH)

C6 - Manufacturing Technology

Laboratory 1 - Additive manufacturing at Valmet (in collaboration with VALMET)

Laboratory 2 - Solder Paste Printing Process (in collaboration with BOSCH)

C5 – Computer Aided Design

L1 – Design of a Specular Vision System

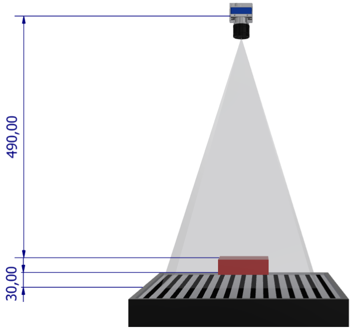
P3-ISR

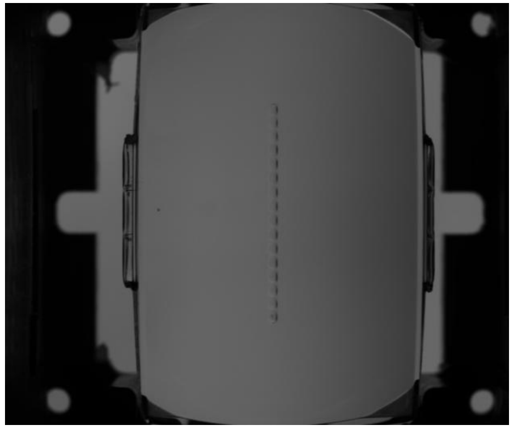
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

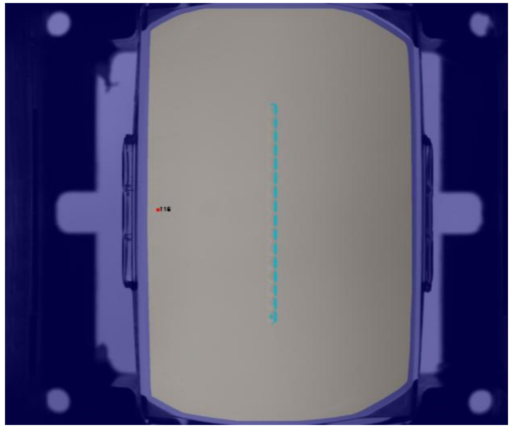
Co-funded by the European Union

Computer Aided Design

Project work - Design of a Specular Vision System







Co-funded by
the European Union

NextGEng

Design of a Specular Vision System demonstrative stand

Project overview:

Objectives	• Design a demonstrative stand for a specular vision system, aiming to illustrate the principles of light reflection and image formation on reflective surfaces • The stand should integrate optical components, mechanical supports, and measurement/observation tools for vision-related applications
Pre-requisite	• Basic skills and knowledge of SolidWorks and of technical drawings • Mechanical Design Fundamentals - machine elements and supports • Basic knowledge of measurement techniques and optics
Equipment used for laboratory	• PCs with SolidWorks

Design of a Specular Vision System demonstrative stand

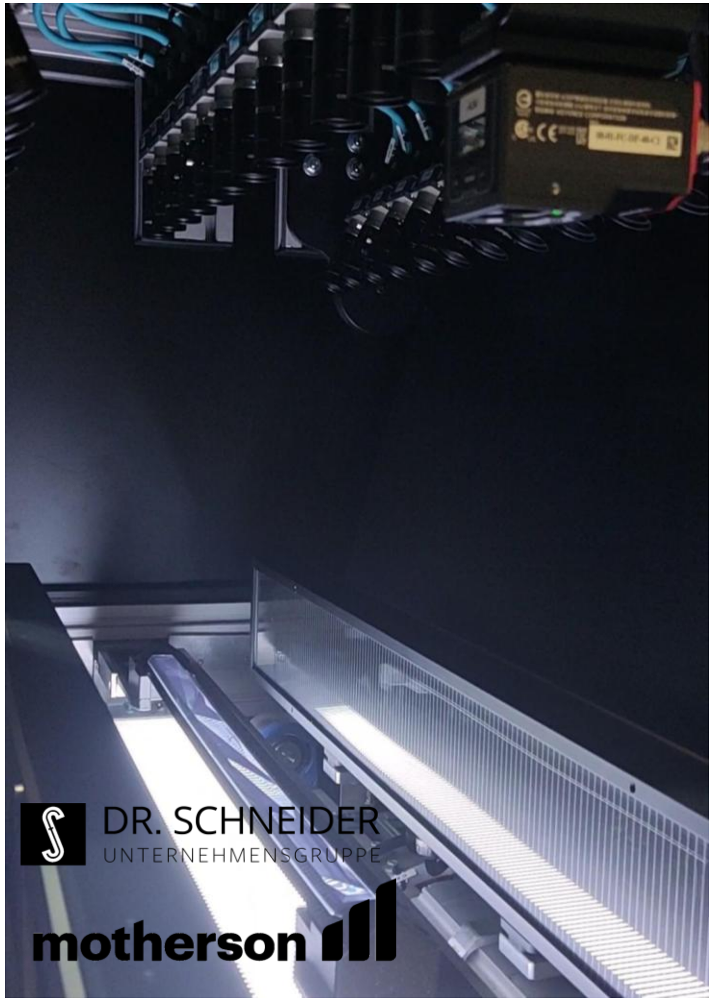
Upon completion of this activity, the student will be able to:

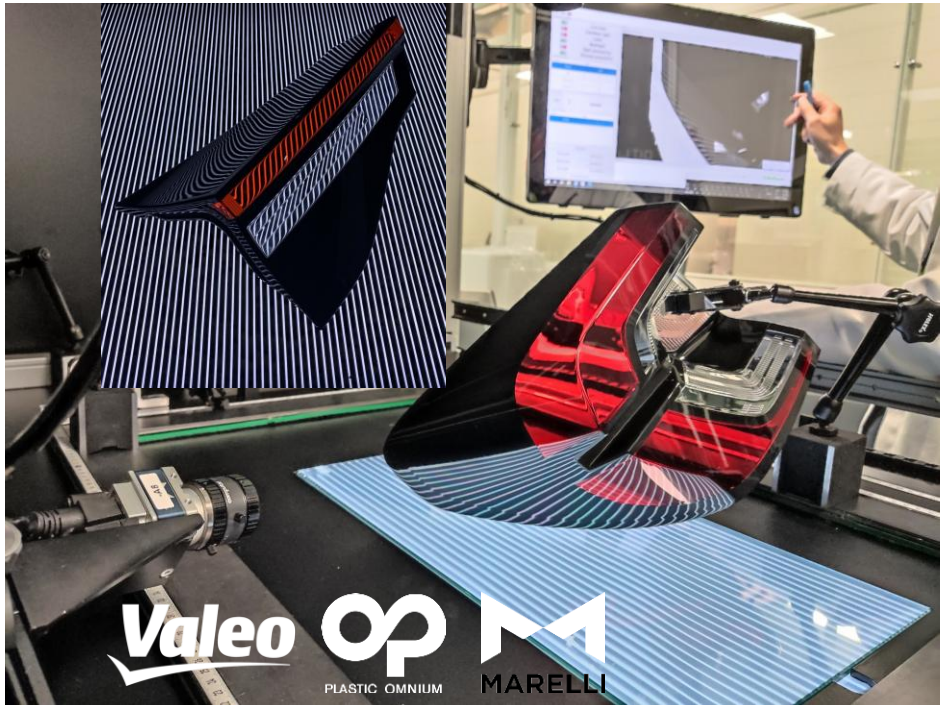
1) Explain the principles of light reflection and image formation on specular surfaces
2) Design and assemble a demonstrative stand integrating optical components, mechanical supports, and measurement/observation tools, considering technical specifications, alignment, functionality, and cost-effectiveness
3) Document, present, and justify design choices; evaluate system performance;

Content

- Introduction
  - Motivation and relevance of specular vision in engineering and applied sciences.
  - Theoretical concepts related to Specular Vision
  - Industrial applications that use Specular Vision
- Project task description
  - Design requirements and constraints
  - Technical specifications
  - Aesthetic and Promotional Aspects
- Summary, Discussions & Feedback

What is Specular Vision





Automatic inspection of **aesthetic quality of parts and components** with **specular surfaces** (transparent and reflective), using **artificial vision** equipment and **patented lighting systems** in:

- ✓ Optical Inspection Technology [OIT ®]

Co-funded by the European Union

How is the process

*I need to inspect **automatically** this part.*

In less than 20 s!

Industry Professional
(our customer)

Free-of-charge feasibility study based on Artificial Vision Techniques

ISR Team
(Innovation and Engineering)

Industrial Inspection System OIT ®

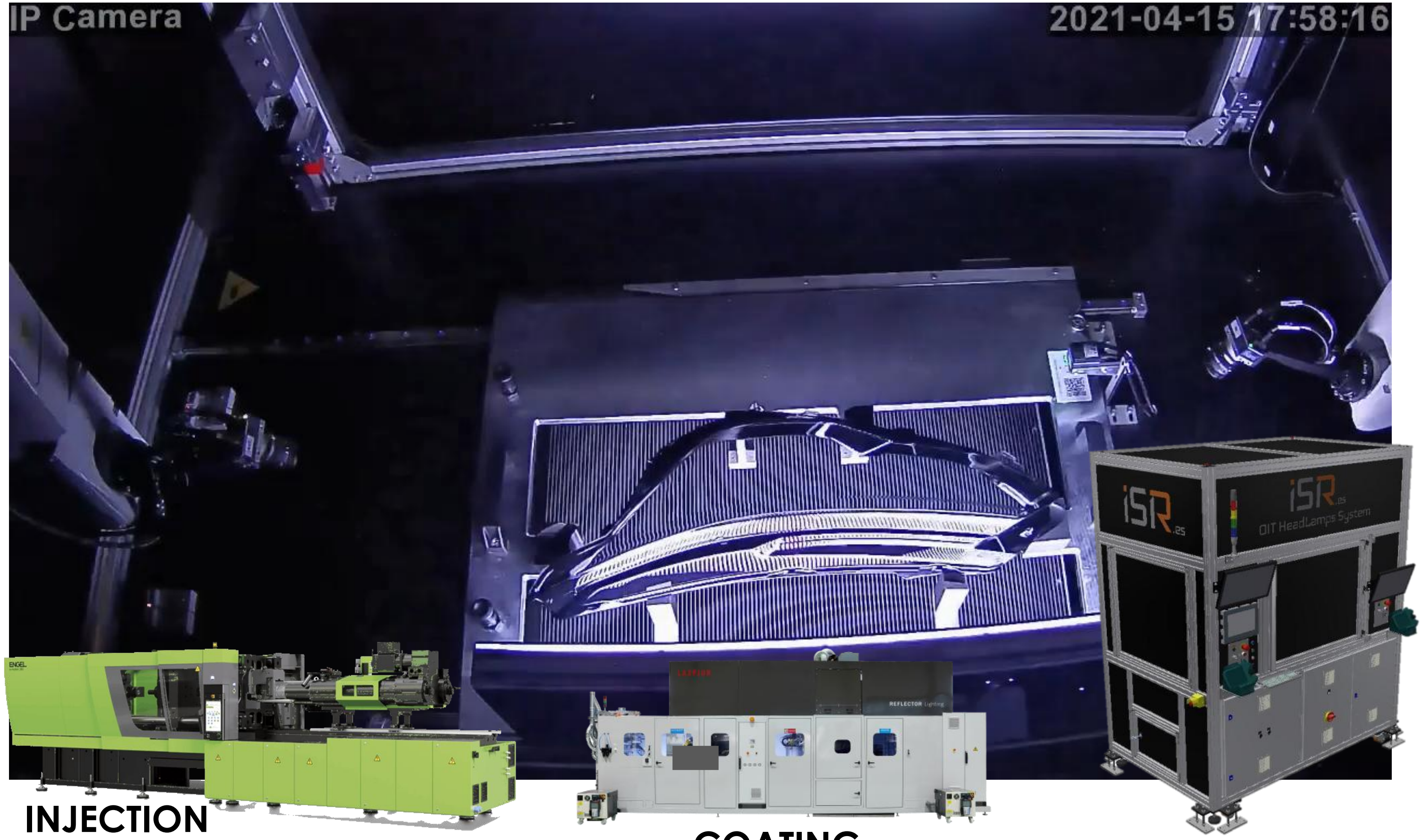
- ✓ **Flexible solutions**
- ✓ **4.0. Ecosystem**
- ✓ **Customer driven quotations**
- ✓ **Adapted to surface**

Co-funded by the European Union

NextGEng

Our OIT solutions in industry

Success Case: OIT HeadLamps (HL) / RearLamps (RL) System

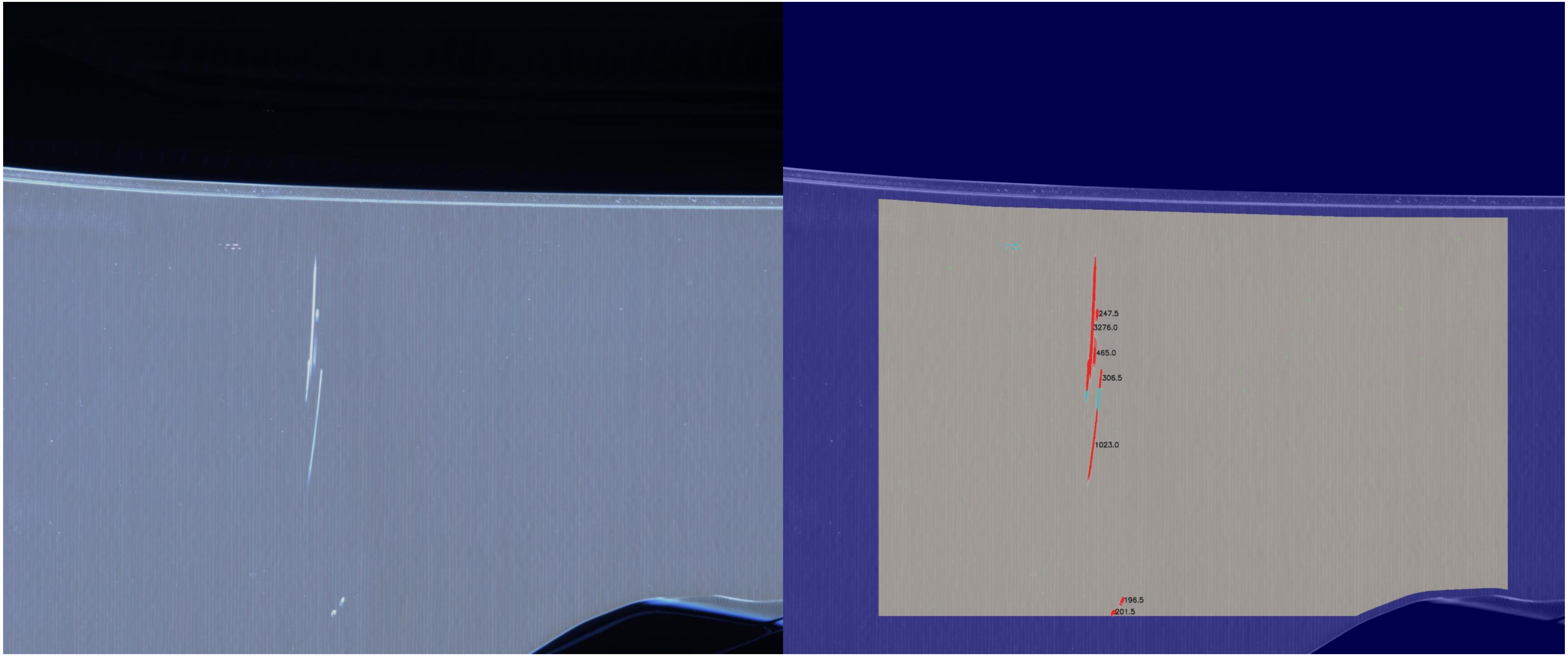


Valeo · PLASTIC OMNIUM · ASPÖCK SYSTEMS · MARELLI

- **Specular Vision ® technology adaptation** considering productive process requirements.
- New **HL / RL models** integration through Vision Jig development.

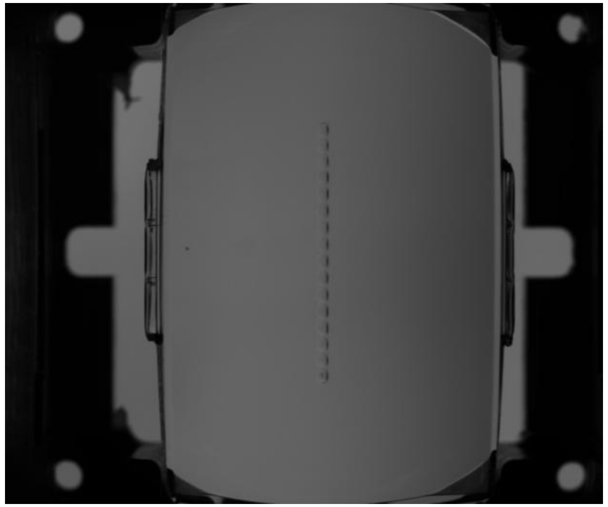
Co-funded by the European Union

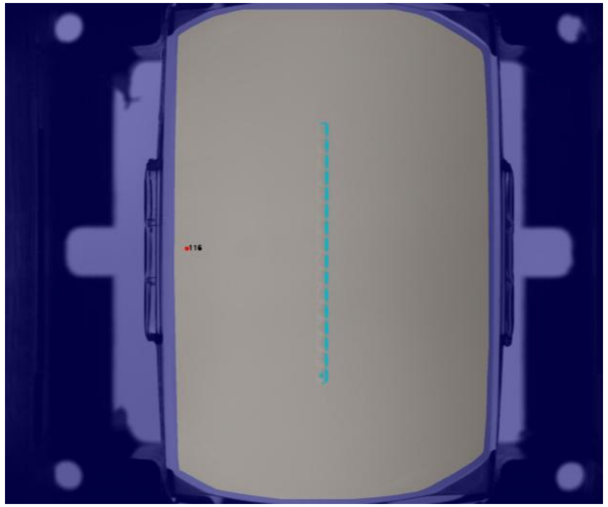
Success Case: OIT HeadLamps (HL) / RearLamps (RL) System

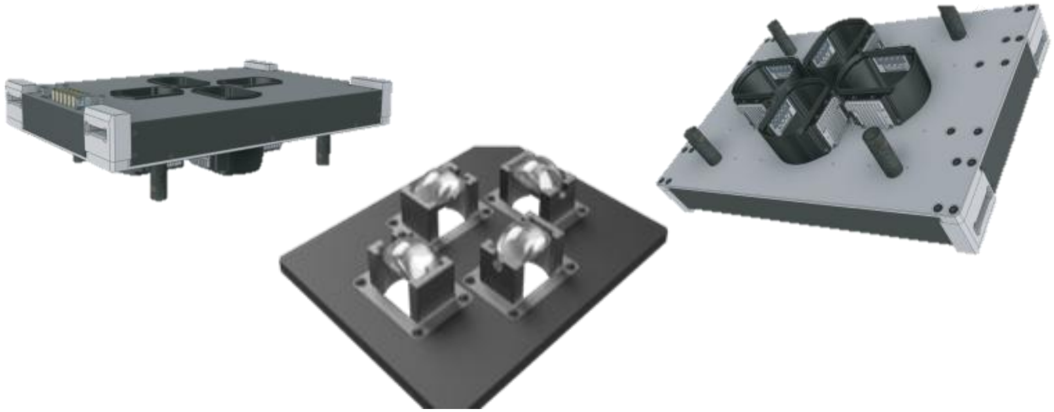


Our OIT solutions in industry

Success Case: OIT Thick Lenses Inspection System





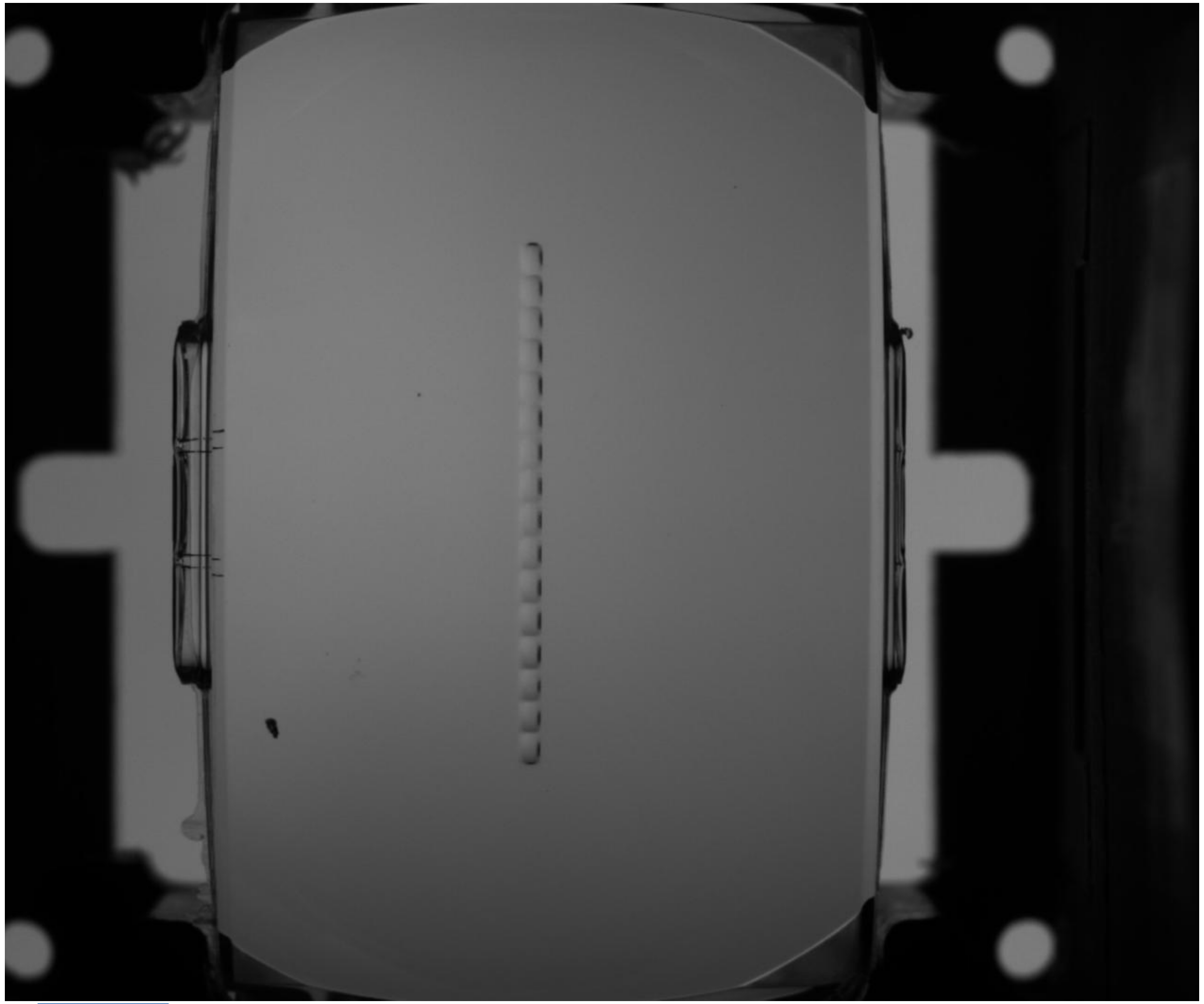


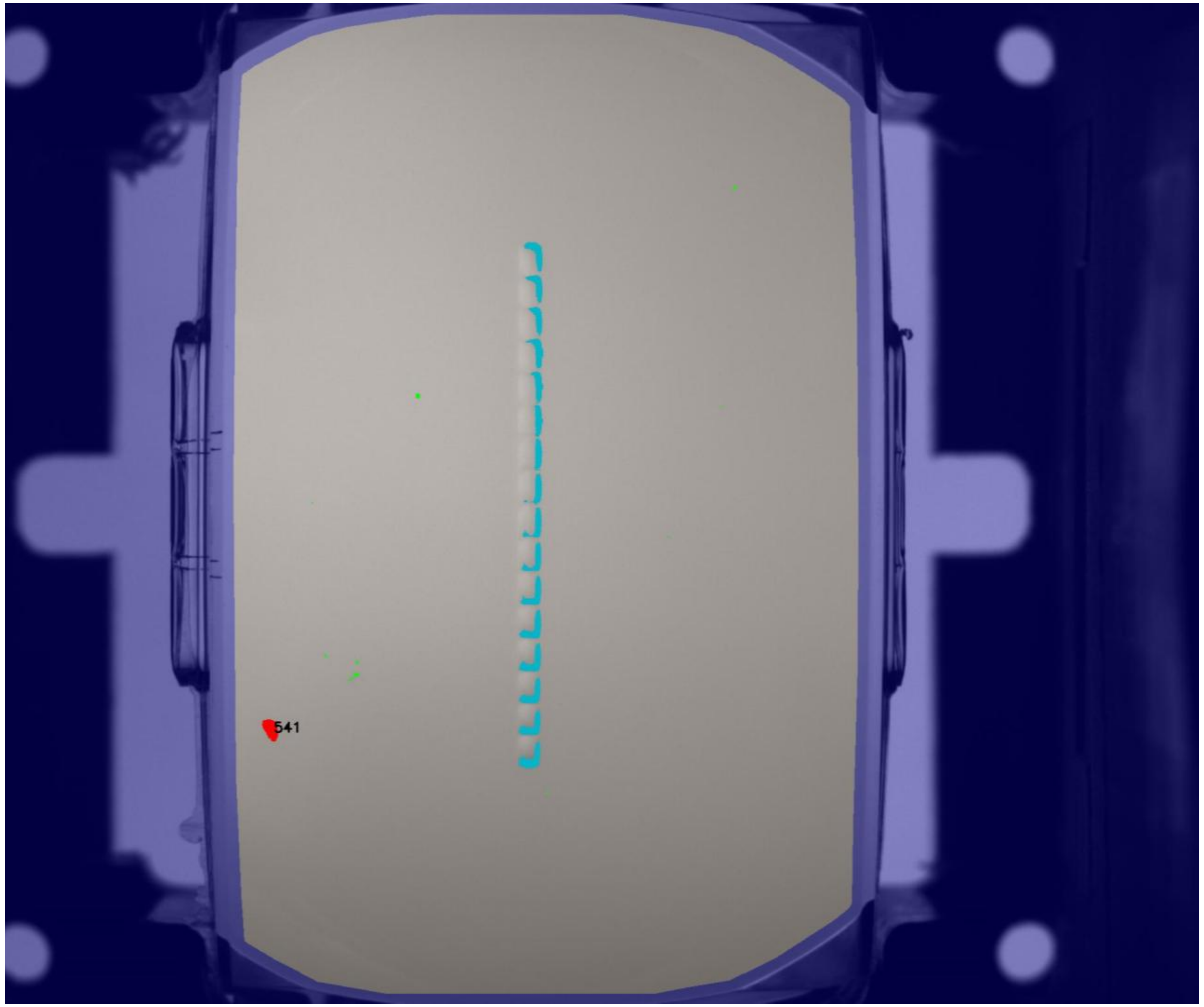
Co-funded by
the European Union

NextGEng

Our OIT solutions in industry

Success Case: OIT Thick Lenses Inspection System





Design challenge: Demonstration System for ISR Inspection Technology

Context and Objective

- Given the need to demonstrate to the public the capabilities of the inspection technology developed by ISR, the design of a compact, functional, and visually attractive demonstration system is proposed. This system will be transferred to Stemmer Imaging, camera supplier and technology partner, for use at trade shows and events such as the upcoming edition in Barcelona. The objective is to increase the visibility of the inspection technology developed by ISR, through a demonstrator that allows its use in exhibition environments without compromising technical quality or incurring unnecessary costs

Restrictions and economic considerations

This system will not generate direct revenue, so the design must prioritize low-cost solutions, using readily available or inexpensive materials without compromising functionality or display aesthetics.

Co-funded by the European Union

Design challenge: Demonstration System for ISR Inspection Technology

Functional concept of the system

- The system is based on the inspection of transparent parts using image composition generated between an illumination panel (LCD) and a camera placed in front of it, pointing towards the screen. The part to be inspected is positioned between these two elements, allowing the evaluation of defects or properties using artificial vision techniques adapted to transparent surfaces.

Demonstration System for ISR Inspection Technology

Technical specifications and requirements

- **Maximum system dimensions:** 800 x 800 x 1600 mm. A reduction in these dimensions is prioritized to facilitate installation on a table. If these dimensions are exceeded, the system must be equipped with wheels to allow for transport.
- **Weight:** It should be limited if used on a tabletop. In freestanding installations, weight is not a limiting factor, provided the solution is stable and easily movable.
- **Part to be inspected:** Maximum size of 200x200mm. The system must integrate centering devices or fixings for:
    - Inspection BILED lens

Co-funded by
the European Union

NextGEng

Demonstration System for ISR Inspection Technology

Components to be integrated:

- Industrial inspection camera
- 19-inch LCD panel
- Industrial PC and switch
- Additional screen for displaying results and system configuration (visible at 2-3 m distance)

Physical and ergonomic design:

- Closed structure with side access (removable door or panel with magnetic fixings)
- Height adjustment of the chamber to adjust the distance to the panel according to the test configuration.
- Possibility of table mounting or in a free-standing configuration with casters

Co-funded by
the European Union

Demonstration System for ISR Inspection Technology

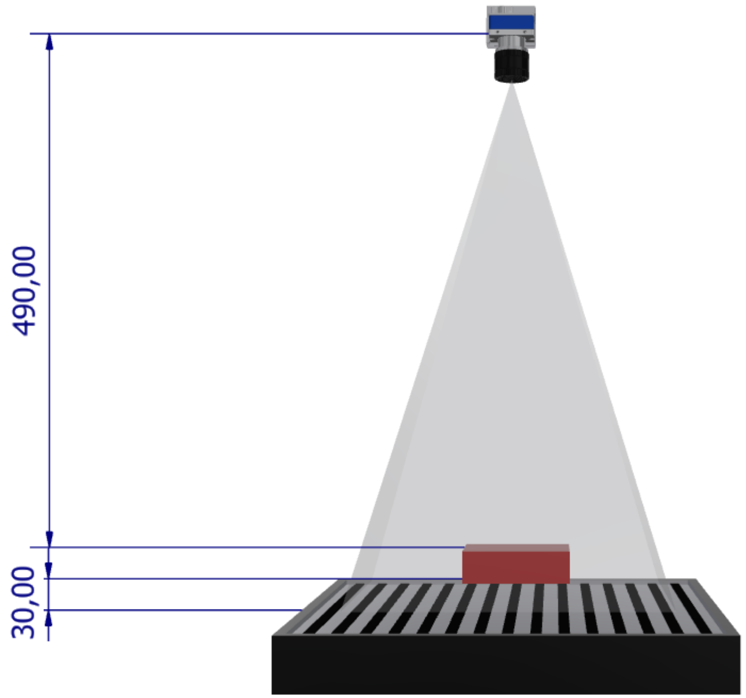
Visual and promotional aspects:

- Striking and professional design, aimed at capturing the attention of visitors at trade shows
- Incorporation of graphic elements or screen printing that reinforce the visual identity of ISR
- Adequate arrangement of the system to facilitate interaction and observation of the process from various angles

Demonstration System for ISR Inspection Technology

Upon completion of this project, the student will be able to:

1) Analyze and interpret technical requirements.
2) Apply optical and vision-based inspection principles.
3) Design a compact and functional demonstrator system.
4) Evaluate cost-effectiveness and technical feasibility.



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

C5 – Computer Aided Design

L2 - Fit-for-purpose 3D modelling

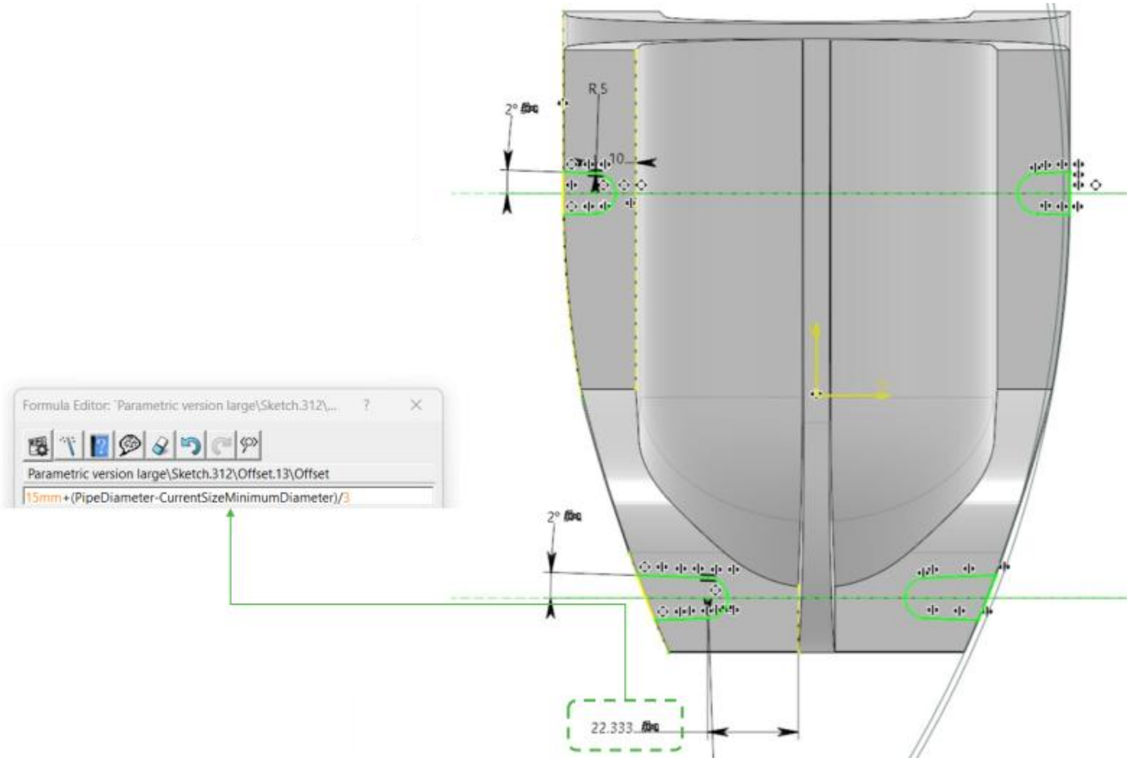
P5 - Valmet

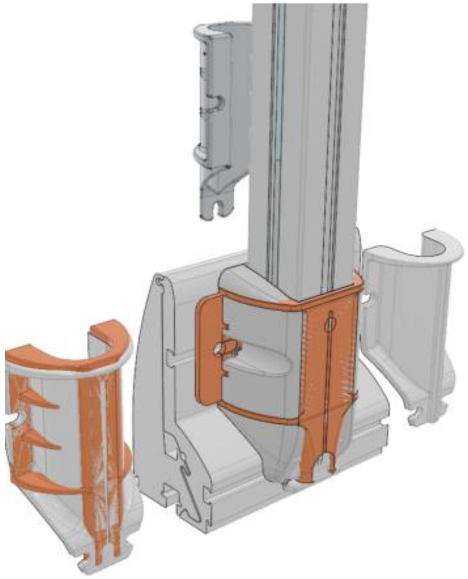
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

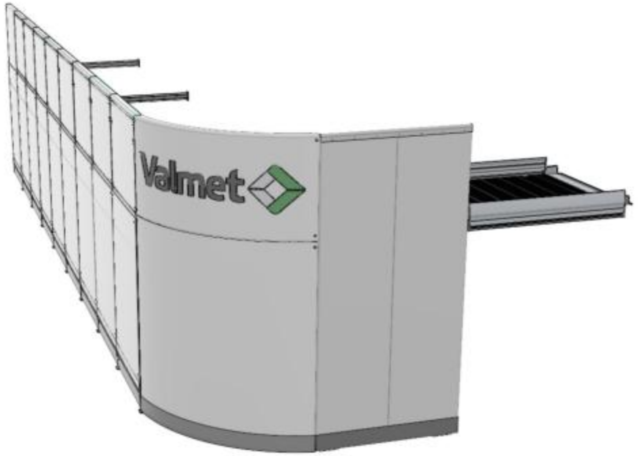
Co-funded by the European Union

Computer Aided Design

Laboratory work - Fit-for-purpose 3D modelling







Co-funded by
the European Union

Fit-for-purpose 3D modelling

Laboratory overview:

Objectives

- acquire the ability to apply different levels of modelling—ranging from PowerPoint CAD and concept models to engineering/development and parametric models—in a resource-efficient manner.
- The activity integrate lean and agile principles, and fosters critical decision-making skills in selecting a "fit-for-purpose" level of detail, thereby avoiding unnecessary complexity and optimizing the modelling process

Pre-requisite

- Basic skills of CAD/3D modelling software
- Fundamentals of manufacturing/product engineering
- Awareness of LEAN and agile principles (avoiding over-processing, maximizing value)

Equipment used for laboratory

- PCs with Katia

Fit-for-purpose 3D modelling

Upon completion of this activity, the student will be able to:

1) Select and justify the appropriate modelling approach for a given design task based on its purpose and available resources;
2) Create 3D models at different levels of resolution (from quick sketches to parameterized models) while avoiding unnecessary features and complexity;
3) Assess when (and when not) parametric modelling or high-detail modelling is worth the additional effort;

Co-funded by the European Union

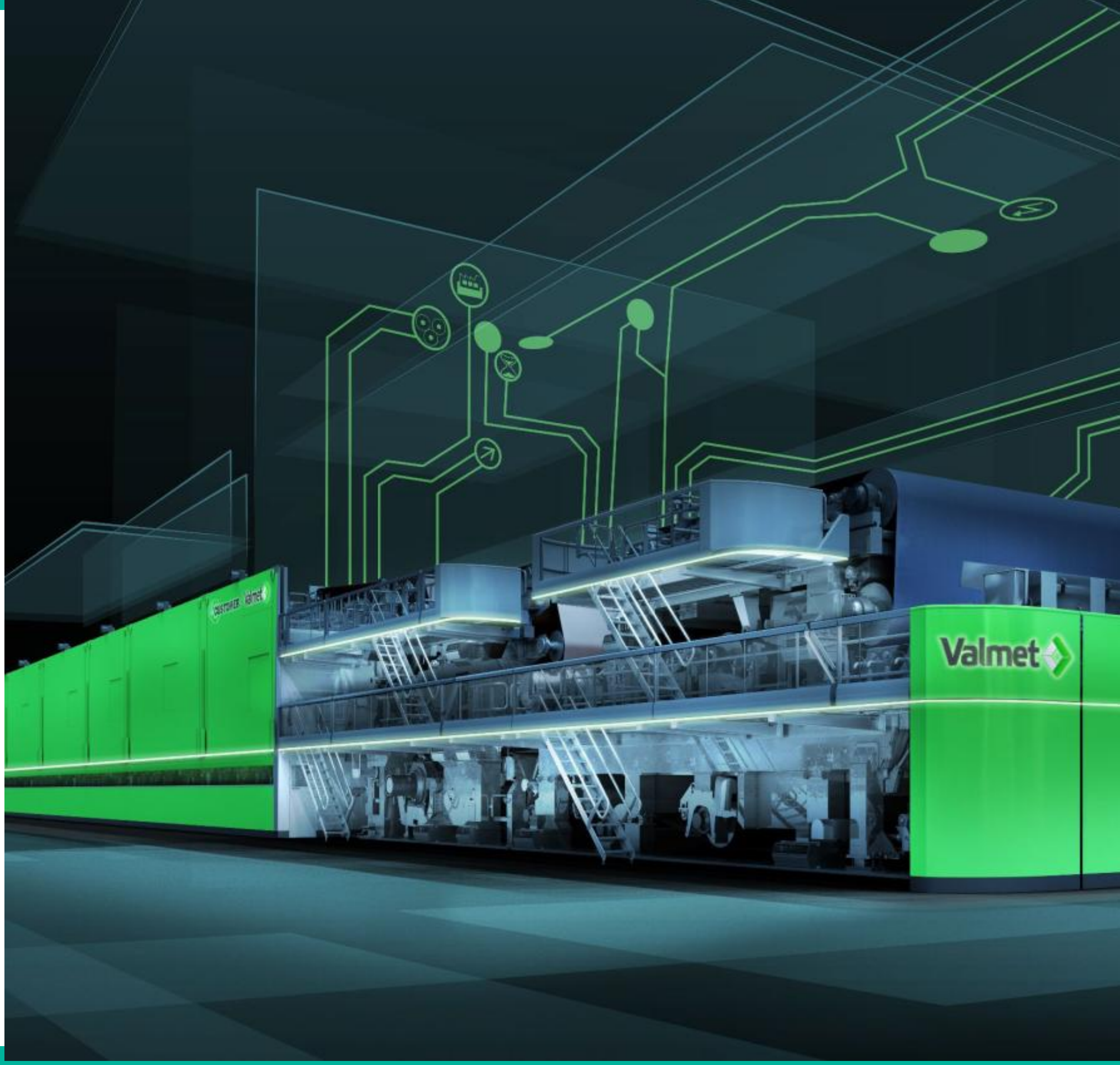
NextGEng

Co-funded by the European Union

NextGEng

Content

- Introduction
- Valmet company introduction
- Modeling 4 different type cases
    - Power point -CAD
    - Concept models
    - Development/engineering models
    - Parametric models
- Summary, Discussions & Feedback



Co-funded by the European Union

1 | Introduction

Valmet

Co-funded by the European Union

2 | Valmet company introduction

This is Valmet

We aim to become the global champion in serving our customers. Our 14,000 professionals around the world work close to our customers and are committed to moving our customers' performance forward – every day.

- Market's widest offering combining process technologies, services and automation
- Research and development spend EUR 71 million in 2019

Market leadership

- Leading market position in all markets

Pulp	#1–2
Energy	#1–3
Board	#1
Tissue	#1
Paper	#1
Services	#1–2
Automation	#1–3

Strong global presence

- Approx. 100 service centers
- 96 sales offices
- 39 production units
- 16 R&D centers
- 14,000 professionals

EMEA	8,700
China	1,800
North America	1,700
Asia-Pacific	900
South America	500

Leader in sustainability

- Eight consecutive years in Dow Jones Sustainability Index
- Four consecutive years in Ethibel Sustainability Index Europe
- A- rating in CDP climate program 2020

A strong financial profile and balanced business portfolio

2022 key figures of Valmet

Orders received
EUR 5,194 million

Net sales
EUR 5,074 million

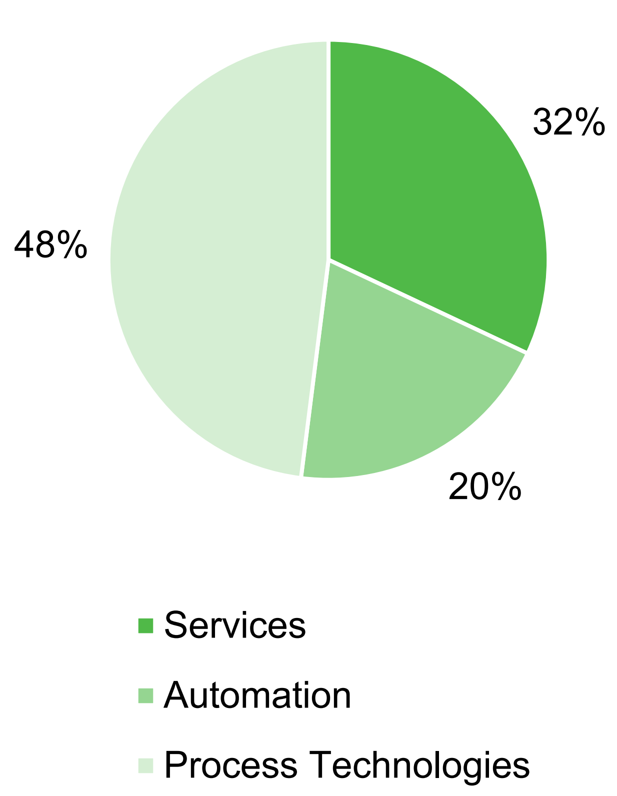
Comparable EBITA
EUR 533 million

Comparable EBITA margin
10.5%

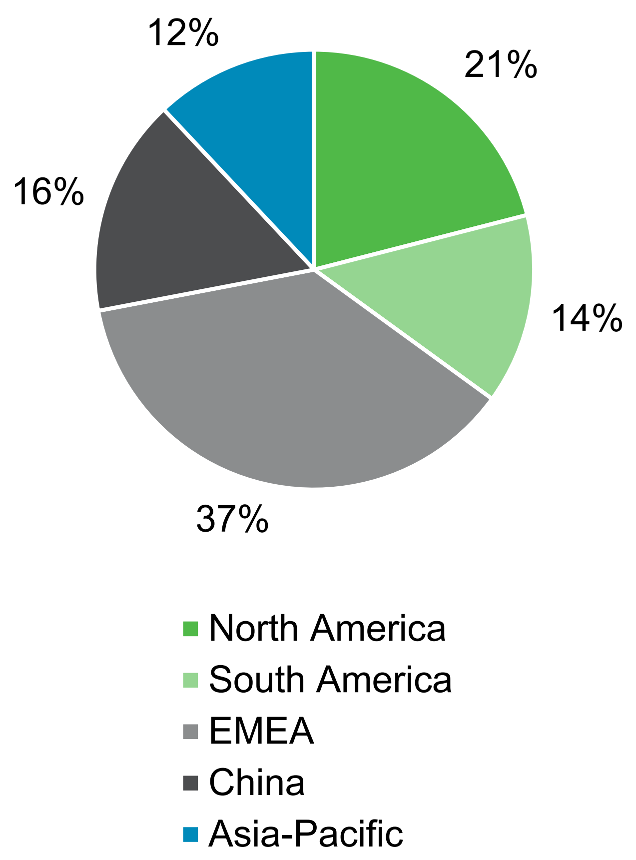
Order backlog
EUR 4,403 million

Employees
19 000+

Net sales by segment



Net sales by area



Valmet

Co-funded by the European Union

Global presence creating a good platform for growth

EMEA
20 R&D centers
86 service centers
24 production units
76 sales offices
Head office

10,787
NET SALES EUR MILLION 1,876

NORTH AMERICA
3 R&D Centers
29 service centers
17 production units
11 sales offices

2,040
NET SALES EUR MILLION 1,058

SOUTH AMERICA
5 service centers
1 production units
8 sales offices

833
NET SALES EUR MILLION 718

CHINA
3 R&D Centers
5 service centers
6 production units
6 sales offices

2,323
NET SALES EUR MILLION 829

ASIA-PACIFIC
2 R&D Centers
11 service centers
6 production units
29 sales offices

1,565
NET SALES EUR MILLION 593

>130 service centers

>50 Production units

28 R&D centers

Personnel as in December 2022

Valmet

Global presence creating a good platform for growth

Co-funded by the European Union

Spain | 6 Valmet locations

Barcelona | Valmet Flow Control Services, valves & spare parts
Bilbao | Pulp and Paper Sales & Service
Madrid | Automation Sales & Service
Zaragoza | Services
Zaragoza | Maintenance center
Zaragoza | Roll Service Center

EMEA
20 R&D centers
86 service centers
24 production units
76 sales offices
Head office

10,787
NET SALES EUR MILLION 1,876

NORTH AMERICA
3 R&D Centers
29 service centers
17 production units
11 sales offices

2,040
NET SALES EUR MILLION 1,058

SOUTH AMERICA
5 service centers
1 production units
8 sales offices

833
NET SALES EUR MILLION 718

CHINA
3 R&D Centers
5 service centers
6 production units
6 sales offices

2,323
NET SALES EUR MILLION 829

ASIA-PACIFIC
2 R&D Centers
11 service centers
6 production units
29 sales offices

1,565
NET SALES EUR MILLION 593

>130 service centers

>50 Production units

28 R&D centers

Personnel as in December 2022

General overview of a paper/board machine | Tending side view

Headbox

- Hundreds of side-by-side nozzles sprays the pulp – a mixture of water and natural fibers – on top of a fabric.

Former (forming section)

- The web is formed and moved between the fabrics, because the material is still too wet to hold its own weight.
- The speed of which the web is moving is typically ~1200-1600 m/min (~60-100 km/h).
- Water is removed mainly gravitationally, with some help of vacuums.

Press

- Water is removed mechanically by pressing the web between ”nips” that are created by two rolls .
- When the web enters the press section, it is already strong enough to support itself and so dry that the drying principle need to be changed (= forming is not viable anymore).

(Pre-)Dryer

- The web is dried to its final dryness with multiple groups of steam-heated cylinders.
- Drying section is covered with a hood, keeping the ambient temperature stable and ensuring good energy-efficiency.
- Temperature inside the hood is very high, up to 100-120°C. People are generally not allowed inside it when the machine is running.

General overview of a paper/board machine | Tending side view

Sizer

- Gluing and coatings are applied to the surface of the web to obtain the desired paper/board properties.
- Mainly the tensile strength and surface quality are being improved.

After-Dryer

- Coatings applied on the sizer section are dried.
- Functionalities and environment are identical to the pre-dryer.

Calender

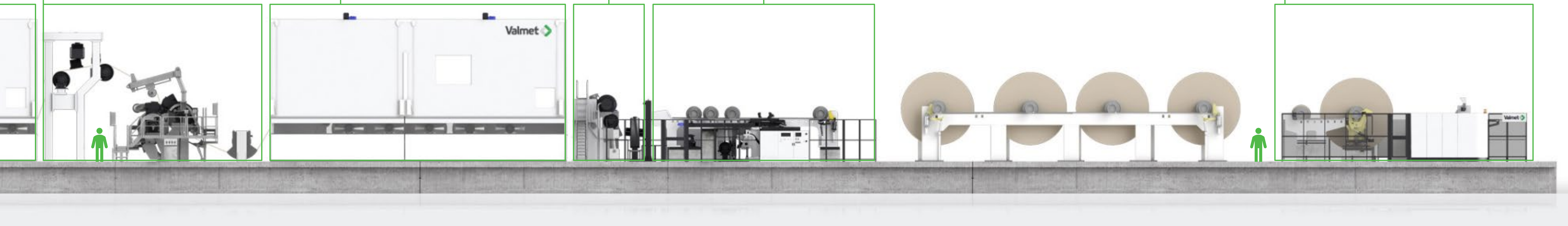
- Surface quality of the web is being improved in nips. The amount of nips may vary.
- This process step produces the desired thickness and a smooth and glossy finish.

Reel

- The finished product is rolled to large parent rolls.
- A temporary store of the parent rolls is located next to the reel section
- Weight of the rolls can be up to 100 tons.

Winder

- Large rolls are ”winded”: They are cut in the machine direction to smaller customer rolls that are better sized for further processing.
- Speeds are considerably higher than with the production process, of up to 3000 m/min (180 km/h).



Traditional paper machine
Valmet | Around 1970-1980s

Modern paper machine | Valmet OptiConcept M | Early **2010s**

Co-funded by the European Union

3 | Modelling

4 different types of cases

Disclaimer: The times stated in the modelling example are times it took to reverse engineer / 3D-model the features. Development times are an order of magnitude longer than what it takes just to model the geometries.

Co-funded by the European Union

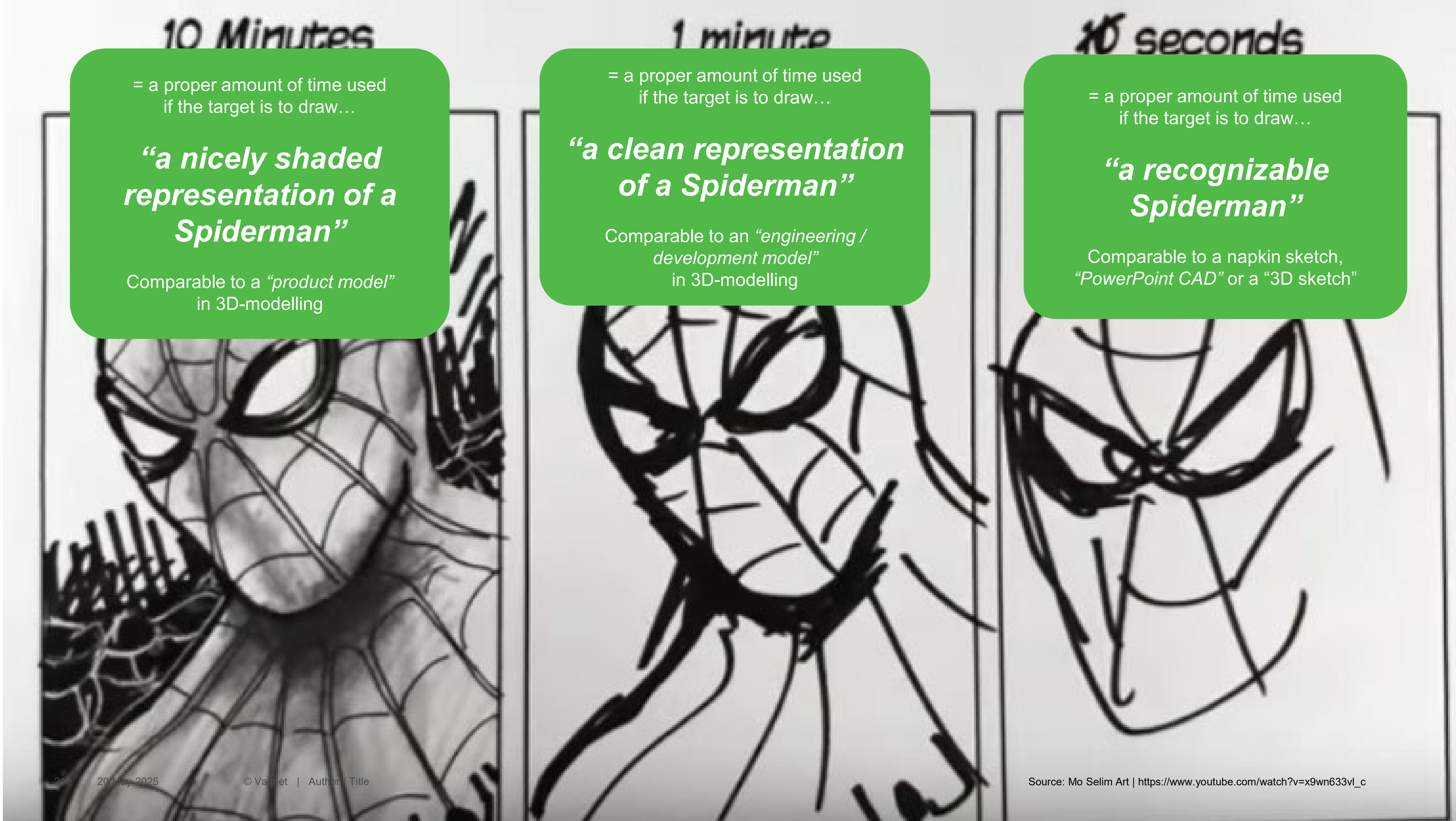
practical resolution

= aiming for the smallest possible effort that achieves the set targets

See also:

- *”The art of maximizing the amount of work not done”* as a foundational principle in agile software development or
- *”Extra processing”* as one of the eight wastes of LEAN

Valmet



= a proper amount of time used
if the target is to draw…

"a nicely shaded representation of a Spiderman"

Comparable to a *"product model"*
in 3D-modelling

= a proper amount of time used
if the target is to draw…

"a clean representation of a Spiderman"

Comparable to an *"engineering / development model"*
in 3D-modelling

= a proper amount of time used
if the target is to draw…

"a recognizable Spiderman"

Comparable to a napkin sketch,
"PowerPoint CAD" or a "3D sketch"

Source: Mo Selim Art | https://www.youtube.com/watch?v=x9wn633vl_c

Bonus question

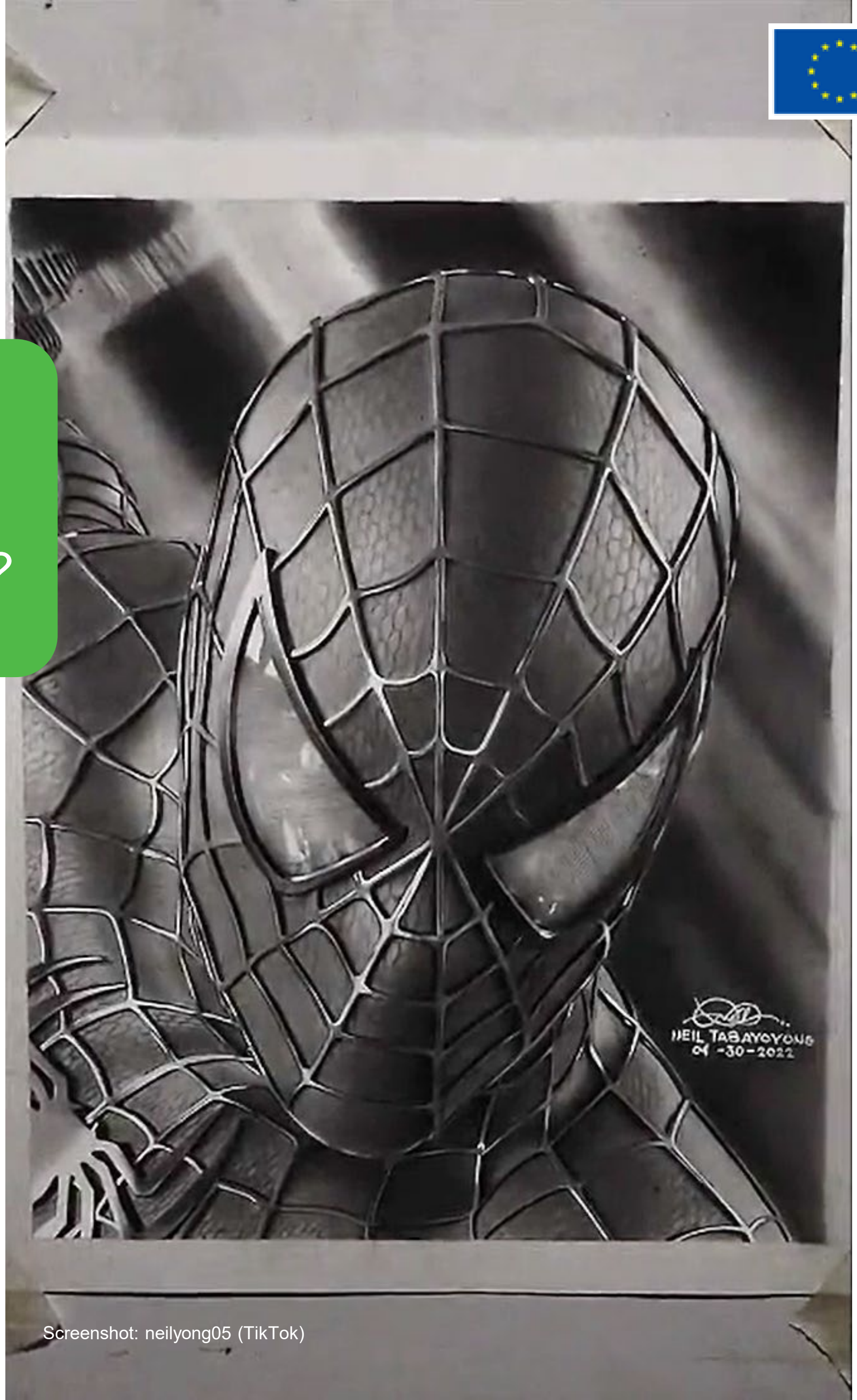
When the equivalent ***"a photorealistic representation of a Spiderman"*** *would be justified in 3D modelling in engineering context?*

(almost)

Never

In a world of finite resources, perfect is the opposite of good.

(Comparable to a parametric model with an excessive range of adjustability in 3D-modelling)

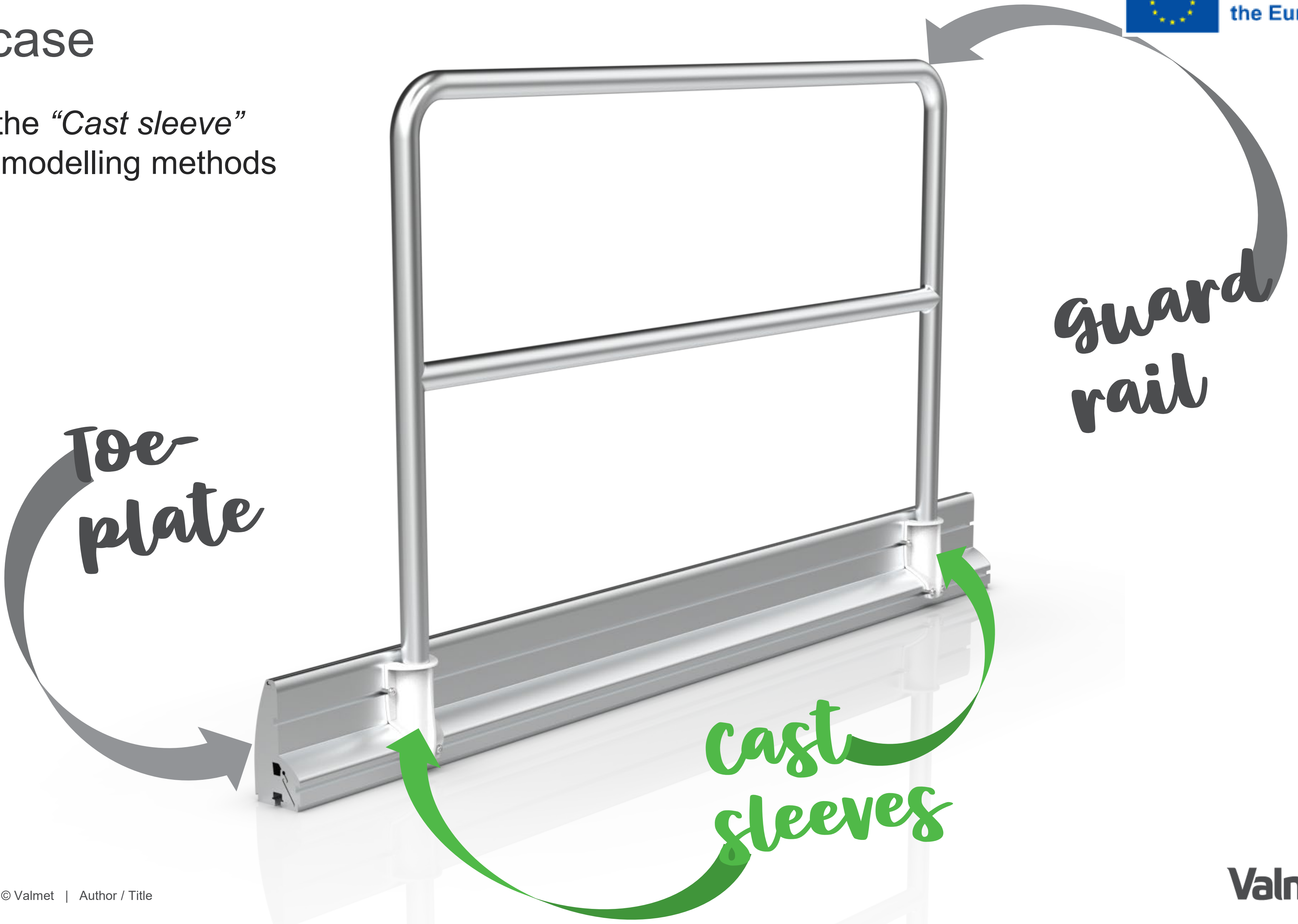


Screenshot: neilyong05 (TikTok)

Co-funded by the European Union

Example case

Today we'll do the *"Cast sleeve"* with 4 different modelling methods



Co-funded by the European Union

Valmet

Co-funded by the European Union

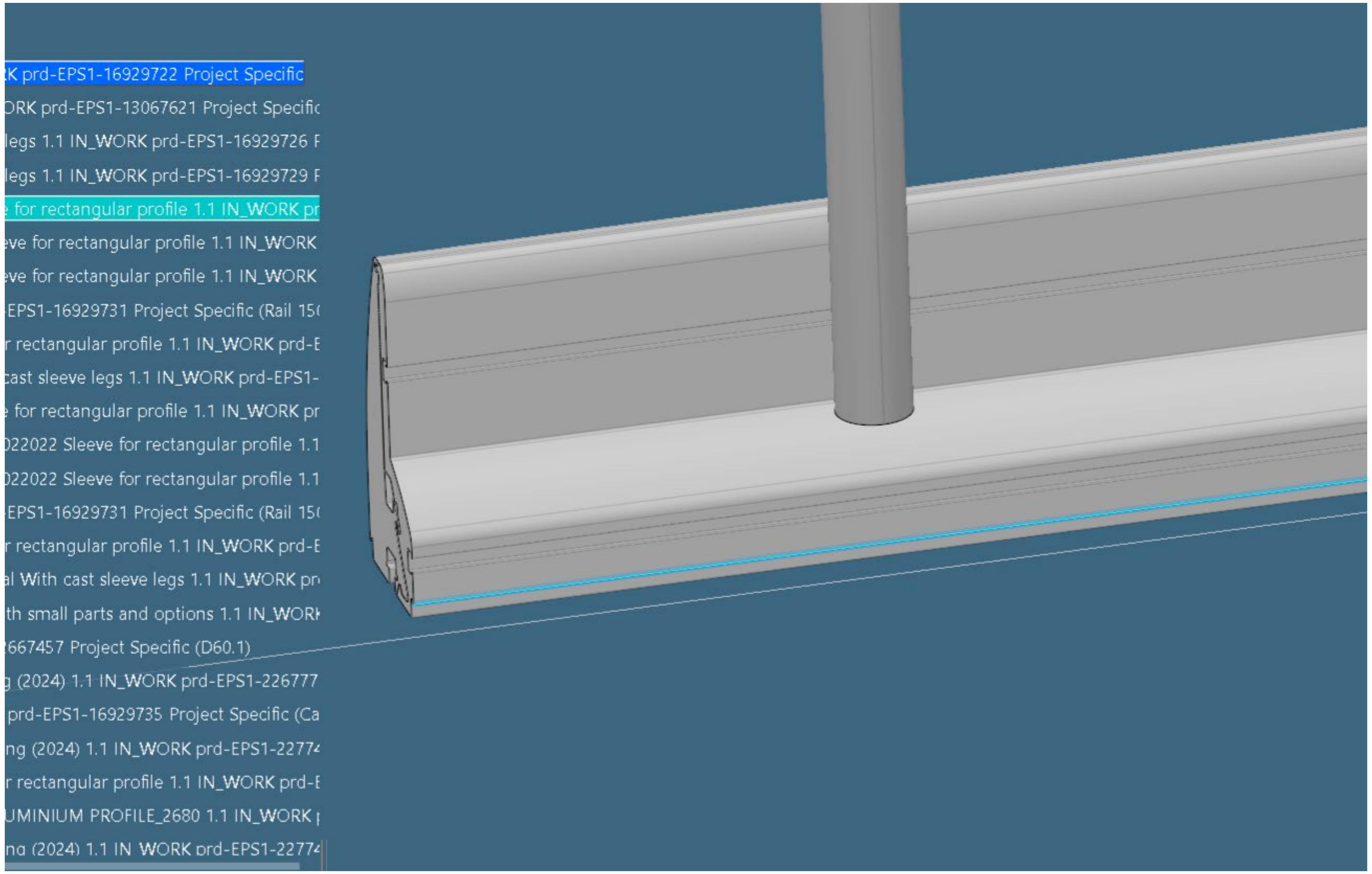
3A. PowerPoint CAD

Essentially first visualizations of an idea to get everyone understand the idea the same way

Examples:
10 seconds for the first example
1 minute for the second example
10 minutes for the third example

10 seconds

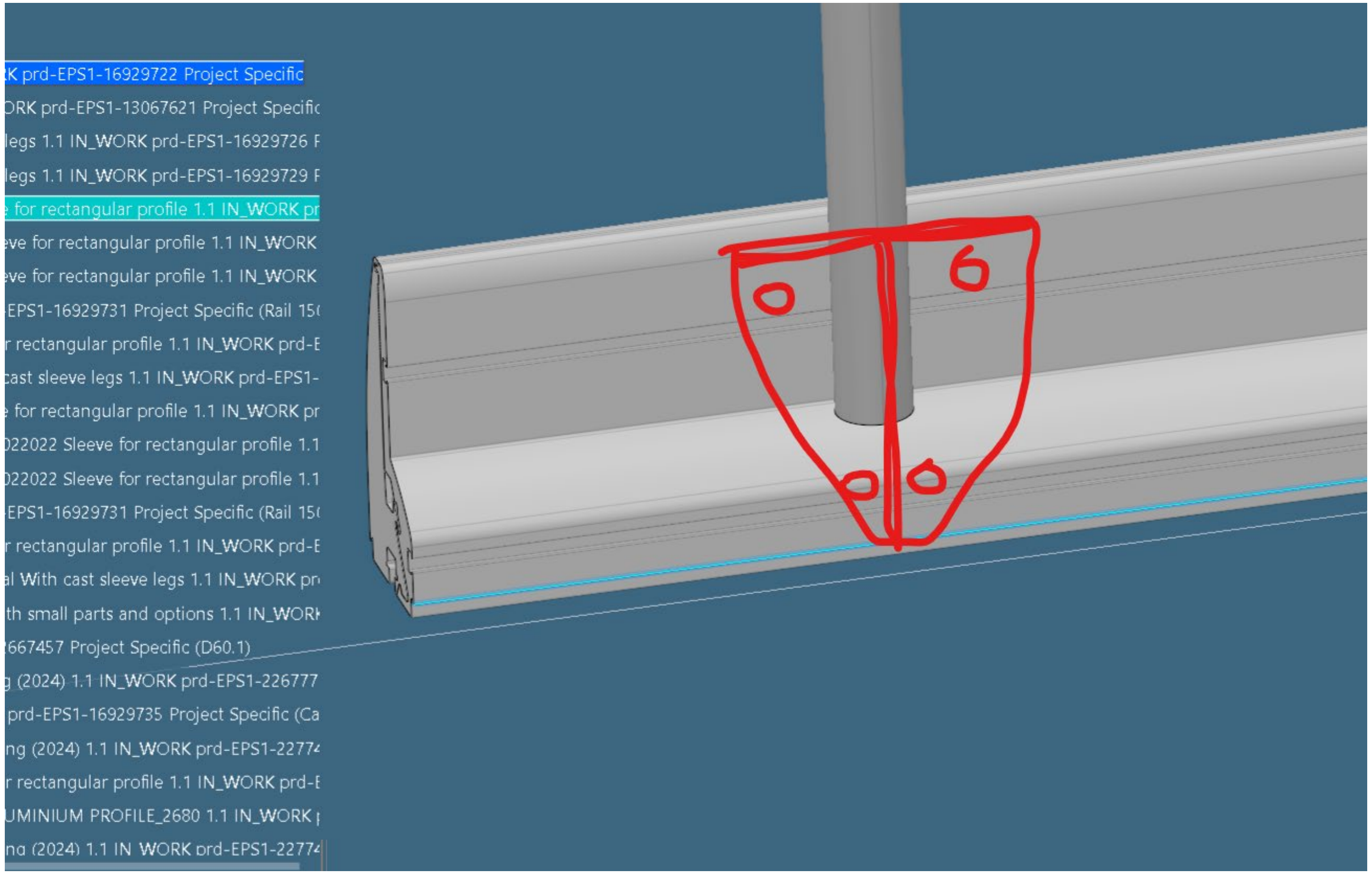
Co-funded by the European Union



Valmet

10 seconds

Co-funded by the European Union



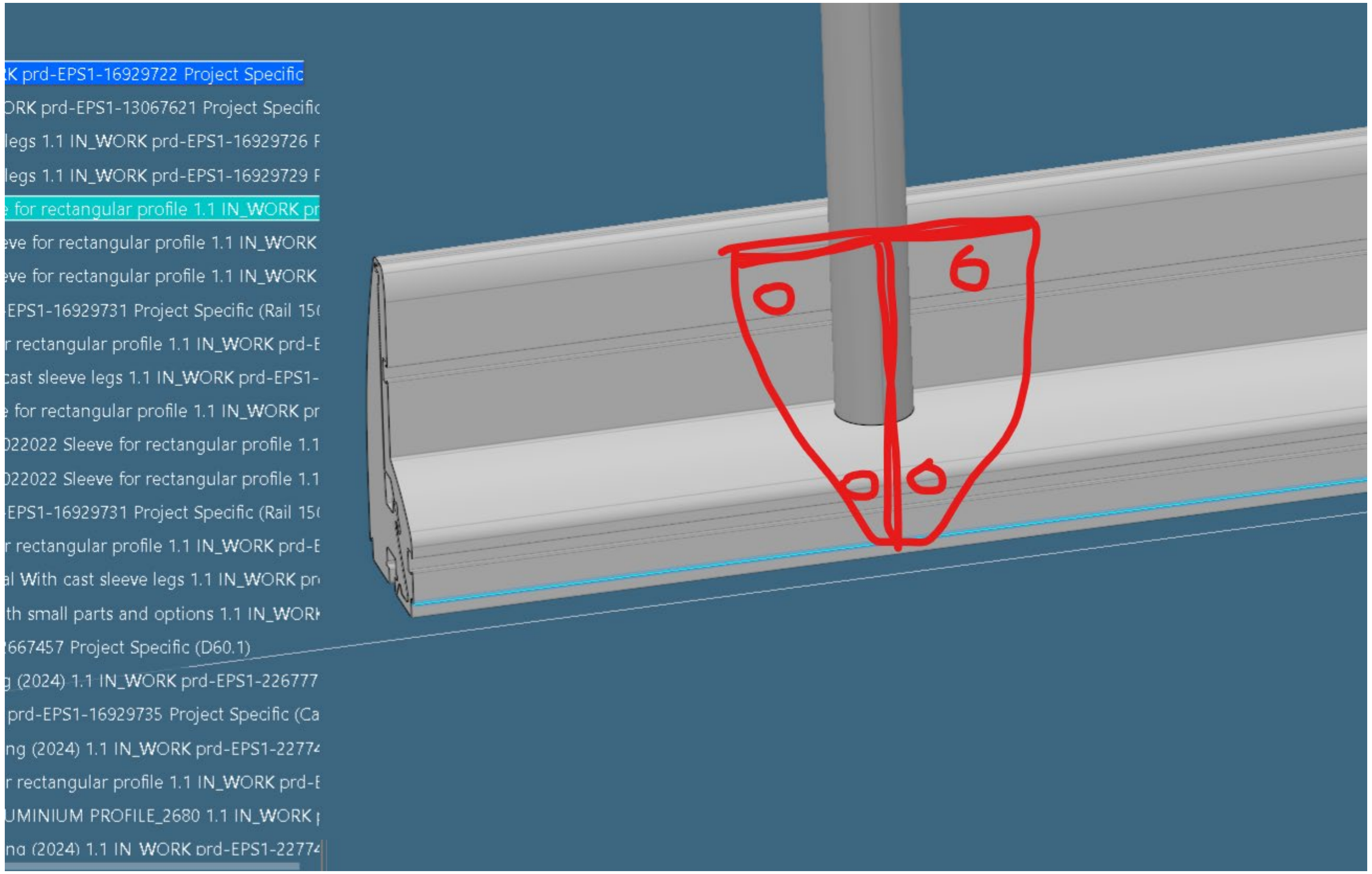
Valmet

10 seconds

Co-funded by the European Union

Uusi valuholkki

Vesa mallintaa ensi palaveriin



Valmet

1 minute

Co-funded by the European Union

1 minute

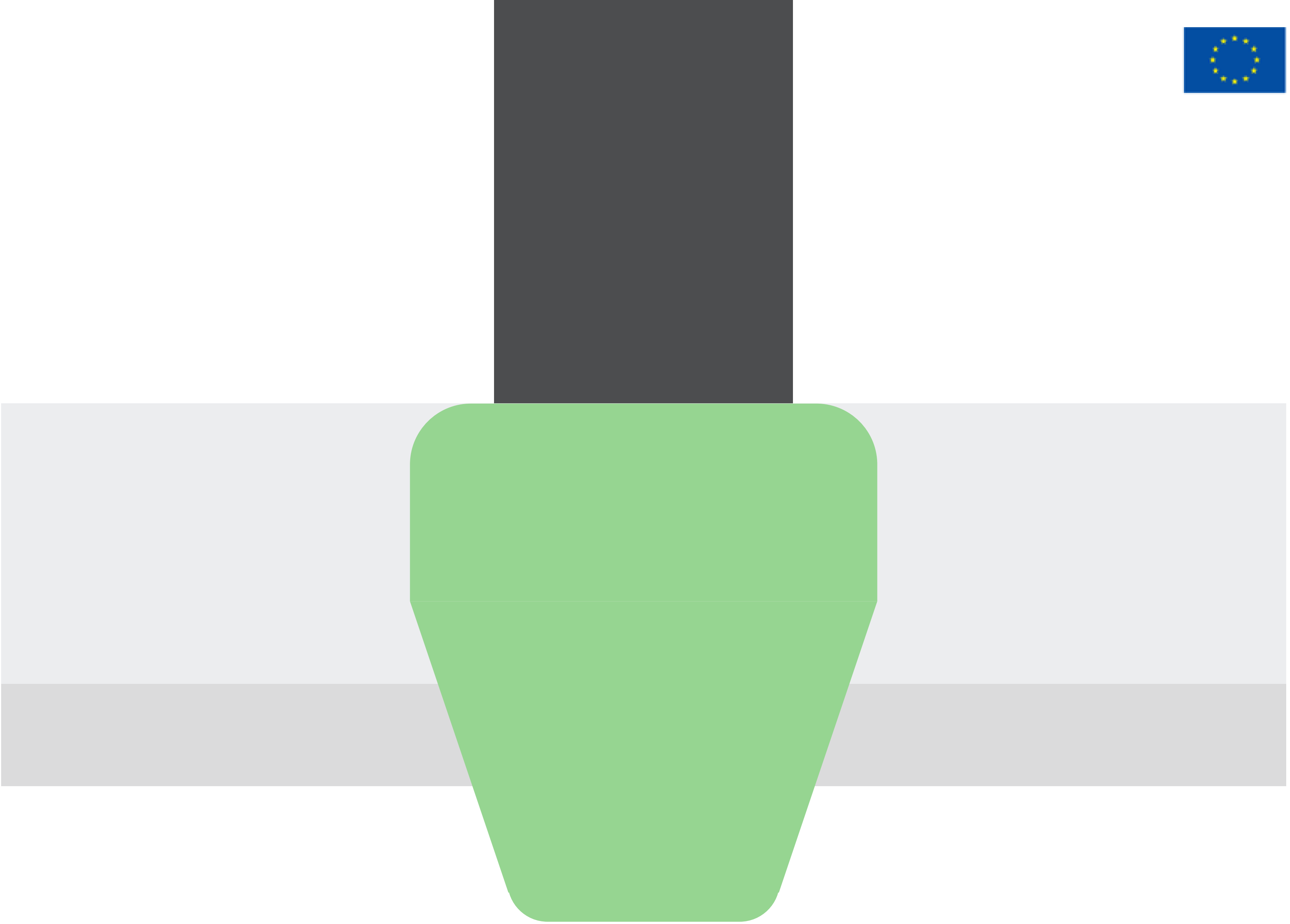
Valmet

Co-funded by
the European Union

1 minute

1 minute

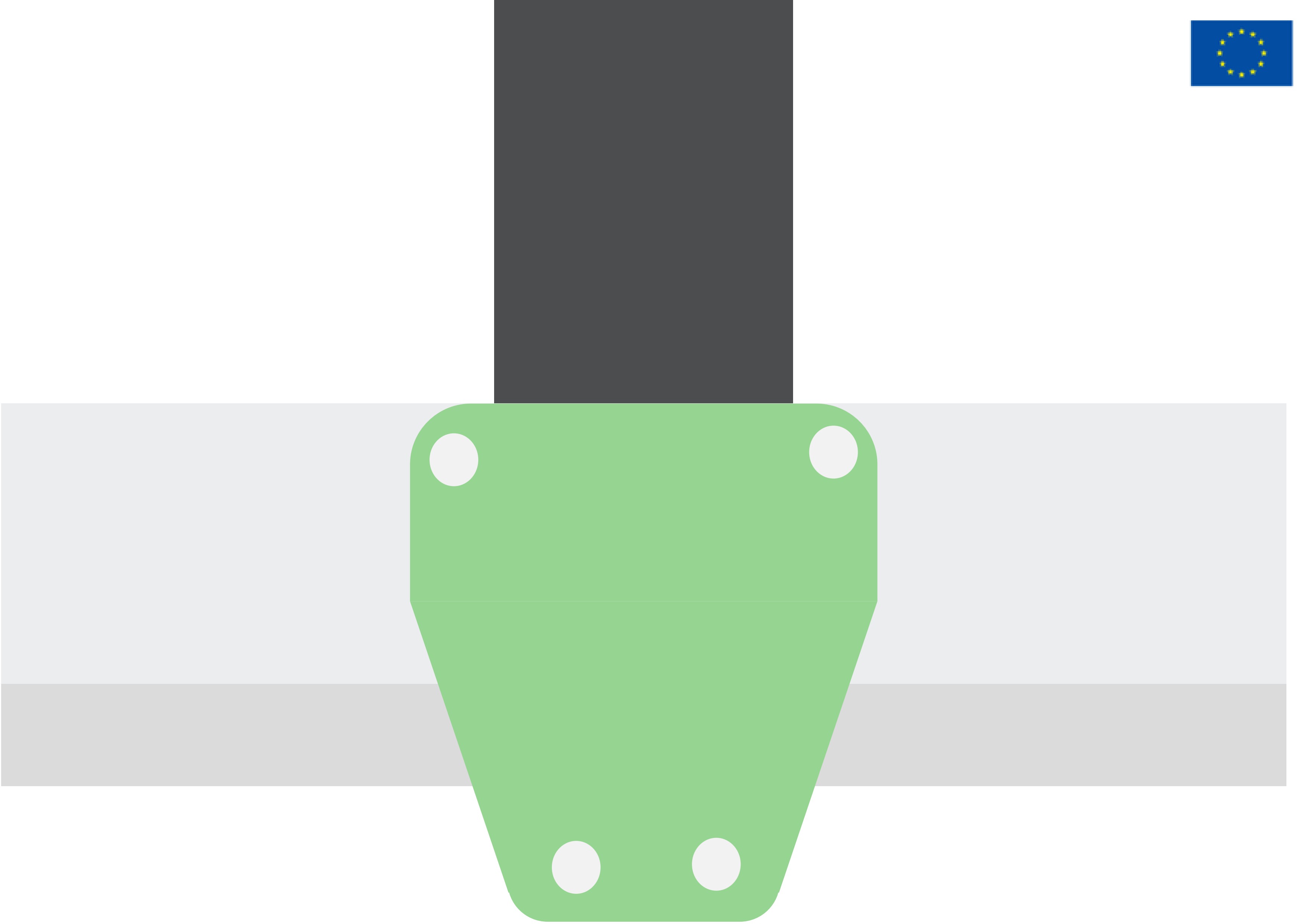
Co-funded by the European Union



Valmet

1 minute

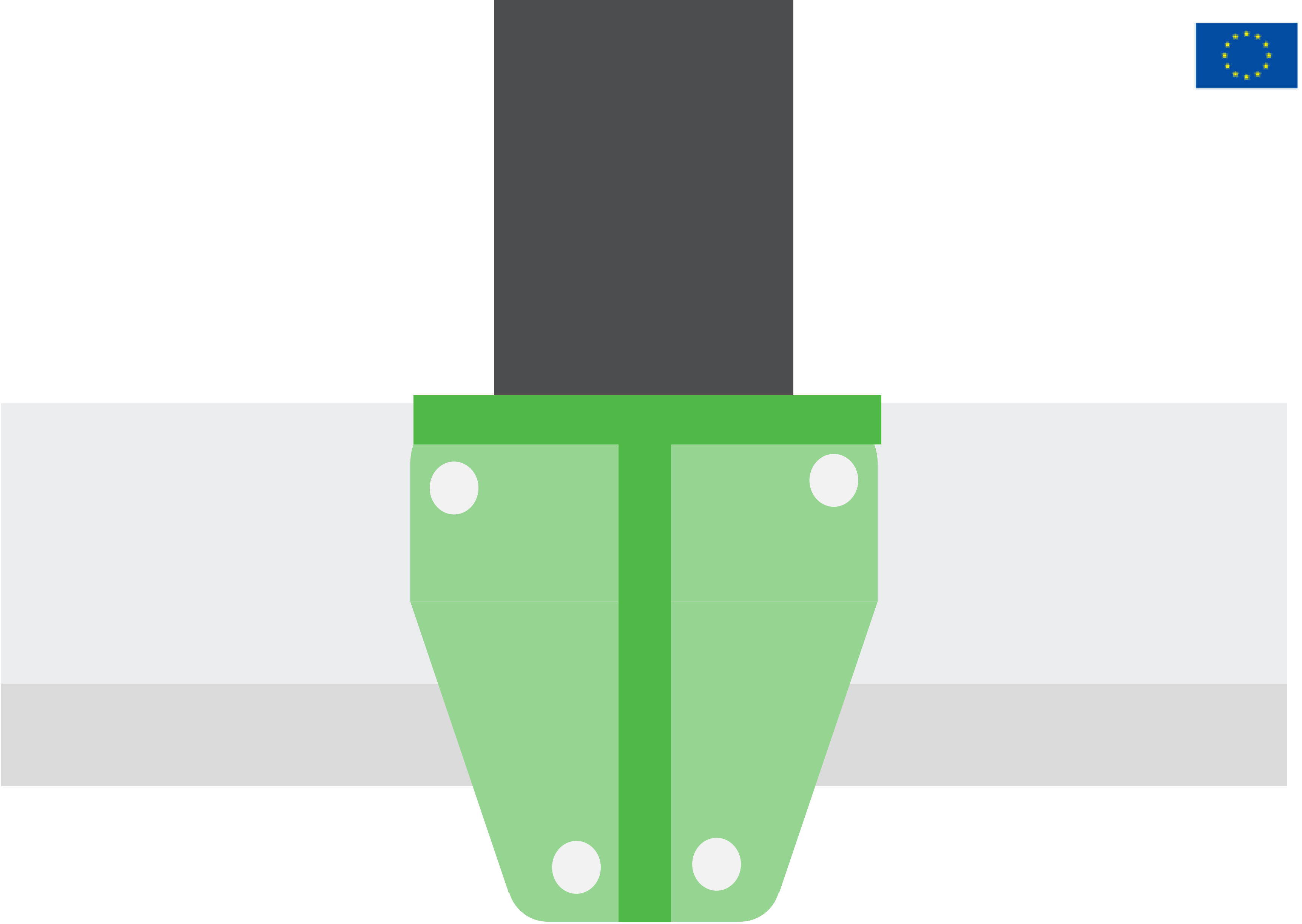
Co-funded by the European Union



Valmet

1 minute

Co-funded by the European Union



10 minutes

Co-funded by the European Union

Toe-plate

Valmet

Co-funded by the European Union

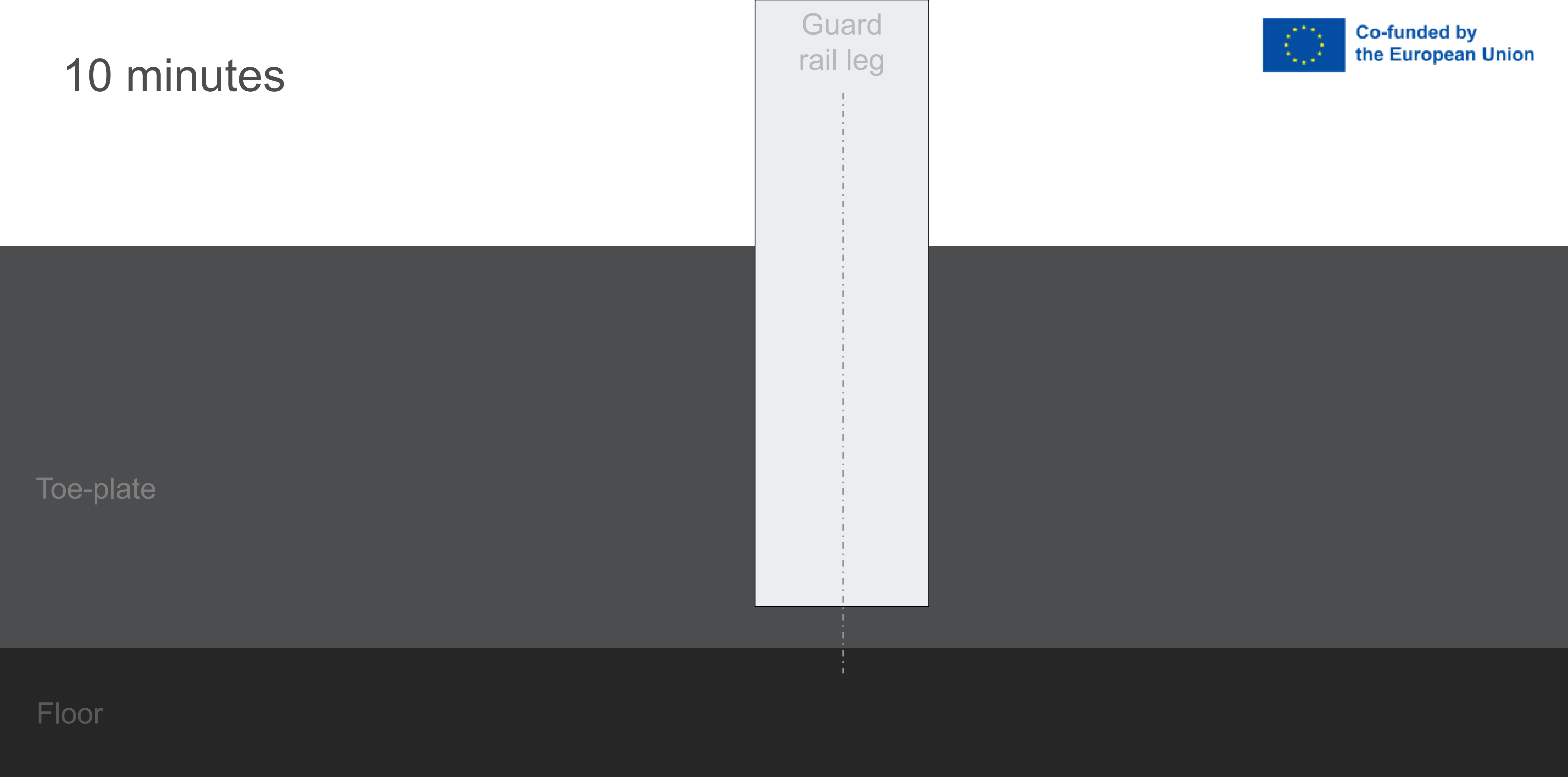
10 minutes

Toe-plate

Floor

10 minutes

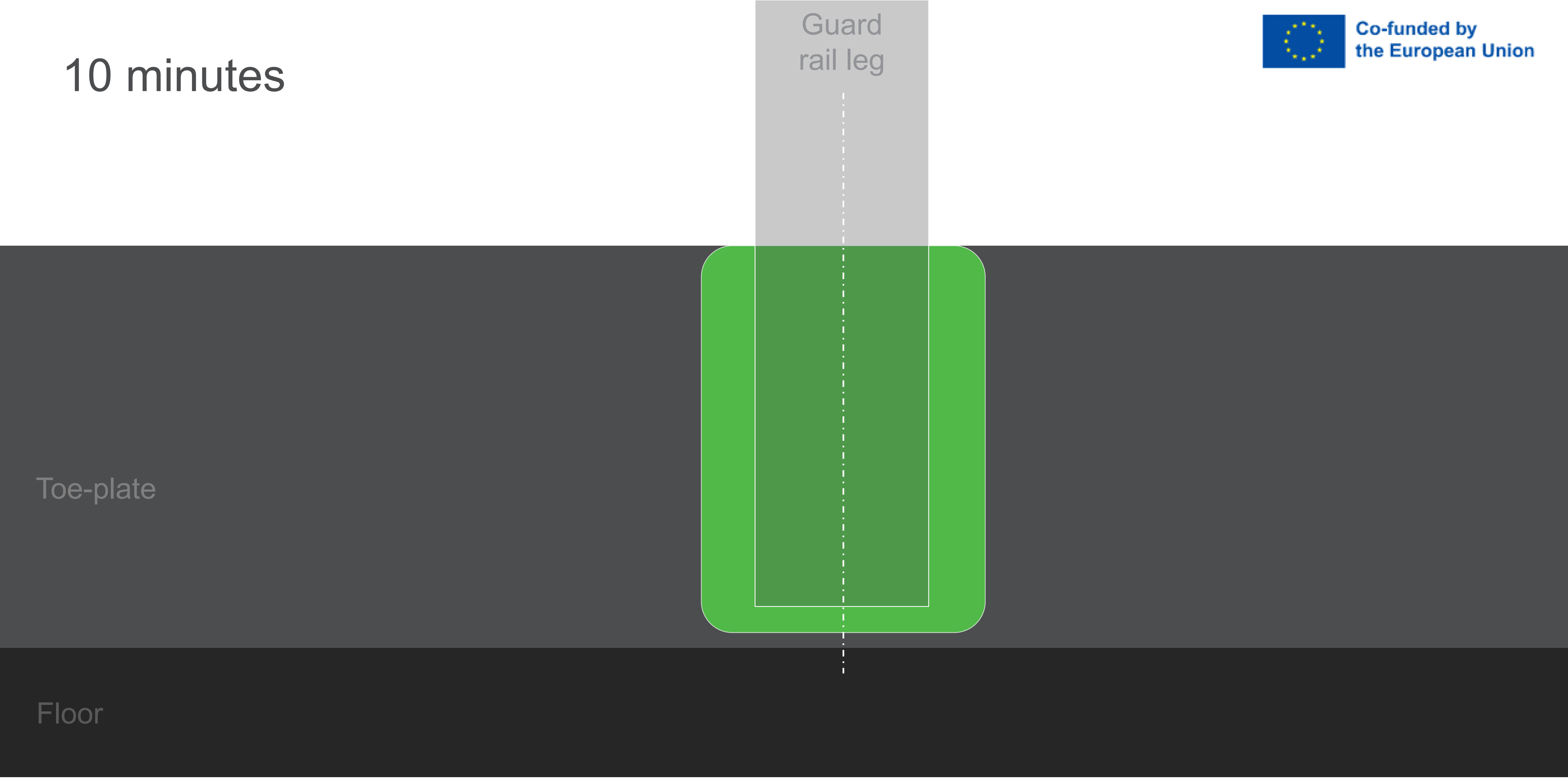
Co-funded by the European Union



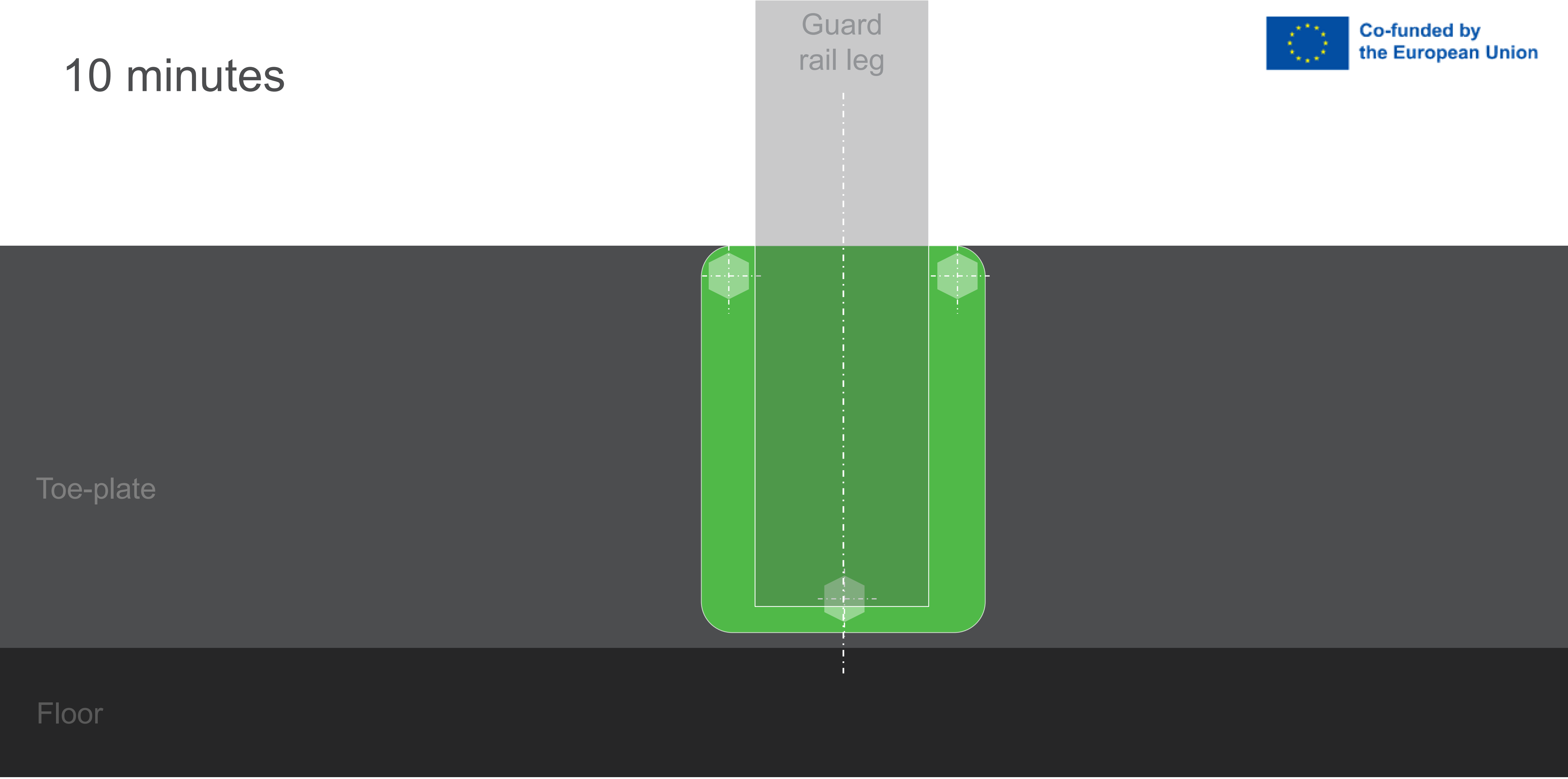
Valmet

10 minutes

Co-funded by the European Union

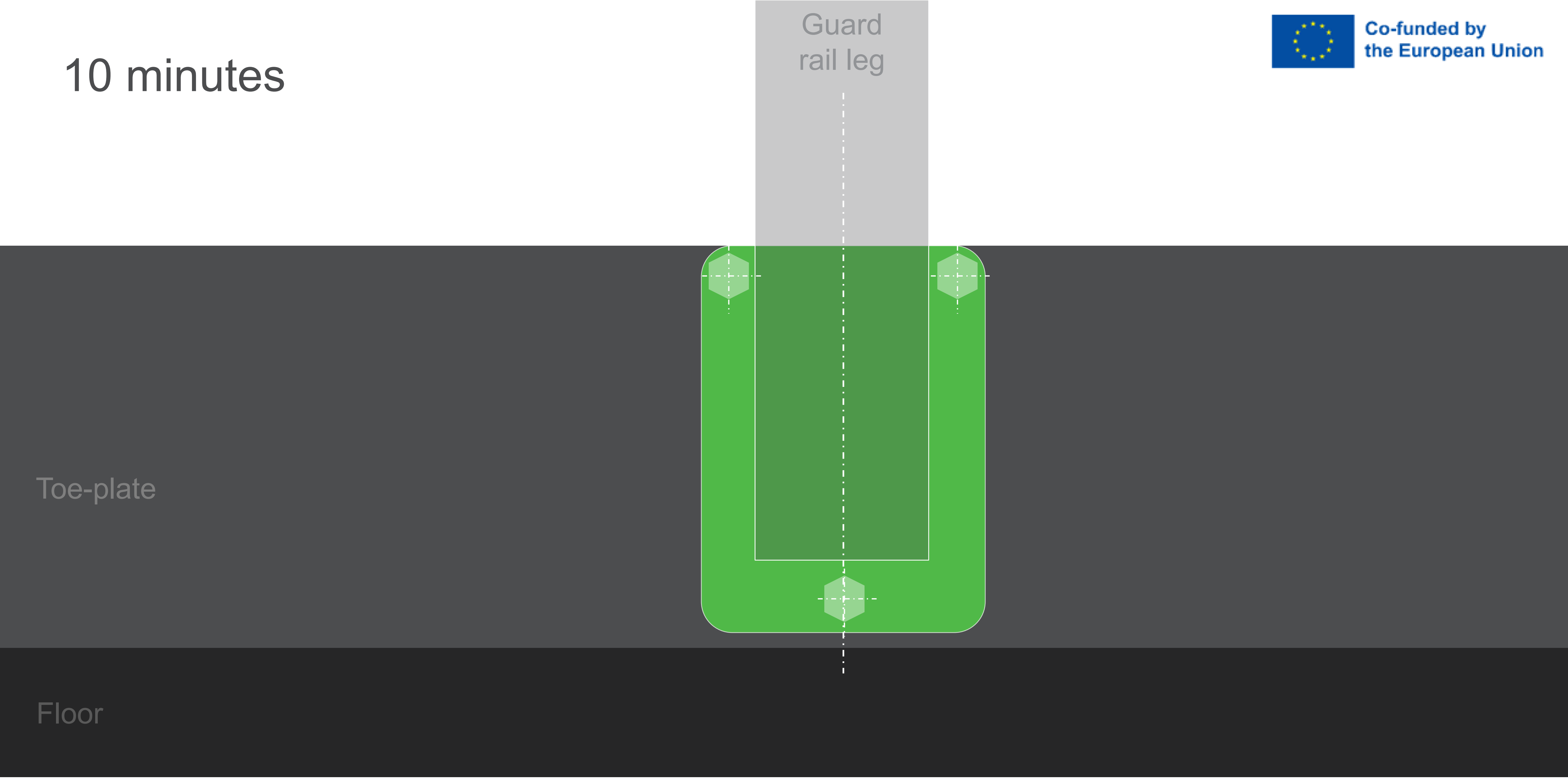


10 minutes



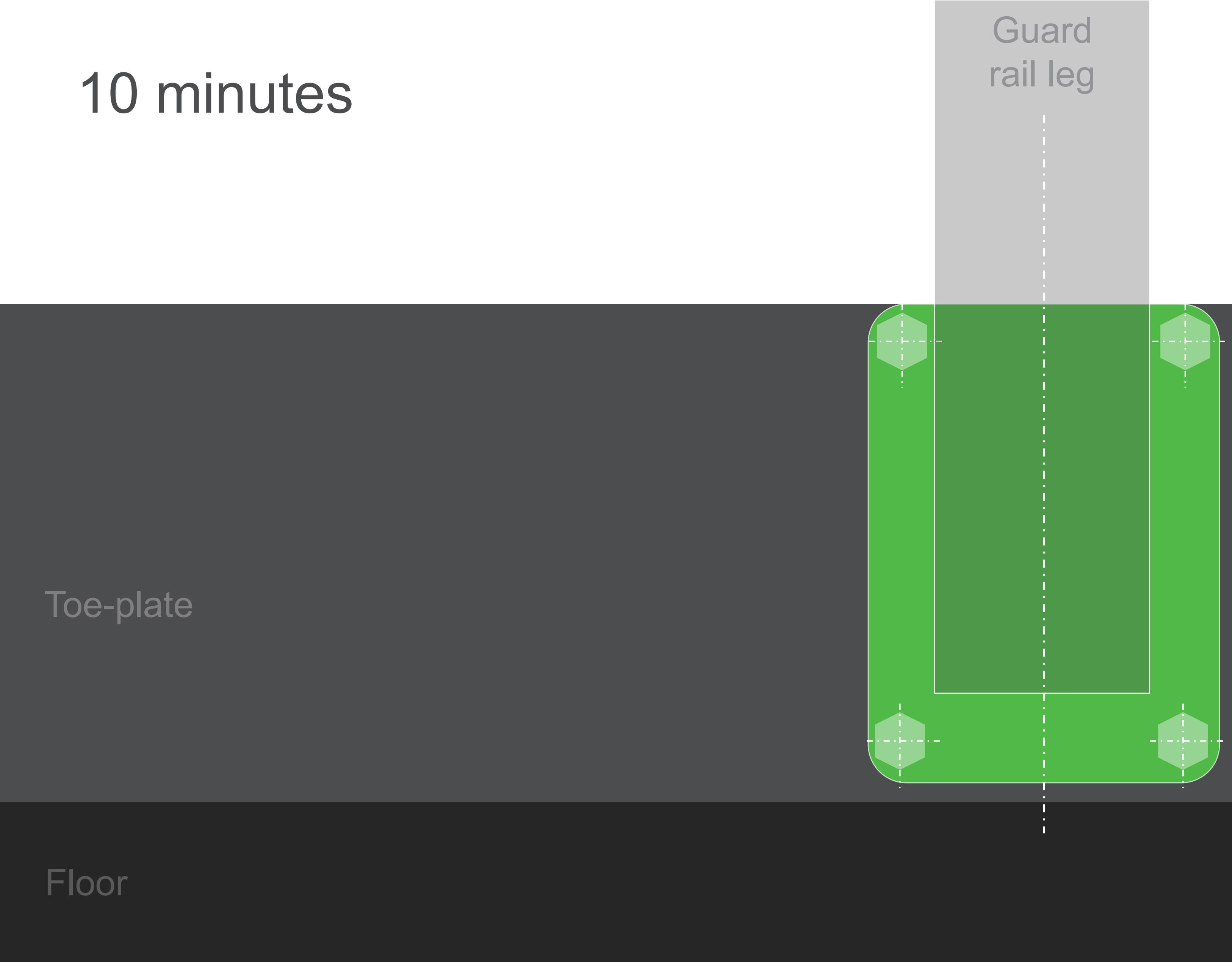
10 minutes

Co-funded by the European Union



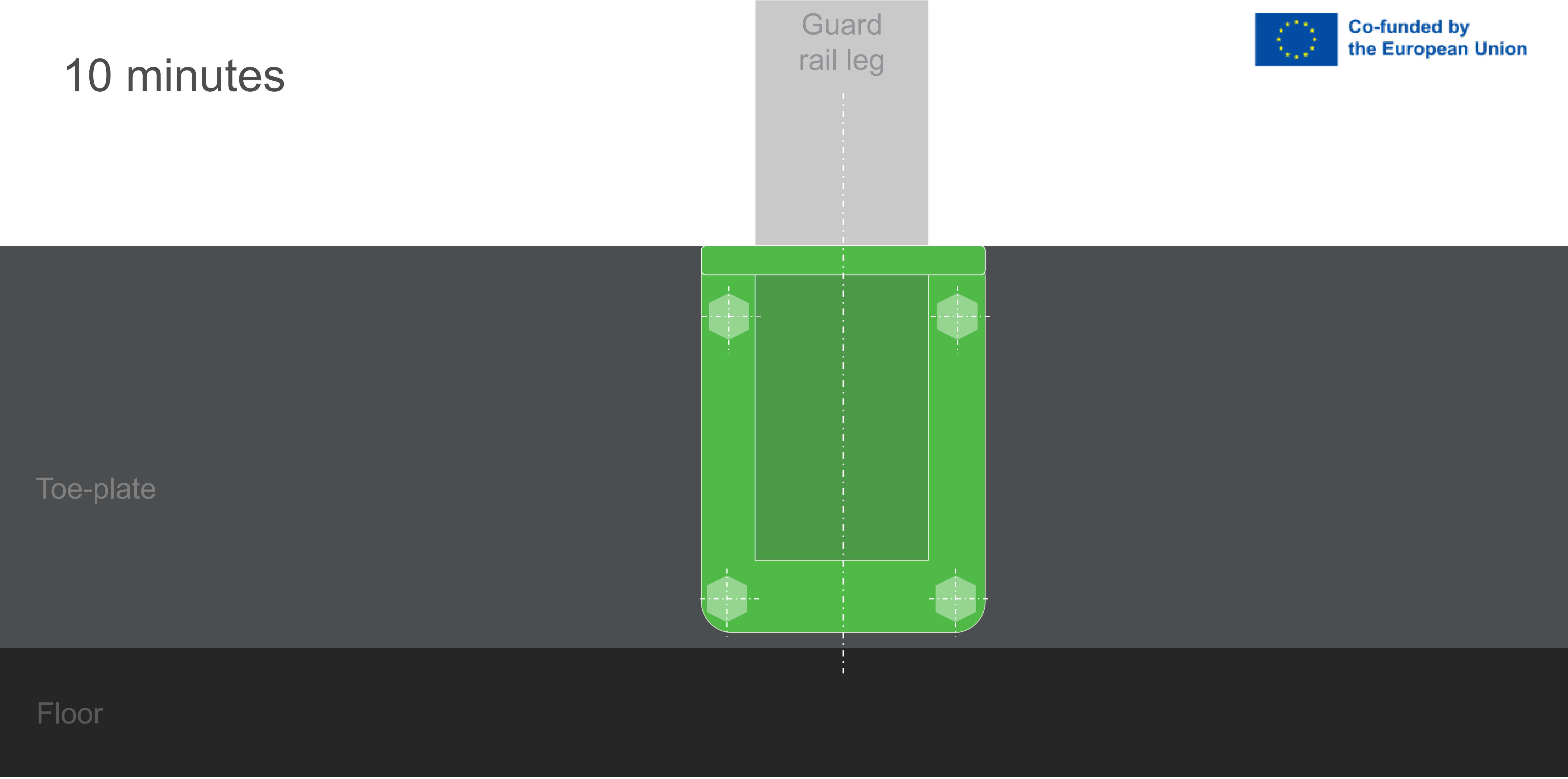
Valmet

10 minutes



10 minutes

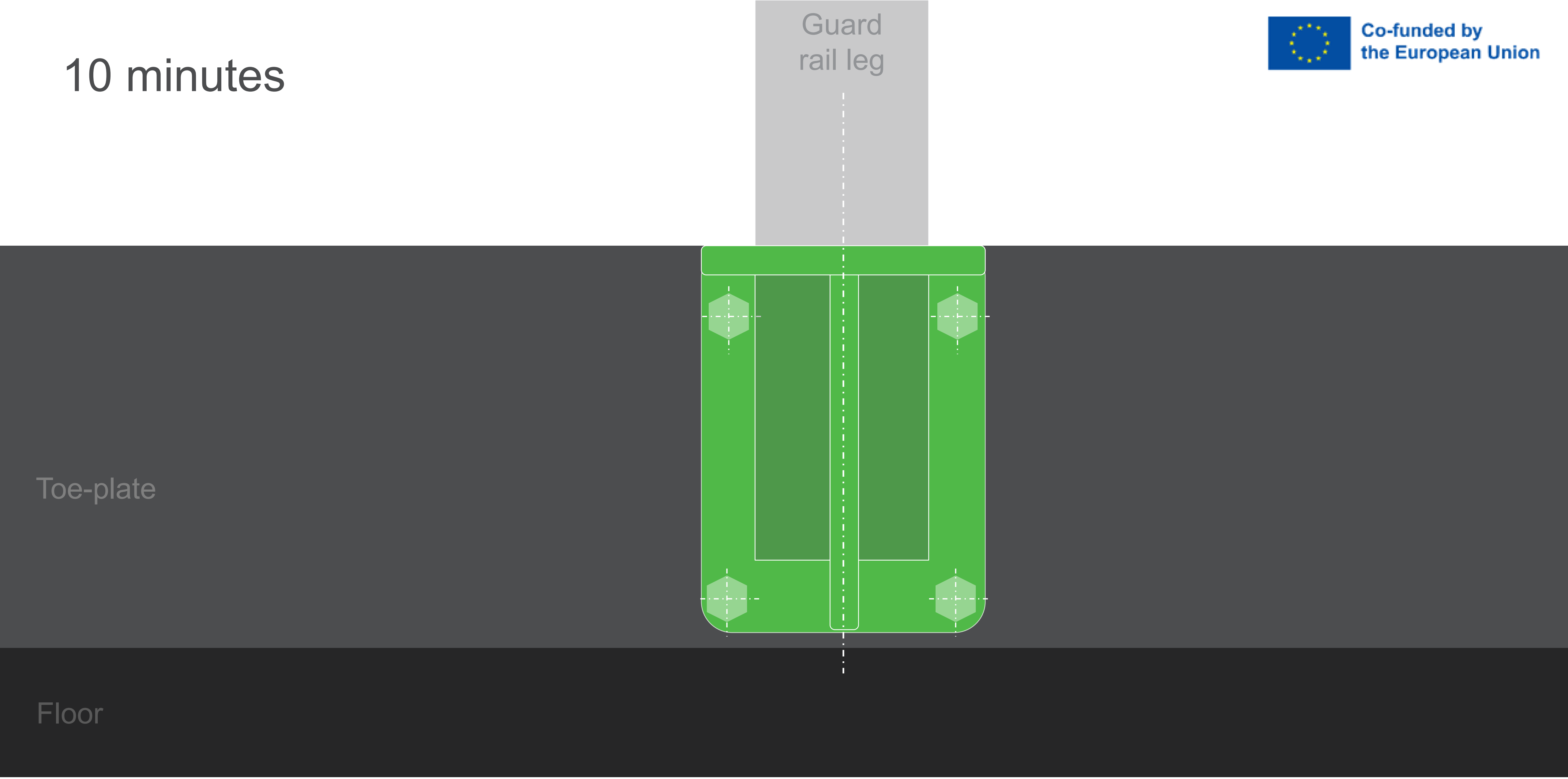
Co-funded by the European Union



Valmet

10 minutes

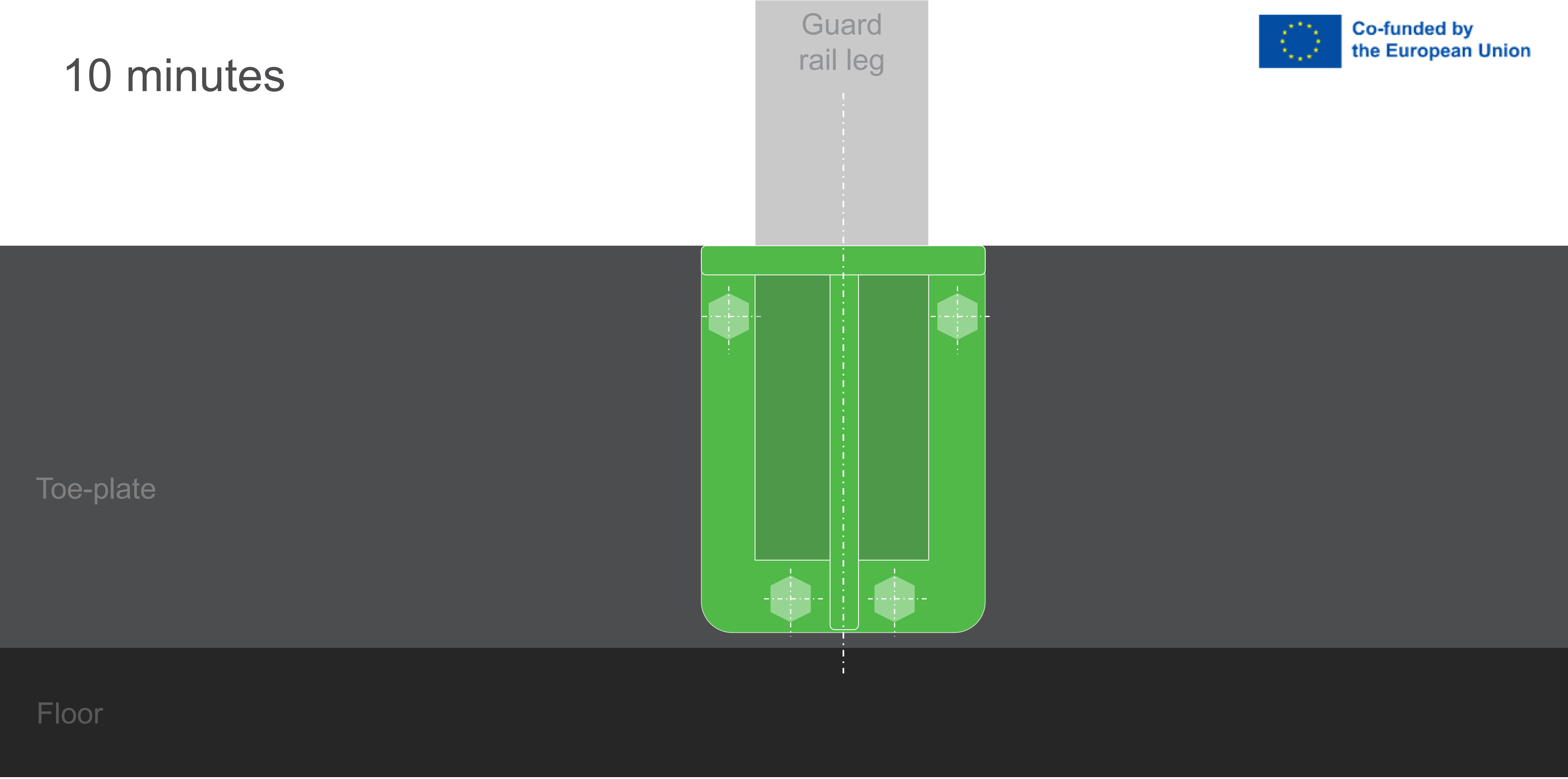
Co-funded by the European Union



Valmet

10 minutes

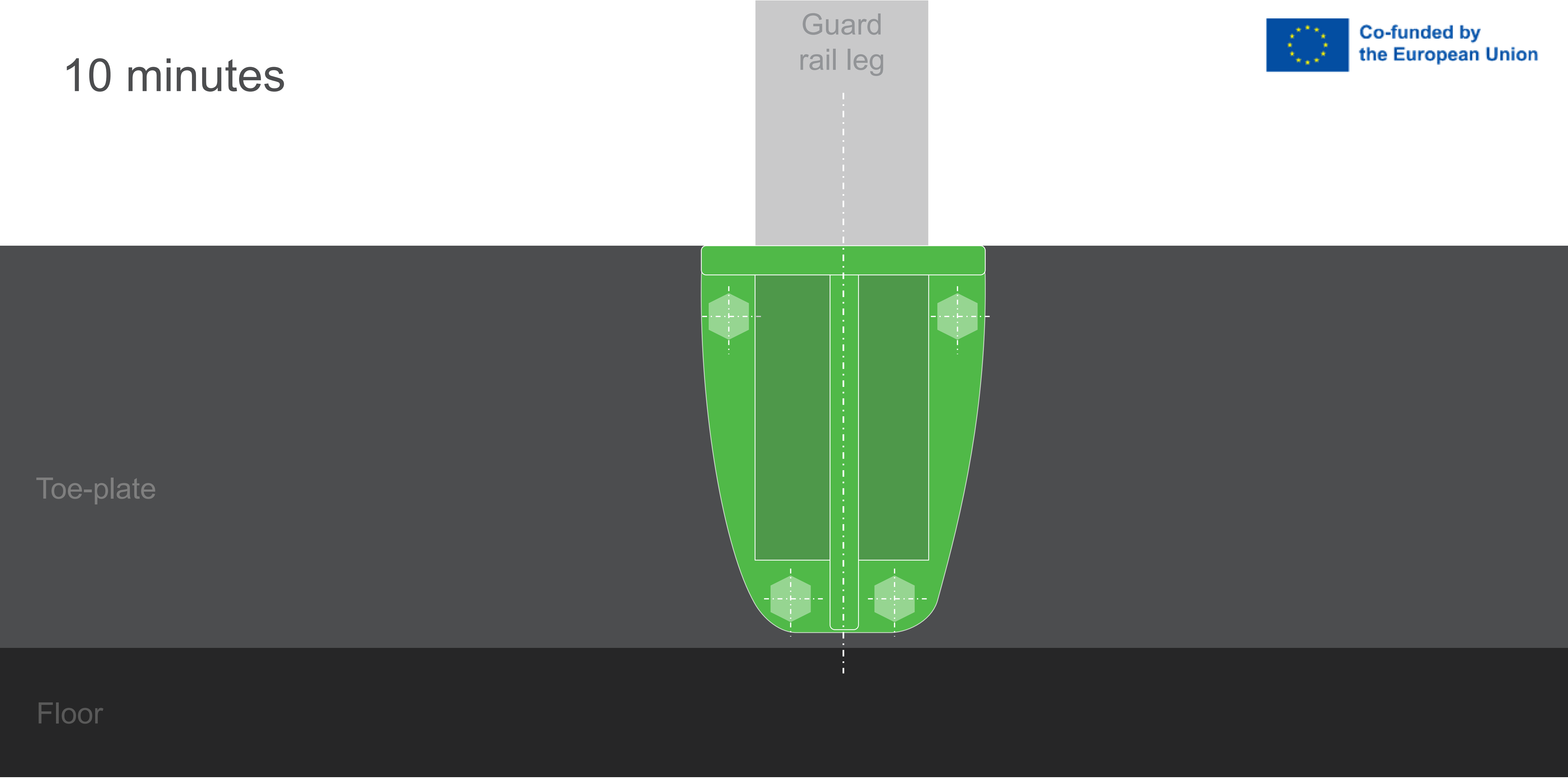
Co-funded by the European Union



Valmet

10 minutes

Co-funded by the European Union



3B. Concept models

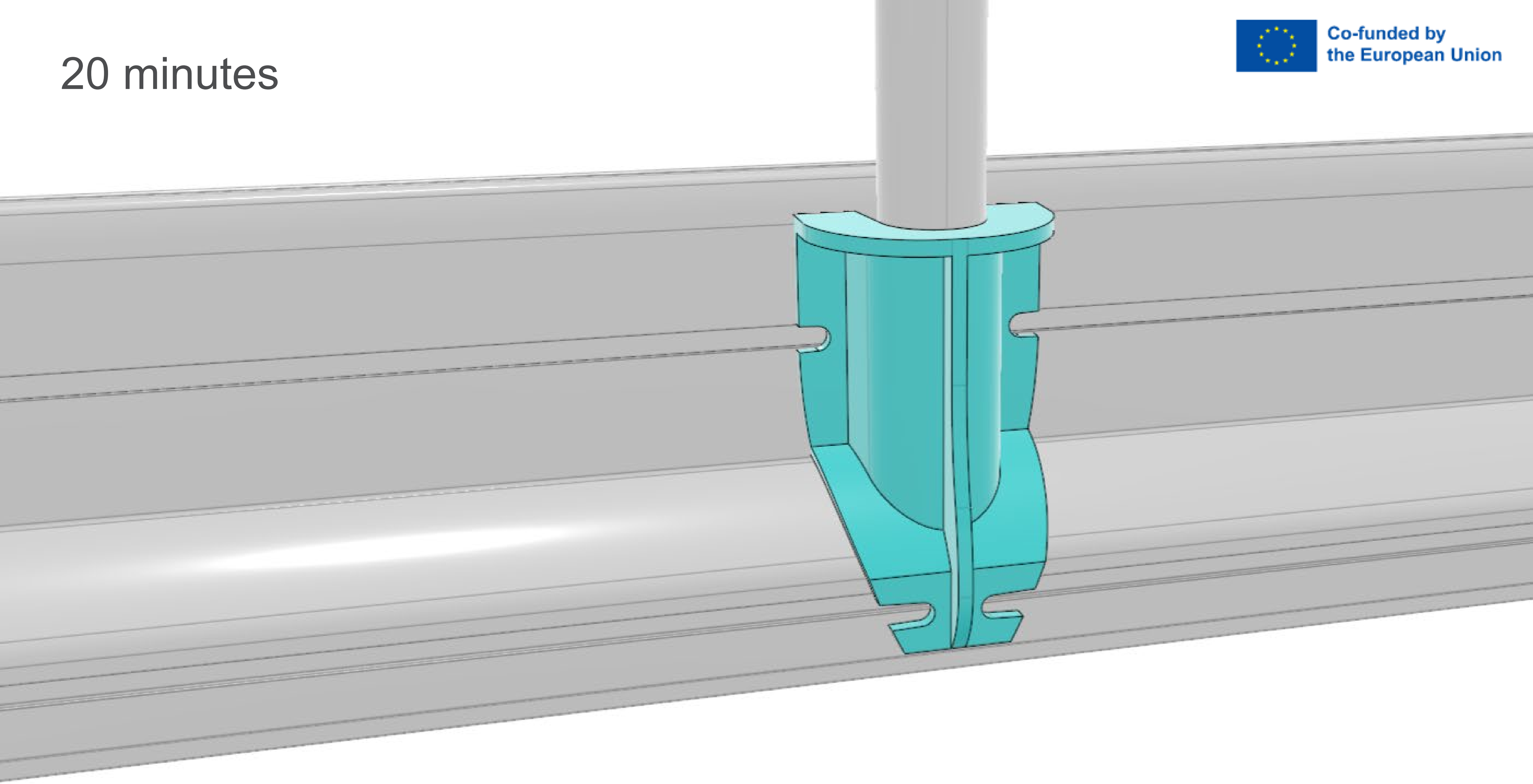
Essentially a “3D-sketch” or an “idea feasibility study in 3D”

Example:
20 minutes to 3D model the plain version
25 minutes to 3D model the filleted version

Co-funded by the European Union

20 minutes

Co-funded by the European Union

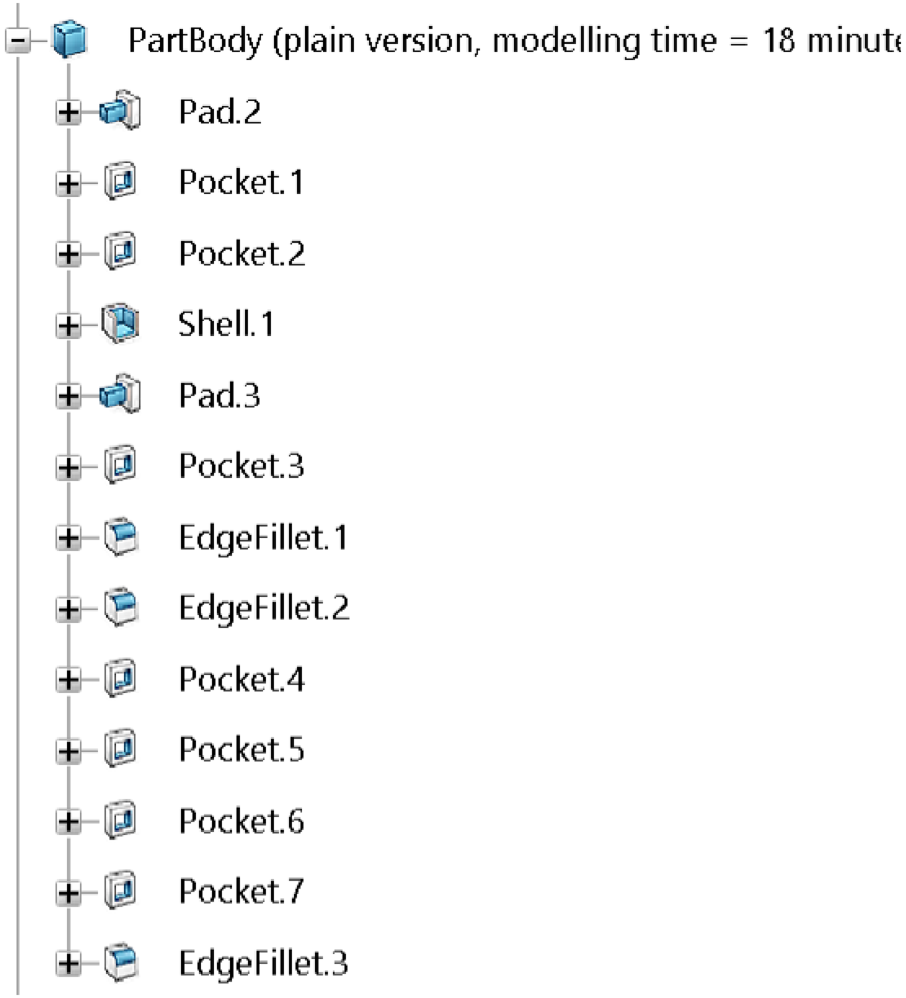


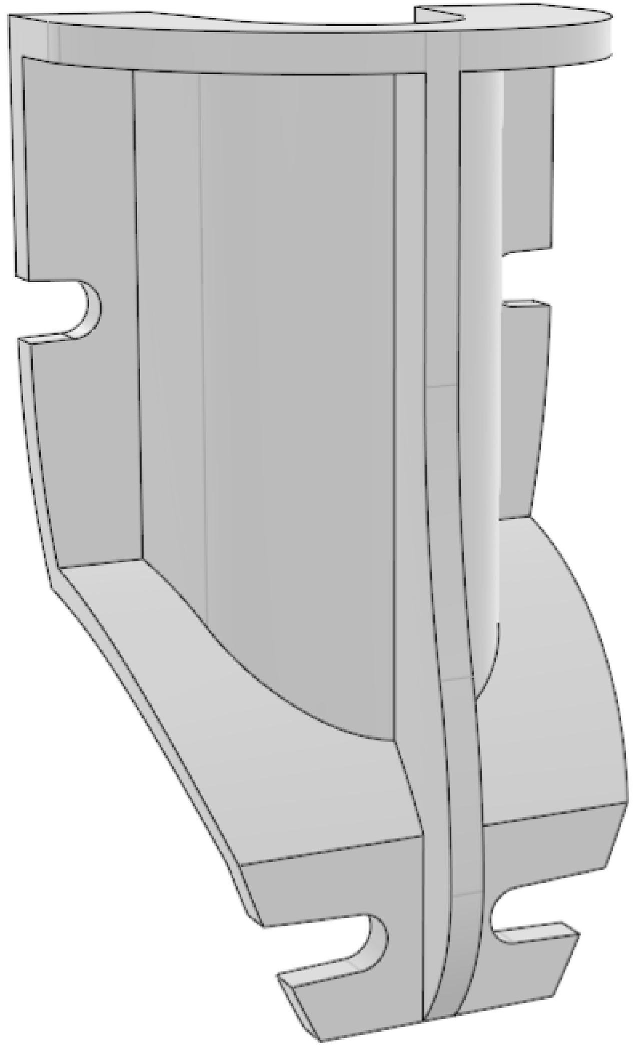
Valmet

Co-funded by the European Union

3D features

Simple, short list
(with the unnecessary
features included)

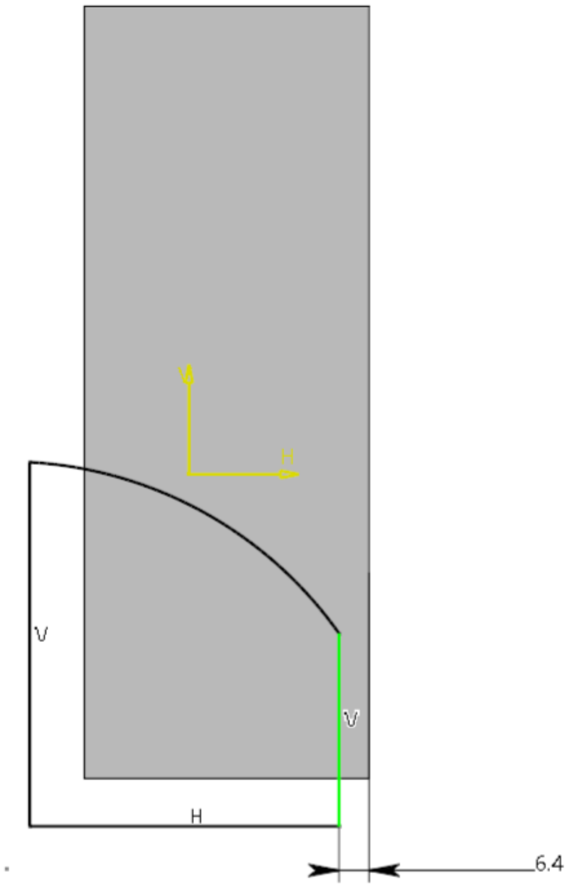


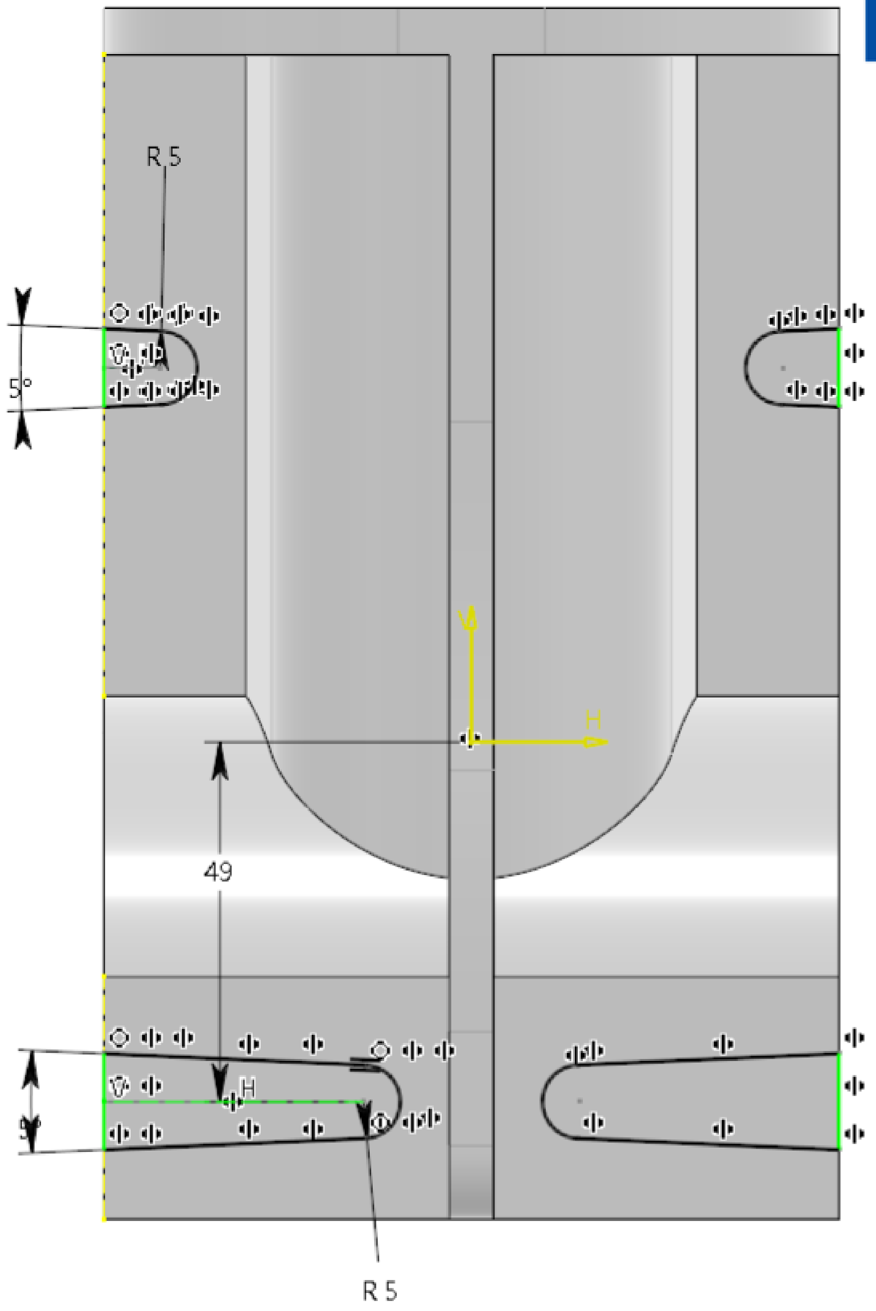


Sketch examples

Co-funded by the European Union

Sketches are only somewhat defined (black vs green color in Catia)





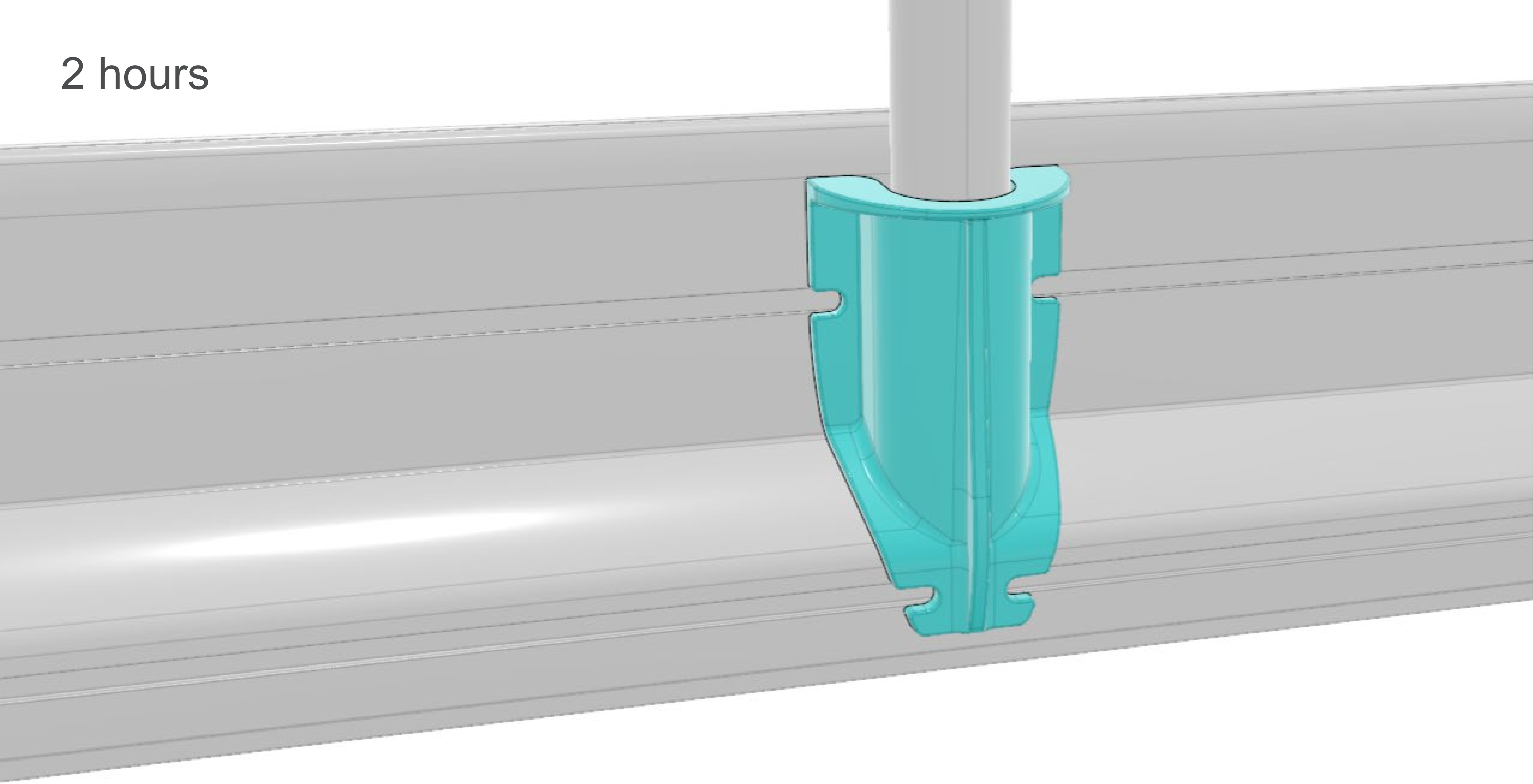
Valmet

Co-funded by
the European Union

3C. Development / engineering models

Example:
2 hours to model

2 hours



Co-funded by the European Union

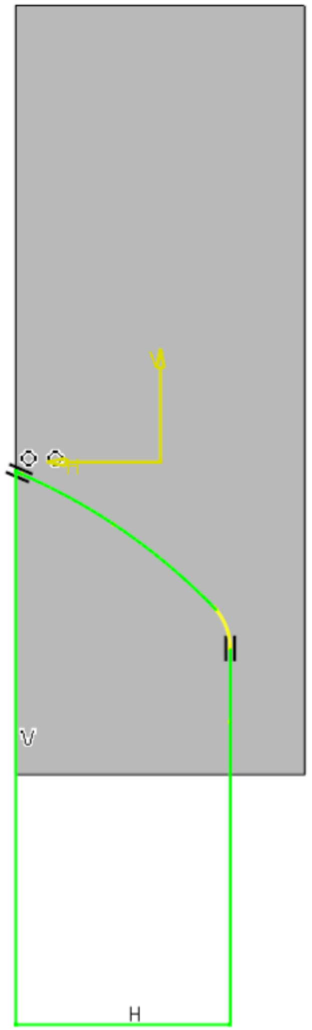
3D features

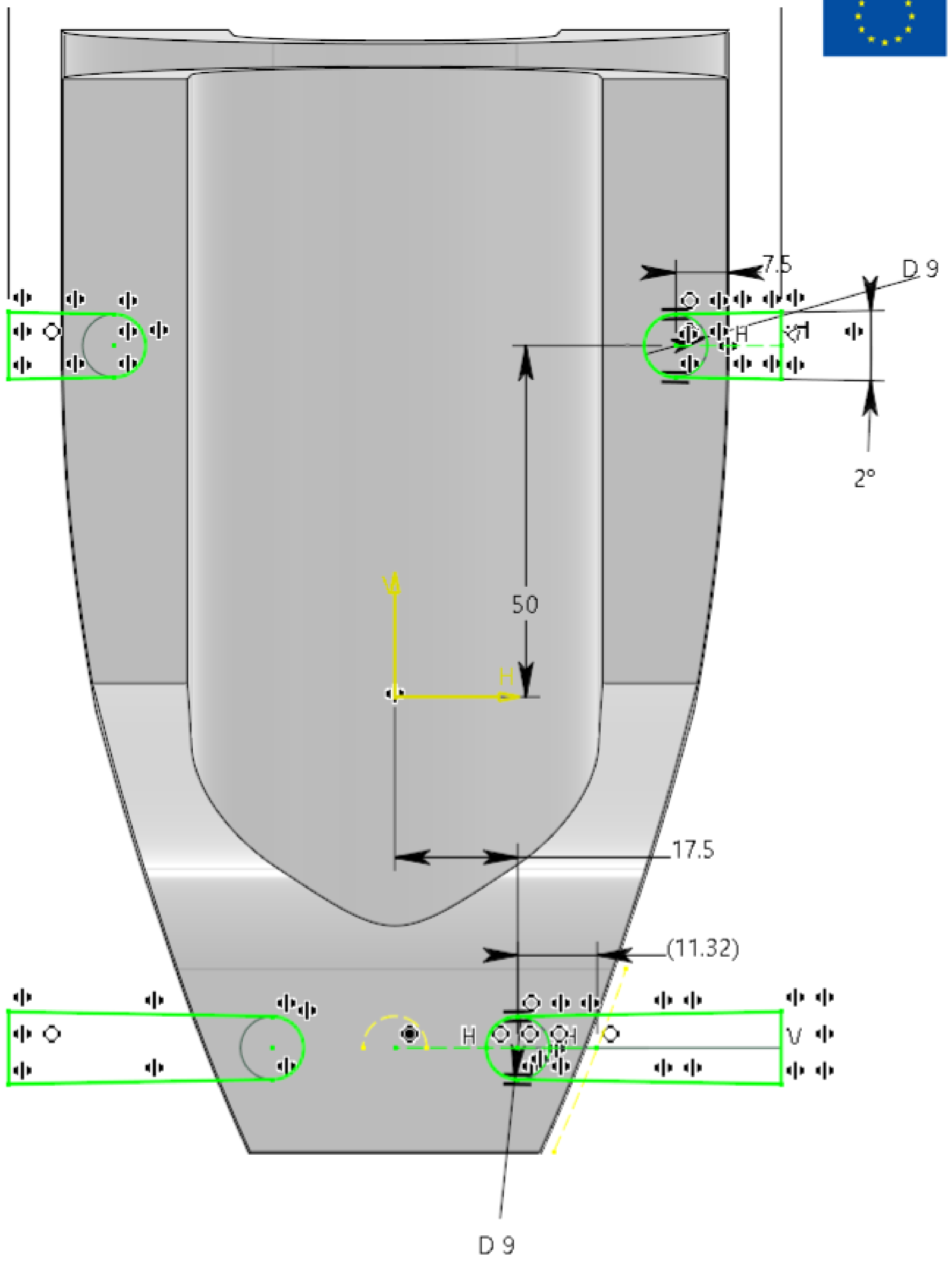
A more extensive list of features (some unnecessary)

- FINAL 2023
  - Pad.70
  - Pocket.122
  - Pocket.123
  - Pocket.124
  - Mirror.17
  - Draft.69
  - Draft.70
  - Pocket.125
  - EdgeFillet.218
  - Shell.10
  - Pad.71
  - Pocket.126
  - Pocket.127
  - Pad.72
  - Draft.71
  - Draft.72
  - Draft.73
  - Pocket.128
  - Pad.73
  - Draft.74
  - EdgeFillet.219
  - EdgeFillet.220
  - EdgeFillet.221
  - EdgeFillet.222
  - EdgeFillet.223
  - EdgeFillet.224
  - EdgeFillet.225
  - EdgeFillet.226
  - EdgeFillet.227
  - EdgeFillet.228
  - EdgeFillet.229
  - EdgeFillet.230
  - EdgeFillet.231
  - EdgeFillet.232
  - EdgeFillet.233
  - Pocket.119 | Maalausreiän mahdollinen paikka
  - Draft.75
  - EdgeFillet.234

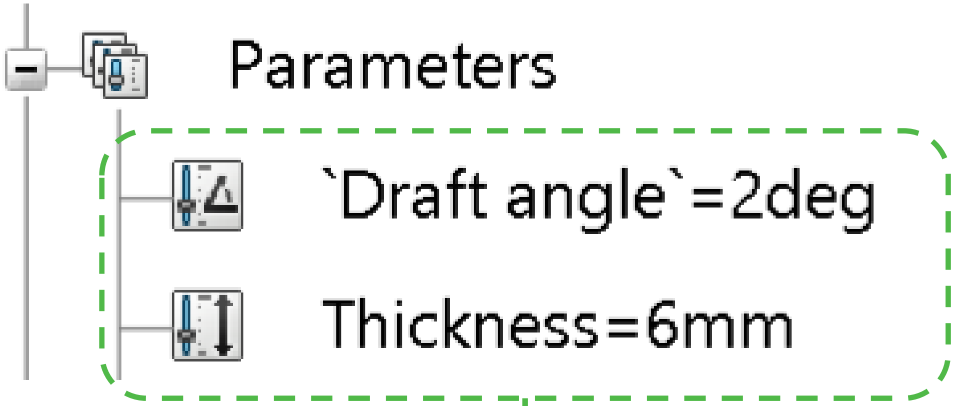
Sketch examples

The sketches are fully defined (manually)





Engineering model

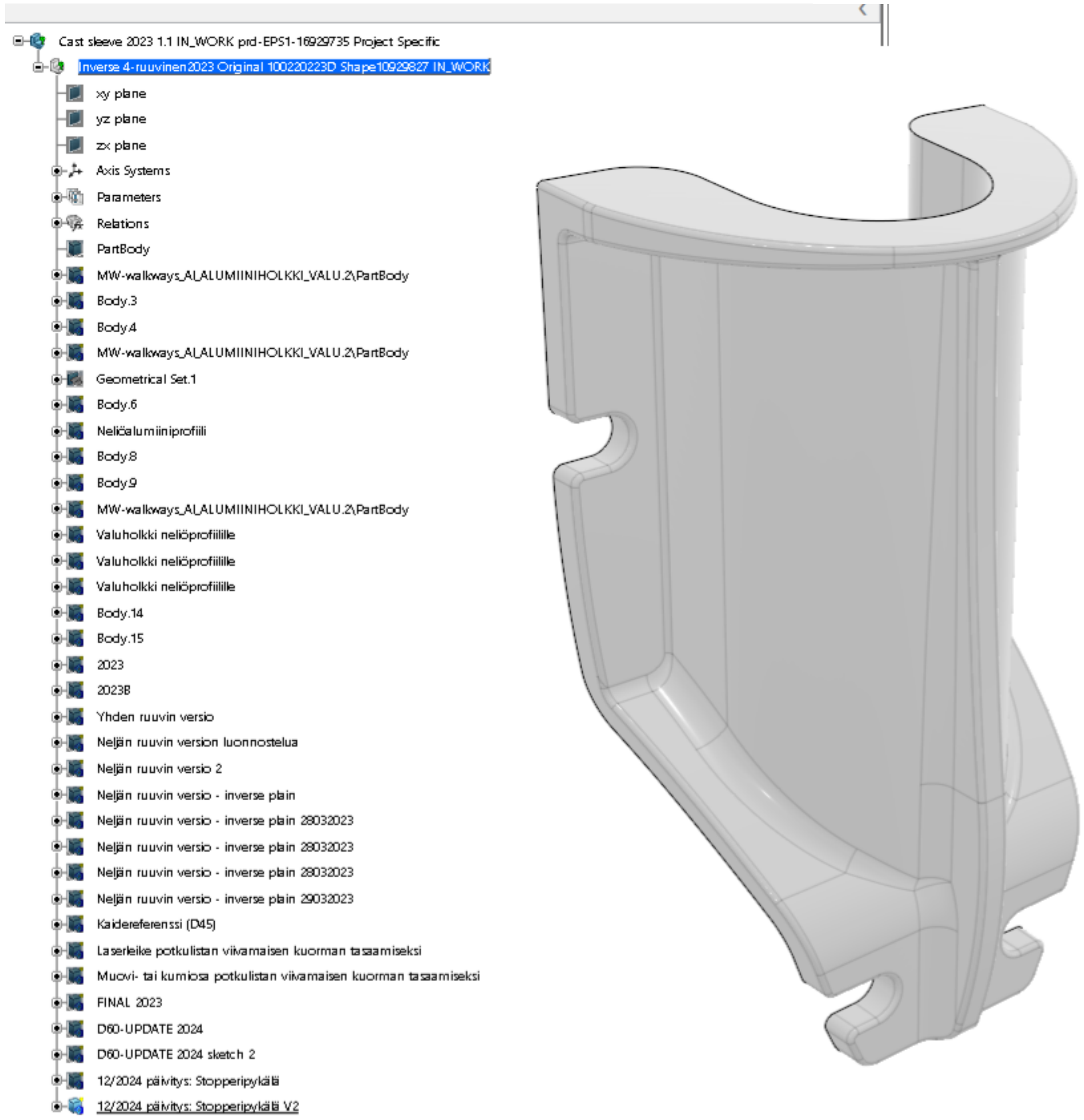


Even if you’re not doing a parametric model, some parameters may still be useful (e.g. measurements that repeat on many instances). Still, don’t overdo this!

Co-funded by
the European Union

Development model

- Multibody part with dozens of obsolete sketches and previous development versions
- Obsolete deactivated commands
- No material specified
- No technical drawings made
- Model not released

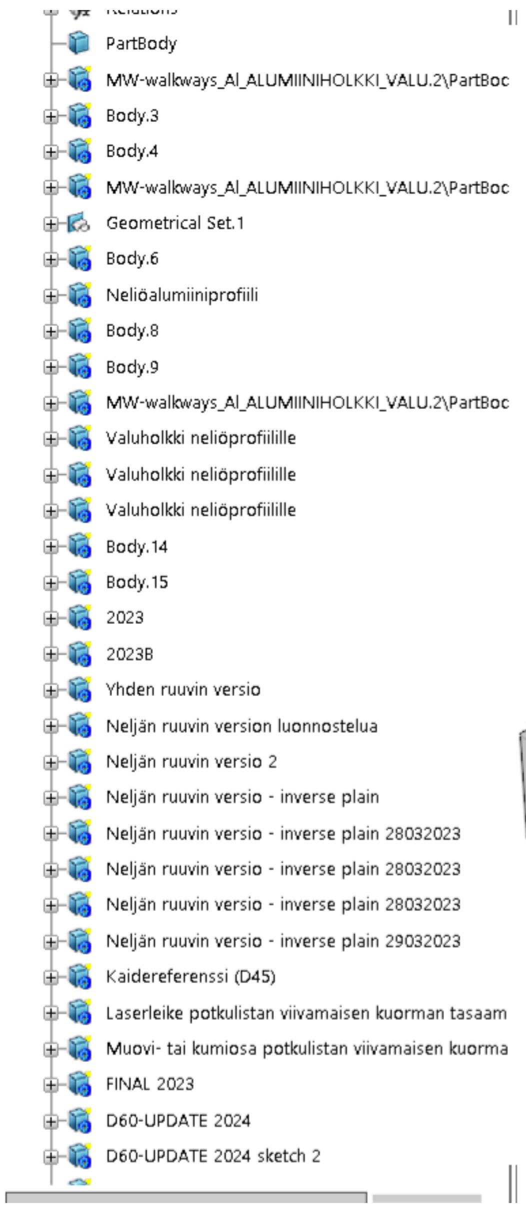


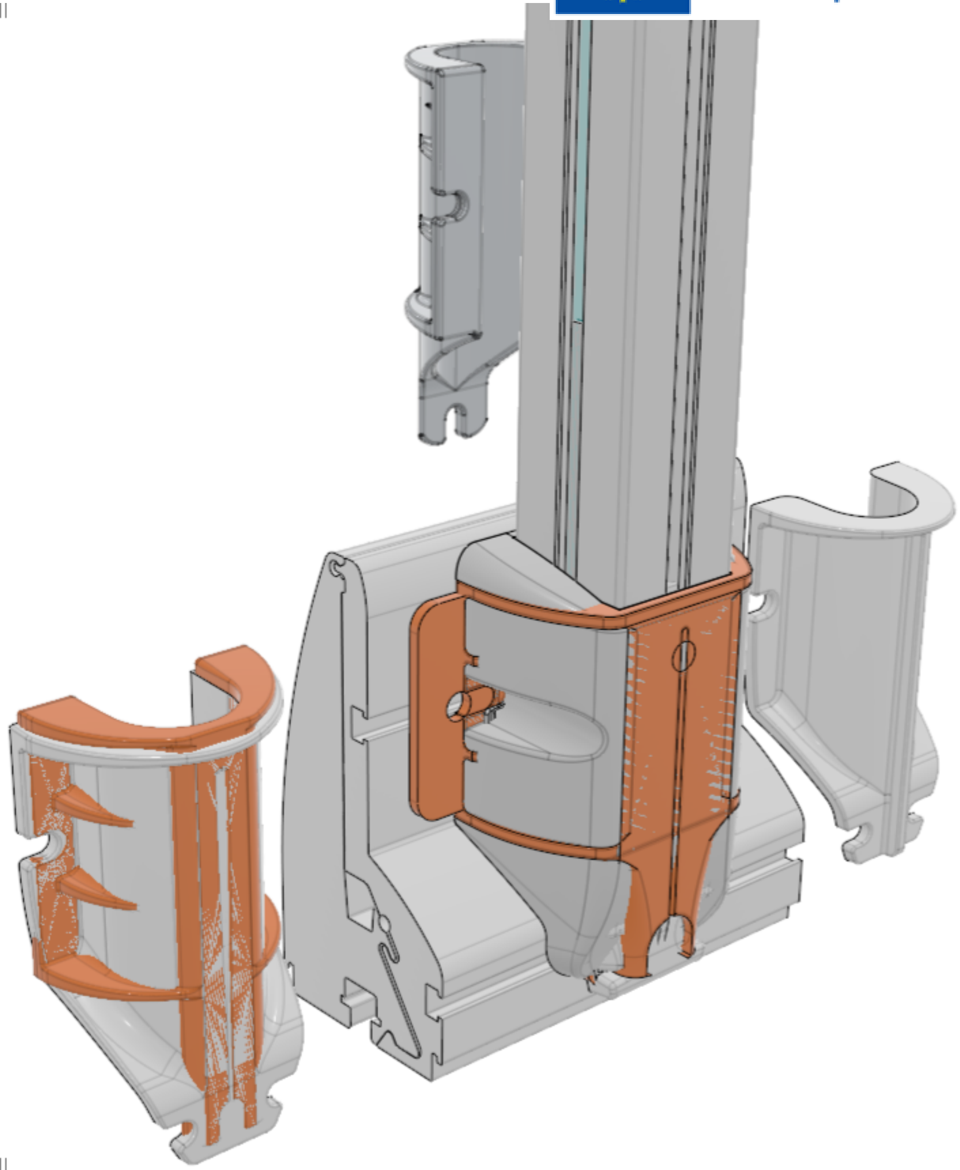
Valmet

Co-funded by the European Union

Development model

- Multibody part with dozens of obsolete sketches and previous development versions
- Obsolete deactivated commands
- No material specified
- No technical drawings made
- Model not released
- (Screenshot: The model with all the hidden bodies made on different development phases unhidden…)



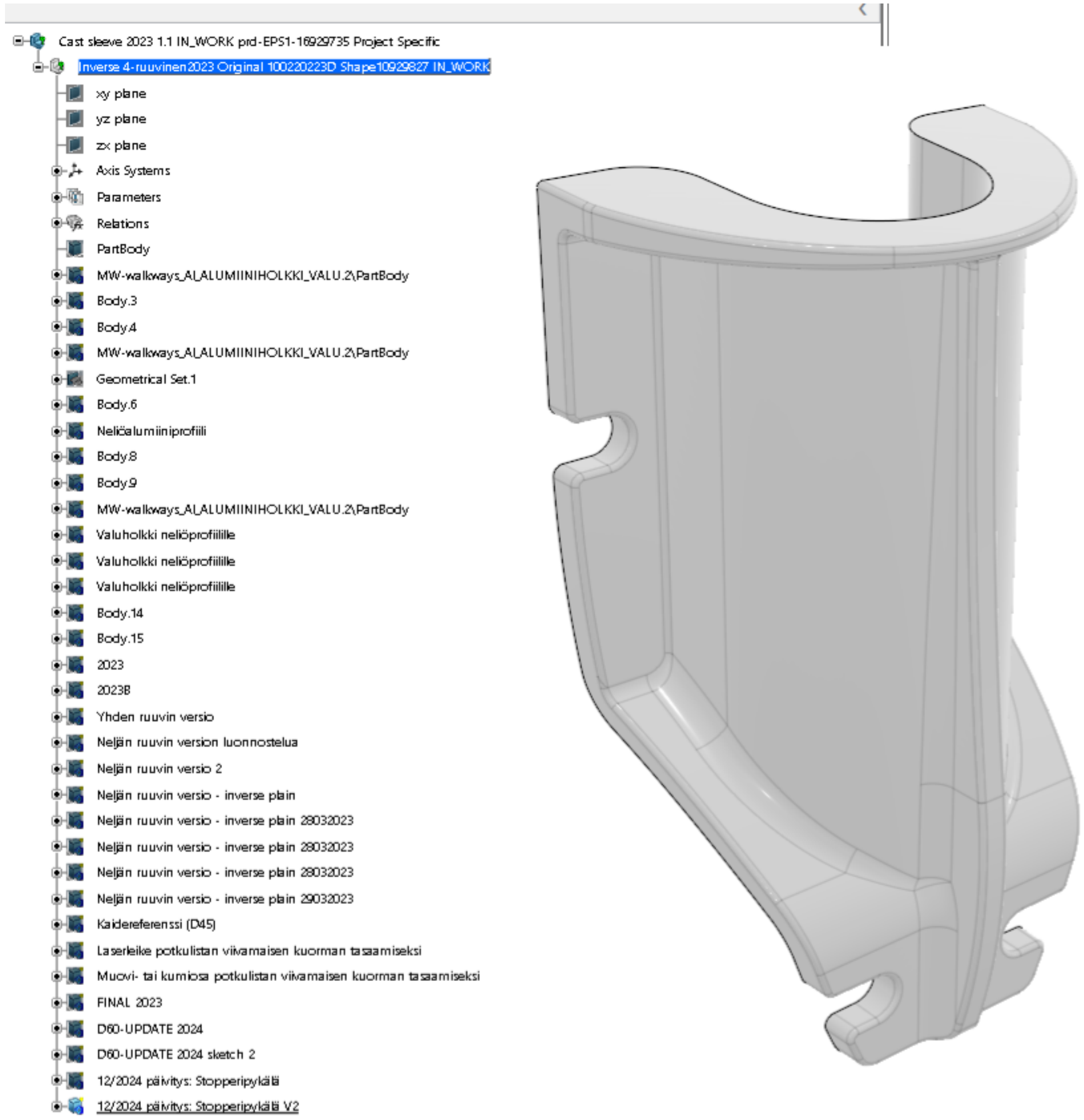


Valmet

Co-funded by
the European Union

Development model

- Multibody part with dozens of obsolete sketches and previous development versions
- Obsolete deactivated commands
- No material specified
- No technical drawings made
- Model not released



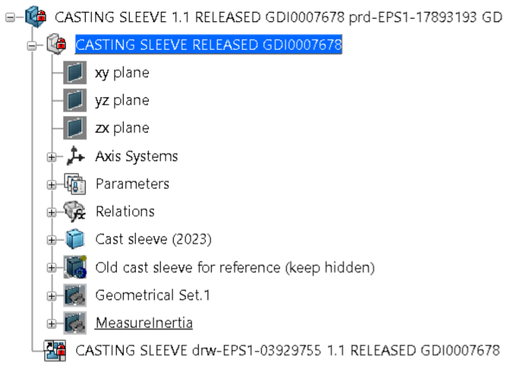
Valmet

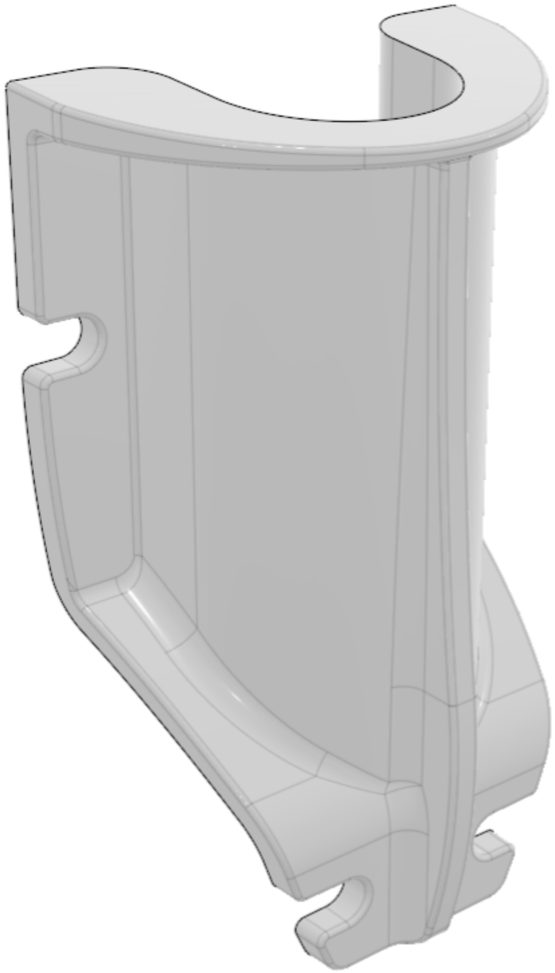
Co-funded by the European Union

Engineering model

Exact same 3D-geometry but:

- Obsolete bodies deleted
- Obsolete deactivated commands deleted
- Technical drawing made & released in product data management systems
- 3D-model released
- “Global standard item number” created
- Etc.





Valmet

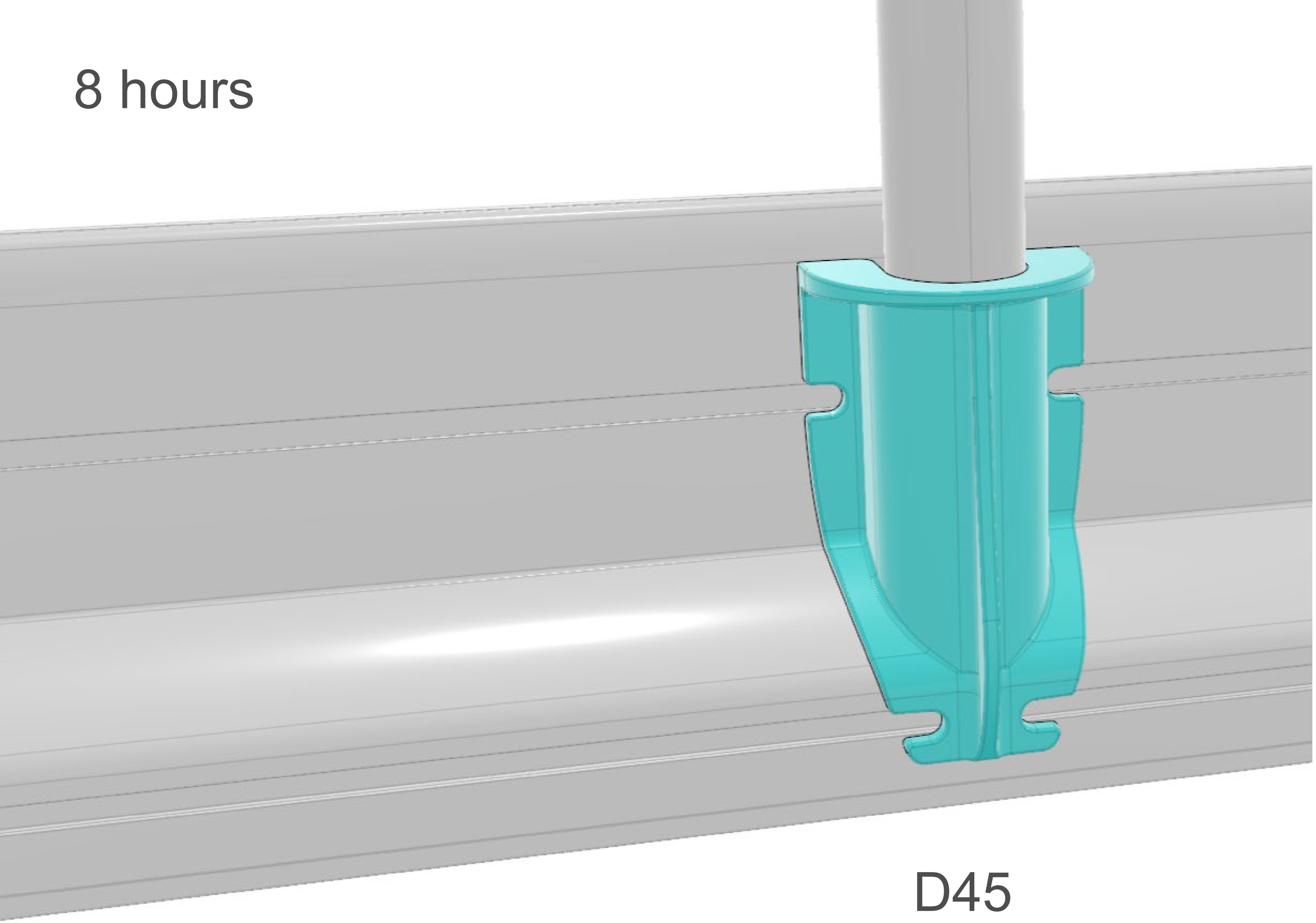
Co-funded by
the European Union

3D. Parametric models

Example:
2 hours for a model that works for pipe diameters 22 mm … 45 mm
8 hours for a model that works for pipe diameters 22 mm … 75 mm

8 hours

Co-funded by the European Union

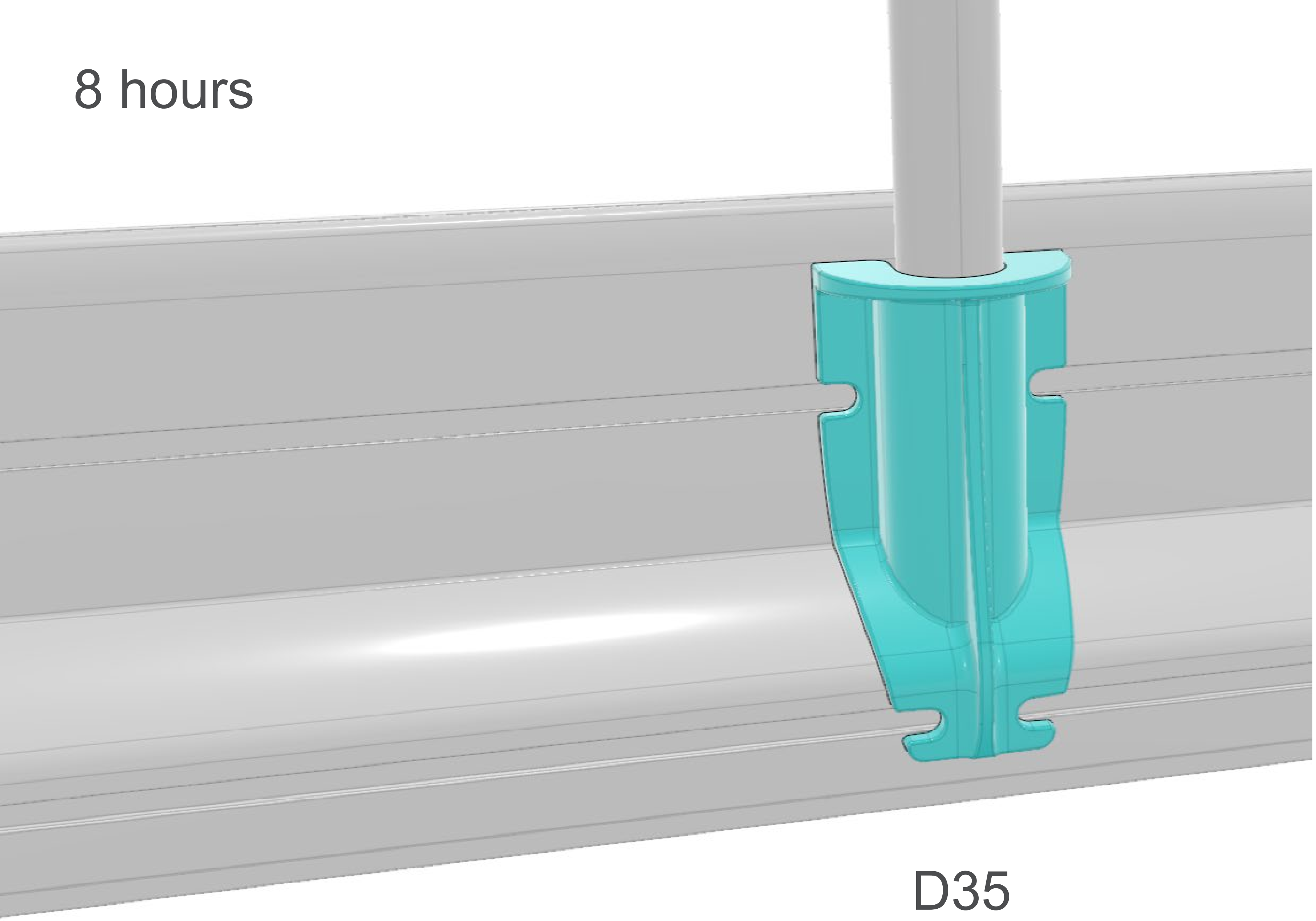


D45

Valmet

8 hours

Co-funded by the European Union

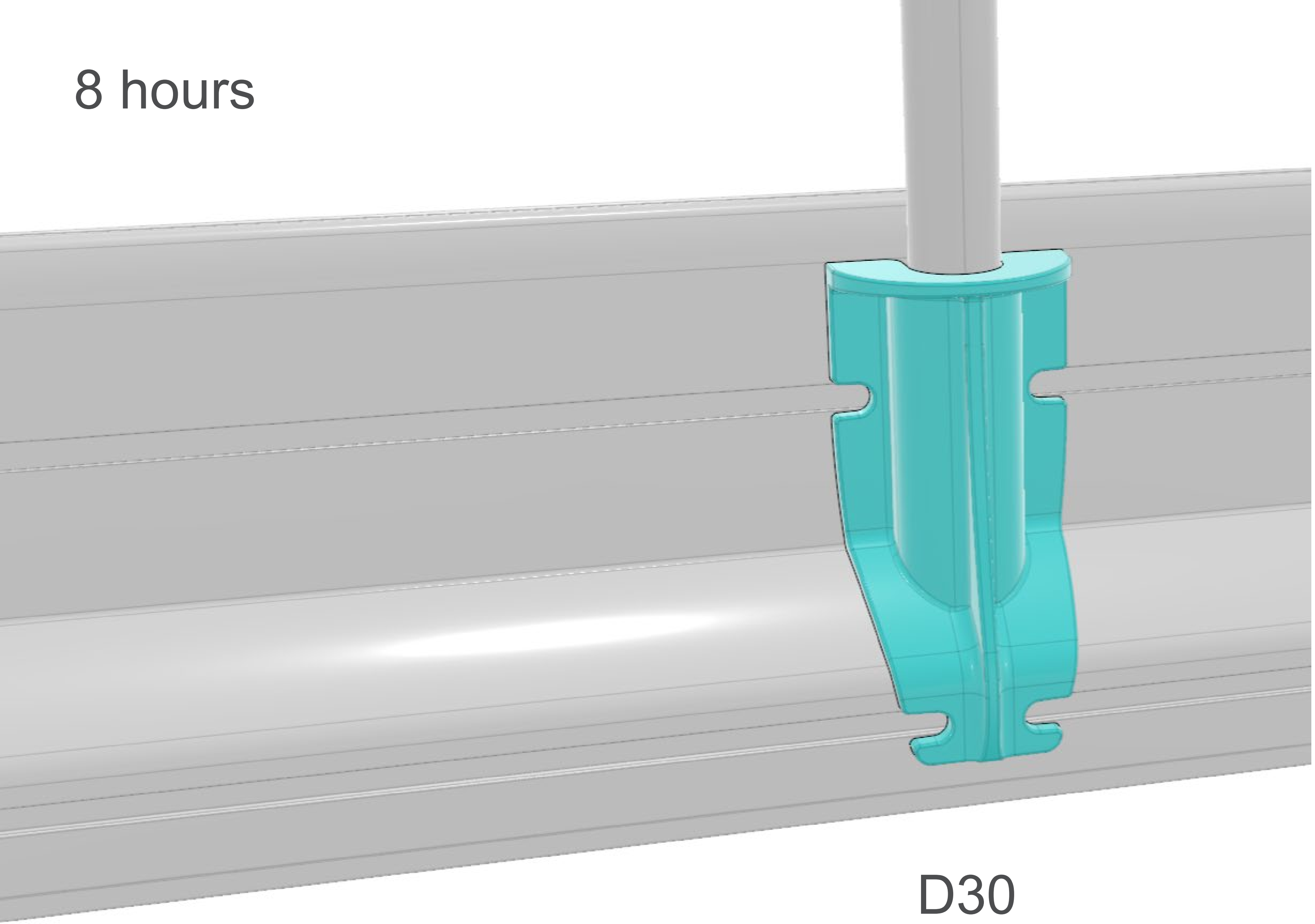


D35

Valmet

8 hours

Co-funded by the European Union

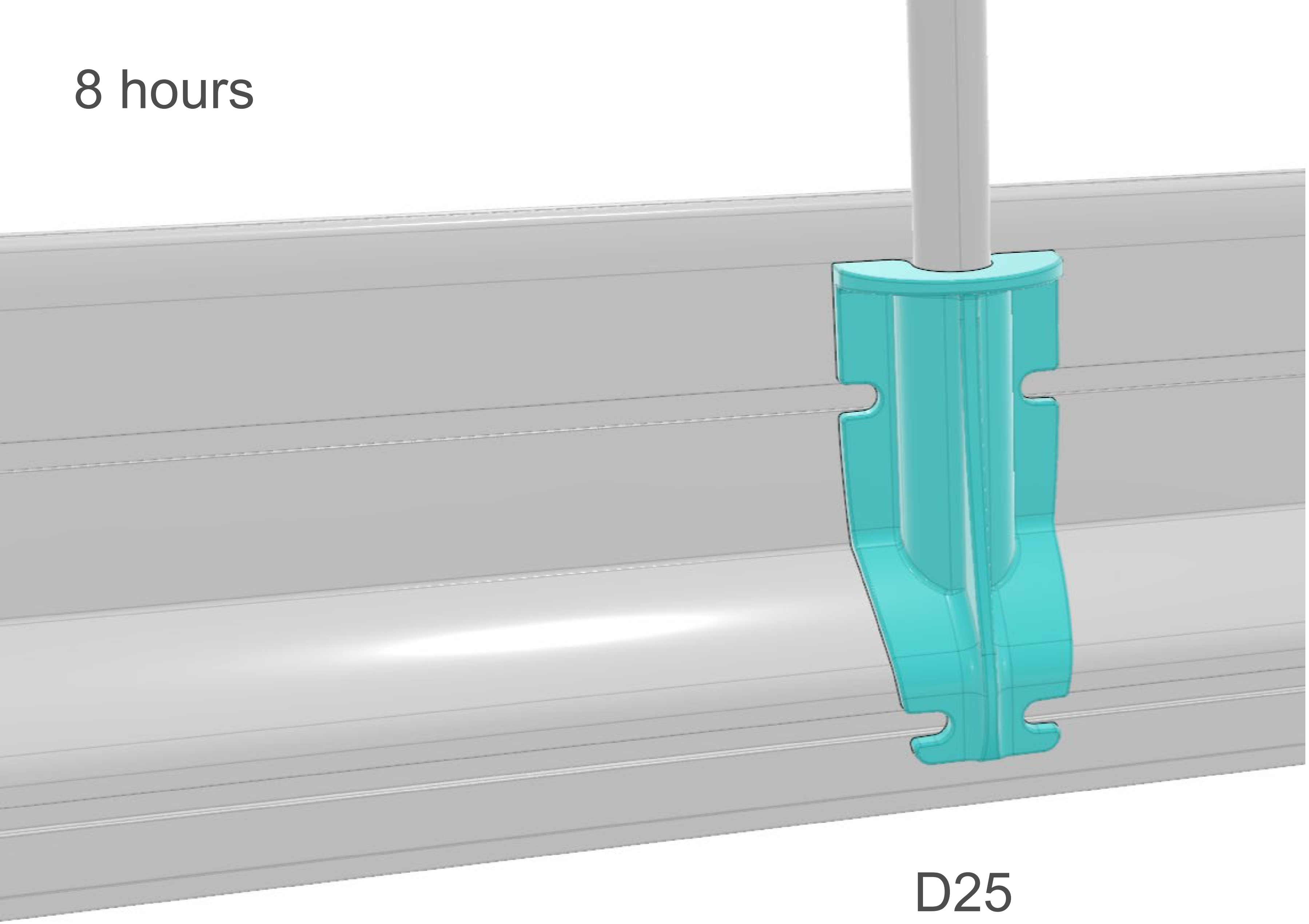


D30

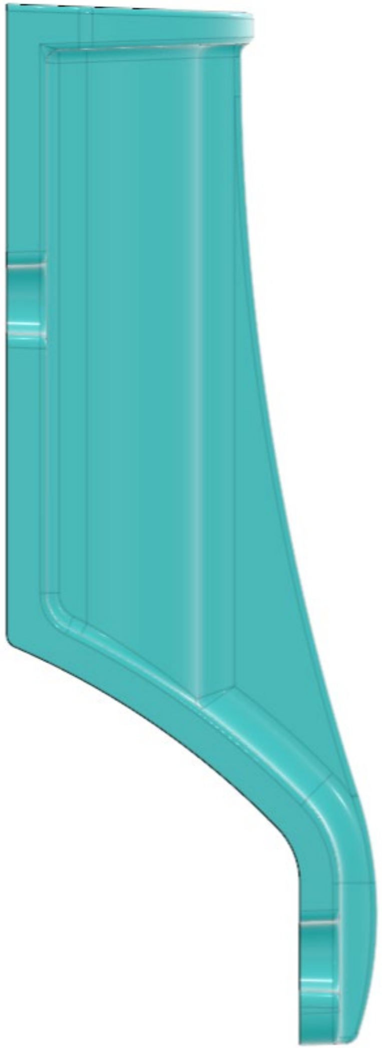
Valmet

8 hours

Co-funded by the European Union



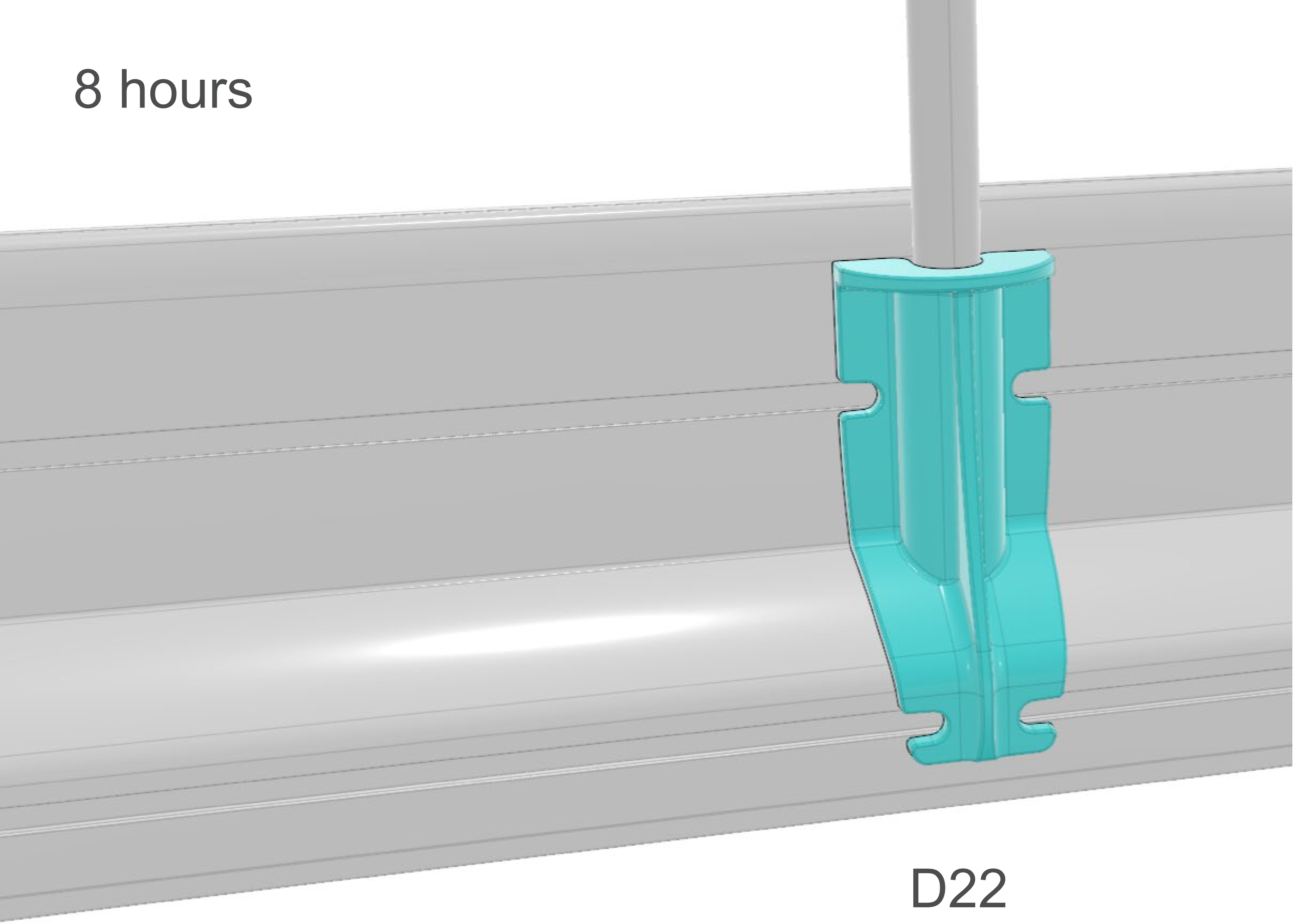
D25



Valmet

Co-funded by the European Union

8 hours

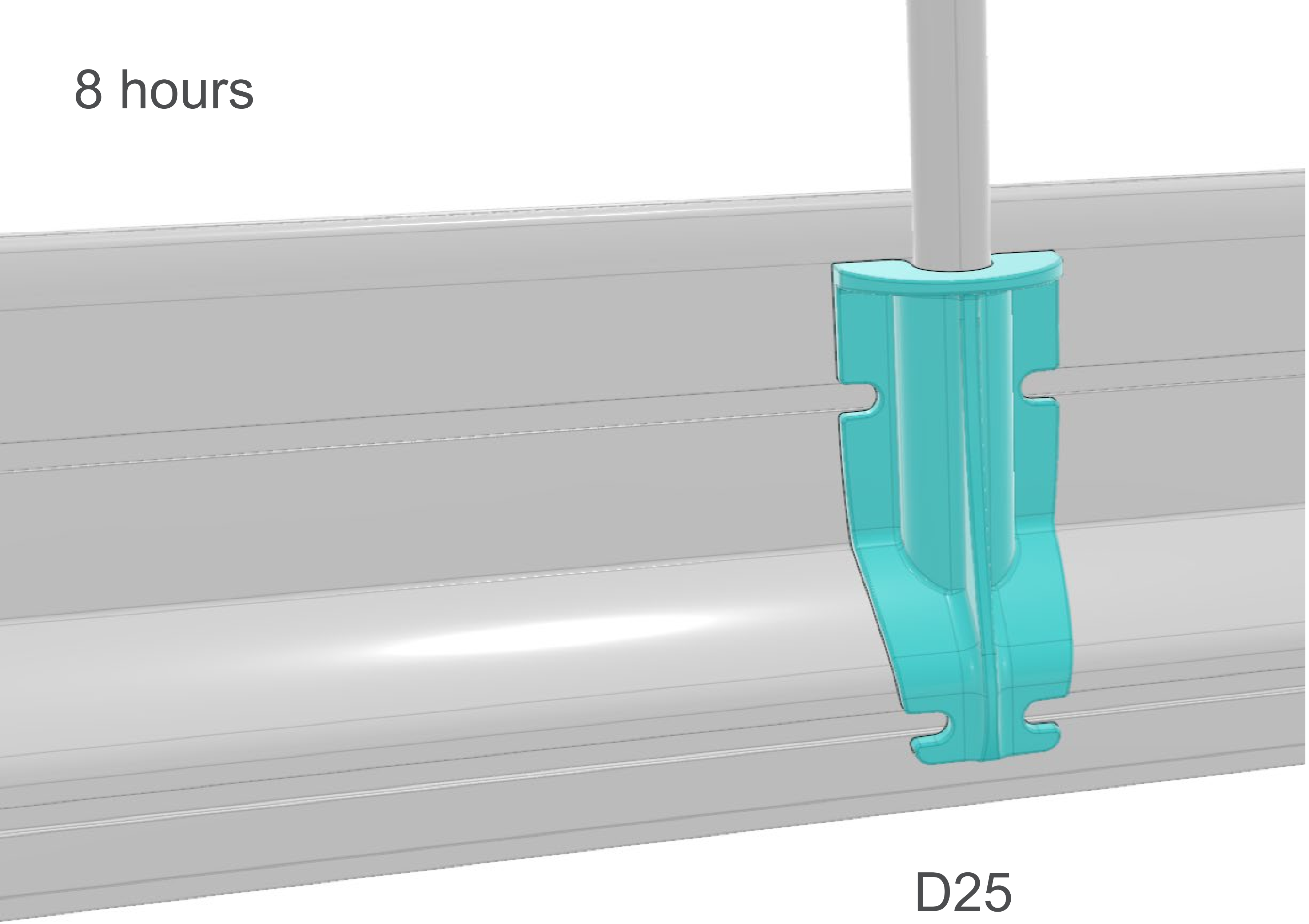


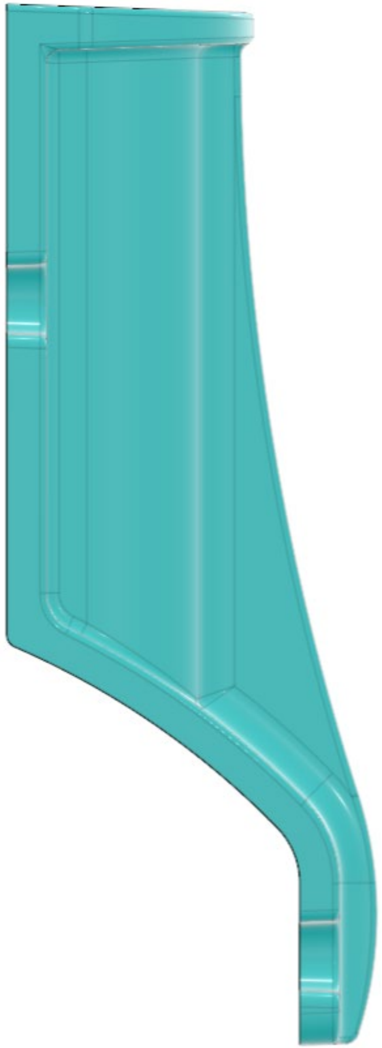
D22

Valmet

8 hours

Co-funded by the European Union

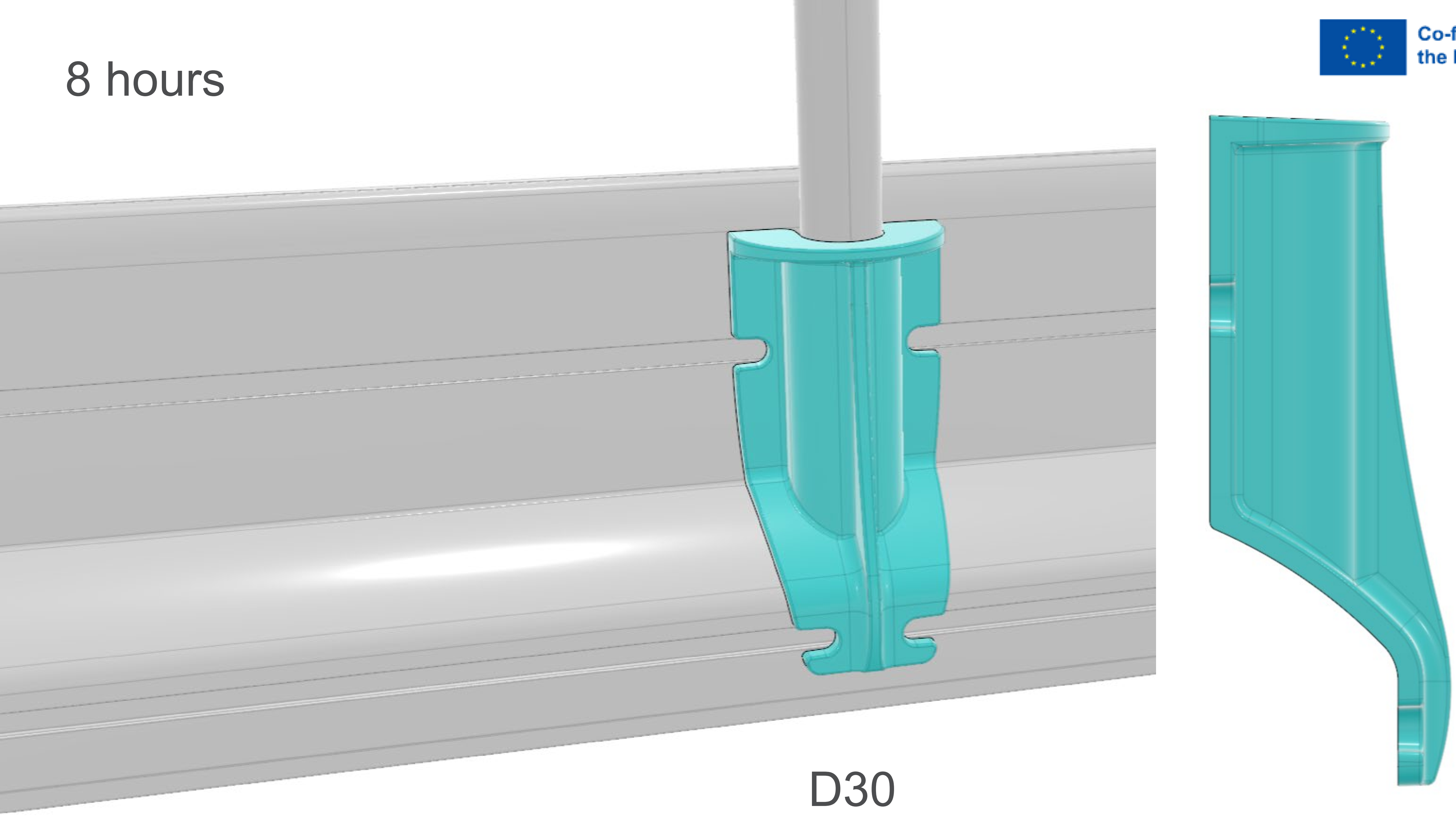




D25

8 hours

Co-funded by the European Union

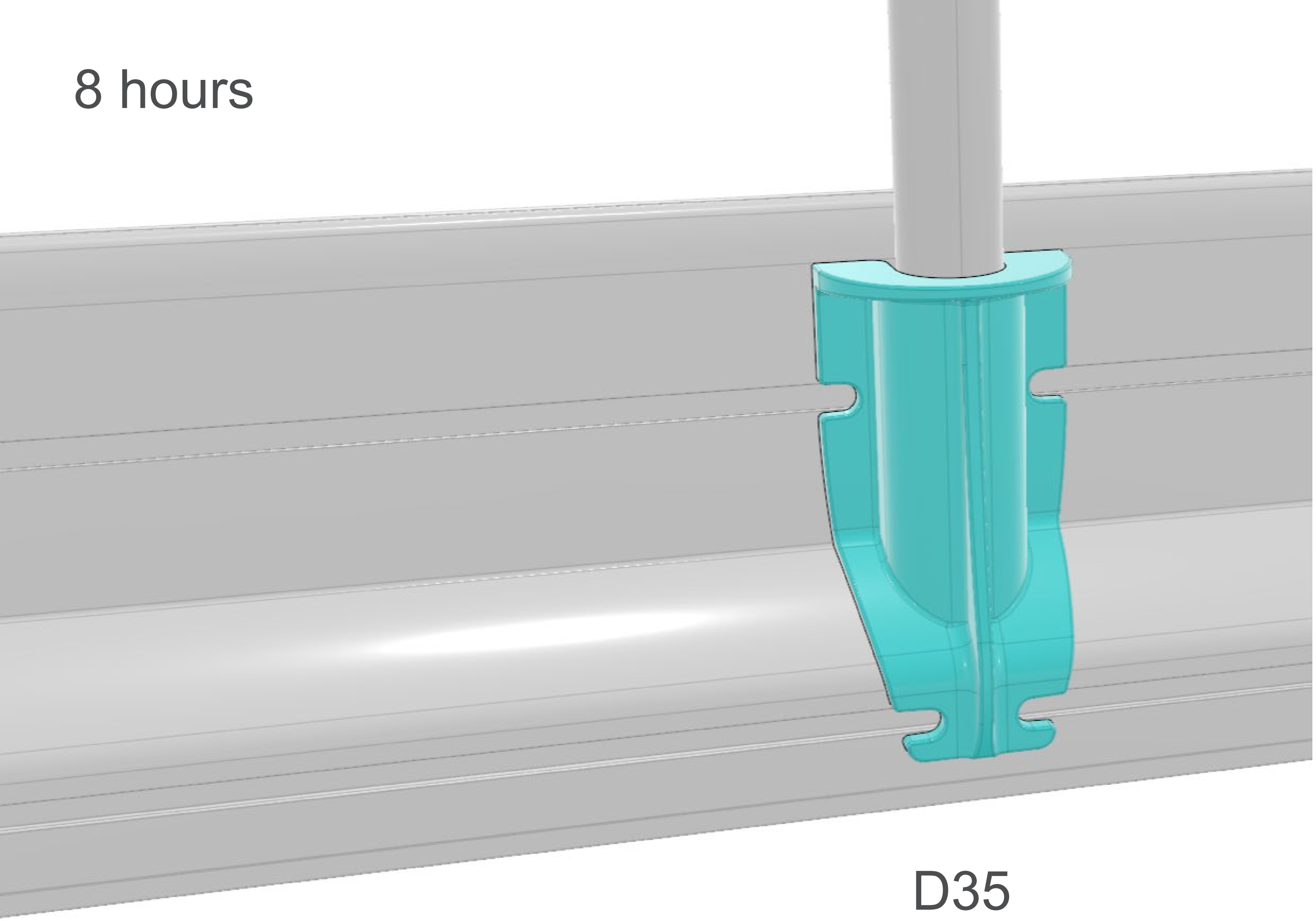


D30

Valmet

8 hours

Co-funded by
the European Union

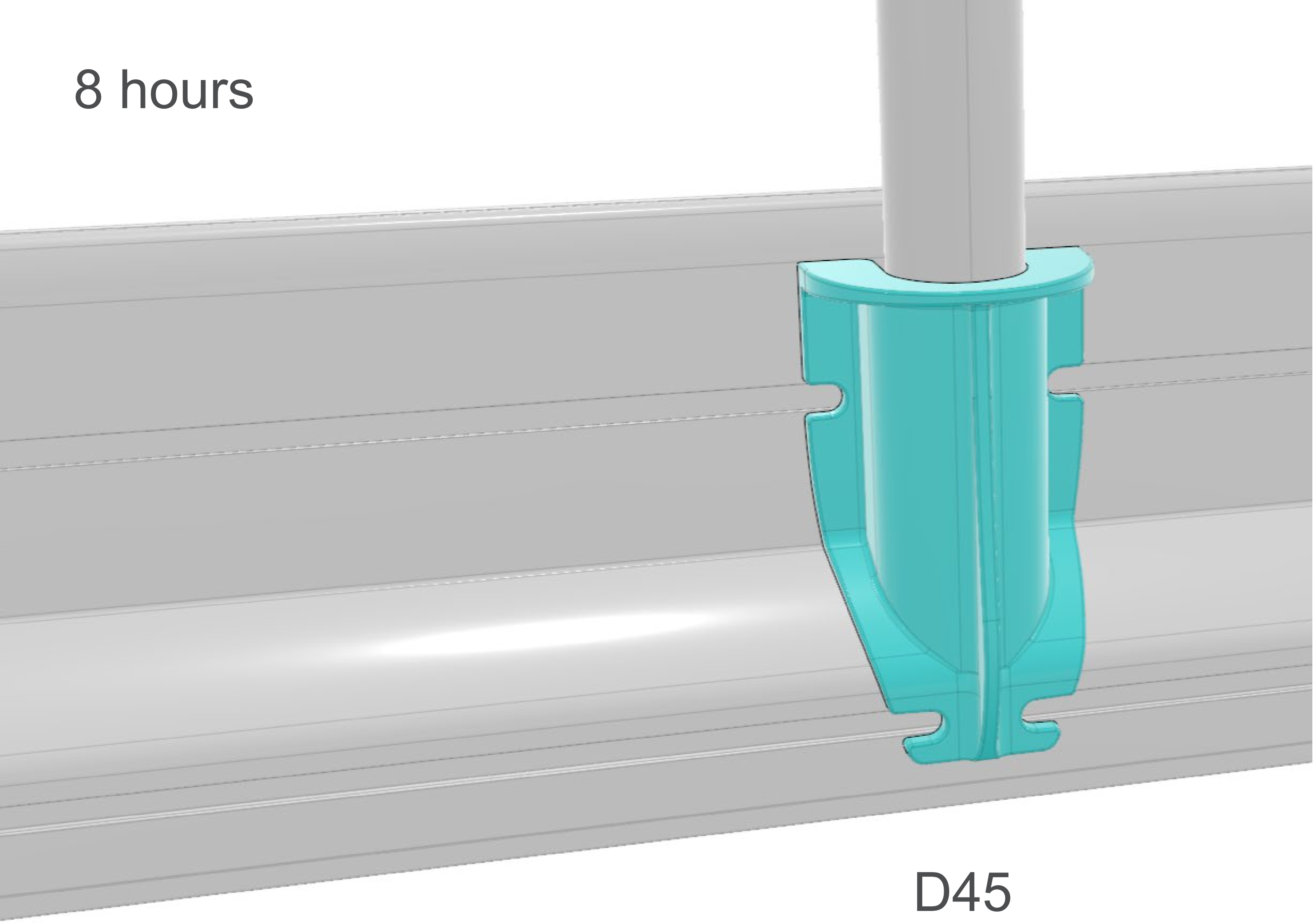


D35

Valmet

8 hours

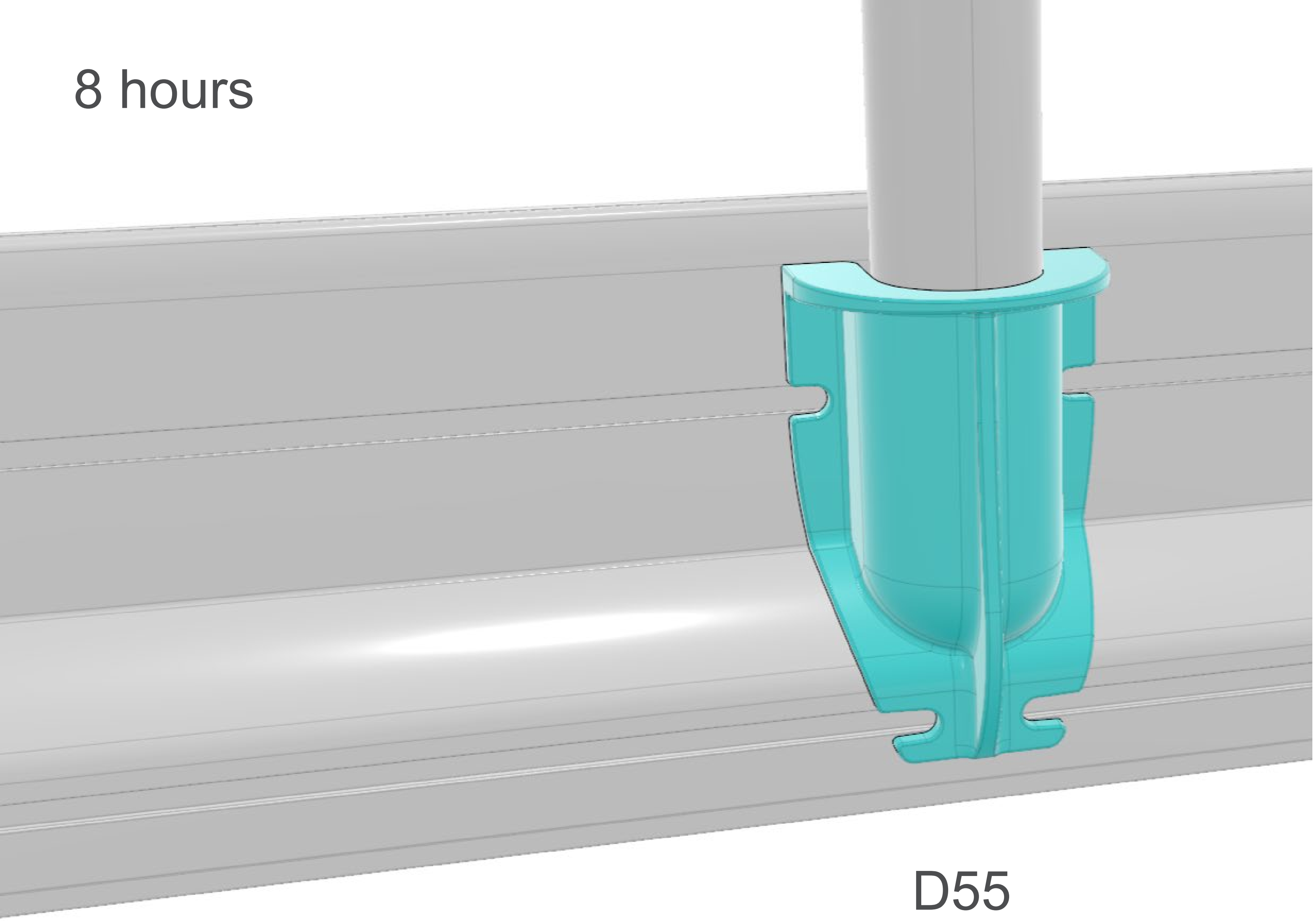
Co-funded by the European Union



D45

Valmet

8 hours

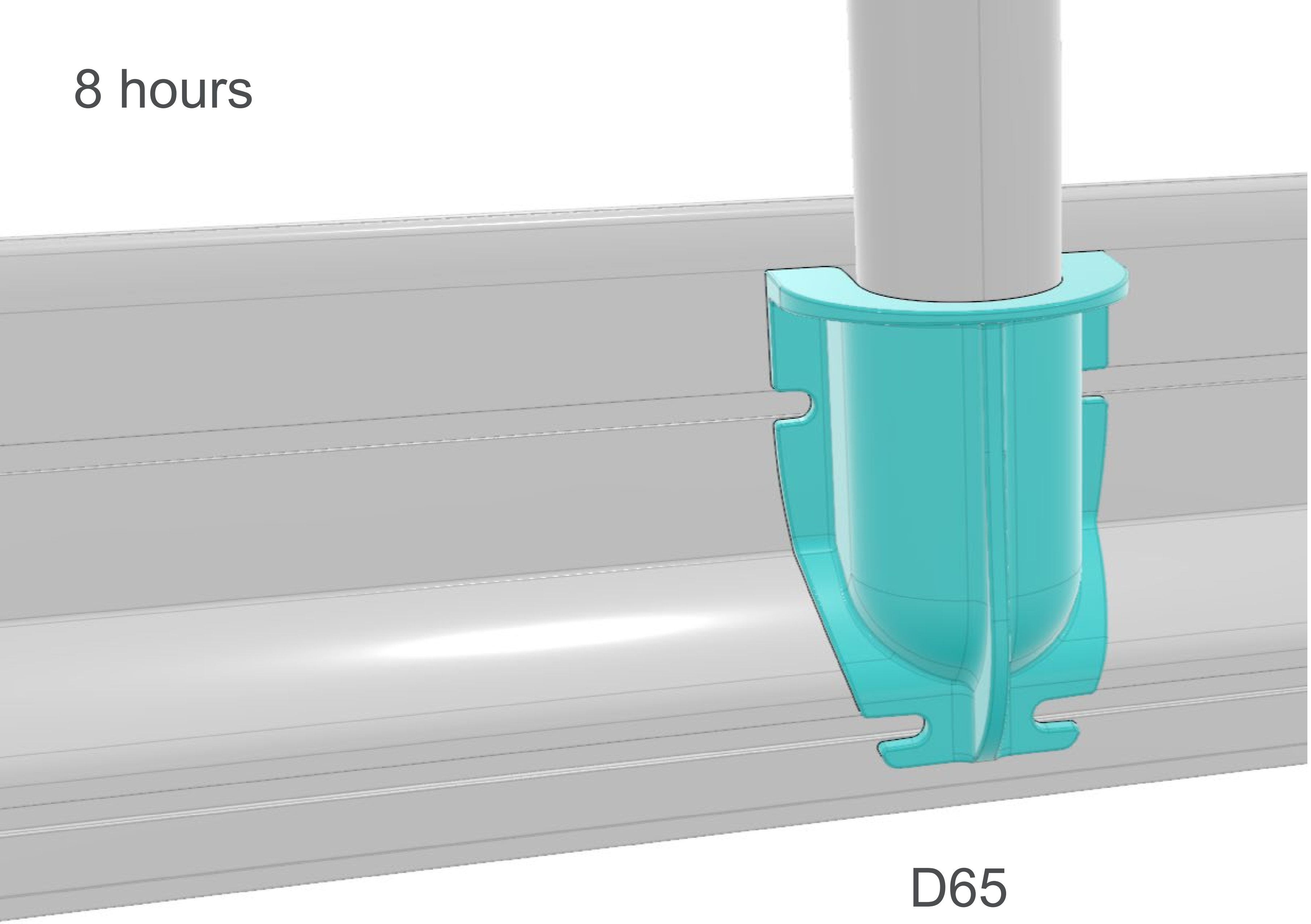


D55

Co-funded by
the European Union

Valmet

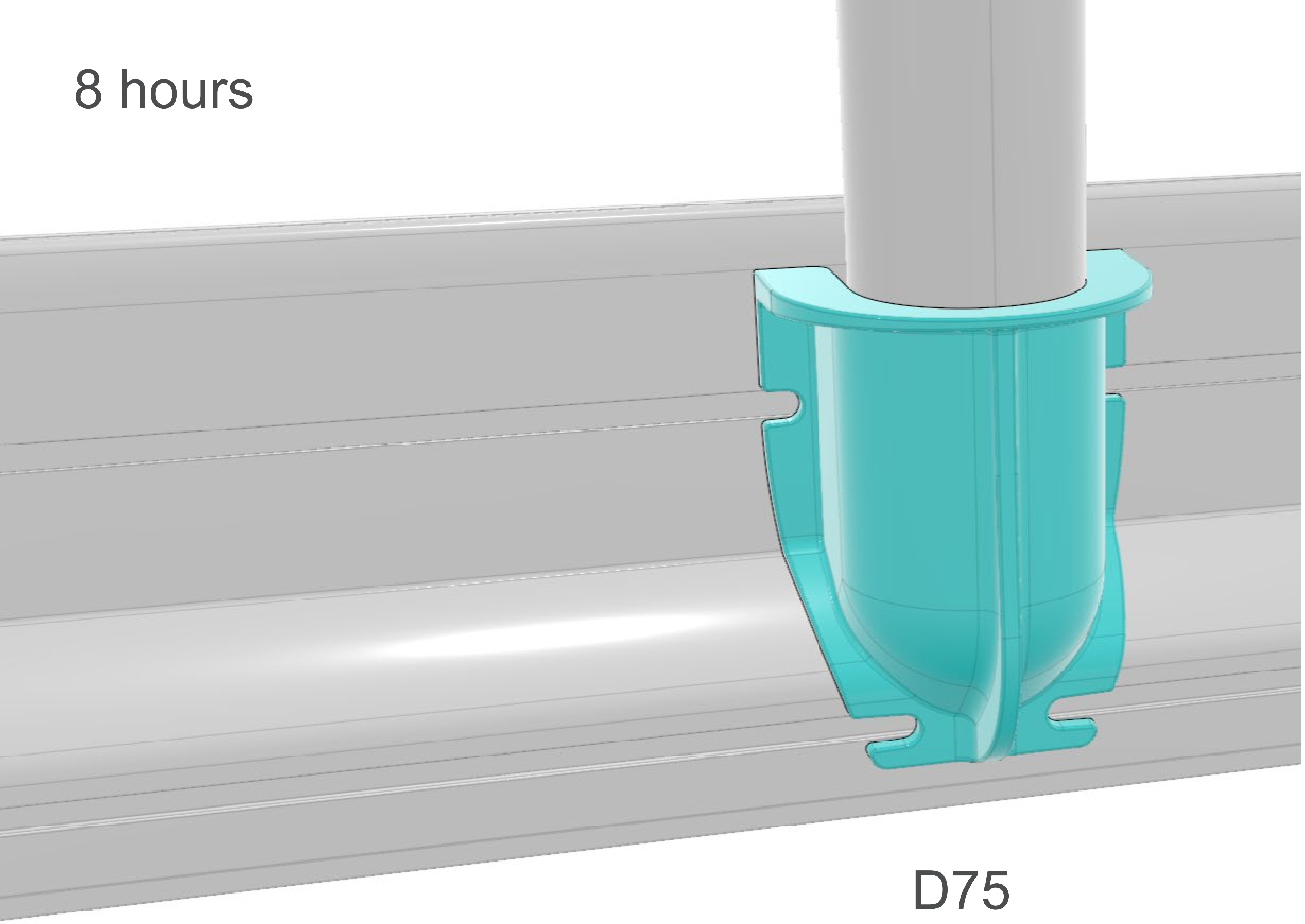
8 hours



D65

8 hours

Co-funded by the European Union



D75

Valmet

Parametric model

Co-funded by the European Union

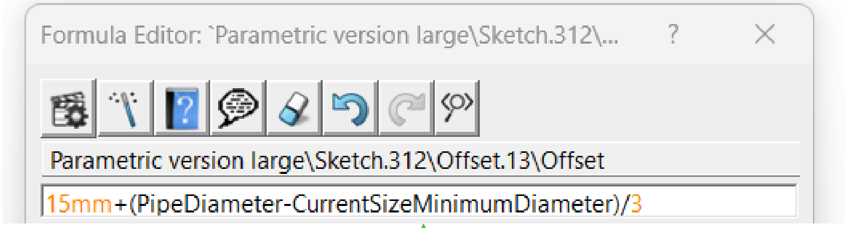
- Parameters
  - `Draft angle`=2deg
  - Thickness=6mm
  - `PipeDiameter (small 22-45, medium 45.1-52.9, large 53-75)`=75mm
  - Size=Large

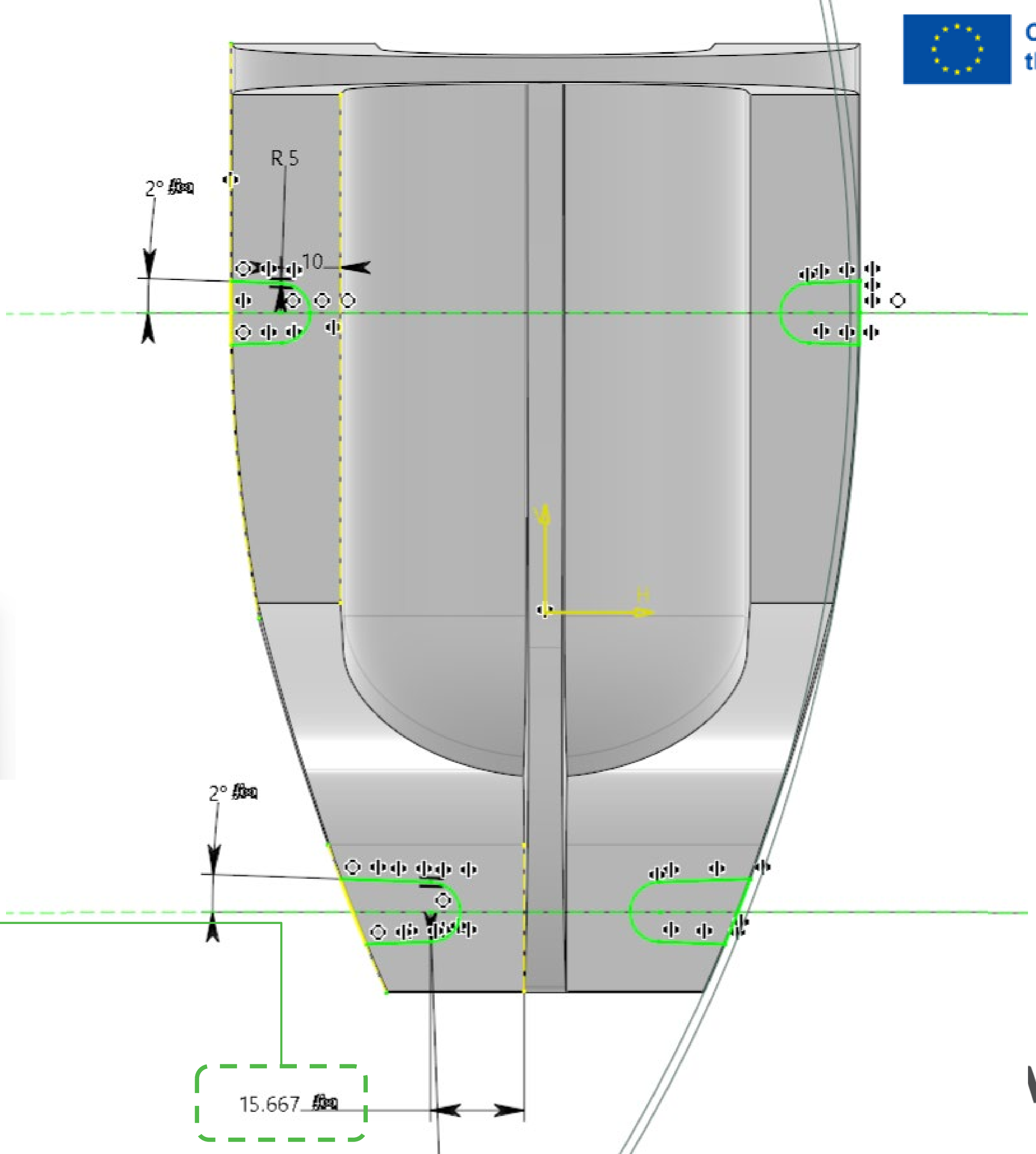
User can define the diameter (between 22-75mm)

Automatically determined by a logic based on the pipe diameter

Sketch example

The sketches are fully defined (with the selected few measurements defined parametrically)



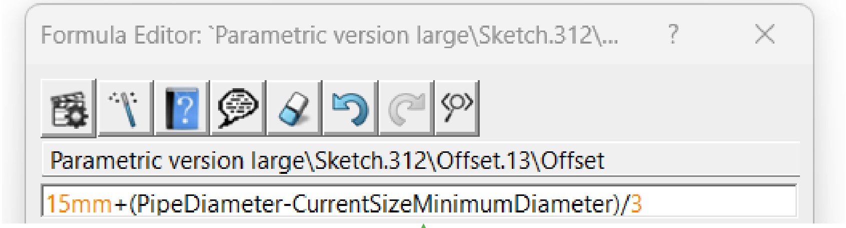


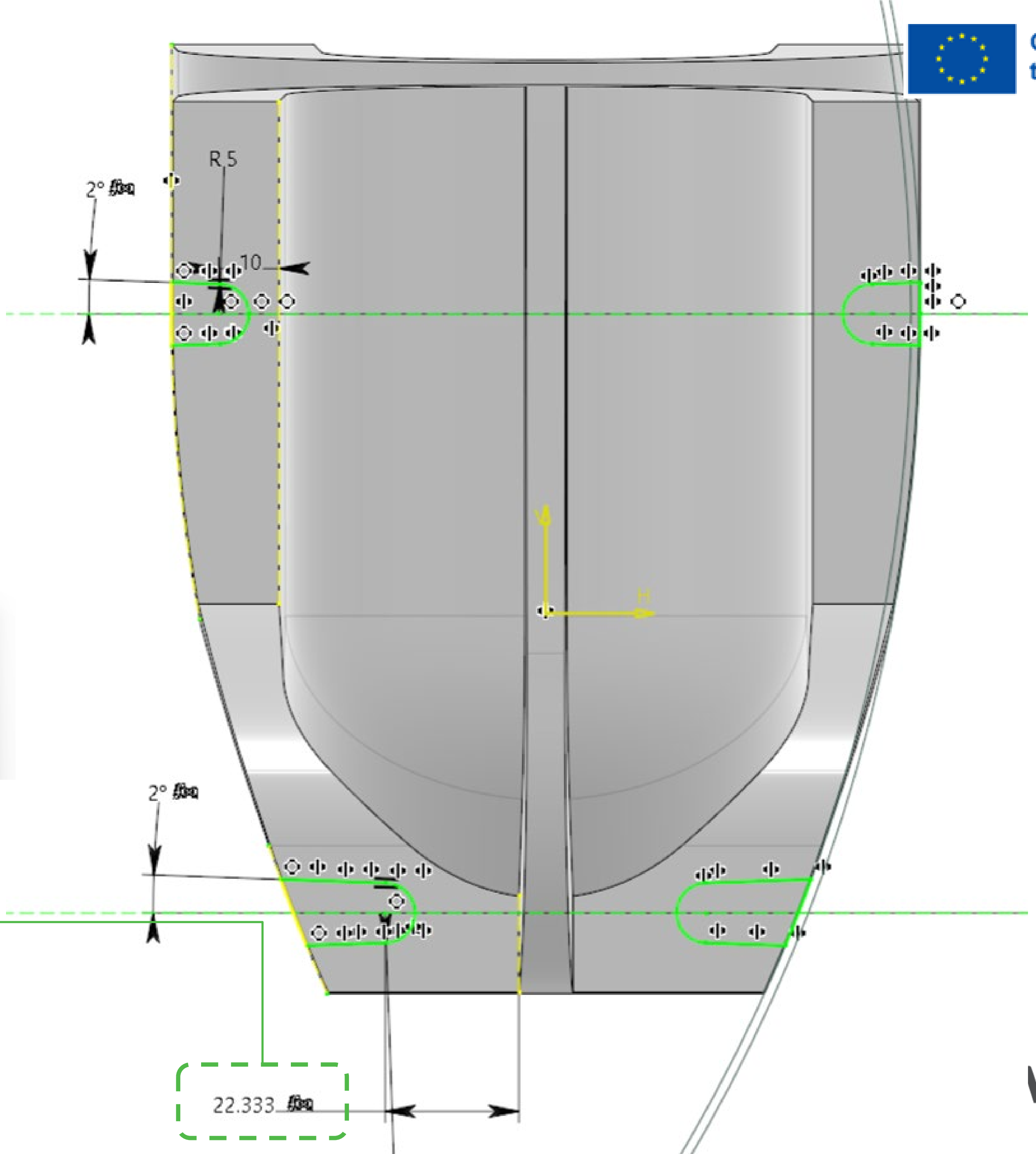
Valmet

Sketch example

Co-funded by the European Union

The sketches are fully defined (with the selected few measurements defined parametrically)

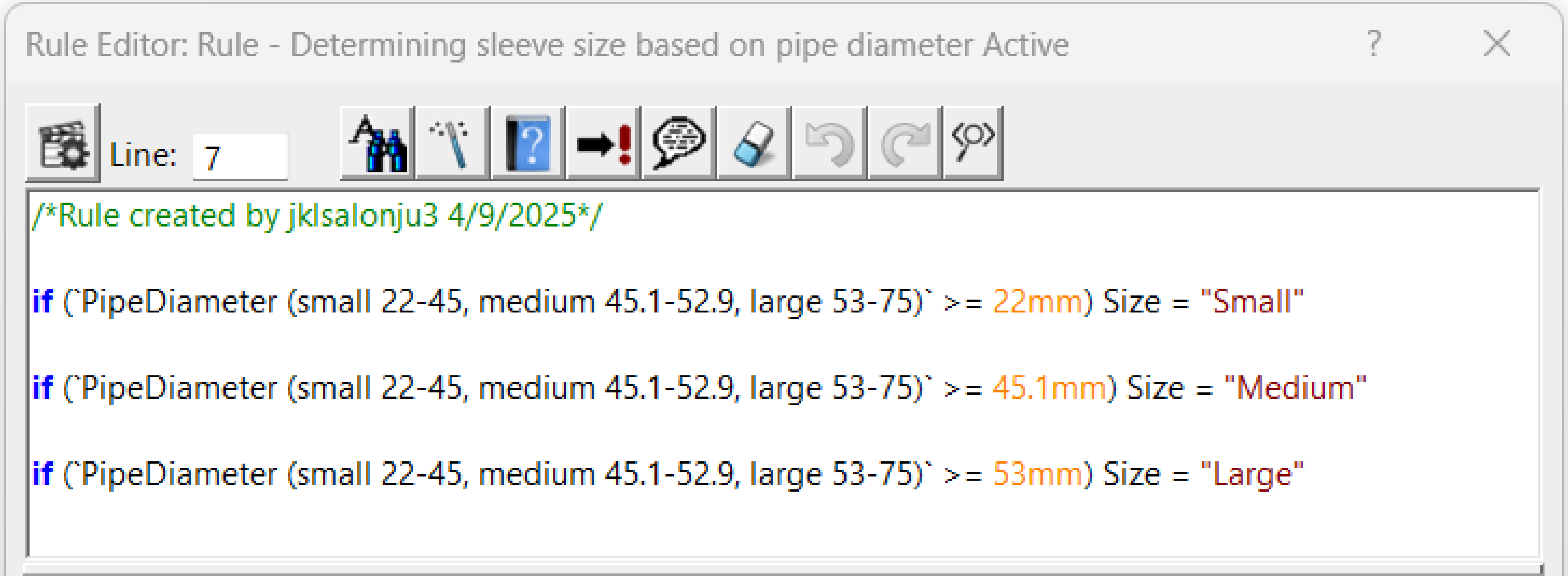




Valmet

Logic: Determining the size based on pipe diameter

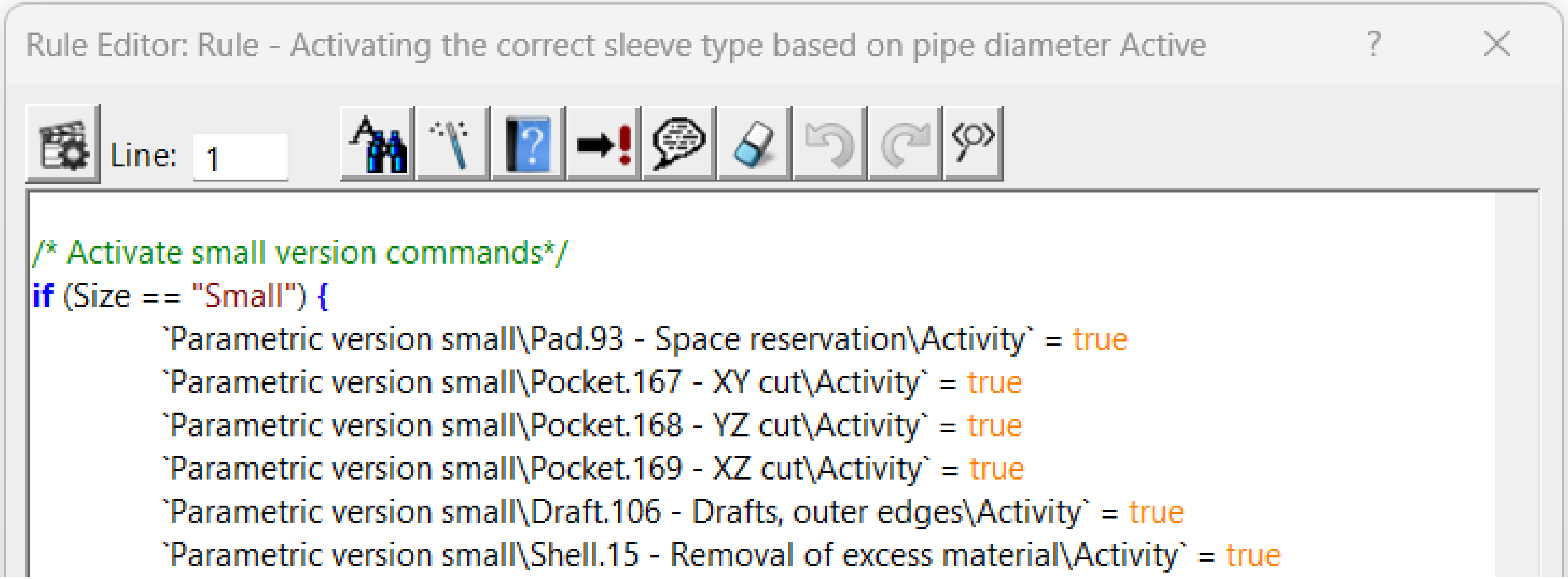
Co-funded by the European Union



Valmet

Co-funded by the European Union

Logic: Activating the proper features based on the size

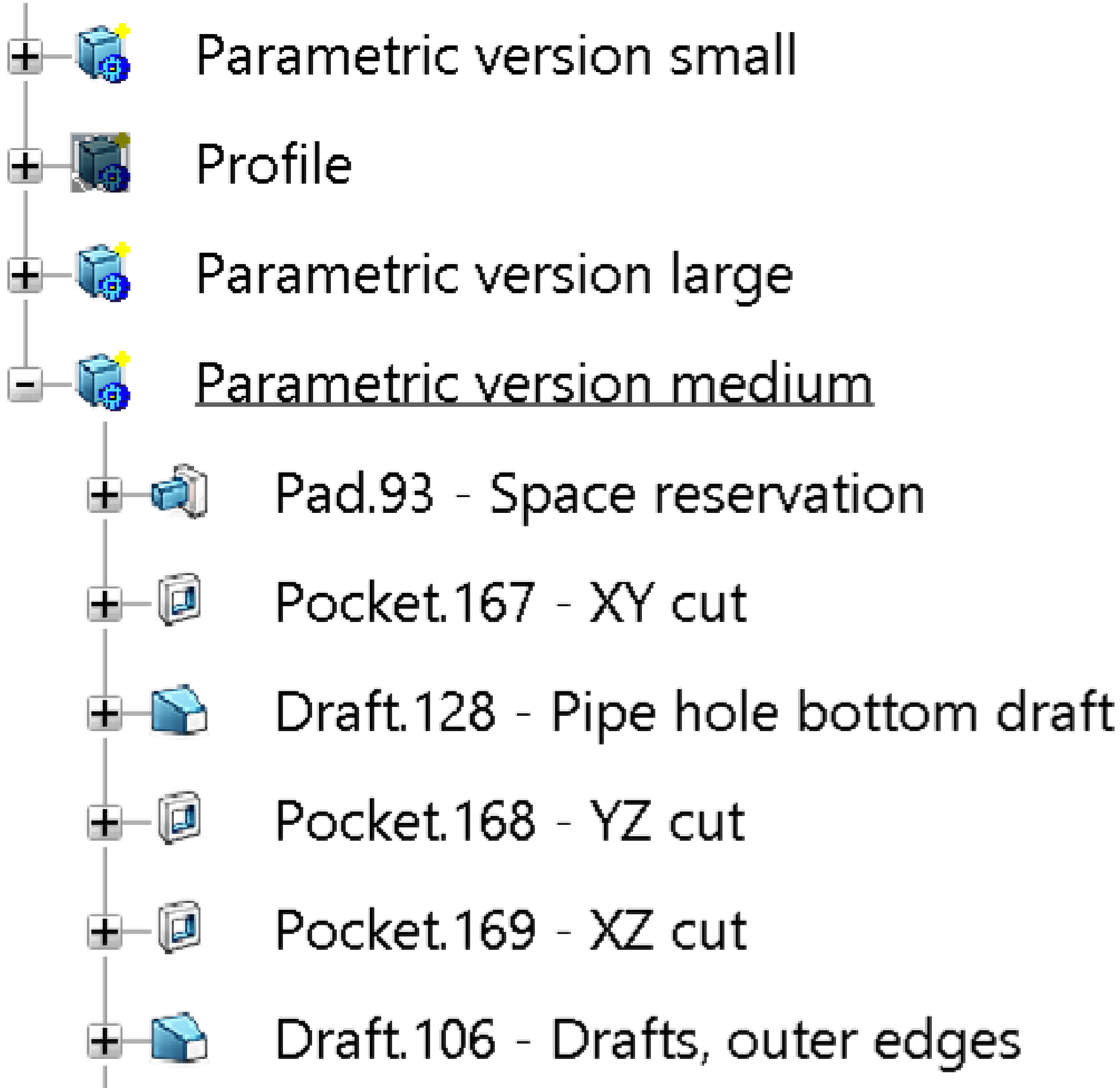


...

Co-funded by the European Union

Logic: Activating the proper features based on the size

Medium size activated (pipe size between the defined limits)

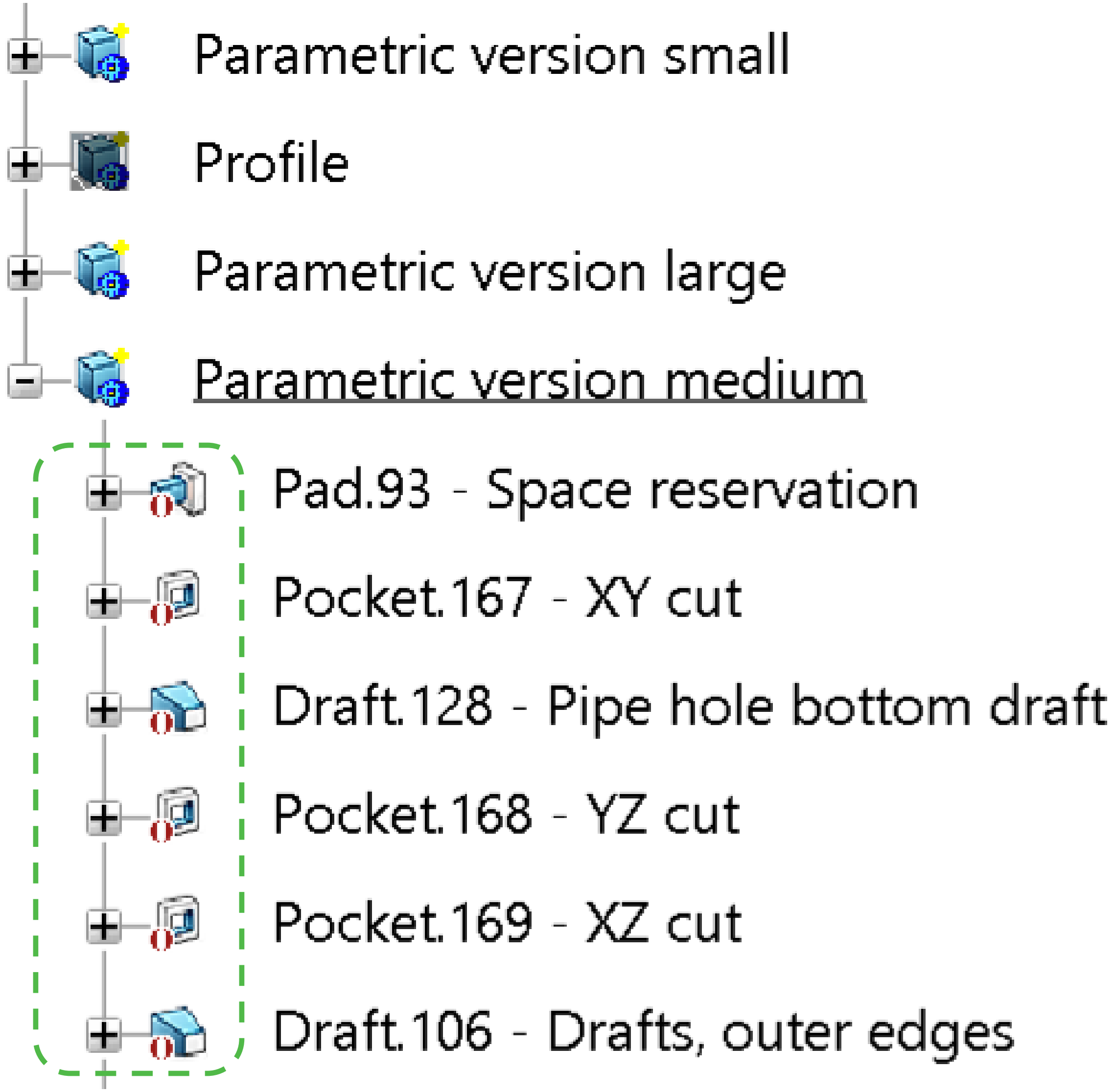


Valmet

Co-funded by
the European Union

Logic: Activating the proper features based on the size

Medium size deactivated (pipe size changed to a value outside defined limits)

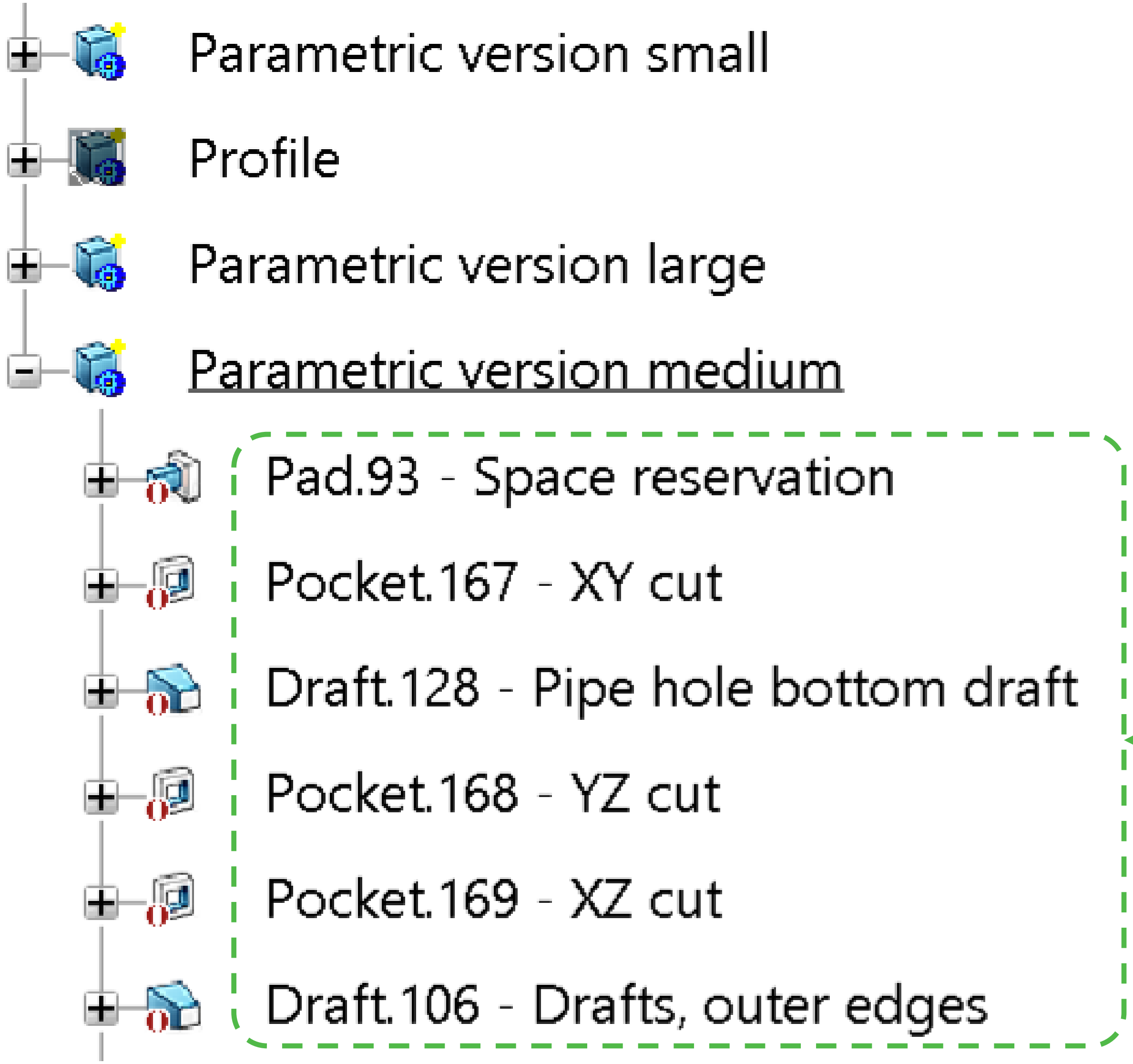


All features deactivated from this size

Valmet

Co-funded by
the European Union

Other notes

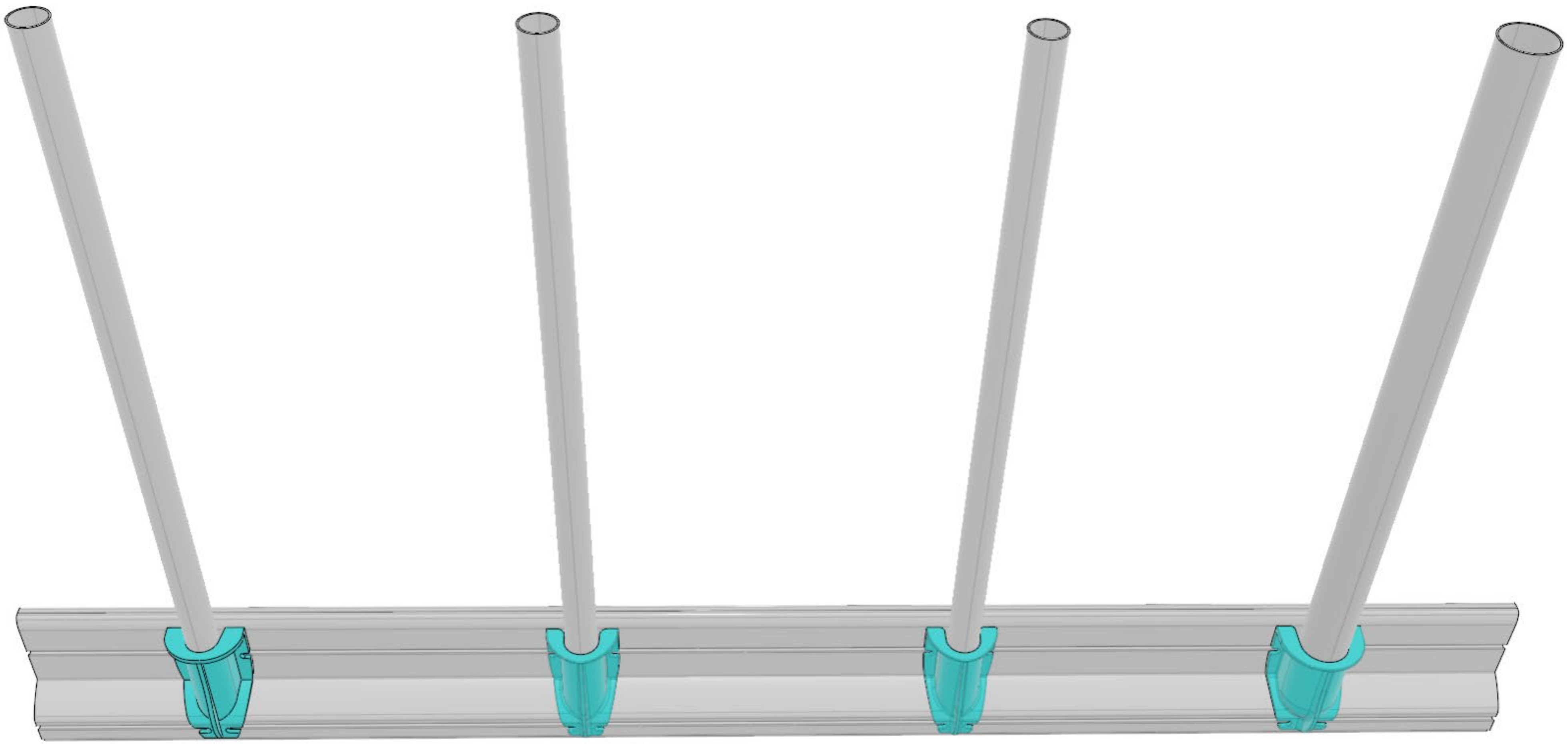


Informatively named features;
No excess features, only what is needed

Valmet

Co-funded by
the European Union

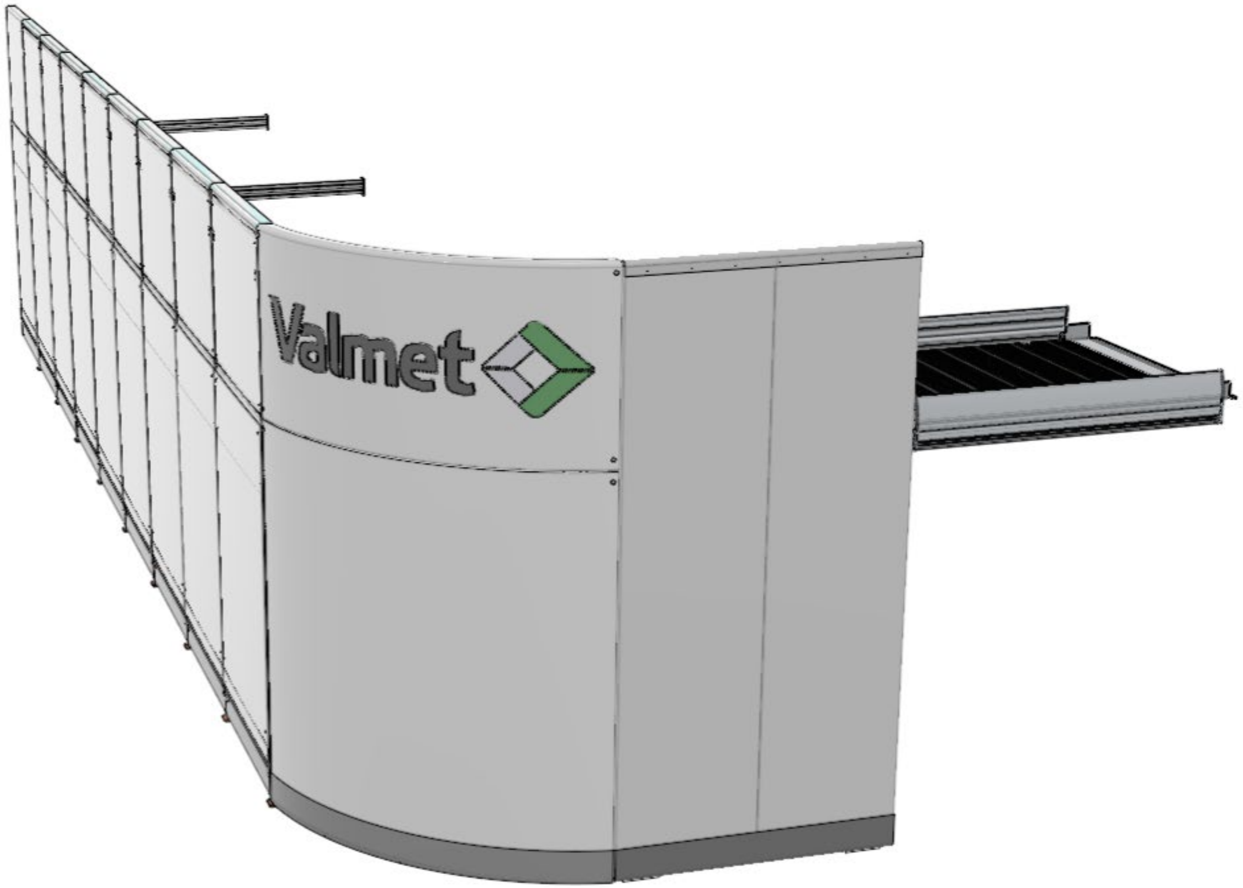
All the 3D models side by side



Co-funded by
the European Union

Product tables: A preferred alternative to varying configurations

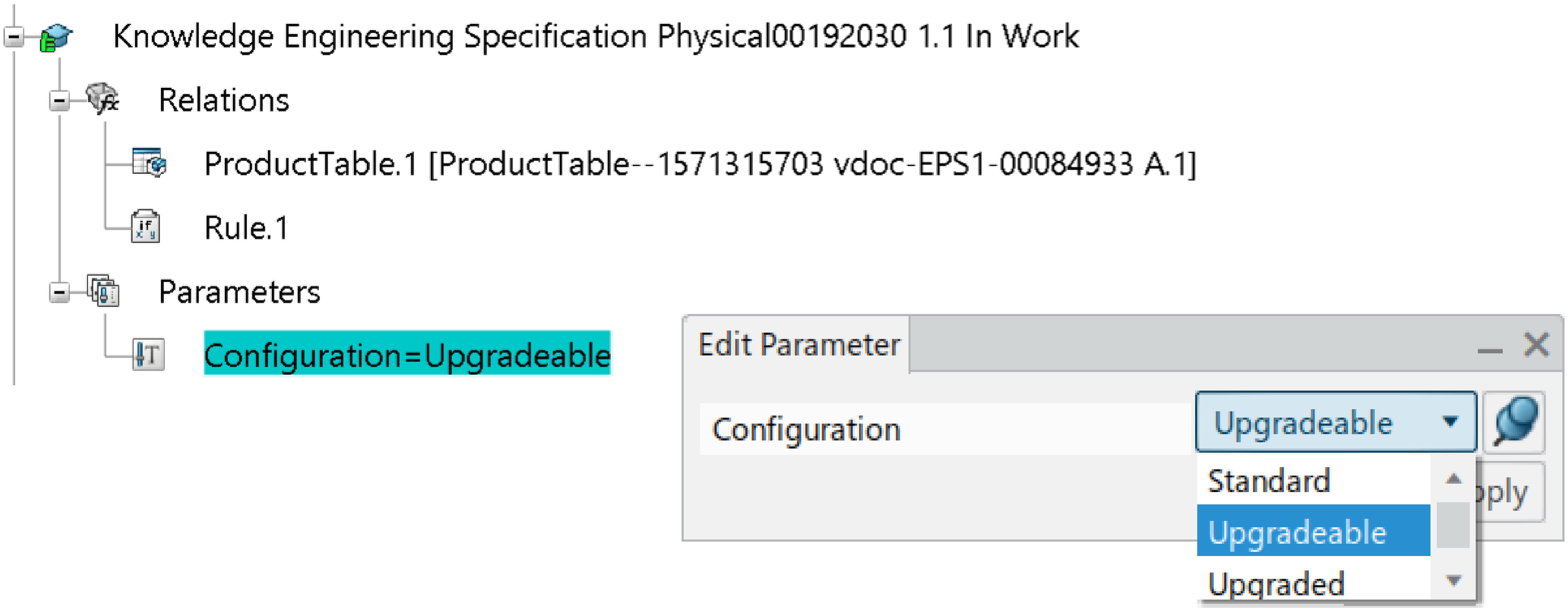
- FRP guard wall assembly 1.1 IN_WORK prd-EPS1-04761356 Project Specific
  - Standard parts prd-EPS1-24120403 Project Specific (Standard parts.1)
  - Upgradeable parts prd-EPS1-24120404 Project Specific (Upgradeable parts.1)
  - Upgraded parts prd-EPS1-24120405 Project Specific (Upgraded parts.1)



Valmet

Co-funded by the European Union

Product tables: A preferred alternative to varying configurations



Valmet

Co-funded by the European Union

Design tables: A preferred alternative to varying configurations

- Knowledge Engineering Specification Physical00192030 1.1 In Work
  - Relations
    - ProductTable.1 [ProductTable--1571315703 vdoc-EPS1-00084933 A.1]
    - Rule.1
  - Parameters
    - Configuration=Upgradeable

	A	B	C	
1	Identifier	Standard	Upgradeable	Upgraded
2	1	true	false	false
3	2	false	true	false
4	3	false	false	true

Valmet

Design tables: A preferred alternative to varying configurations

- Knowledge Engineering Specification Physical00192030 1.1 In Work
  - Relations
    - ProductTable.1 [ProductTable--1571315703 vdoc-EPS1-00084933 A.1]
    - Rule.1
  - Parameters
    - Configuration=Upgradeable

Rule Editor: Rule.1 Active

Line: 10

```
/*Rule created by jklsalonju4 17.10.2019*/

IF Configuration == "Standard"
        `Knowledge Engineering Specification Physical00192030 1.1 In Work\Relations\ProductTable.1` .ConfigurationRow=1

IF Configuration  == "Upgradeable"
        `Knowledge Engineering Specification Physical00192030 1.1 In Work\Relations\ProductTable.1` .ConfigurationRow=2

IF Configuration == "Upgraded"
        `Knowledge Engineering Specification Physical00192030 1.1 In Work\Relations\ProductTable.1`  .ConfigurationRow=3
```

Co-funded by the European Union

5 | Summary

Co-funded by the European Union

Takeaways from today

- Use the modelling/visualization method that is just enough for the purpose
  - Check 12 principles of agile software development (= the art of maximizing work not done in particular)
  - Check 8 wastes of LEAN (= no extra processing in particular)
- Only do parametric models when your design is frozen, and you know what parameters are needed and what are their required ranges (e.g. pipe diameter for the cast sleeve)
  - Enabling a wider range of adjustability that is needed can multiply the work required several times over (e.g. 4x more from 22-45mm to 22-75mm)

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

C5 – Computer Aided Design

L3 – Design of parametrized parts with applications in logistics

P5 - Bosch Cluj Plant

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

Design of parametrized parts with application in logistics

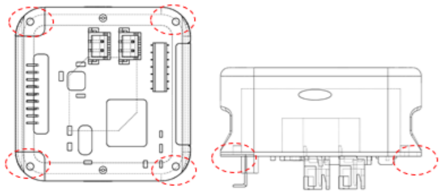
Co-funded by the European Union

NextGEng

C5 – Computer Aided Design – Laboratory activity

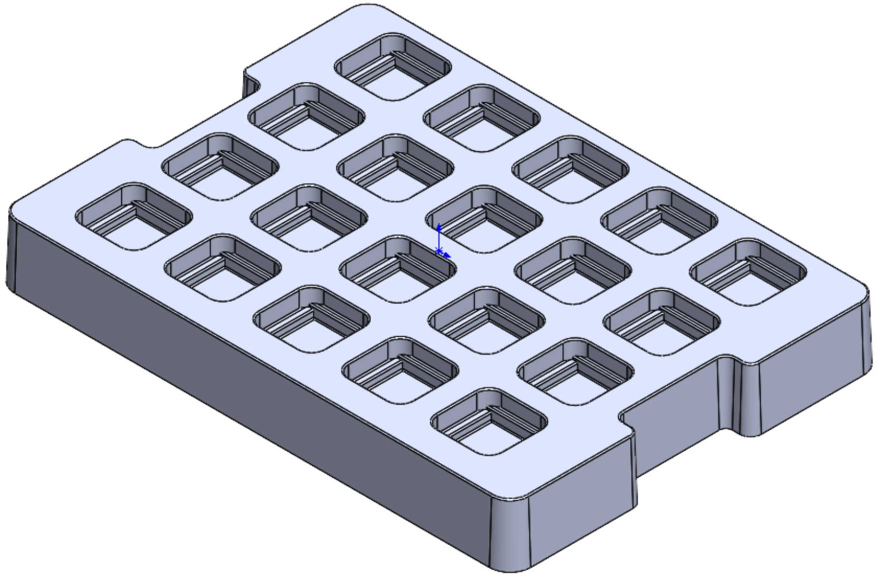
Topic: Design of parametrized parts with application in logistics

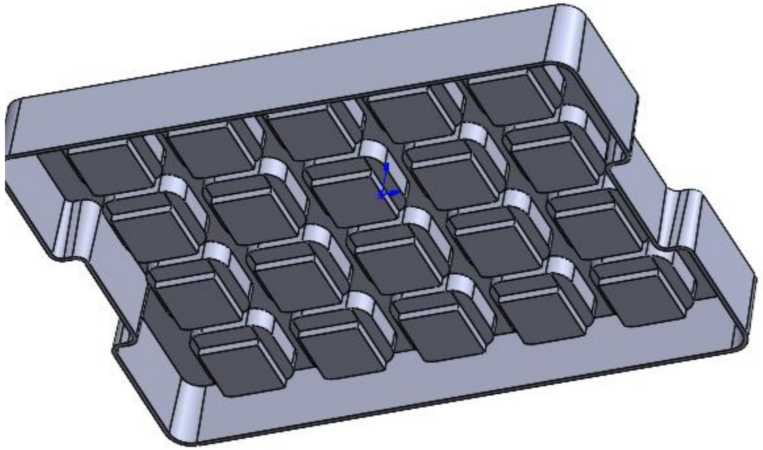
Table 1. Blister design parameters

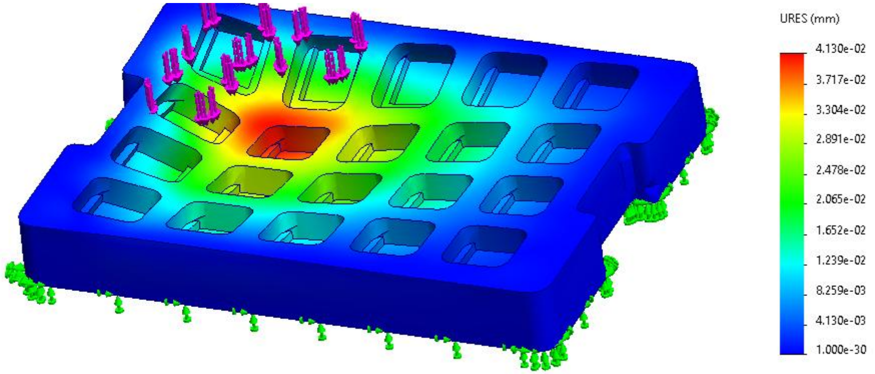
Student	Parameters		Value	Measurement units
S1	Blister length	L	415-10	[mm]
S1	Blister width	W	300-10	[mm]
S1	Blister height	H	50	[mm]
S1	Blister connection radius (raza racord)	Rc	15	[mm]
S2	Blister lateral support/wall Angle	LsA	2	[deg]
	Handle length	Hl	90	[mm]
	Handle width	Hw	20	[mm]
	Handle filet radius	Hr	15	[mm]
S3	Minimal distance from the blister edge/border	Db	20	[mm]
S3	Positioning height of the piece compared to the blister surface	Hp	10	[mm]
S2	Blister thickness	Tk	2	[mm]
S2	Blister – component contact distance	Cd	1	[mm]
S2	Blister – component clearance distance	Cld	2	[mm]
S3	Blister – component contact zones 			
S3	Positioning of the component on the blister	☐ Parallel with the blister edge	☐ At an angle Angle value: .... [deg]	

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

TECHNICAL UNIVERSITY jamk Universidad de Jaén iSR www.isr.es Valmet BOSCH Invented for life







Co-funded by the European Union

NextGEng

Design of parametrized parts with application in logistics

Laboratory overview:

Objectives	• Design a blister based on a set of prerequisite requirements (manipulated part, materials etc.) • Define the blister geometric parameters to be compatible with manufacturing process
Pre-requisite	• Basic skills and knowledge of SolidWorks • Basic knowledge in technical drawings • Basic knowledge manufacturing and plastic thermoforming
Equipment used for laboratory	• PCs with SolidWorks

Design of parametrized parts with application in logistics

Upon completion of this laboratory, the student will be able to:

1) Define parametrized parts
2) Define the negative of a given part that could be used to design dedicated transportation modules (blisters)
3) Design parametrized parts that could be manufactured using plastic thermoforming
4) Implement rapid prototyping procedures for testing blisters

Content

- Introduction
- Theoretical concepts
  - Design procedure of a blister used in logistics
  - Defining the negative of a part
  - Parametrized parts / Parametric modelling
- Laboratory task
  - Define the main design parameters and restrictions
  - Desing the blister based on the imposed requirements
  - Testing procedures for the designed part
- Summary, Discussions & Feedback

Co-funded by
the European Union

Introduction

Co-funded by
the European Union

Introduction

- **Blister -** pre-formed plastic cavity used to securely hold and protect a large variety of products

- **Applications:**
  - Electronics industry
  - Pharmaceutical industry
  - Consumer goods
  - Food industry
  - Production lines

Introduction

- **Advantages:**
  - Product protection
  - Efficient automation
  - Cost-effective
  - Lightweight
  - Customization
  - Product visibility

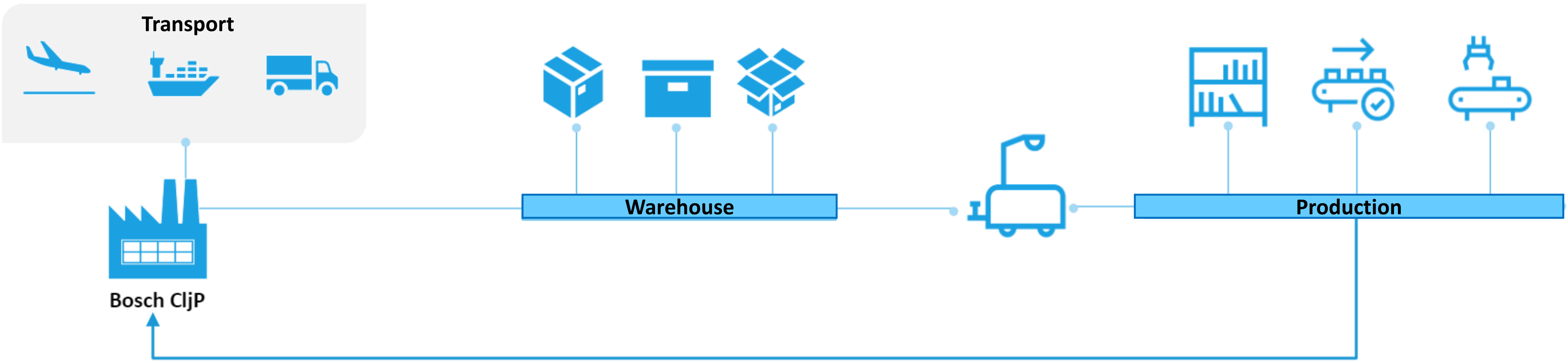
- **Limitations:**
  - Limited size and shape flexibility
  - Environmental concerns
  - Lower structural strength
  - Cost of custom tooling

Co-funded by
the European Union

Introduction

Logistics processes – *blister role*

- Packaging



Introduction

- **Benefits of using blisters on production lines & logistics**

- automation

- Easy and safe transportation

- Optimal storage

Theoretical concepts

Blister design procedure

Goal – design a blister that is ***functional***, ***efficient*** and ***cost-effective***

Constraints:

- Product properties
- Material used
- Manufacturing technology
- Production processes

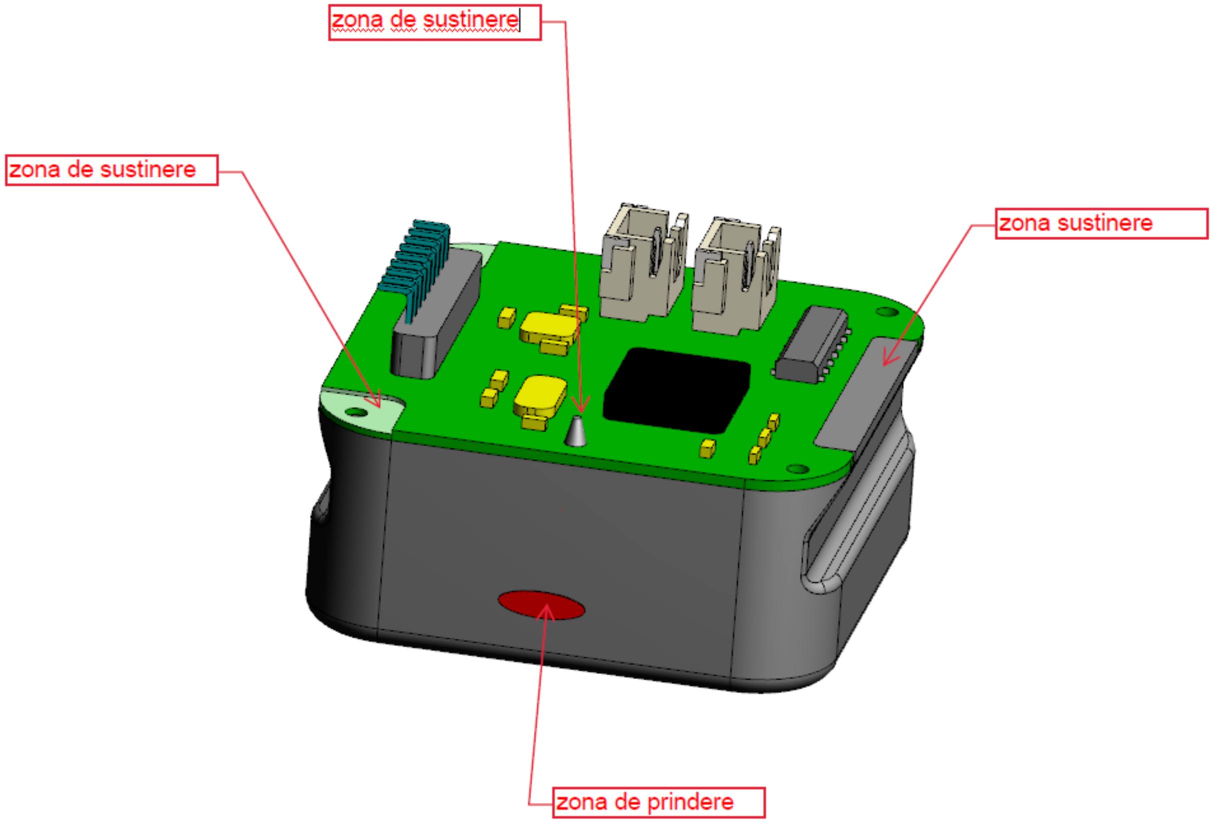
Blister design procedure

Design steps for the blister

<u>I. Understand the Product and Requirements:</u>

Product analysis

- evaluate the ***physical characteristics*** (size, shape, weight) and the manipulated system
- Identify ***sensitive areas*** on the product that needs to be protected (ex. thin sections, protruding components, or smooth surfaces may need extra space or cushioning in the blister design)



Blister design procedure

Design steps for the blister

<u>I. Understand the Product and Requirements:</u>

Logistic specific constrains

- determine how the product is transported, stored, and handled during the logistic process
- *Ergonomic Aspects and Manual Handling*
- *Process Size Limitations (Conveyor Belt, Container, Box, Pallet)*

Blister design procedure

Design steps for the blister

II. Material Selection

- Material selection influence: overall strength, flexibility, environmental impact, and cost of the packaging

PET (Polyethylene Terephthalate)

- good strength
- good protection of product from physical damage and env. Factors

PVC (Polyvinyl Chloride)

- good strength
- good protection of product from physical damage and env. factors

HIPS (High Impact Polystyrene)

- strong impact resistance
- cheap

PP (Polypropylene)

- lightweight
- durable
- chemically resistant
- excellent resistance to moisture and heat

Co-funded by the European Union

Blister design procedure

Design steps for the blister

II. Material Selection - **Environmental Impact**

Eco-friendly measures in blister packaging:

- **Use of Recyclable Materials**

Polypropylene (PP)

-most eco-friendly due to its recyclability

Polyethylene Terephthalate (PET)

- highly recyclable and commonly used in packaging

High Impact Polystyrene (HIPS)

- less environmentally friendly than PP and PET
- recyclable in certain facilities

Polyvinyl Chloride (PVC)

- least eco-friendly
- PVC is difficult to recycle
- releases harmful chemicals during production and disposal

Co-funded by the European Union

Blister design procedure

Design steps for the blister

II. Material Selection - **Environmental Impact**

Eco-friendly measures in blister packaging:

- **Use of Recyclable Materials -** replacing PVC, which is hard to recycle, with more sustainable alternatives like PET or RPET (recycled PET).
- **Modular Design**: Creating reusable or refillable blister packaging that reduces the need for single-use plastics
- **Sustainable Sourcing**: Using backing materials, such as paper or cardboard, from certified sustainable sources

Co-funded by the European Union

Blister design procedure

Design steps for the blister

<u>III. Blister design specification</u>

- **Size and shape**
- **Thickness**
- **Contact clearance**
- **Number of parts / blister**
- **Contact points**

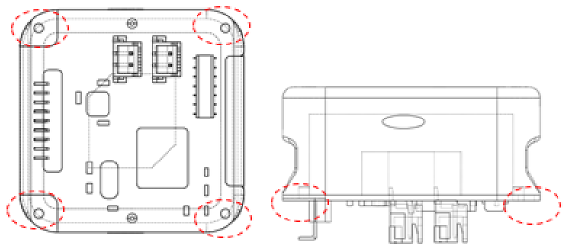
Co-funded by the European Union

NextGEng

C5 – Computer Aided Design – Laboratory activity

Topic: Design of parametrized parts with application in logistics

Table 1. Blister design parameters

Student	Parameters		Value	Measurement units
S1	Blister length	L	415-10	[mm]
S1	Blister width	W	300-10	[mm]
S1	Blister height	H	50	[mm]
S1	Blister connection radius (raza racord)	Rc	15	[mm]
S2	Blister lateral support/wall Angle	LsA	2	[deg]
	Handle length	Hl	90	[mm]
	Handle width	Hw	20	[mm]
	Handle filet radius	Hr	15	[mm]
S3	Minimal distance from the blister edge/border	Db	20	[mm]
S3	Positioning height of the piece compared to the blister surface	Hp	10	[mm]
S2	Blister thickness	Tk	2	[mm]
S2	Blister – component contact distance	Cd	1	[mm]
S2	Blister – component clearance distance	Cld	2	[mm]
S3	Blister – component contact zones 			
S3	Positioning of the component on the blister	☐ Parallel with the blister edge	☐ At an angle Angle value: .... [deg]	

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

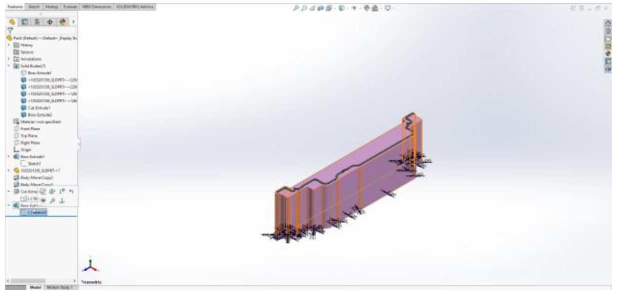
NextGEng

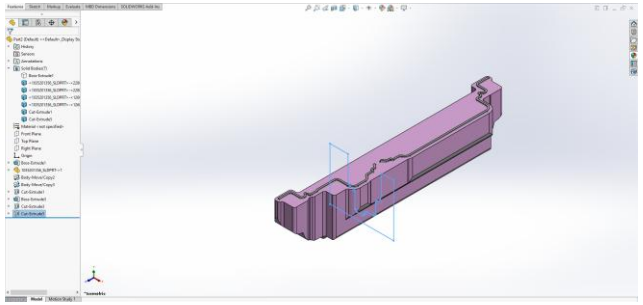
Blister design procedure

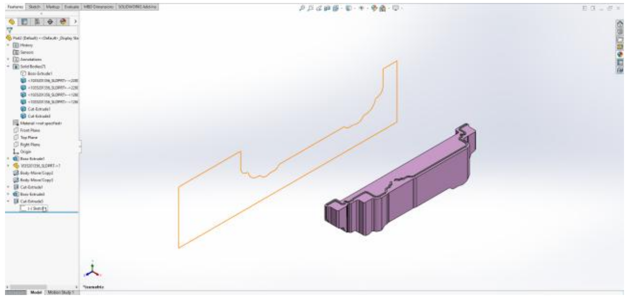
Design steps for the blister

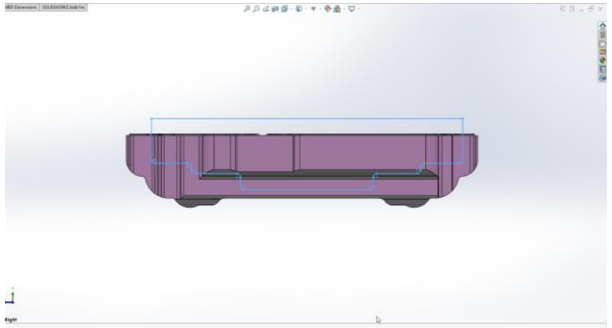
IV. Prototyping

- **Develop the negative of the part**
  - **Method 1**







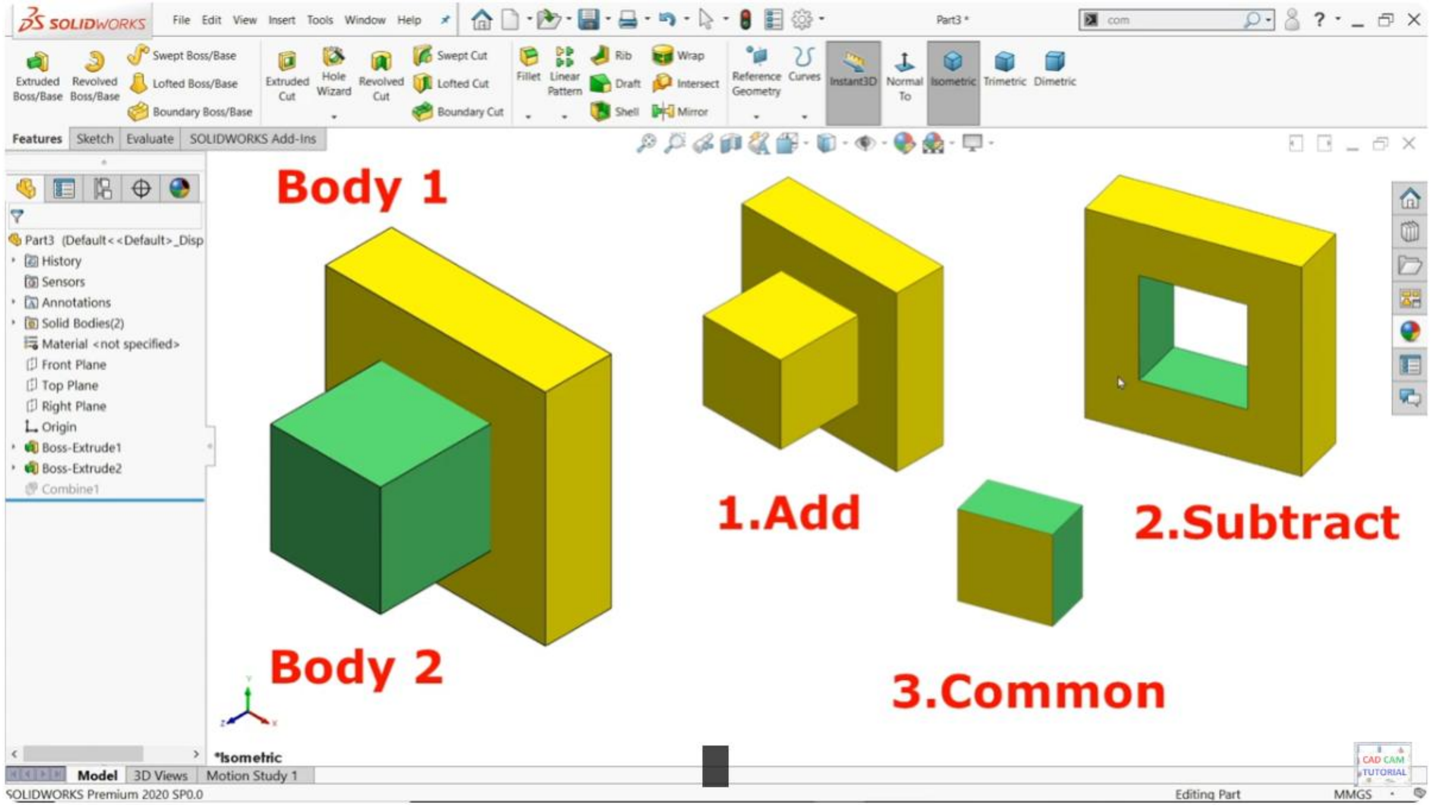


Blister design procedure

Design steps for the blister

IV. Prototyping

- **Develop the negative of the part**
- **Method 2**



Co-funded by the European Union

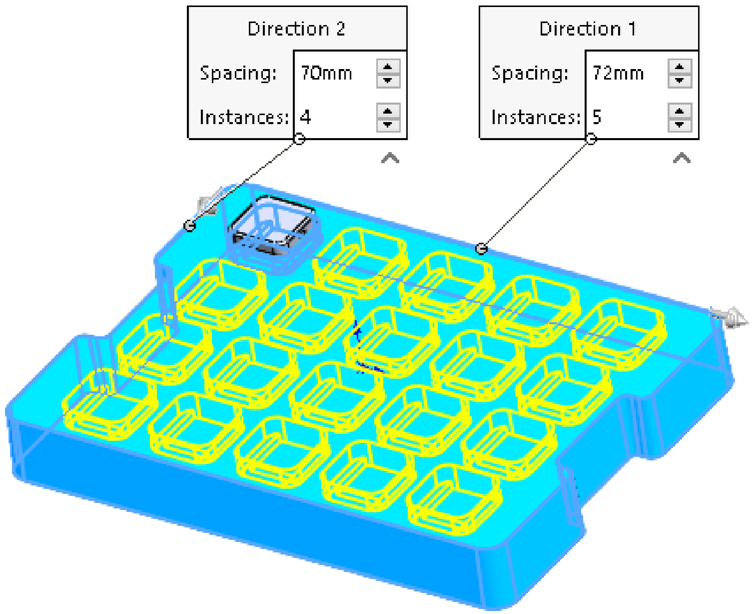
NextGEng

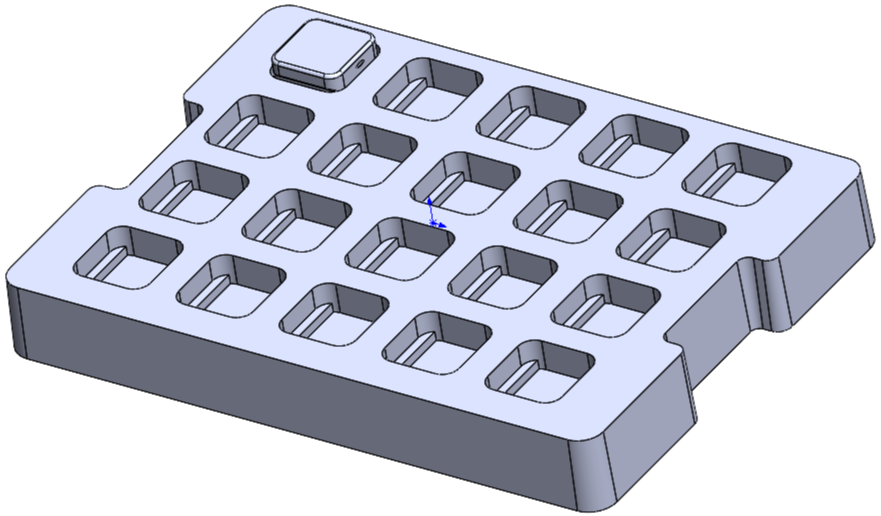
Blister design procedure

Design steps for the blister

IV. Prototyping

- **Multiply the negative of the part to obtain the blister**





Blister design procedure

Parametrized parts / Parametric modelling

- Def - **Parametric modelling** is a process where the geometry of a CAD model is defined using dimensional parameters; these parameters help to alter the model geometry just by adjusting their values.

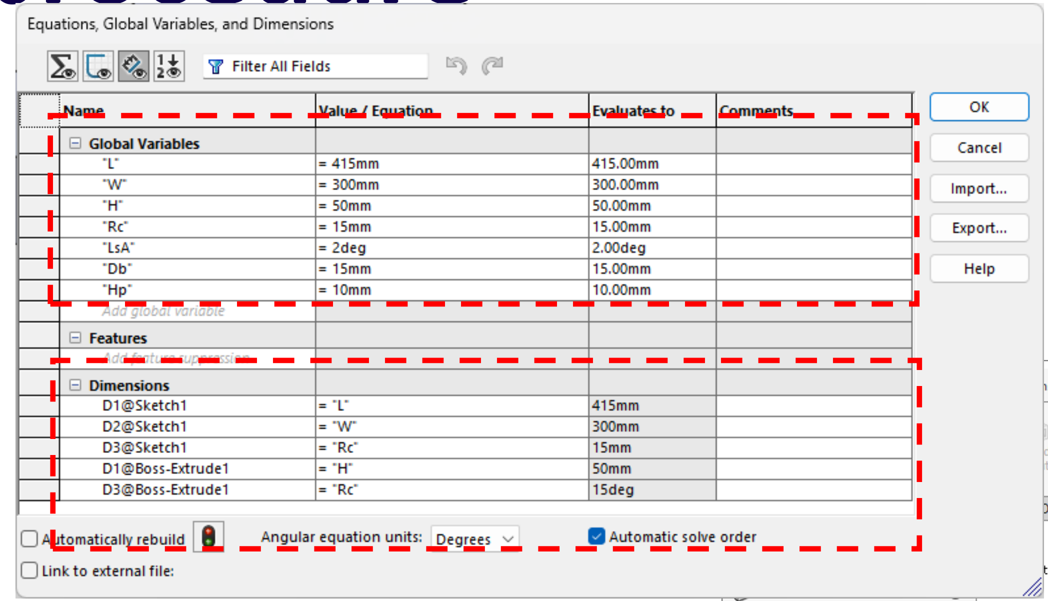
- Advantages
  - Creating dependencies between the dimensions of the part
  - Simplifies the part modification process
  - Mathematical relationships can be used for dimensioning

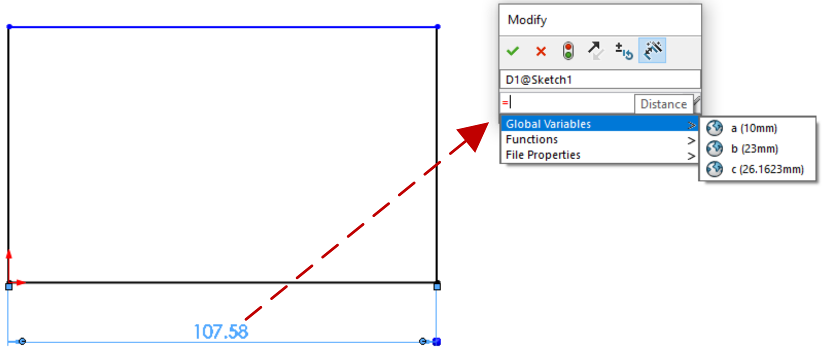
Co-funded by the European Union

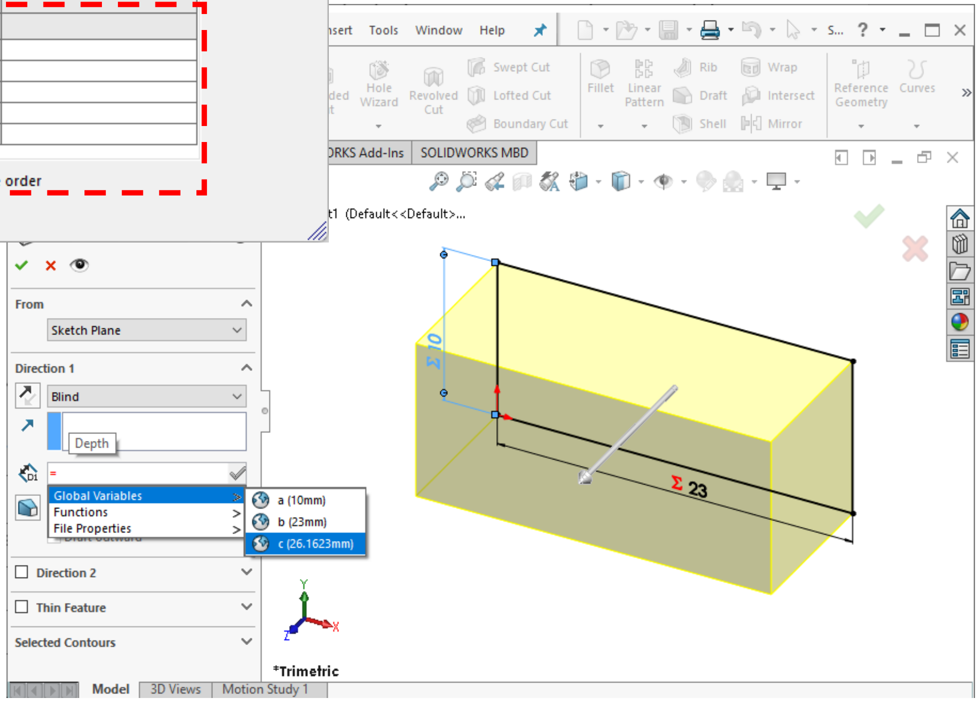
Blister design procedure

Parametric modelling

- How to?





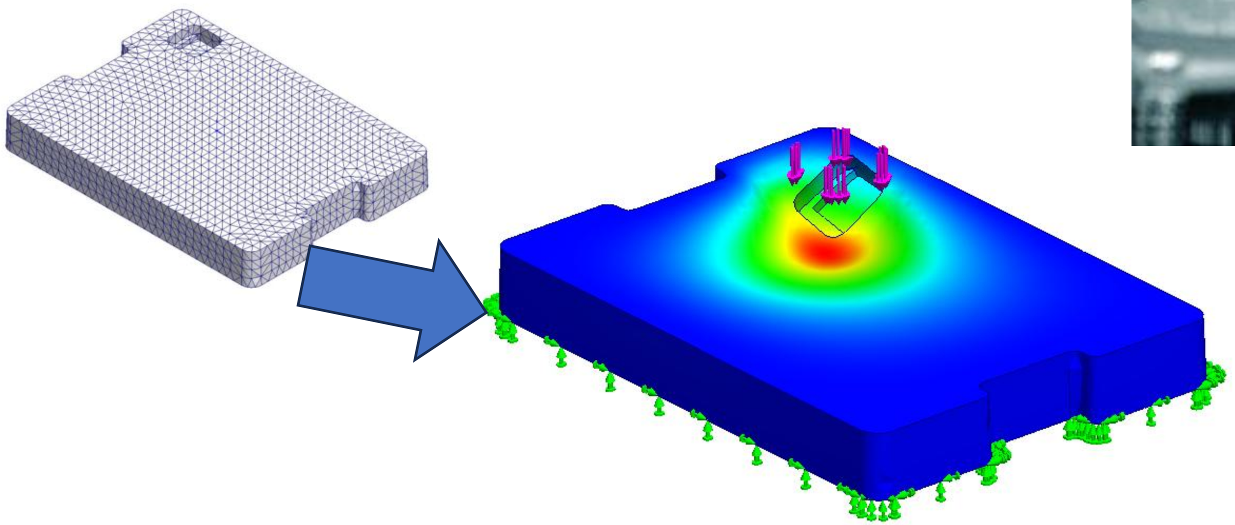


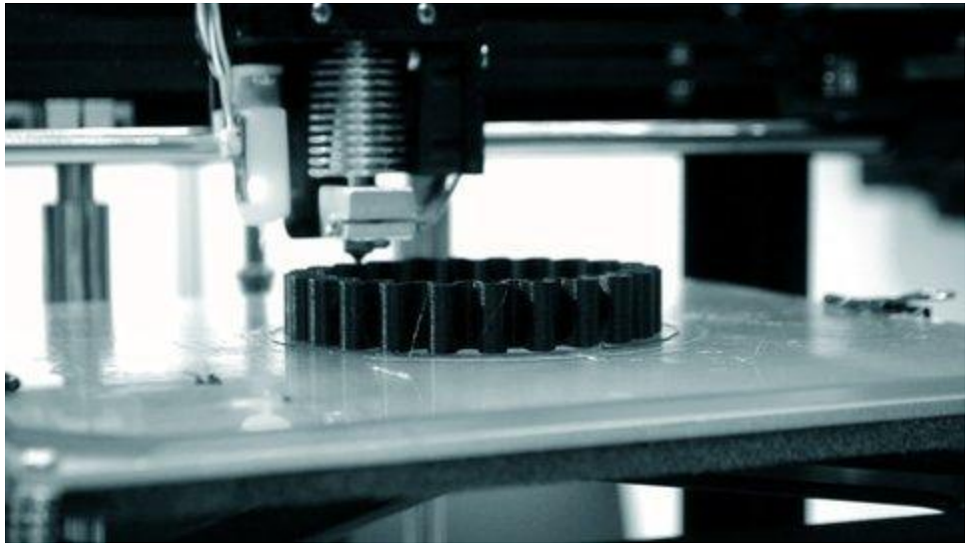
Blister design procedure

Design steps for the blister

<u>IV. Test process of the Prototyping</u>

- **Simulations**
- **3D printing**





Co-funded by
the European Union

NextGEng

Laboratory work

Co-funded by
the European Union

Design requirements

Working procedure:

- groups of 3 students
  - student 1 – logistics;
  - student 2 – ergonomics & thermoforming
  - student 3 – engineering & production

***Task**: Each student identifies the parameters specific to its field which influence the blister design and introduce the data inf provided document*

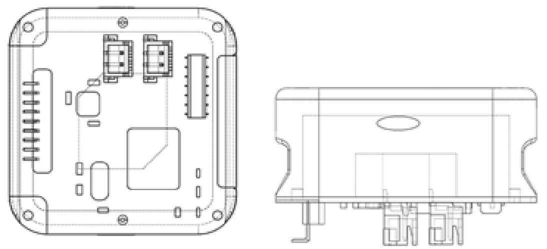
Co-funded by the European Union

NextGEng

C5 – Computer Aided Design – Laboratory activity

Topic: Design of parametrized parts with application in logistics

Table 1. Blister design parameters

Student	*Parameters*		*Value*	*Measurement units*
S1	*Blister length*	*L*	415-10	[mm]
S1	*Blister width*	*W*	300-10	[mm]
S1	*Blister height*	*H*	50	[mm]
S1	*Blister connection radius (raza racord)*	*Rc*	15	[mm]
S2	*Blister lateral support/wall Angle*	*LsA*	*2*	*[deg]*
S3	*Minimal distance between parts*	*Dp*	*15*	[mm]
S2	*Blister thickness*	*Tk*	*2*	*[mm]*
S2	*Blister – component contact distance*	*Cd*	*1*	*[mm]*
S2	*Blister – component clearance distance*	*Cld*	*2*	*[mm]*
S3	*Blister – component contact zones* 			
S3	*Positioning of the component on the blister*	☐ *Parallel with the blister edge*	☐ *At an angle* *Angle value: .... [deg]*	
S3	*Inaltime pozitionare piesa fata de suprafata blister*	*Hp*	*5*	*[mm]*

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

TECHNICAL UNIVERSITY jamk Universidad de Jaén iSR www.isr.es Valmet BOSCH Invented for life

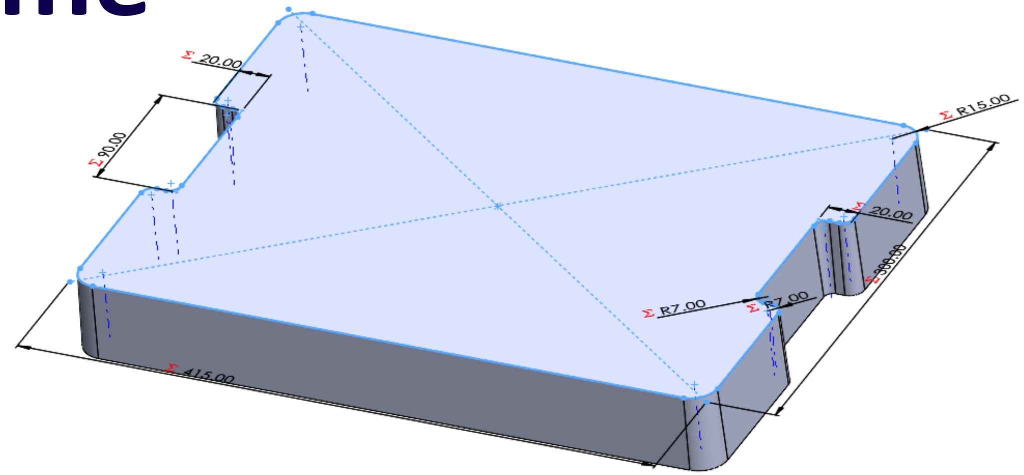
3D model of the blister frame

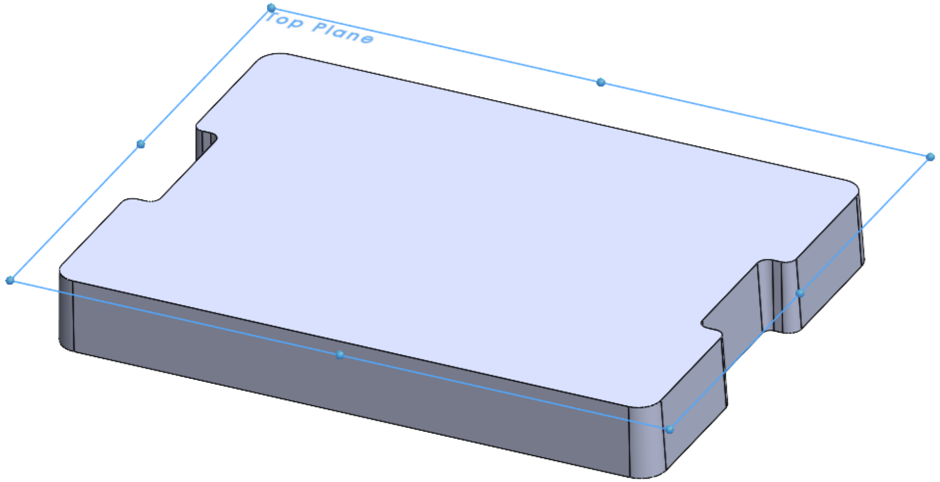
Working procedure:

- The work is performed by each student individually

***Tasks**:*

- *Introduce in equations the obtained parameters*
- *Define the bister frames using the eq. param.*

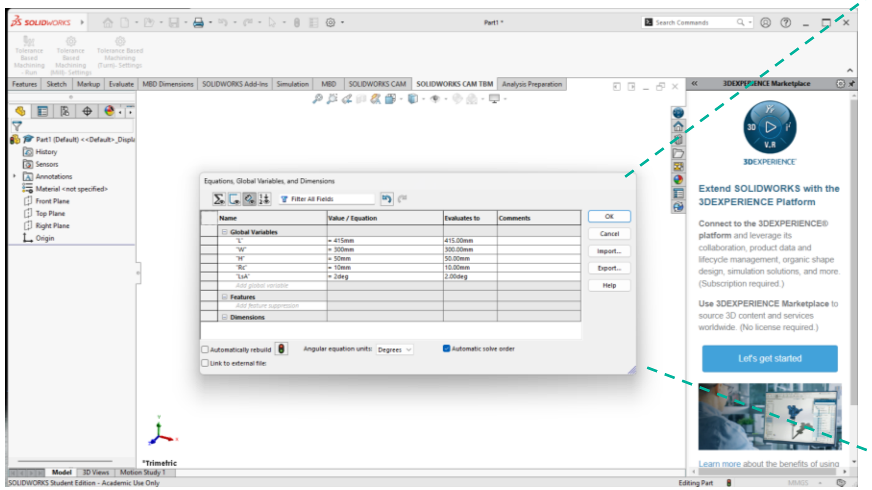


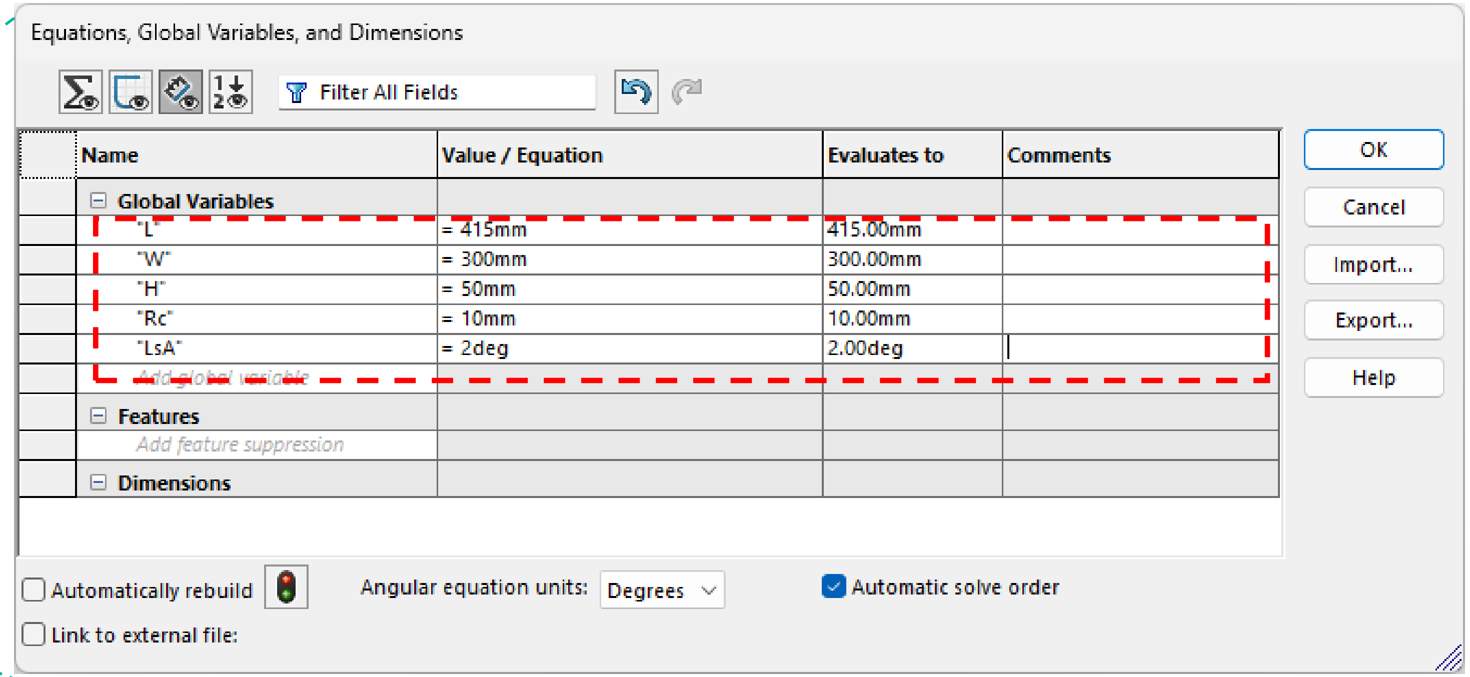


3D model of the blister frame

Step 1

- A new part is created in SolidWorks.
- In the new part, from the *Tools* menu, the *Equation* command is used to define the blister's geometric parameters.

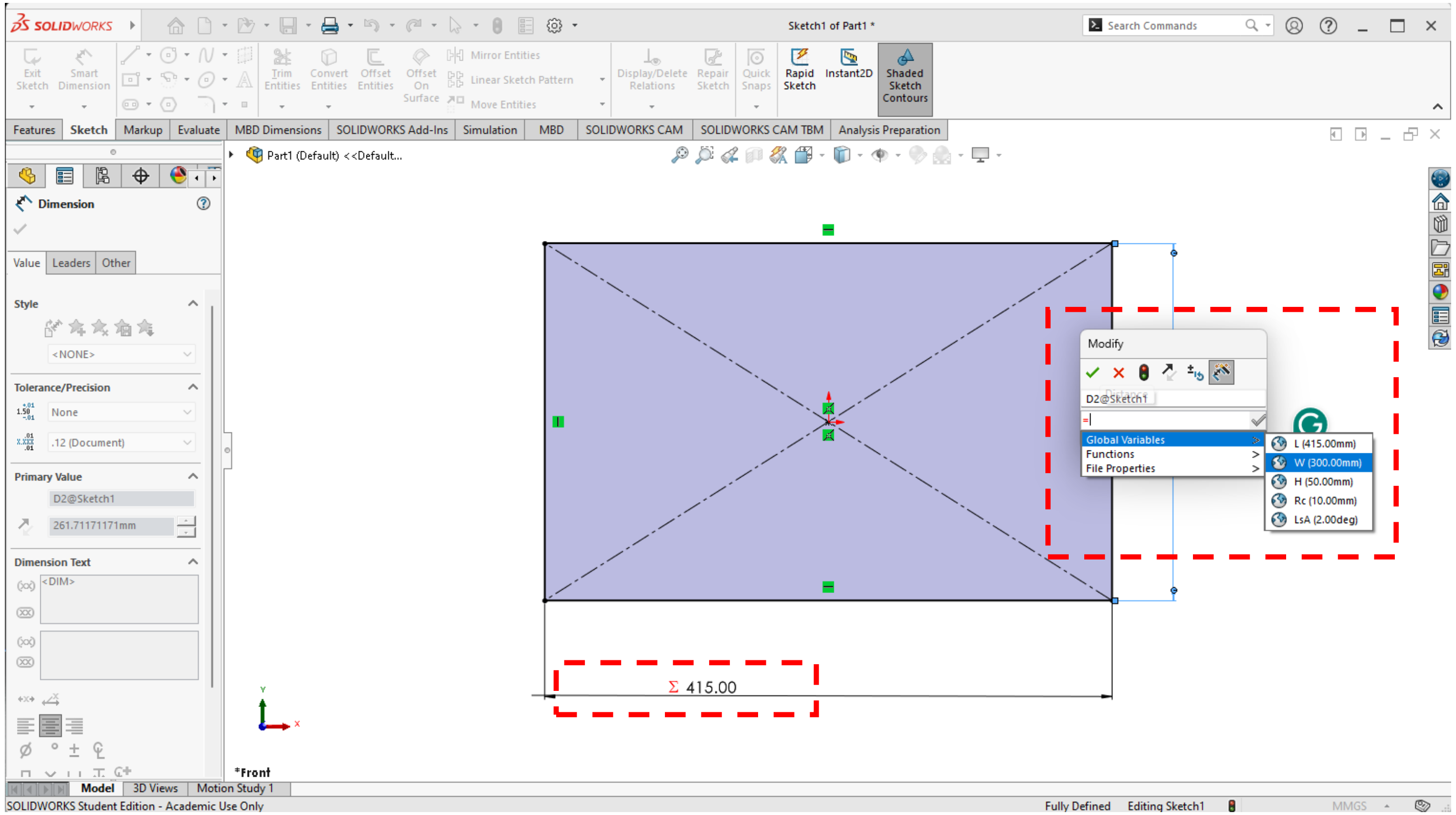




3D model of the blister frame

Step 2

- On the **Top Plane**, a new sketch is created
- define the blister frame using the previously defined parameters.

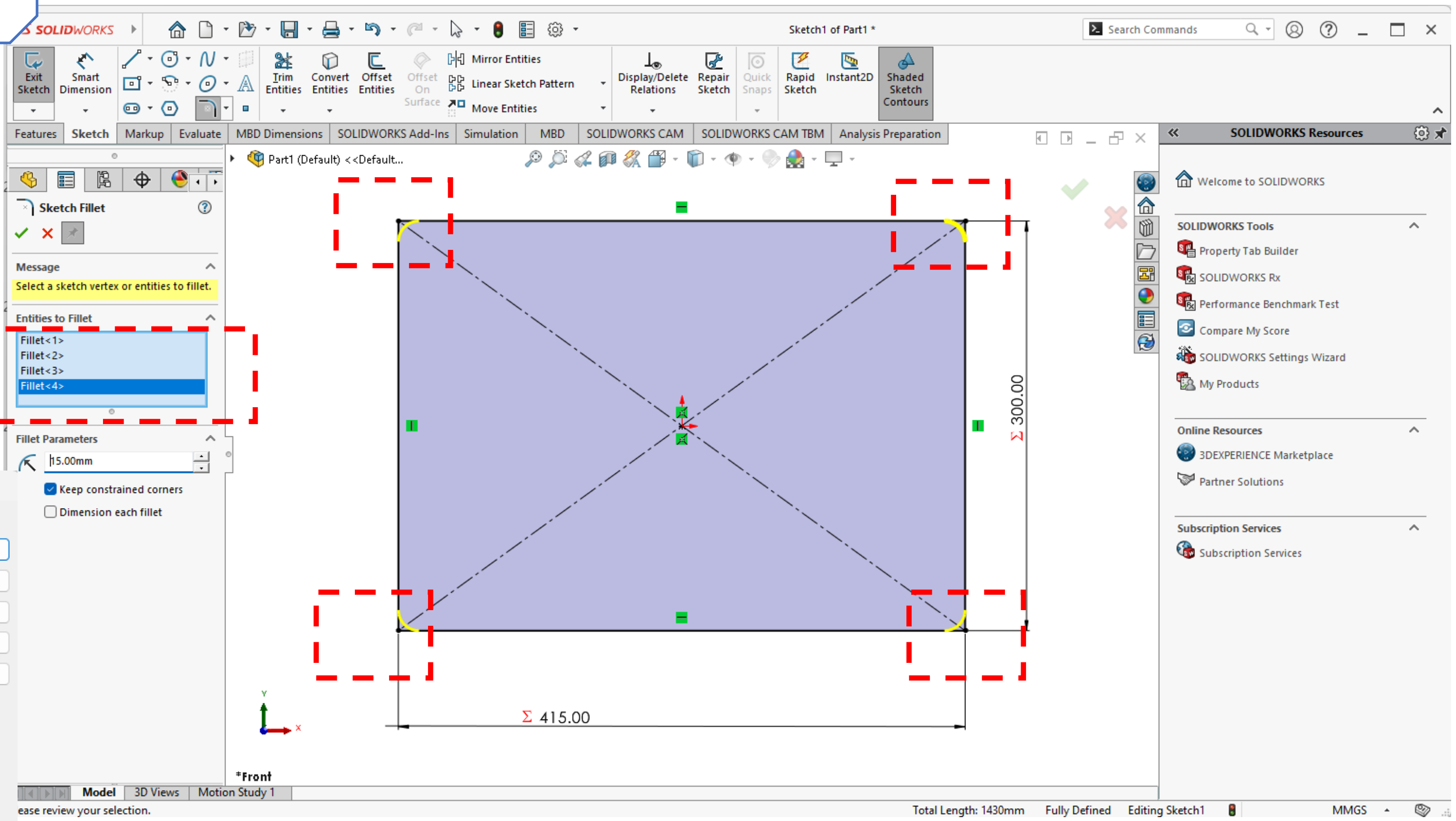


3D model of the blister frame

Step 3

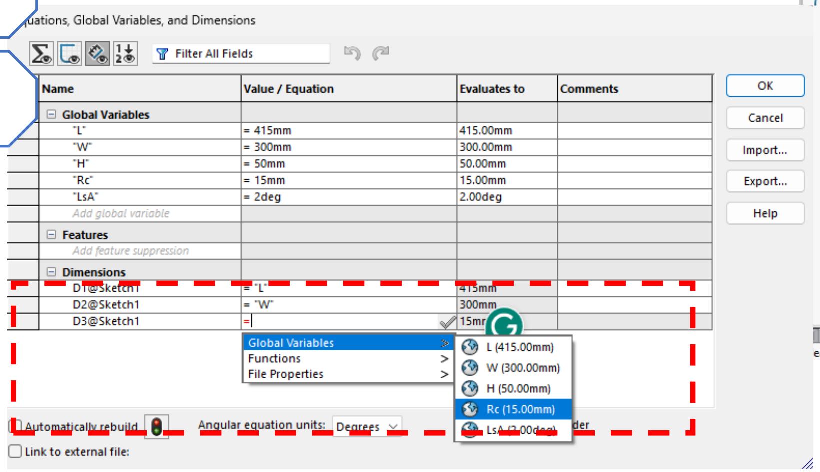
- Use *Sketch-Fillet* command to define the connection radius
- Associate in Equations the new radius with Rc variable

1



2

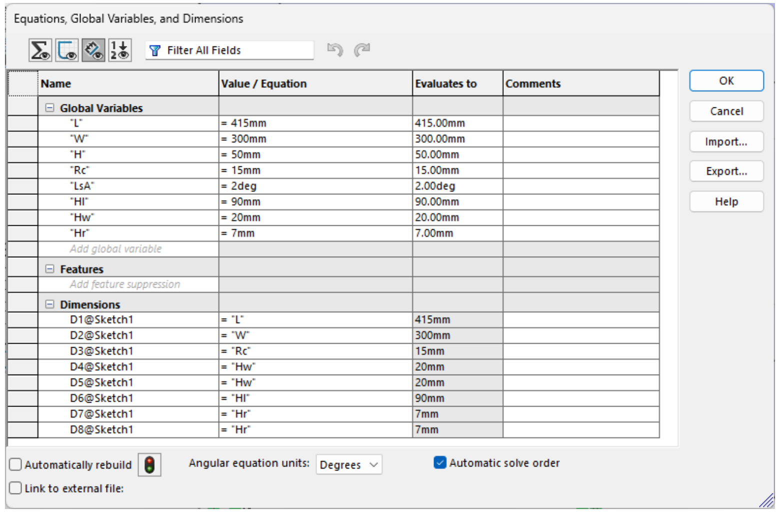
2



3D model of the blister frame

Step 4

- Define handle for the human operator
    - The handle is centred on the left and right side of the blister
    - Dimensions Hr, Hl and Hr


Equations, Global Variables, and Dimensions

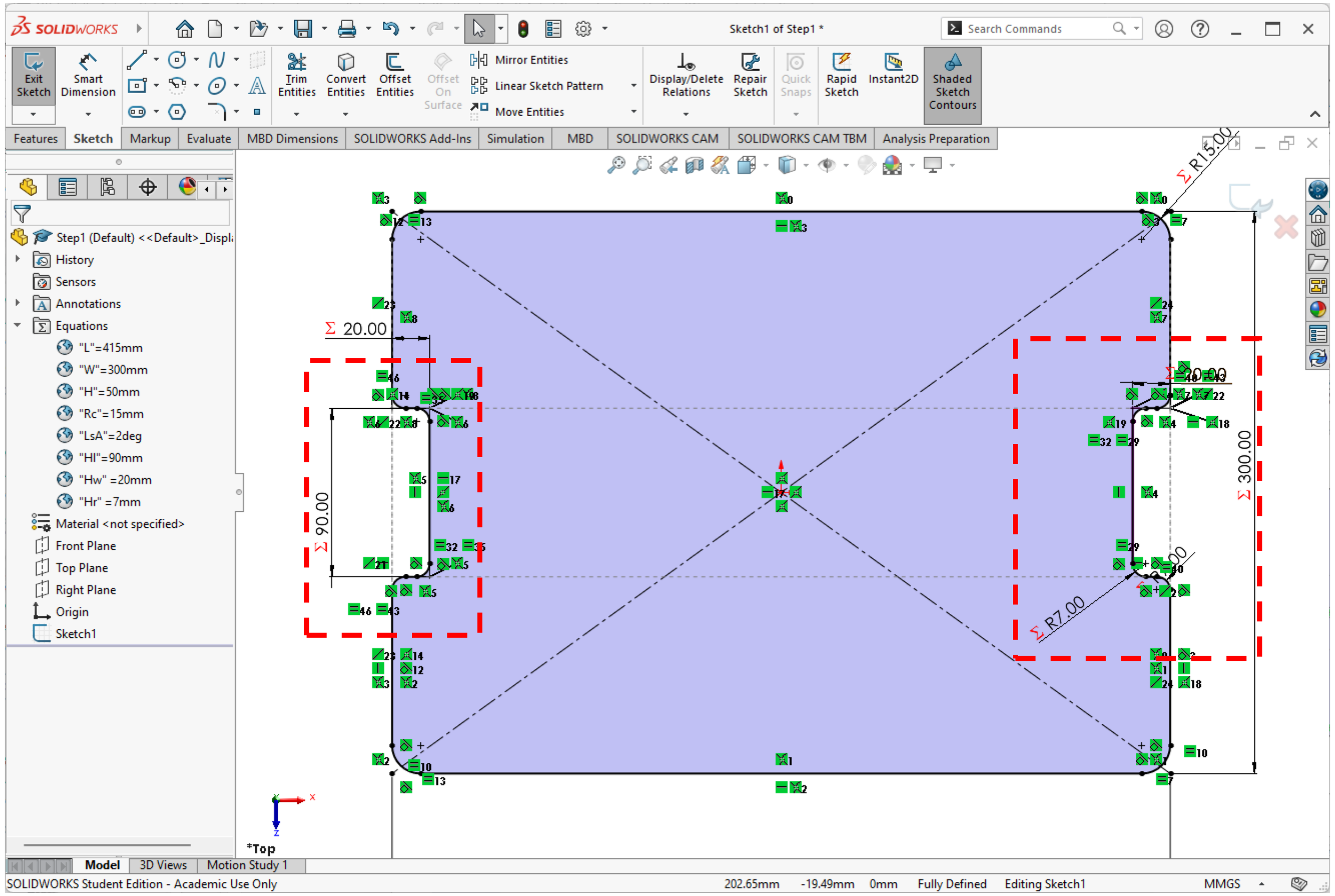
Filter All Fields

Name	Value / Equation	Evaluates to	Comments
Global Variables			
"L"	= 415mm	415.00mm	
"W"	= 300mm	300.00mm	
"H"	= 50mm	50.00mm	
"Rc"	= 15mm	15.00mm	
"LsA"	= 2deg	2.00deg	
"Hl"	= 90mm	90.00mm	
"Hw"	= 20mm	20.00mm	
"Hr"	= 7mm	7.00mm	
Add global variable			
Features			
Add feature suppression			
Dimensions			
D1@Sketch1	= "L"	415mm	
D2@Sketch1	= "W"	300mm	
D3@Sketch1	= "Rc"	15mm	
D4@Sketch1	= "Hw"	20mm	
D5@Sketch1	= "Hw"	20mm	
D6@Sketch1	= "Hl"	90mm	
D7@Sketch1	= "Hr"	7mm	
D8@Sketch1	= "Hr"	7mm	

OK Cancel Import... Export... Help

Automatically rebuild Angular equation units: Degrees Automatic solve order

Link to external file:



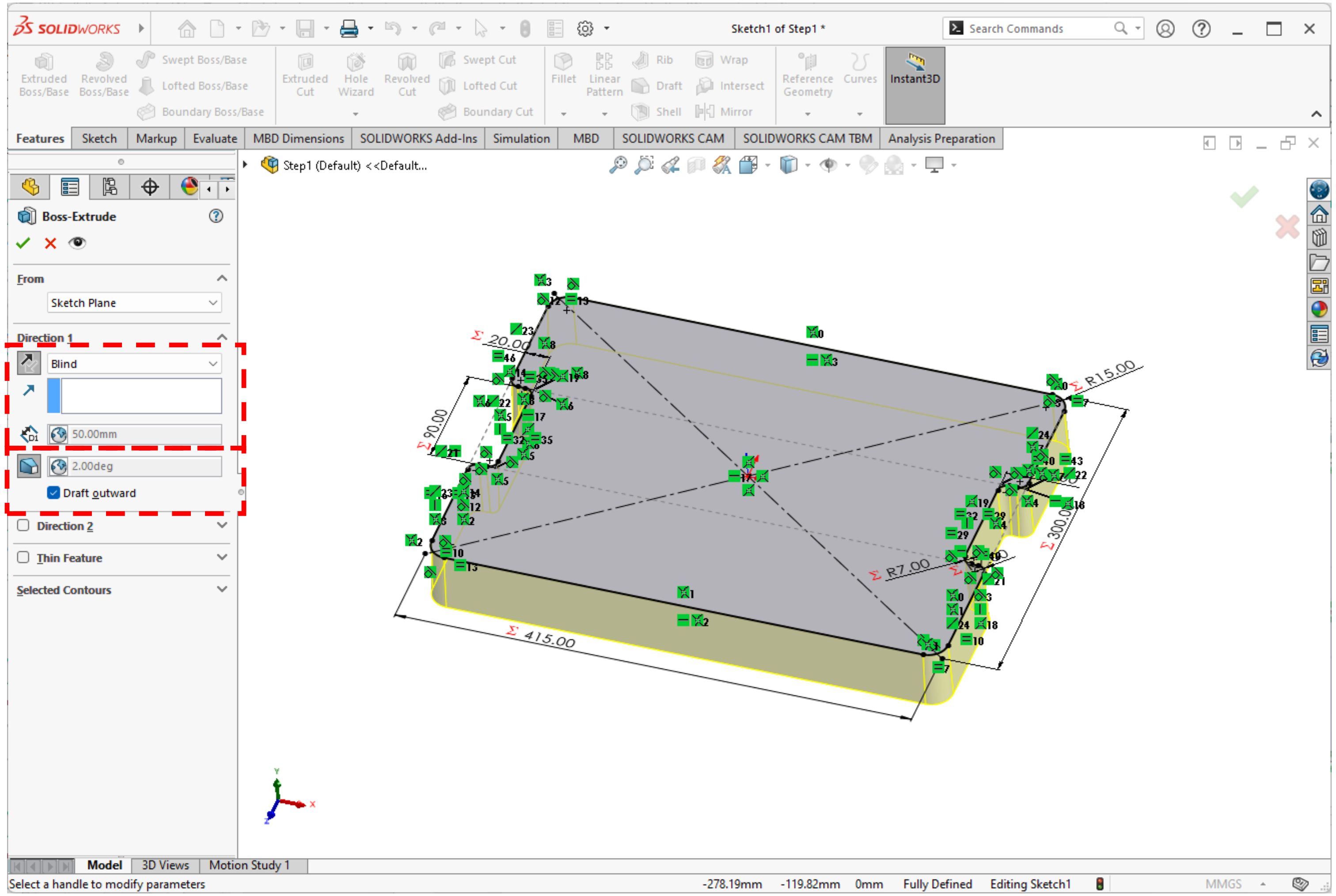
Co-funded by the European Union

NextGEng

3D model of the blister frame

Step 4

- Use *Boss- extrude* command to define the blister's body



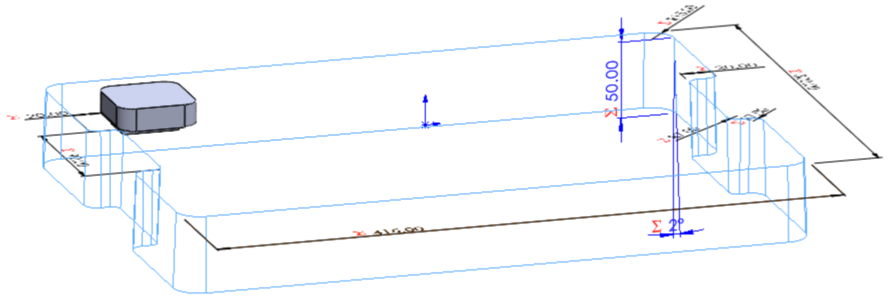
Co-funded by the European Union

NextGEng

Define the negative of the part

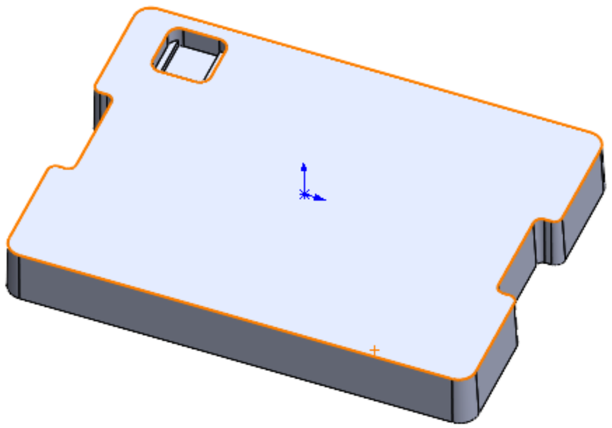
Working procedure:

- The work is performed by each student individually



Tasks:

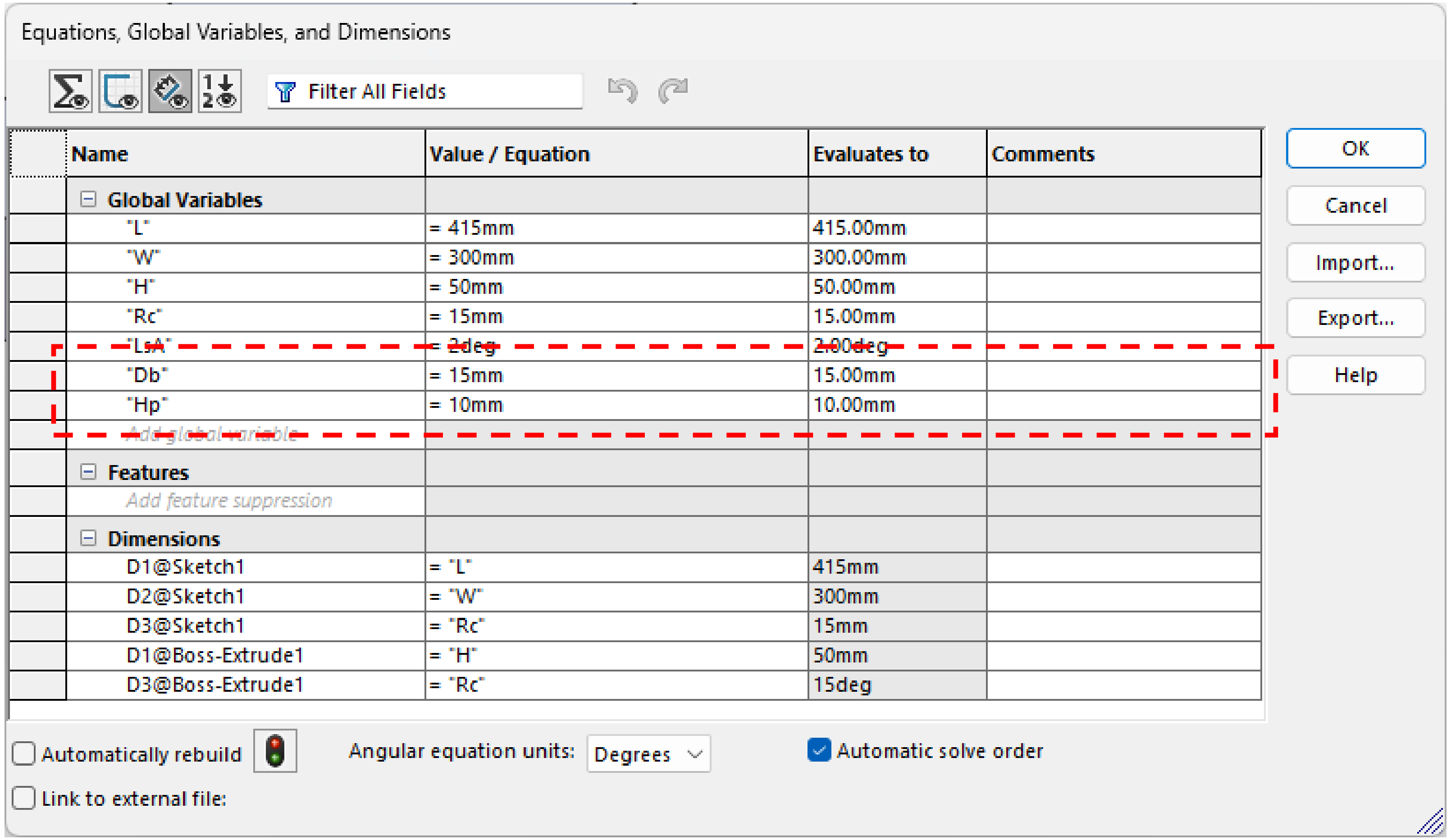
- *Insert the part in SW*
- *Create the negative of the part*
- *Create the nest/cavity for the part*



Define the negative of the part

Step 1

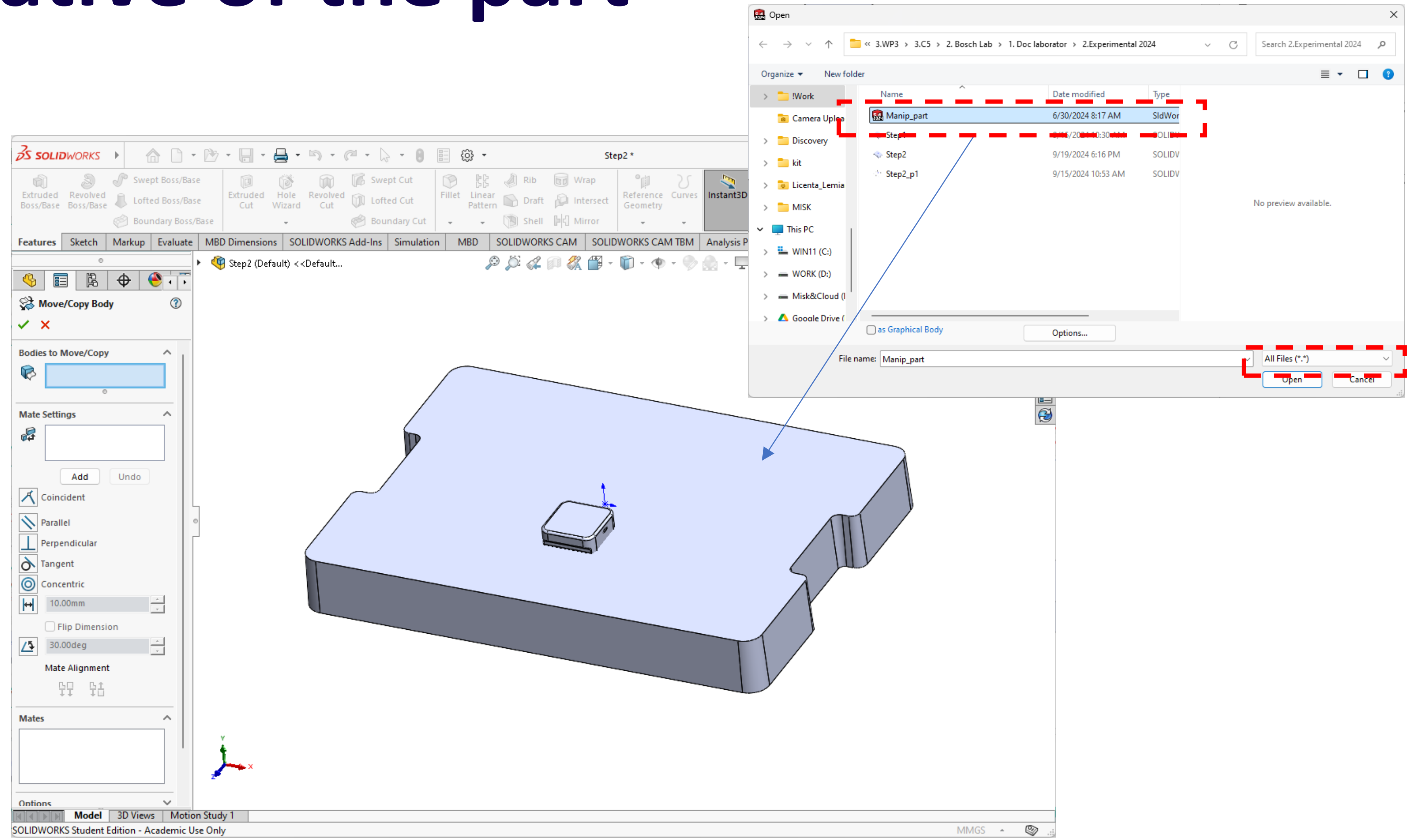
- Define in Equation the parameters for the position of the first part on the blister



Define the negative of the part

Step 2

- **Insert the component in the part**
    - Menu ***Insert***, command *Part*
    - In file type select *“All files”*



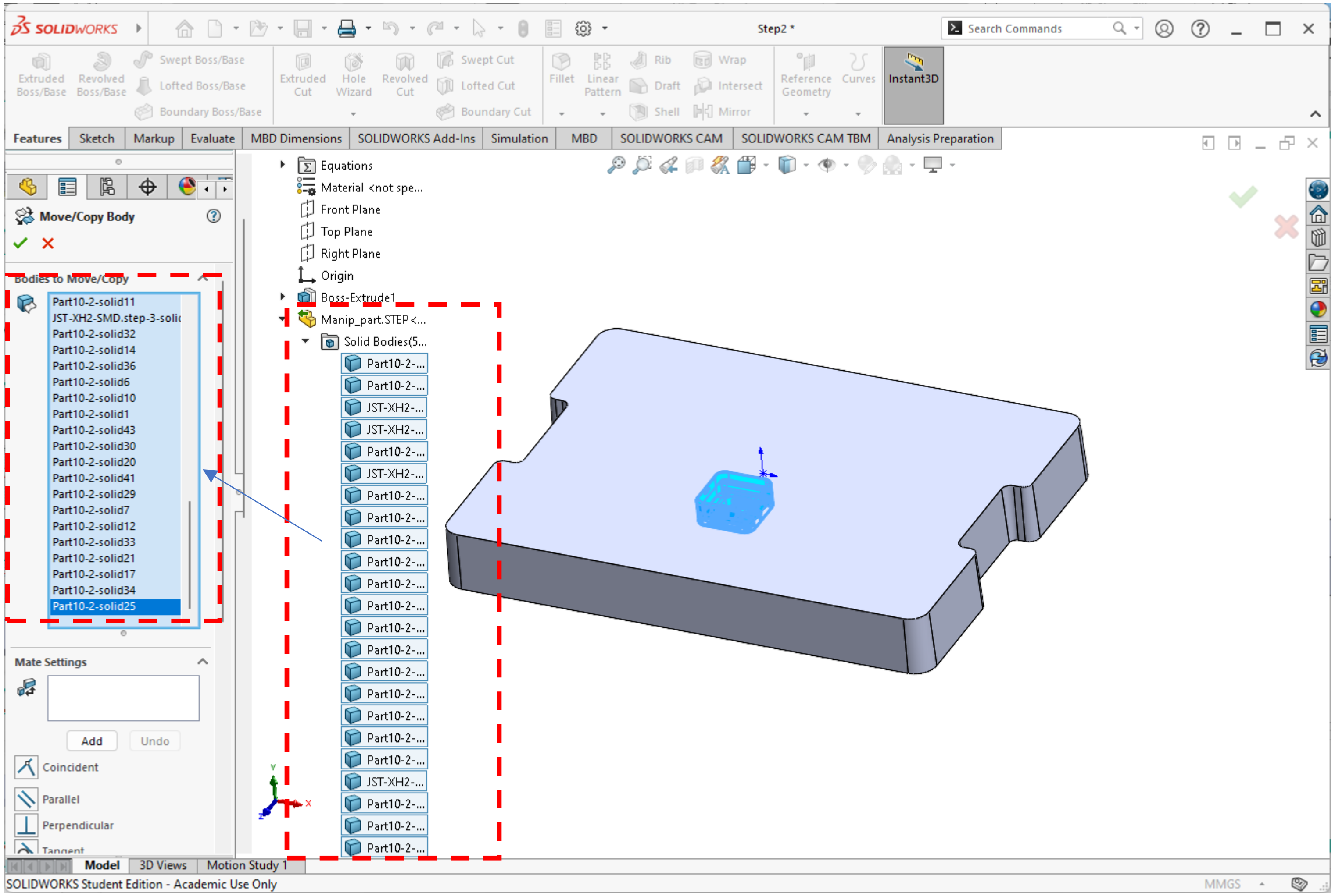
Co-funded by the European Union

NextGEng

Define the negative of the part

Step 3

- **Position the inserted component to the first nest location**
  - menu ***Insert/Surface*** command *Move/Copy…*
  - in *Bodies to move* select all bodies from the *step* part



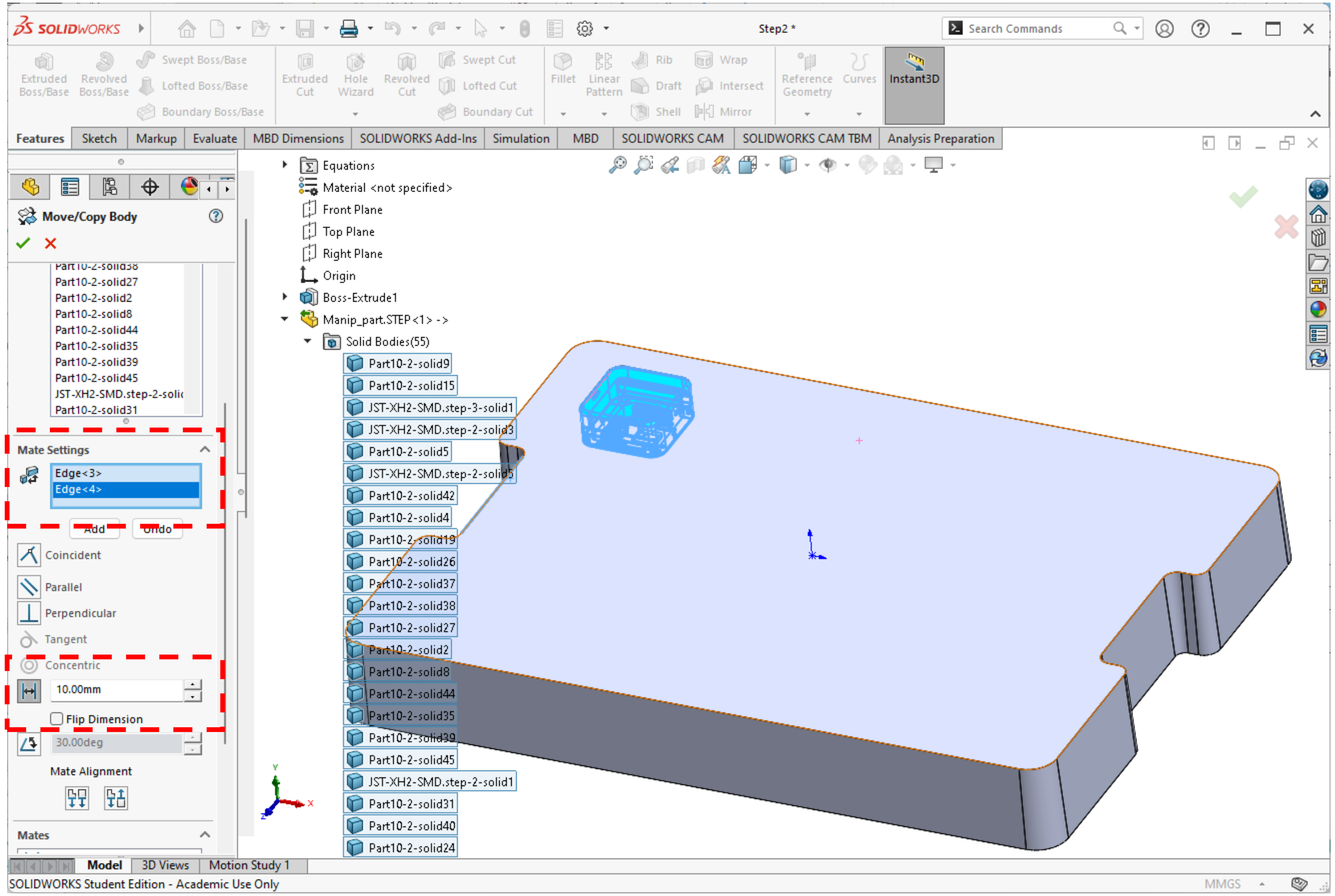
Co-funded by the European Union

NextGEng

Define the negative of the part

Step 3

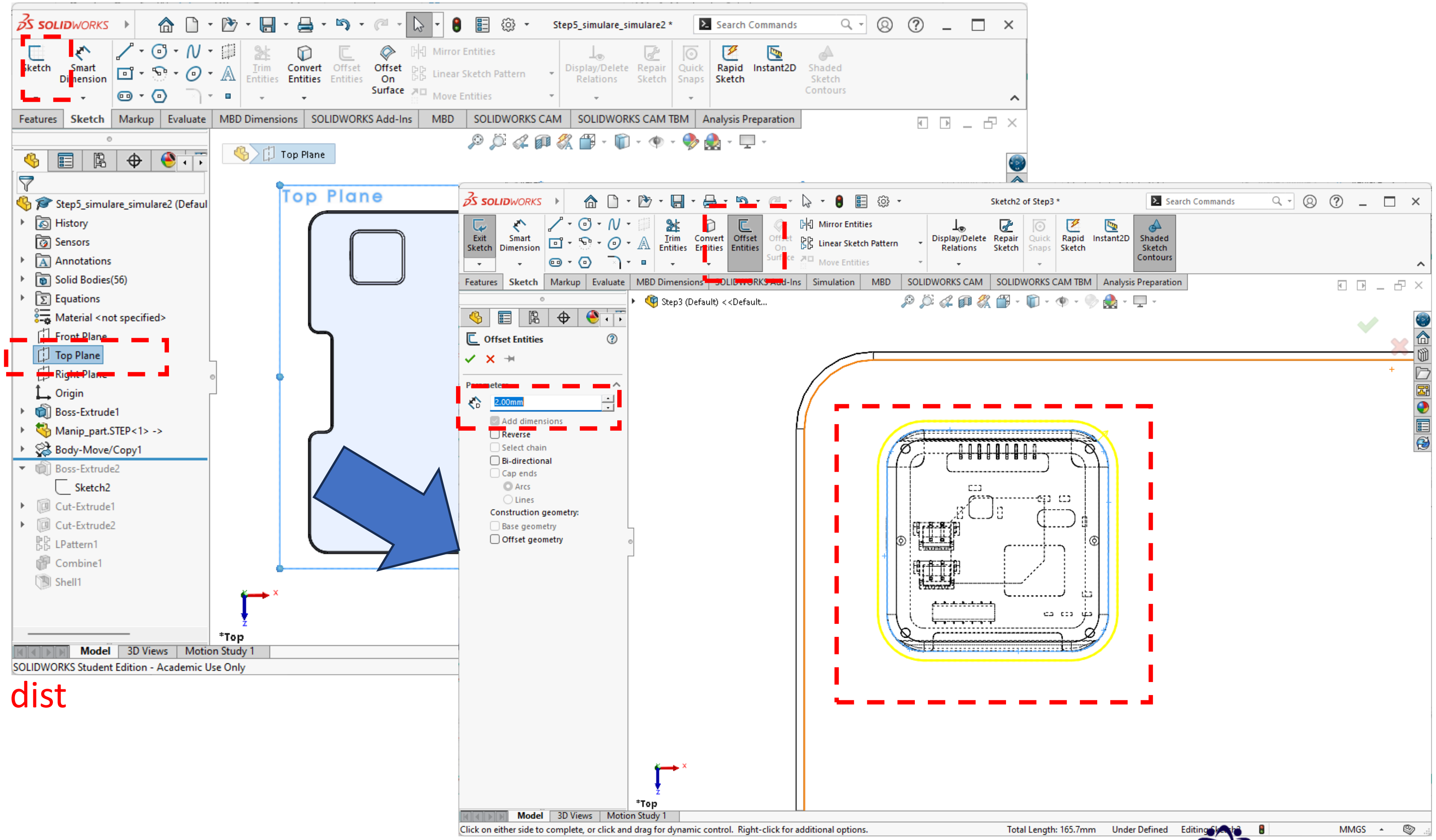
- **Position the inserted component to the first nest location**
  - Define distance mates between component and blister margins
  - Define distance mate between the top component face and blister's top face



Define the negative of the part

Step 4

- Define the component contour on ***Top Plane***
  - Create a new sketch on *Top plane*
  - Use *Offset Entities* to define the contour of the part

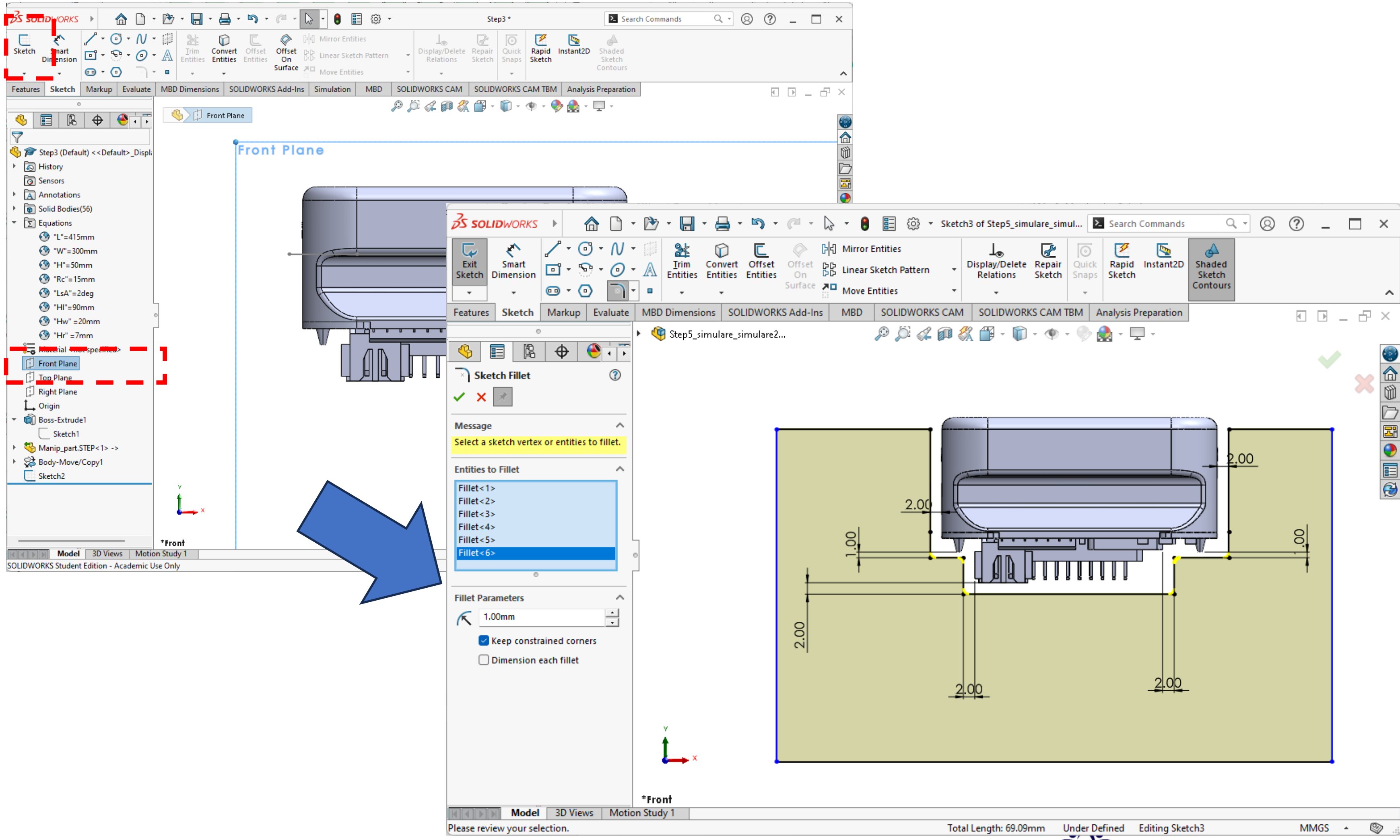


REFACERE POZE cu dist

Define the negative of the part

Step 5

- Define the component contour on ***Front Plane***
    - Create a new sketch on *Front plane*
    - Use *Offset Entities and lines* to define the contour of the part
        - Clearance – 2 mm
        - Contact 1 mm
        - Filet 1 mm



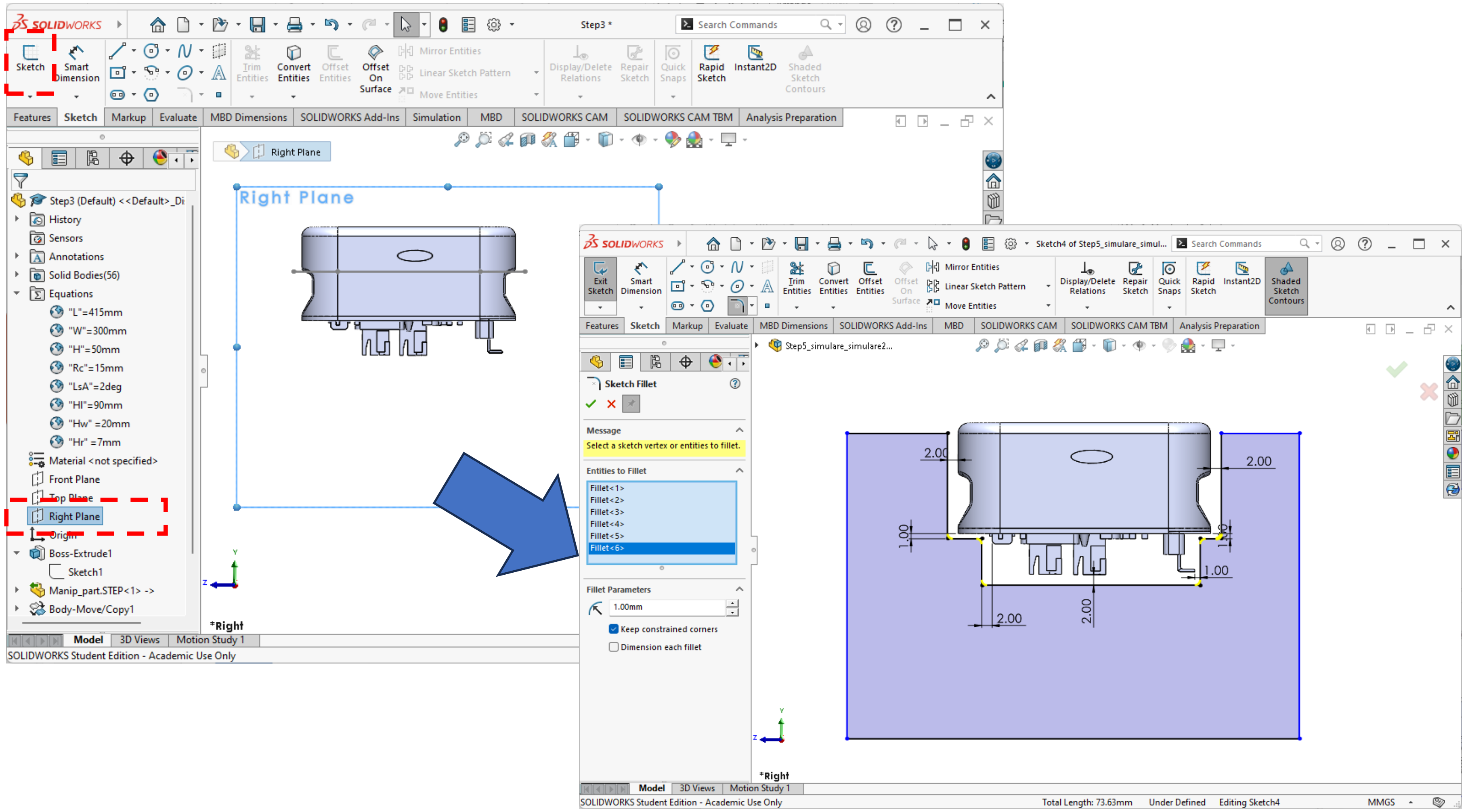
Co-funded by the European Union

NextGEng

Define the negative of the part

Step 6

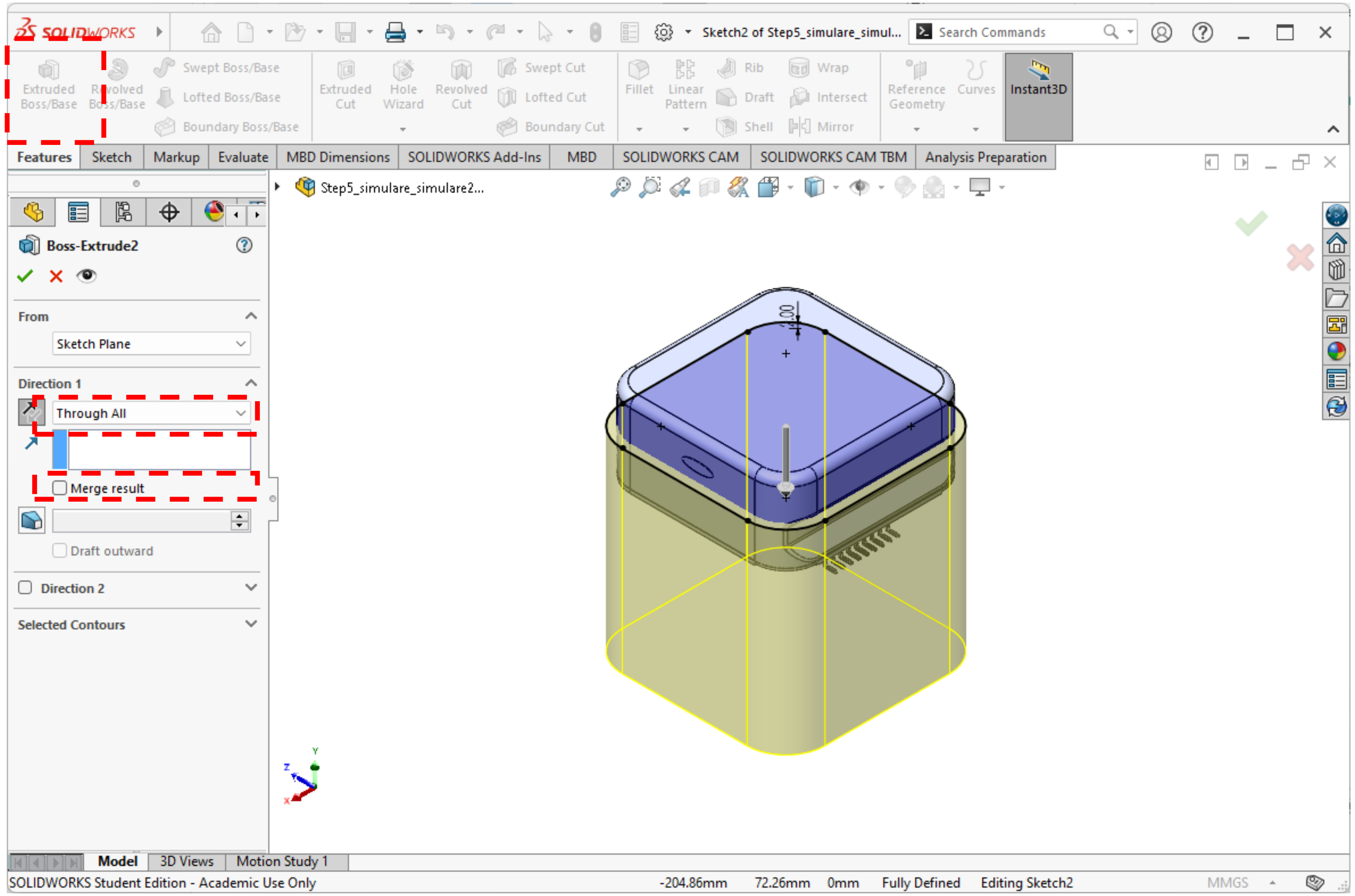
- Define the component contour on ***Right Plane***
  - Create a new sketch on *Right plane*
  - Use *Offset Entities and lines* to define the contour of the part



Define the negative of the part

Step 7

- On *Sketch 2* (Top plane) – use Extrude Boss
  - Through all
  - Unselect *merge result* option



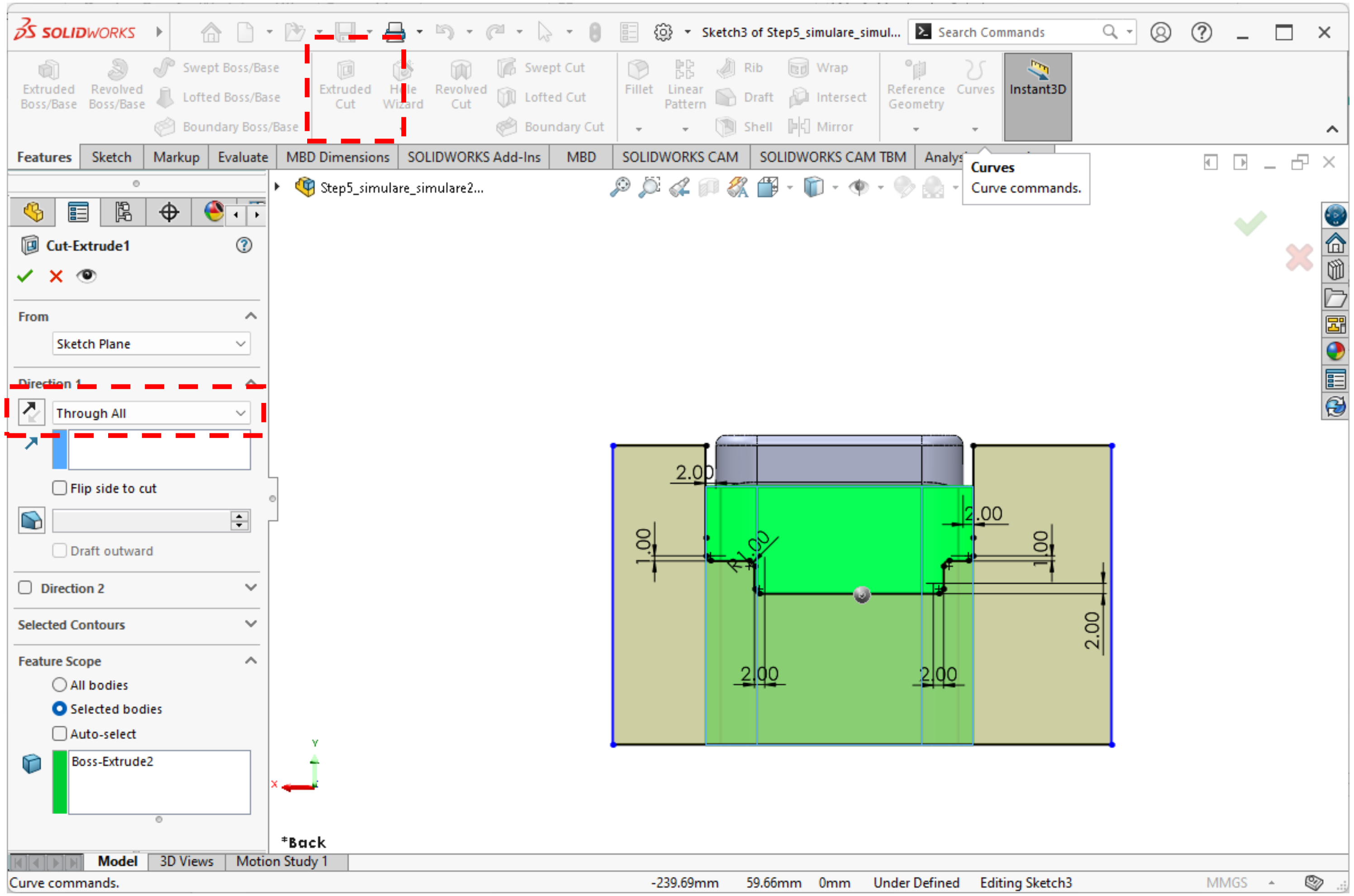
Co-funded by the European Union

NextGEng

Define the negative of the part

Step 8

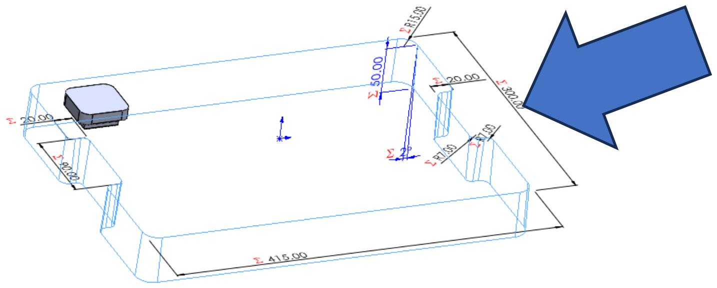
- On *Sketch 3* (Front plane) – use Extrude Cut
    - Option: *Through all*

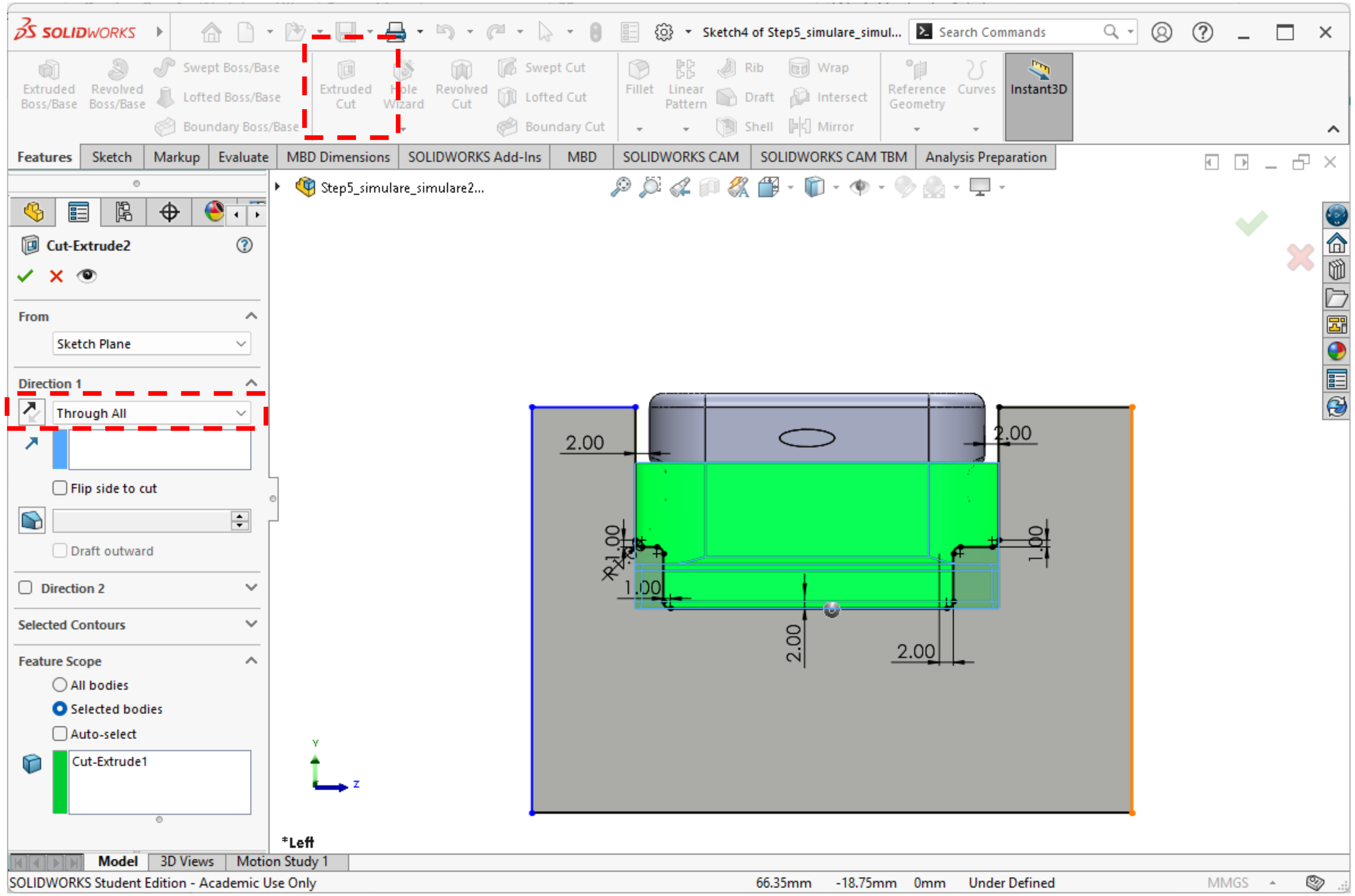


Define the negative of the part

Step 9

- On *Sketch 4* (Right plane) – use Extrude Cut
  - Through all





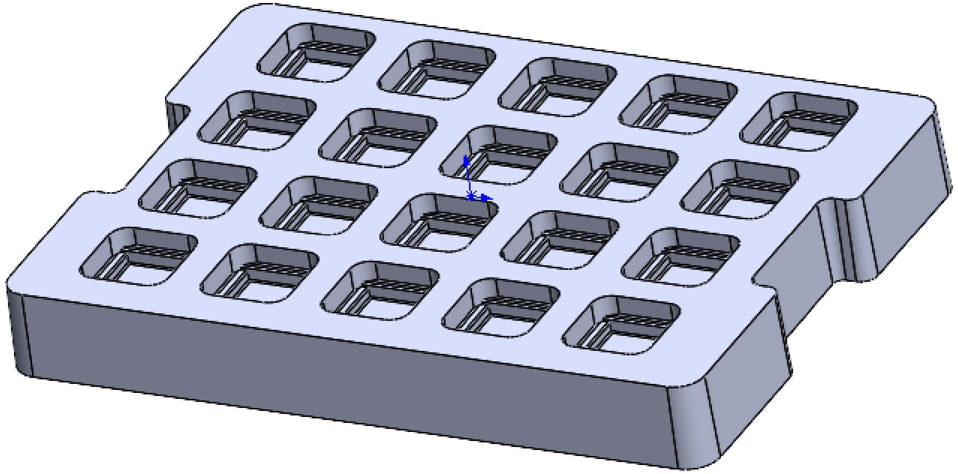
Define all nest on the blister

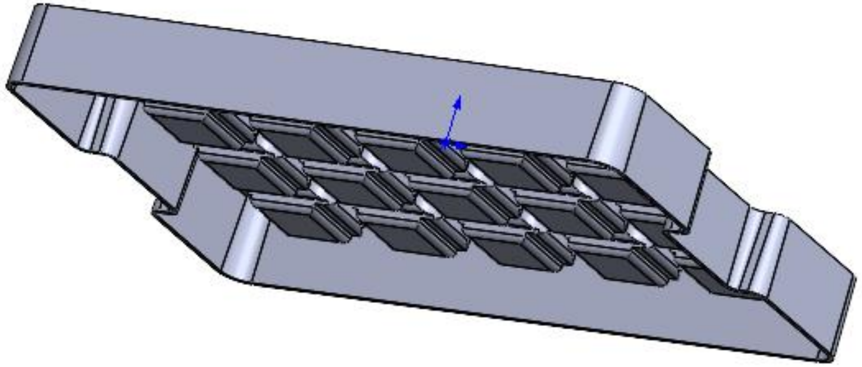
Working procedure:

- The work is performed by each student individually

Tasks:

- *Multiply the negative of the part*
- *Use combine command to obtain the nests*
- *Use shell to create the body of the blister*

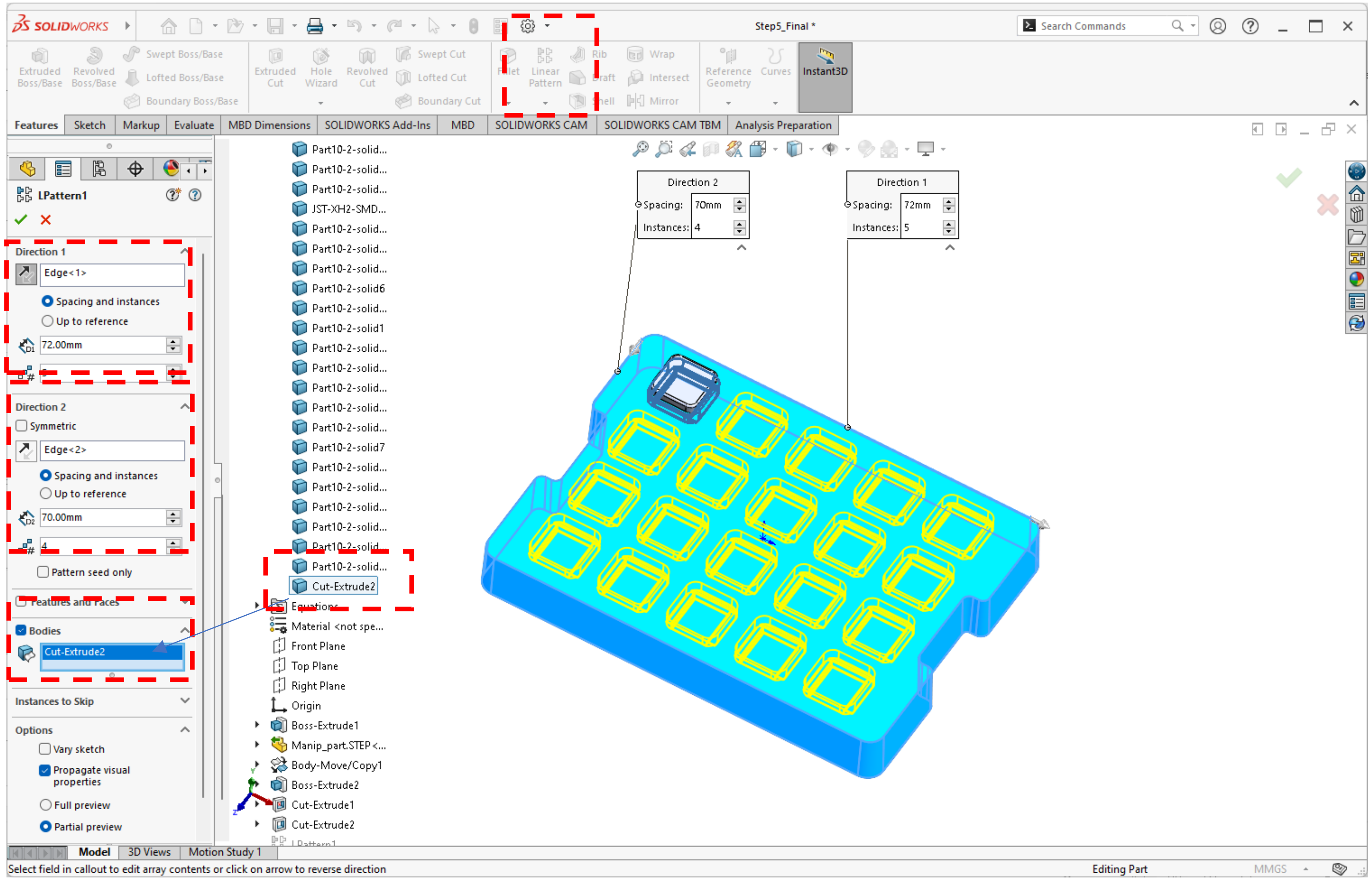




Define all nests on the blister

Step 1

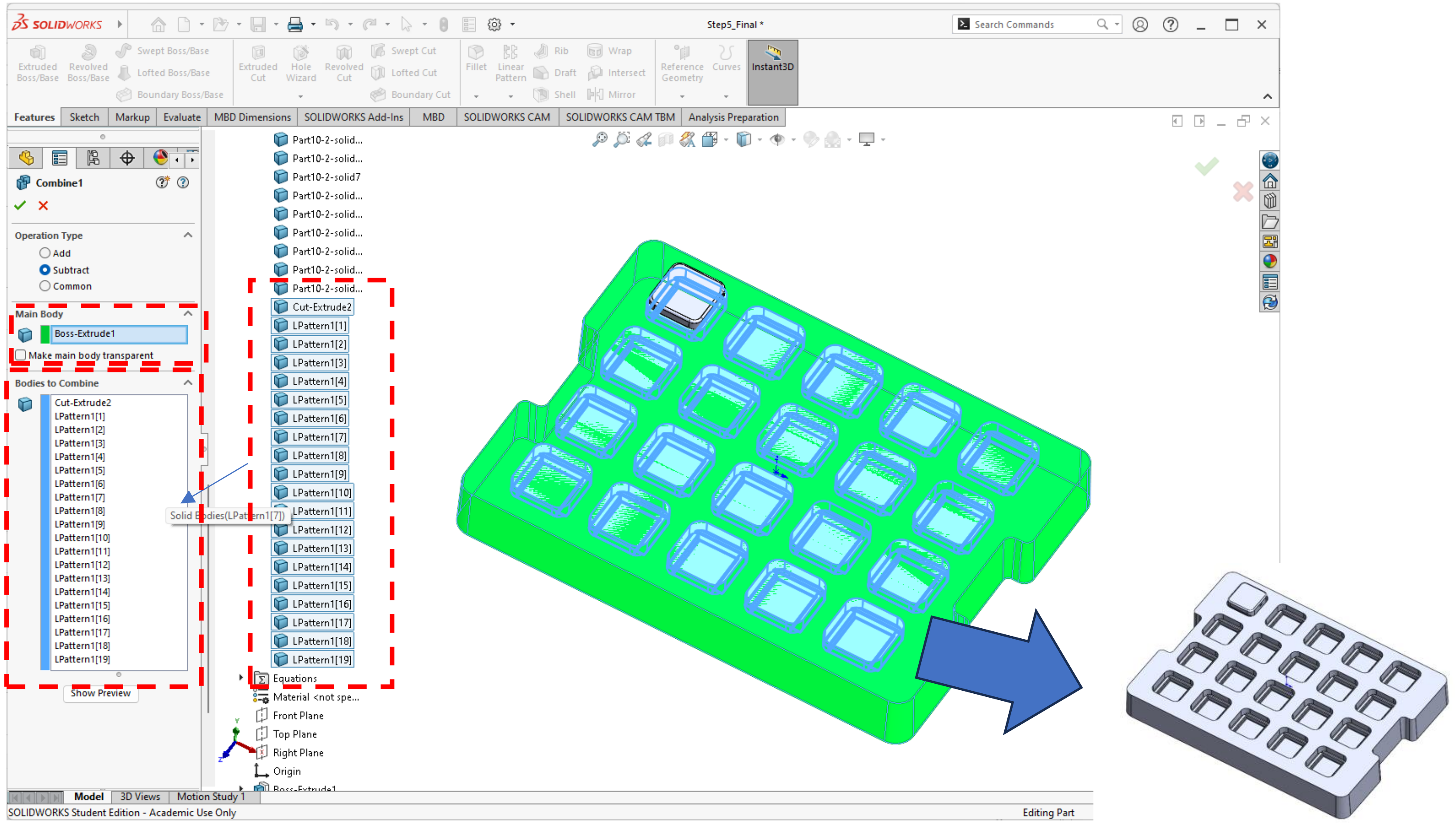
- Use the command *linear pattern*



Define all nests on the blister

Step 2

- Create the nests using the command: *Insert/Features/Combine*
  - Select from *Solid Bodies*
    - ***Main Body:*** *Boss Extrude 1*
    - ***Bodies to combine****:* *Cut extrude 1, LPattern 1…n*



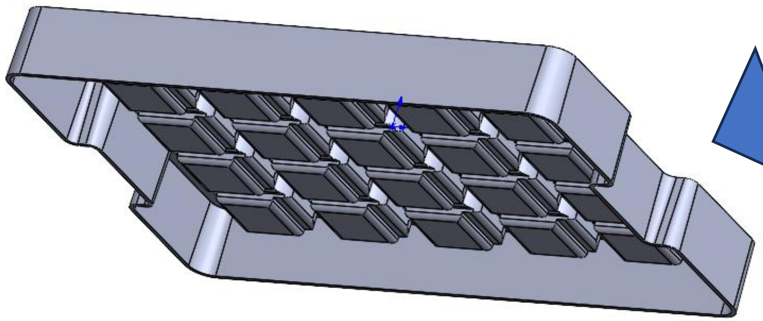
Co-funded by the European Union

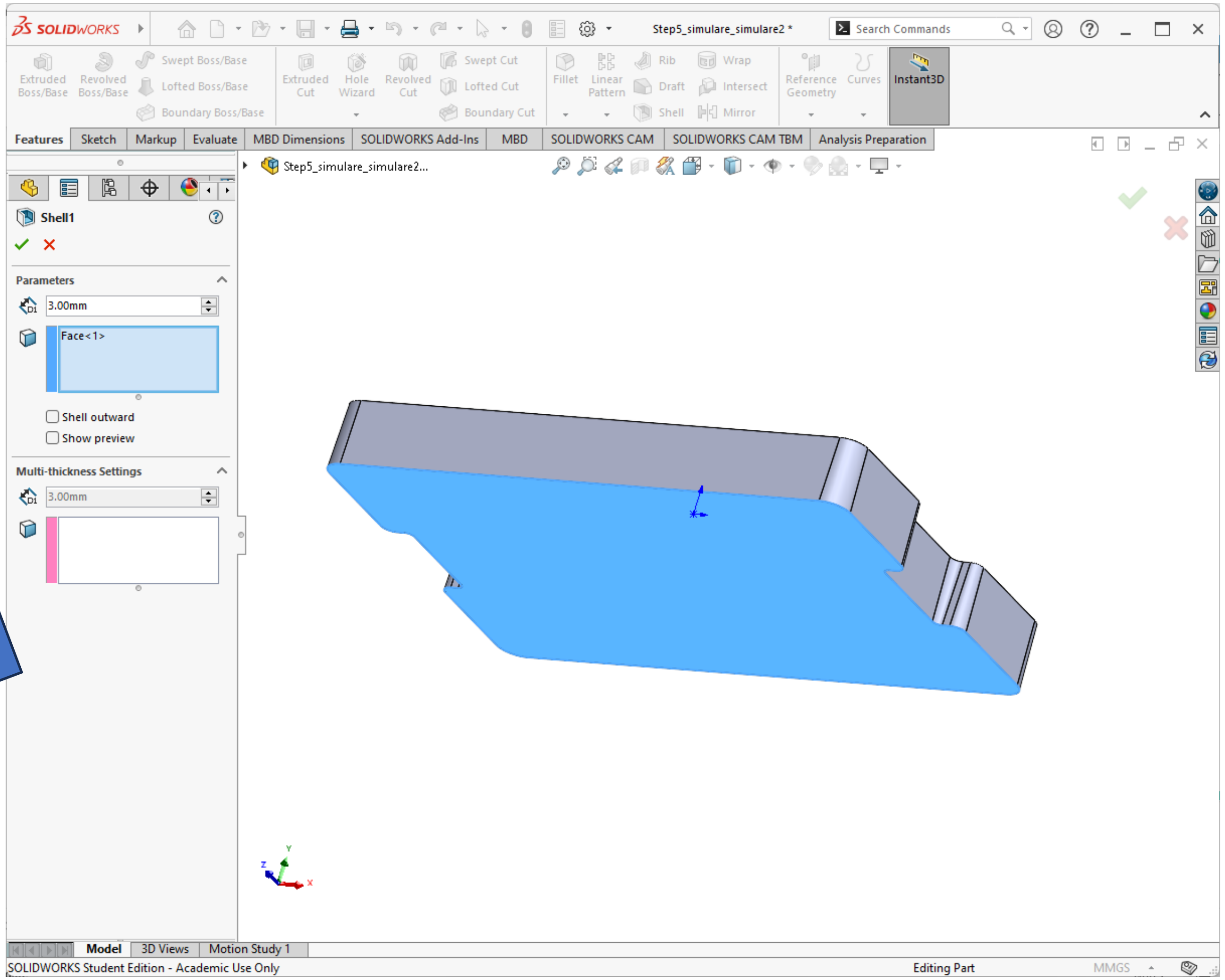
NextGEng

Populate the blister

Step 3

- On *Shell* command with a thickness of 3 mm

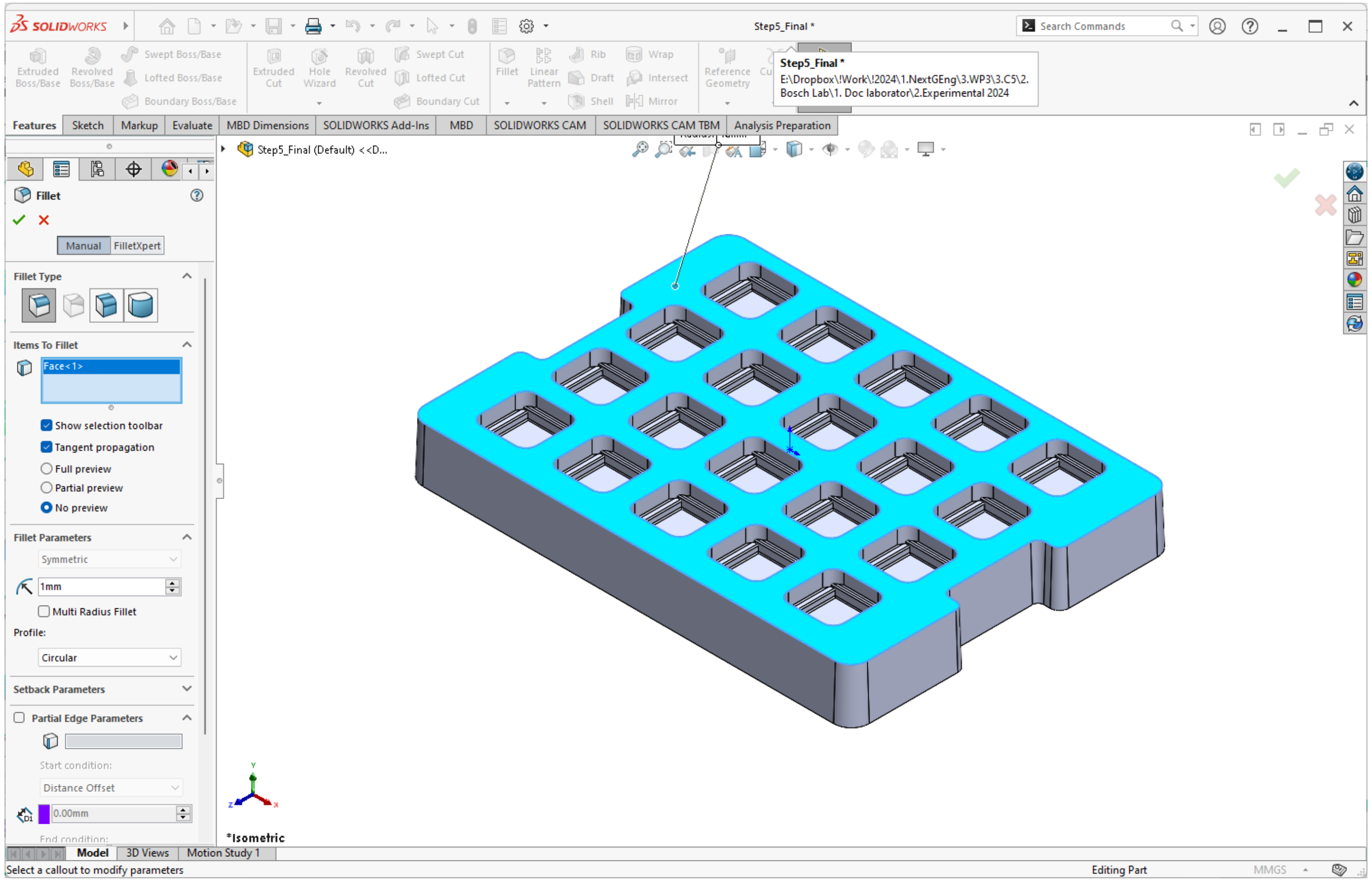




Populate the blister

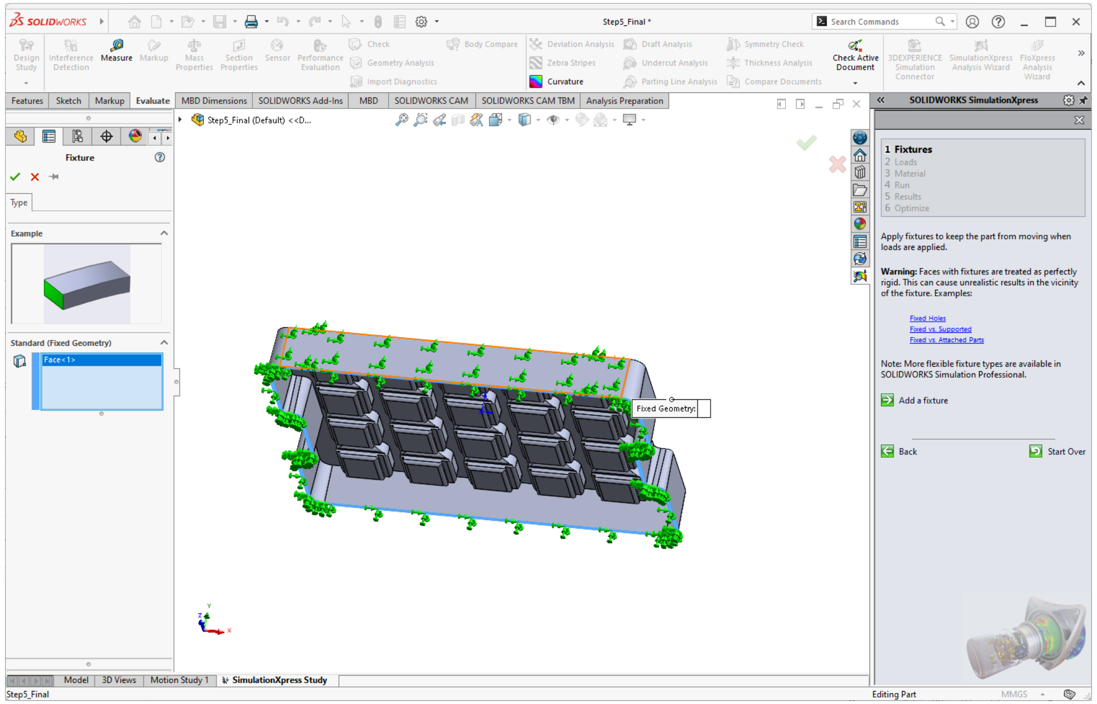
Step 4

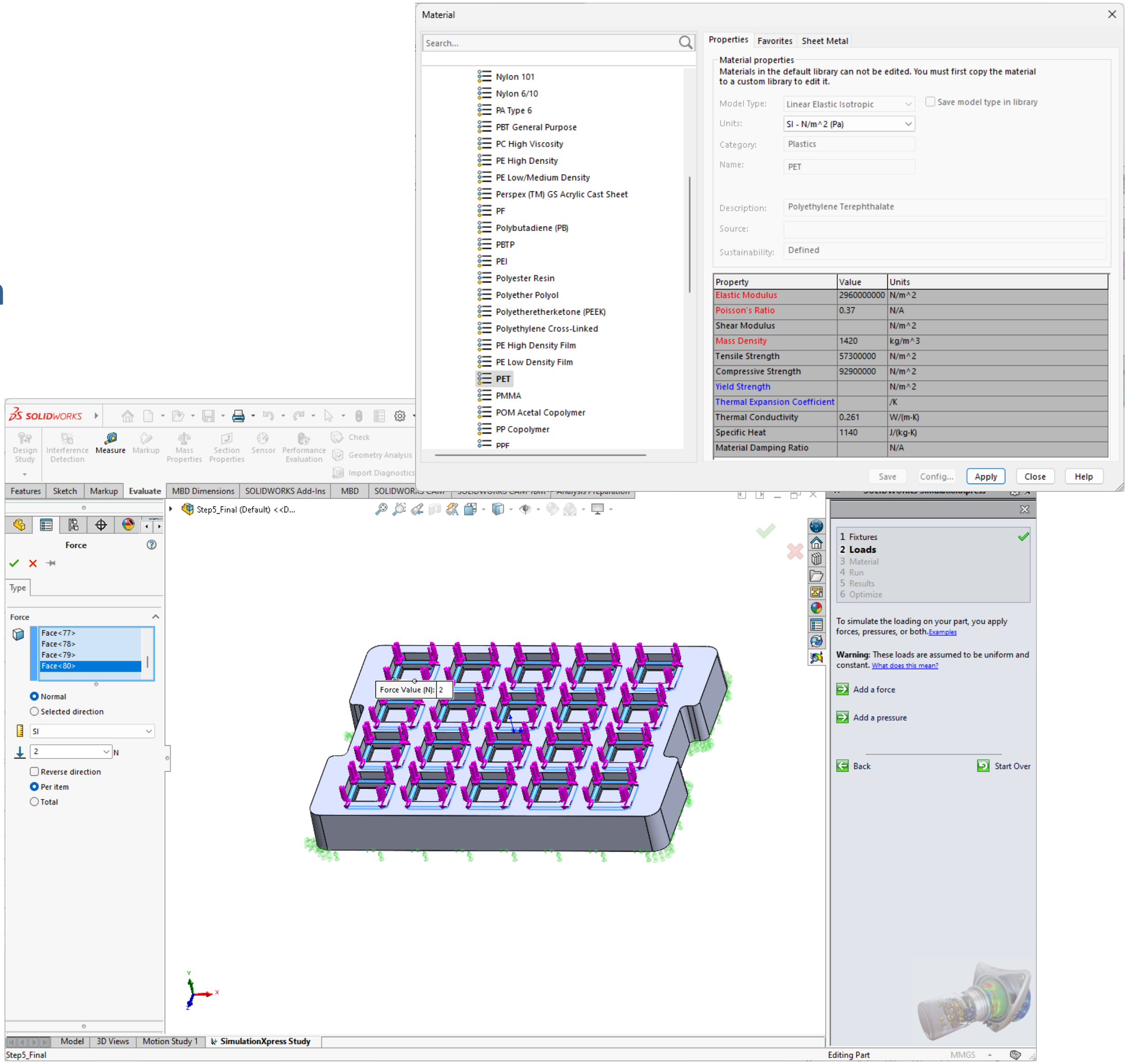
- On *Filet* command with a radius of 1 mm



Test the blister

- Test procedure : use FE method to estimate the deformation



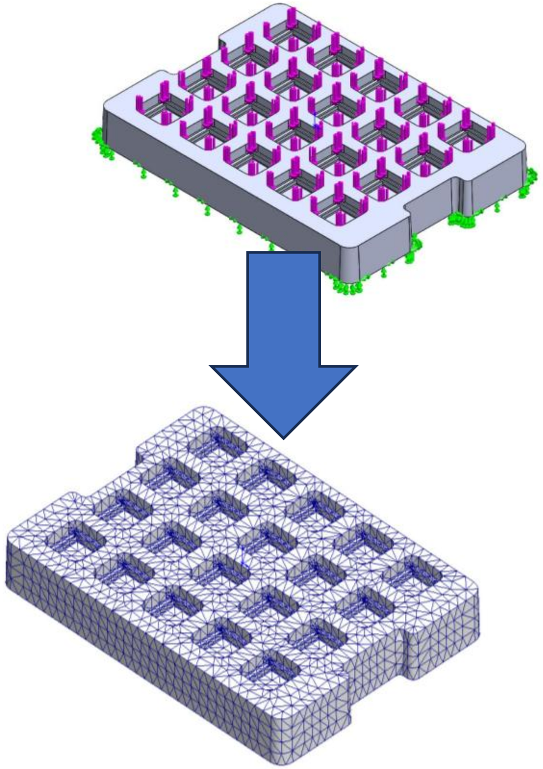


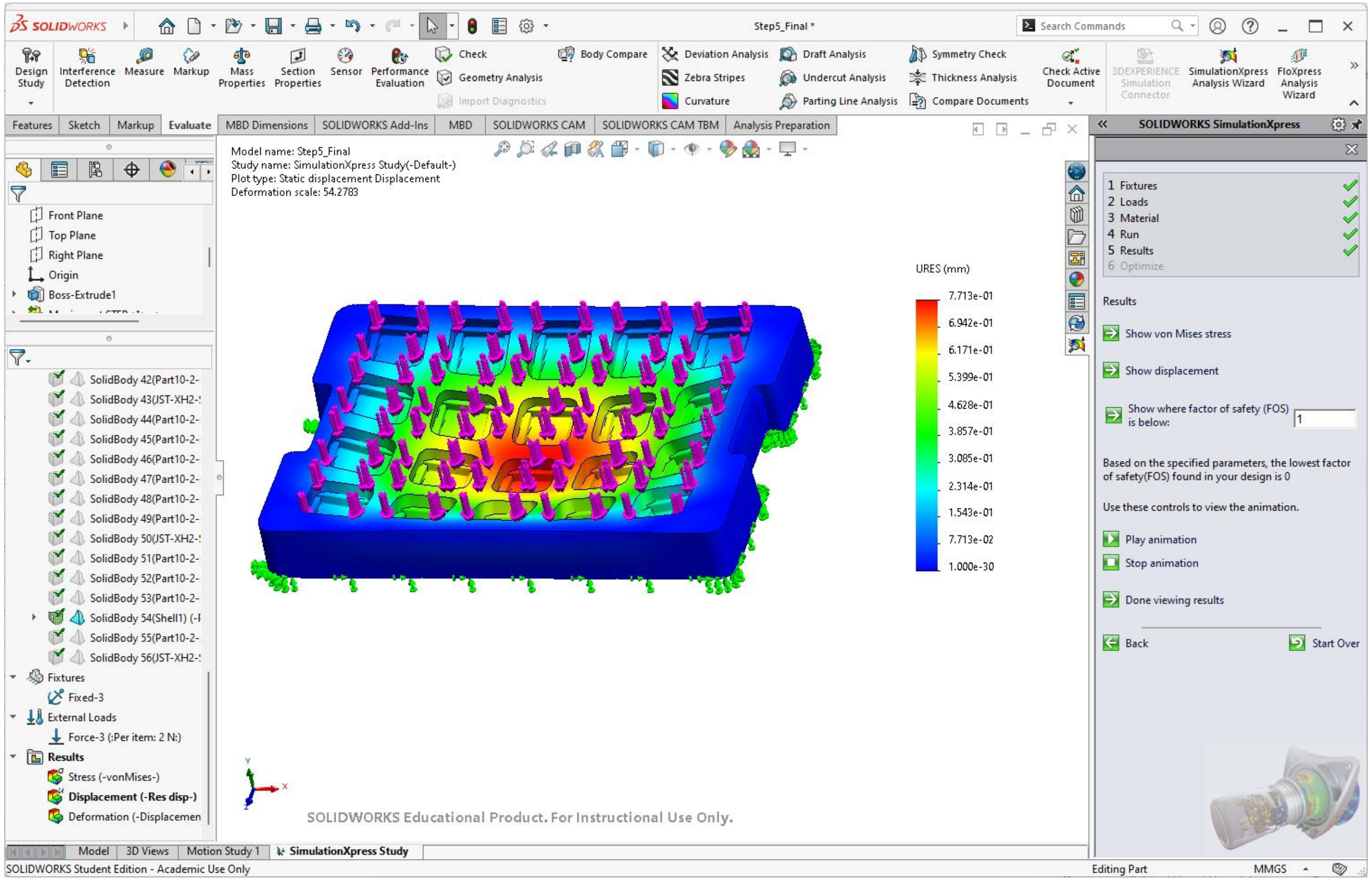
Co-funded by
the European Union

NextGEng

Test the blister

- Analyze the simulation results





Co-funded by the European Union

NextGEng

Summary & Discussions

Design of blisters prototypes

Topics of discussions

- The most difficult part of designing the blister
- What are the main factors that influence the environment related to the design process
- What testing methods could be used for the blister

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by
the European Union

C6 – Manufacturing Technology

L1 - Additive manufacturing at Valmet

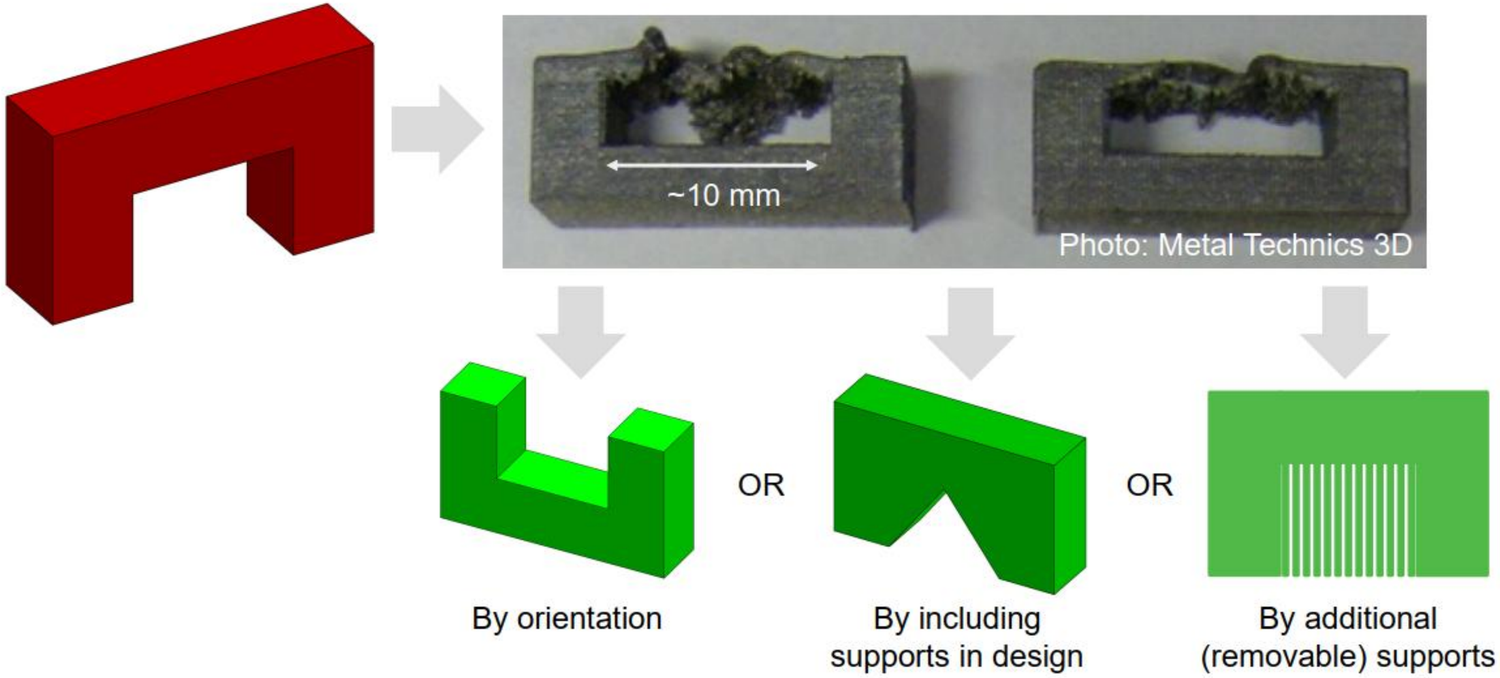
P4 - VALMET

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

Additive manufacturing at Valmet

Make geometry manufacturable



Co-funded by
the European Union

NextGEng

Additive manufacturing at Valmet

Laboratory overview:

Objectives	• To study the principles and process parameters of additive manufacturing technologies (e.g., FDM, SLA, SLS) and their influence on the quality of fabricated parts • To fabricate and analyze a 3D-printed component in order to evaluate dimensional accuracy, surface finish, and mechanical properties compared to the design specifications.
Pre-requisite	• Basic knowledge of CAD modeling – ability to design or interpret 3D models using CAD software • Familiarity with manufacturing processes – understanding of conventional manufacturing methods and their limitations
Equipment used for laboratory	• PCs with SolidWorks

Co-funded by the European Union

Additive manufacturing at Valmet

Upon completion of this activity, the student will be able to:

1) Explain the fundamental principles and process parameters of additive manufacturing technologies
2) Operate a 3D printer to fabricate a part from a CAD model while following proper safety procedures
3) Evaluate the quality of printed components by comparing dimensional accuracy, surface finish, and mechanical performance to design specifications.

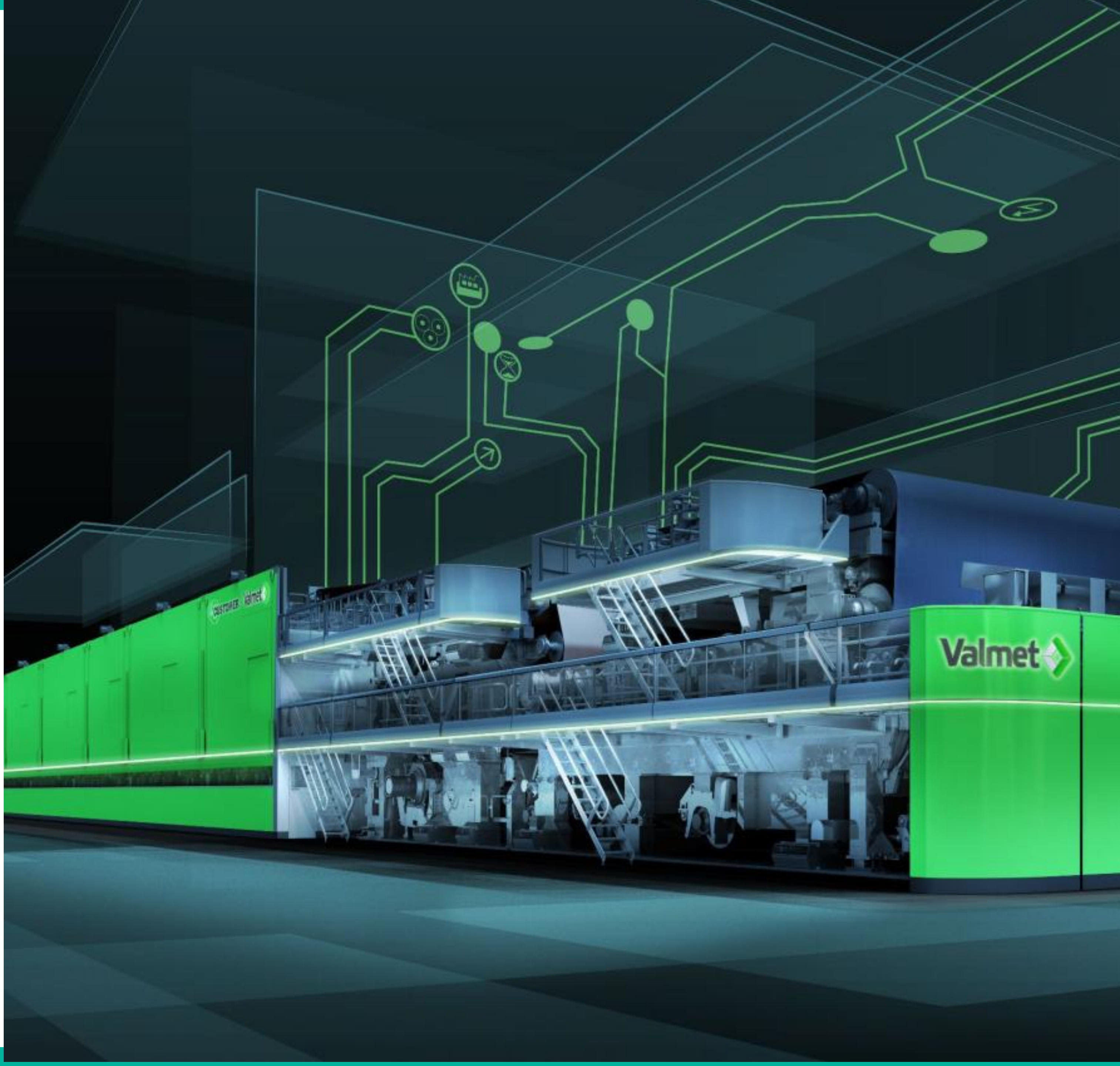
Co-funded by
the European Union

Co-funded by the European Union

NextGEng

Content

- Introduction
- Basics of AM
- Design for additive manufacturing
- Real-life case from Valmet
- Summary, Discussions & Feedback



Introduction

Silver jewellery from SS13-13 –collection (Juhana Tampere) | **2012**
Multiple contributors

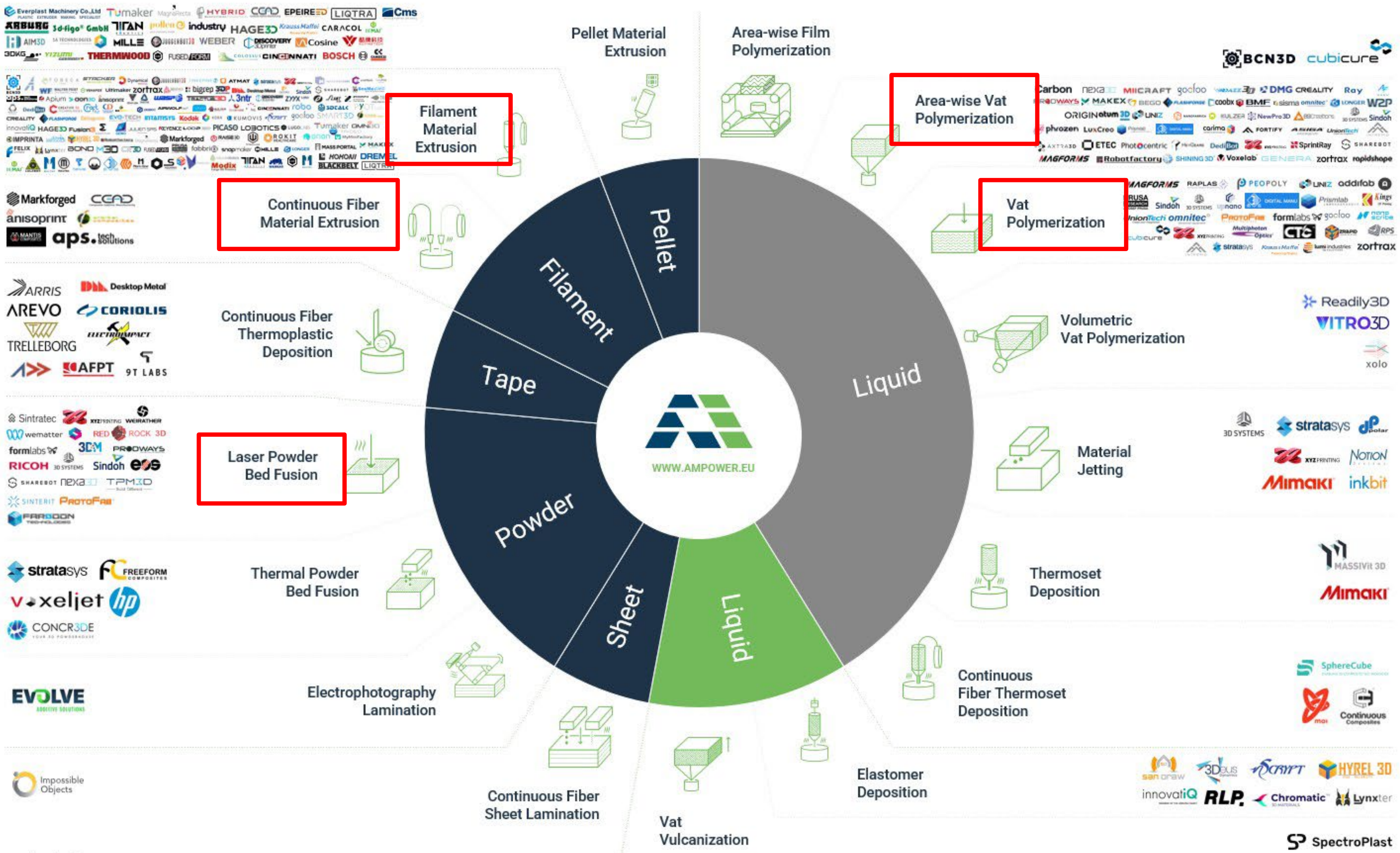
Valmet in a nutshell

- Global company
- 20 000 employees
- 5 500 MEUR turnover
- Locations on all over the world, mostly in Europe
- Machinery processing natural fiber (Paper, board and tissue machines, automation, flow control, pulp and energy and industrial services)

OCM Machine | **2010s**

Basics of AM

Polymer Additive Manufacturing technology landscape



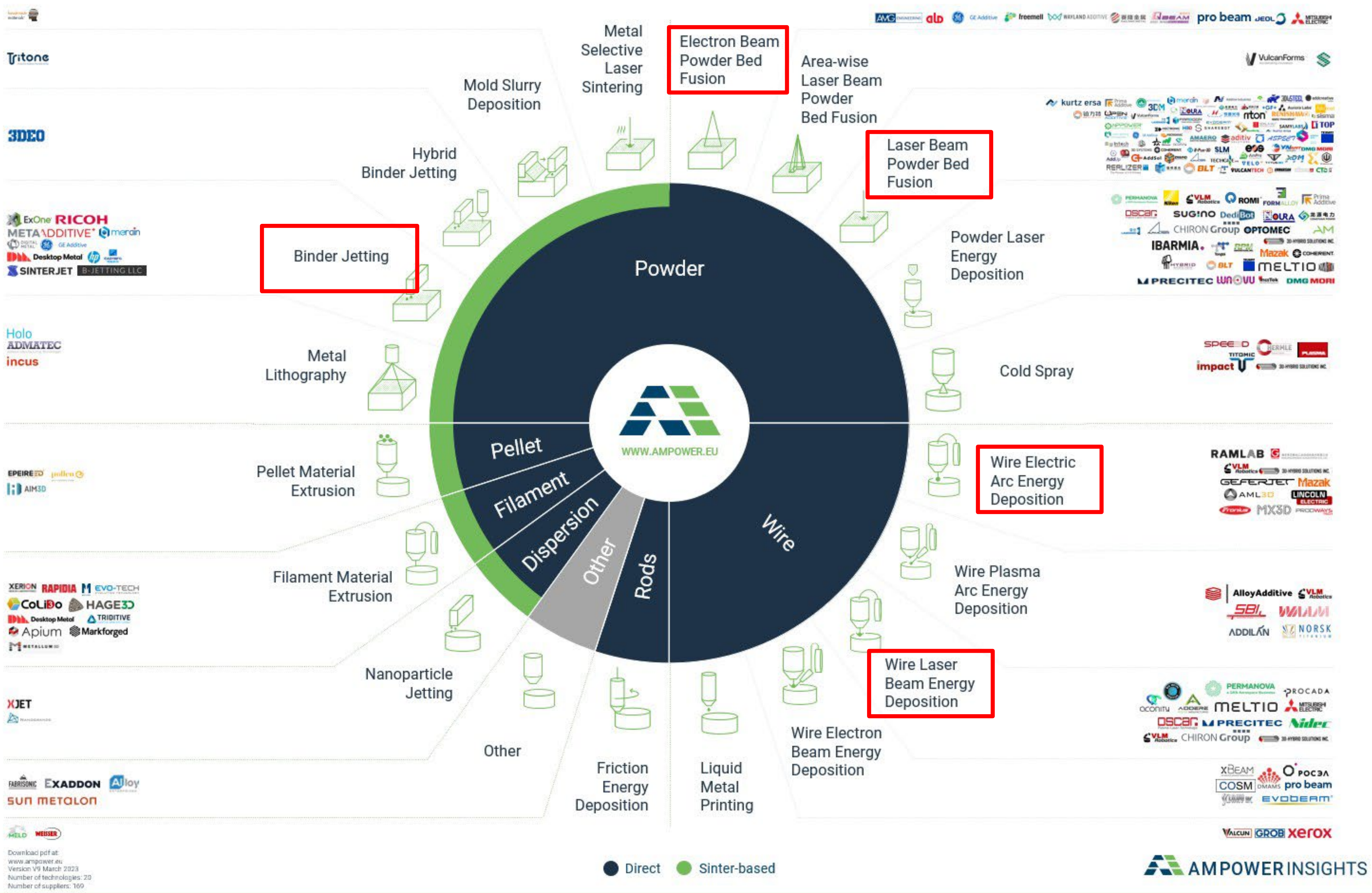
Download pdf at:
www.ampower.eu
Version V6 March 2023
Number of technologies: 17
Number of suppliers: 234

Thermoset Elastomer Thermoplastic

AMPOWER INSIGHTS

Valmet

Metal Additive Manufacturing technology landscape



Polymer AM main technologies comparison

	Fused Deposition Modeling (FDM)	Stereolithography (SLA)	Selective Laser Sintering (SLS)
Build envelope	Typically 300 x 250 x 300 mm Over 1000 x 1000 x 1000 mm possible	Up to 1500 x 750 x 500	300 x 300 x 300 mm Up to 750 x 550 x 550 mm
Materials	Thermoplastics: ABS, PLA, PC, PETG, PEI…	Photopolymers	Thermoplastics: PA2200 (nylon) and variants, PA3200GF, TPU, Alumide
Dimensional accuracy	± 0.15% (lower limit ± 0.2 mm)	± 0.15% (lower limit ± 0.01 mm) - industrial	± 0.2% (lower limit of ± 0.2 mm)
Advantages	- Fast! (for one offs) - Cost-effective	- Very high dimensional accuracy - Excellent surface quality - Special materials available (clear, flexible, castable)	- No need for supports - Good isotropic mechanical properties - Excellent for small & medium batch production
Drawbacks	- Lowest dimensional accuracy - Surface quality - Needs supports - Anisotropic structure	- Generally can be brittle - Needs supports - Some resins properties degrade over time	- Surface quality (but better than FDM) - Internal porosity may exist with some machines (post processing needed for watertightness) - Large flat surfaces & small holes are not accurate (warping & oversintering)

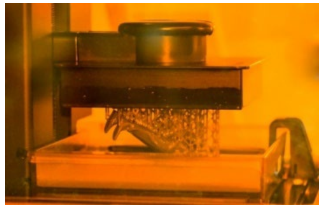



Photo: Materflow

Achievable properties of metal AM

	Laser Powder Bed Fusion (LPBF)	Direct Energy Deposition (DED)	Binder jetting
Density	99,999 % ->	99,5 % - 99,9 %	~97-99 %
Dimensions	Typically 280 x 280 x 365 mm (as big as the controlled build chamber)	1000 x 1000 x 3000 mm (as big as the range of the robotic arm)	400 x 250 x 250 mm (as big as the build chamber, sintering limits part size)
Materials	316L, Ti6Al4V, AlMg10Si, Maraging steel, Inconel 718 & 625…		316L, copper, 17-4PH Ti6Al4V, ceramics, sand..
Part accuracy	+/- 0,1 mm (typical)	+/- 0,1 % (min +/- 0,1 - 0,2 mm)	+/- 0,1 mm
Surface roughness	In general Ra 10-15 µm	In general Ra 15-50 µm, WAAM even worse	In general Ra 6 µm
Advantages	- Very complex internal cavities - High precision - Possibility to affect material properties	- Highest speed - Large parts possible with - Different materials can be used along the build direction	- No thermal stresses - Best surface quality - No need for supports in printing Highest precision - Faster than LPBF
Drawbacks	- High energy → Thermal stresses - Slowest technology	- Less precise than LPBF, and BJ - Lack of powder bed limits geometrical complexity - No ability to influence material properties through the layers (limited remelting)	- Sintering may distort components - Component size limited but improving (~100 x 100 x 100 mm)

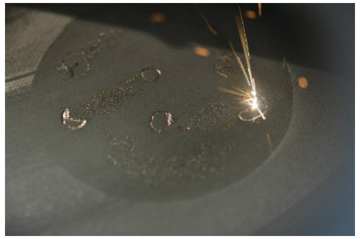
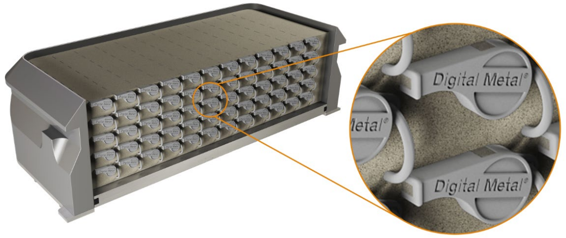



Photo: Canadian metalwork



Why AM should be used?

Some of the benefits listed

Design related

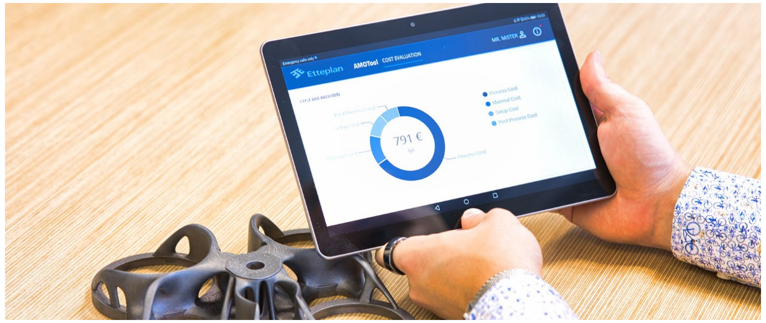
- Design freedom
- Lightweighting
- Part consolidation
- Customization
- Part performance

Production related

- Rapid prototyping
- On-Demand Production
- Reduced lead time
- Toolless production

Economics related

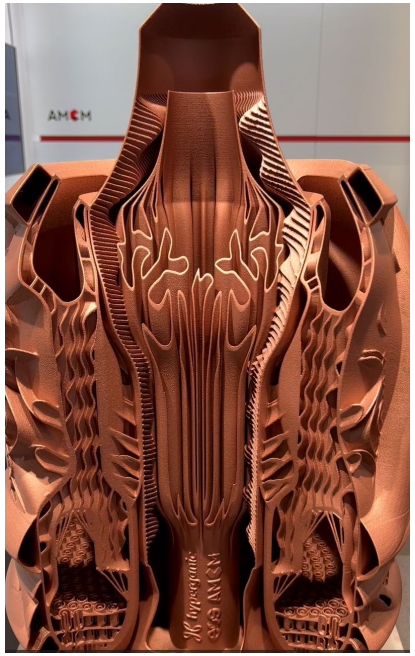
- Material efficiency
- Supply chain simplification (localized production, reduced logistics)
- Digital inventory



Design freedom

Why AM should be used?

- AM allows for the creation of parts with **complex geometries** that would be challenging or impossible to produce with traditional methods
  - This includes intricate internal structures, undercuts, and organic shapes.



Aerospike engine

Aluminum housing

Footrest

Lightweighting

Why AM should be used?

Image: EOS

Image: Desktop Metal

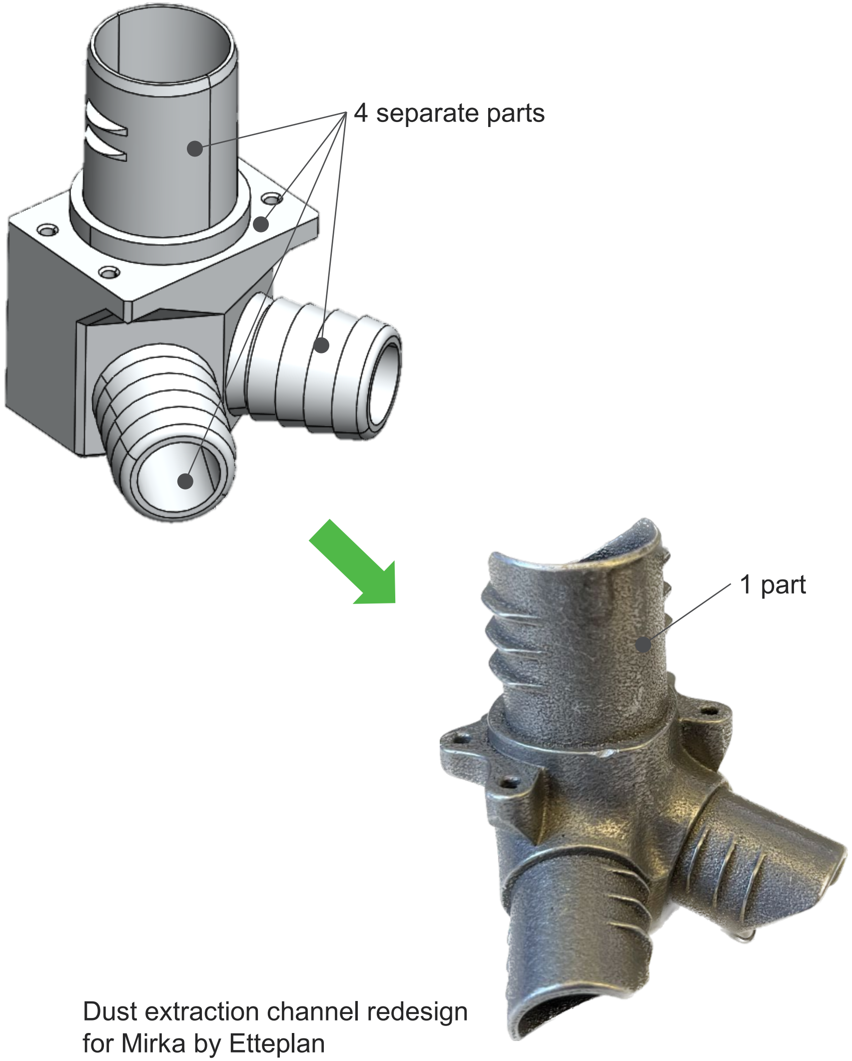
Image: EOS

Image: Liebherr

Part consolidation

Why AM should be used?

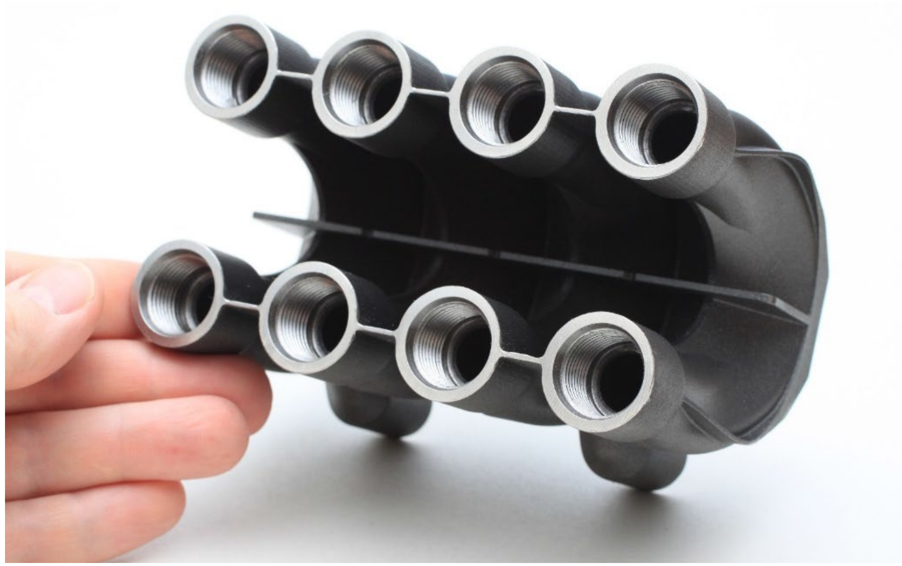
Image: nTop



Dust extraction channel redesign
for Mirka by Etteplan

Improving performance

Why AM should be used?



Hydraulic block for John Deere by Etteplan

Image: Materialise

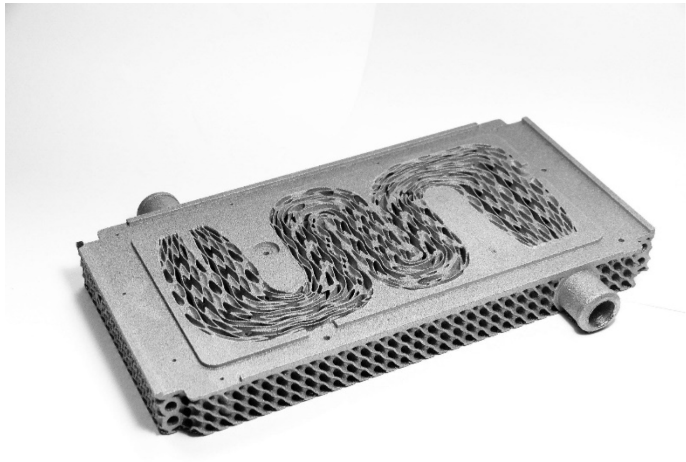


Image: nTop

Rapid prototyping

Why AM should be used?

4 years

100 patents pending

600 prototypes

Images: Dyson

On-demand production

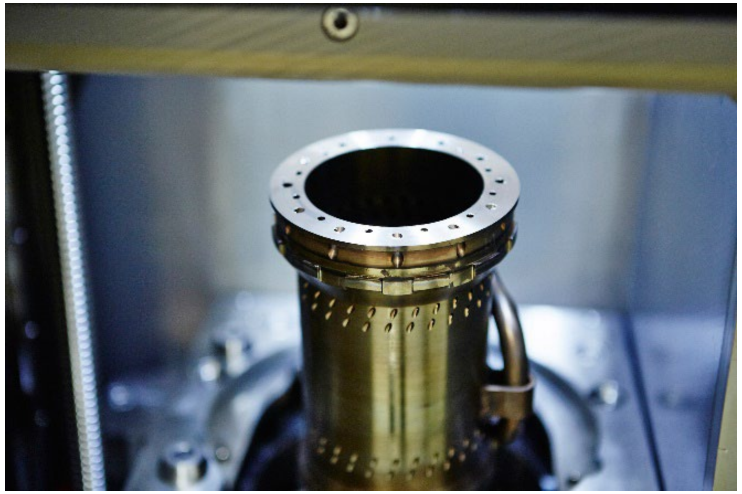
Why AM should be used?

Image: 3D Formtech

- 100+ printed parts
- No actual prototypes
  - Each drone is an end product as well as a prototype
  - If new developed part works, it will be sold
- Continuous development
- No spare parts in storage
  - No risk to waste money
  - FAST delivery times
- *"Nordic Drones wouldn't exist without 3D printing, because there are no other reasonable ways to make our products"*

Reducing lead-time

Why AM should be used?

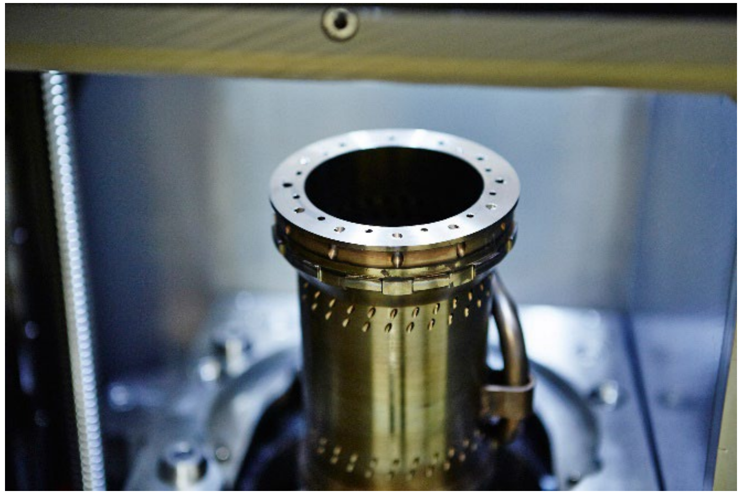


Lead time

44 weeks

Reducing lead-time

Why AM should be used?



Lead time

4 weeks

Digital inventory

Why AM should be used?

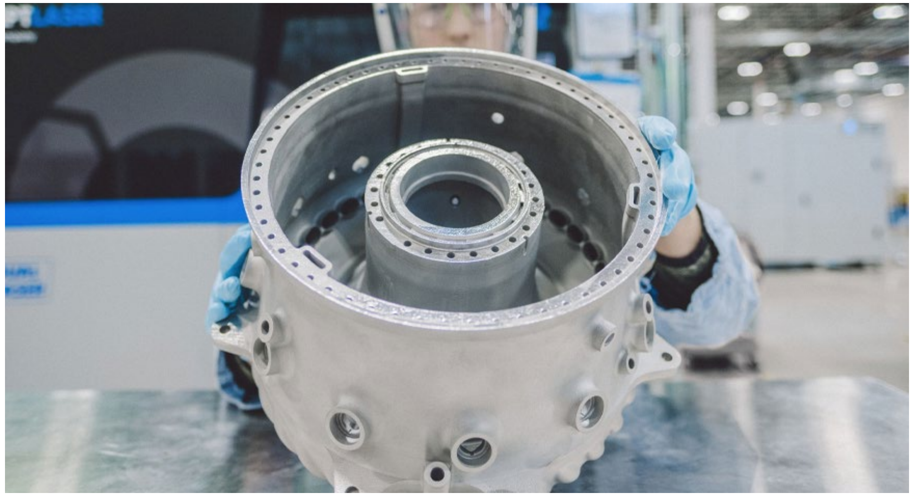
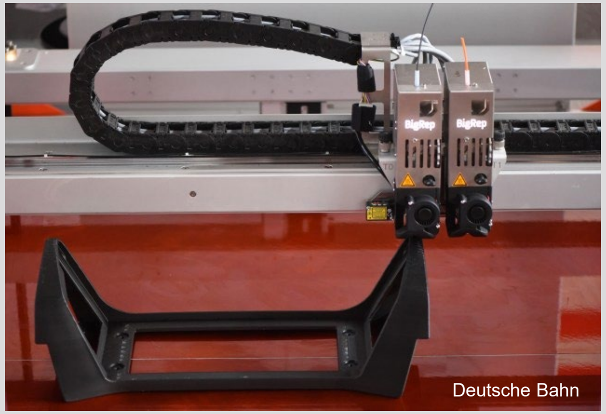


Image: GE

3D printed and machined secondary roll stop



Headrest in the making to old train model

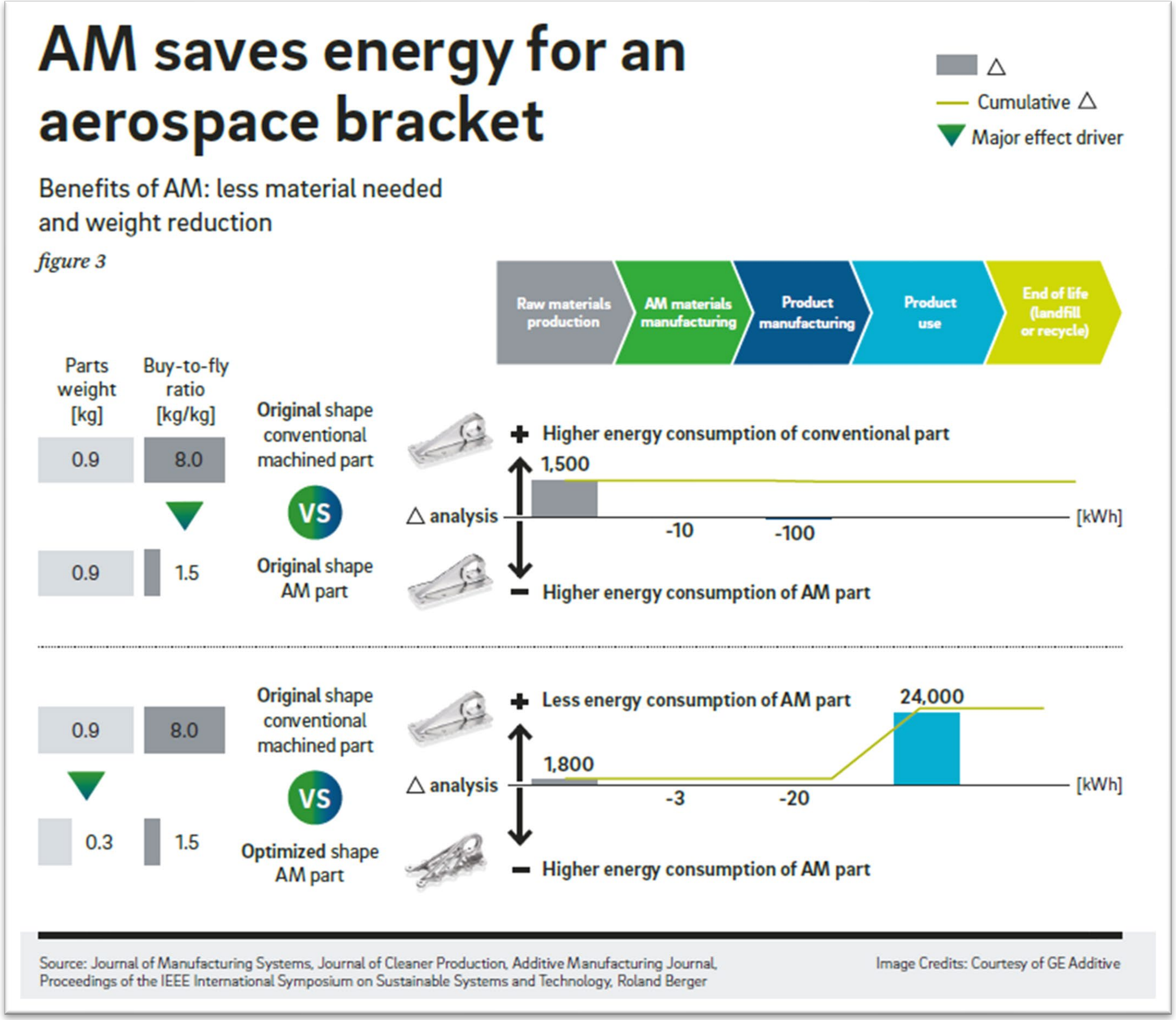
3D printed and machined bearing cover

Another motivation is that after 20 years, the spare parts are simply no longer produced. Some devices are also obsolete, like everything related to electricity. Over time, standard wear-and-tear and brittleness gradually weaken the injection-molded parts, meaning that they need to be replaced every 10 to 15 years. Rail vehicles are designed to have a service life of over 25 years, but it is not uncommon for a train to remain in service for 40 to 50 years, or even longer in exceptional cases. 3D printing allows you to redo parts you no longer find.

Spare parts for old models / end of service

Energy efficiency = Sustainability

Why AM should be used?

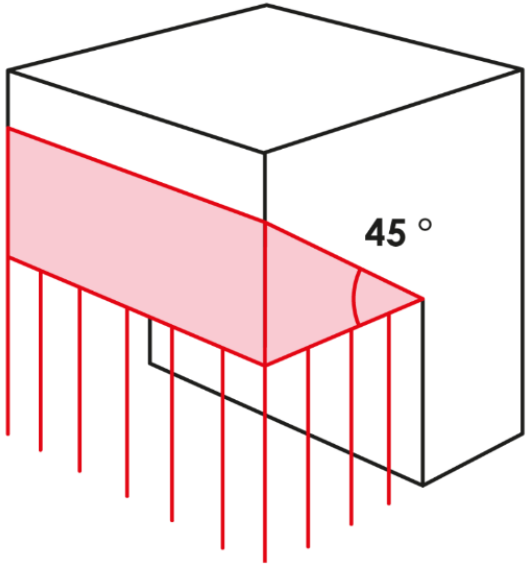


Roland Berger Report on Sustainable Additive Manufacturing

Design for additive manufacturing

Support structures

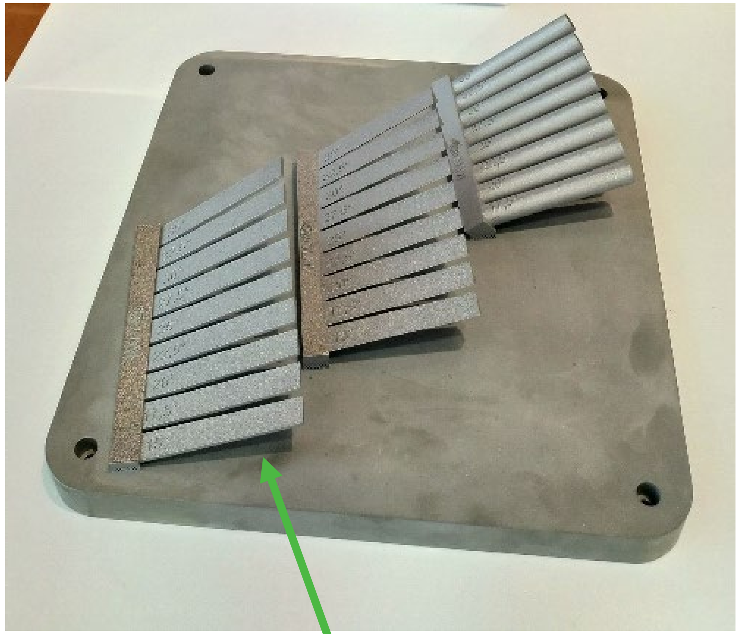
- Laser Powder Bed Fusion (LPBF)
  - Depends on material and process parameters but rule of thumb is 45 degrees
    - Stainless steels: 30 degrees
    - Inconels: 45 degrees
    - Titanium: ~30 degrees
    - Aluminium: 45 degrees
    - Cobalt chrome: 30 degrees



- Fused Deposition Modelling (FDM)
  - 45 degrees
- Selective Laser Sintering (SLS)
  - Not needed

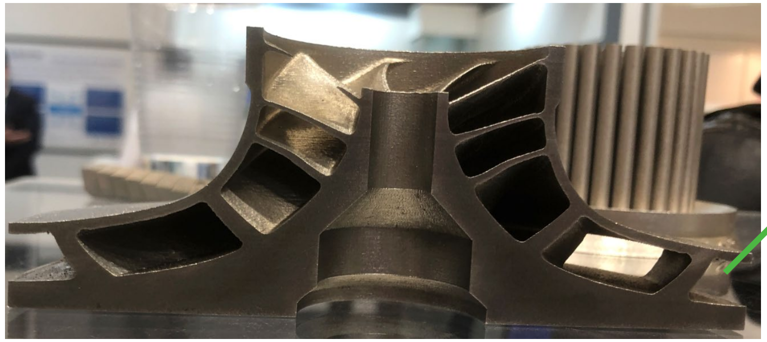
Constant development to get rid off supports

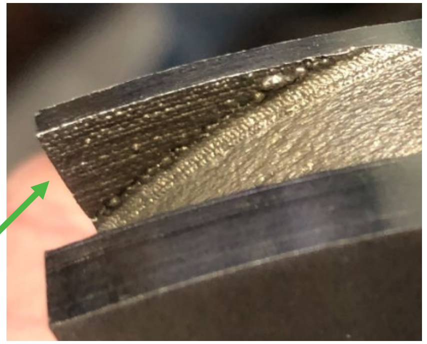
SLM

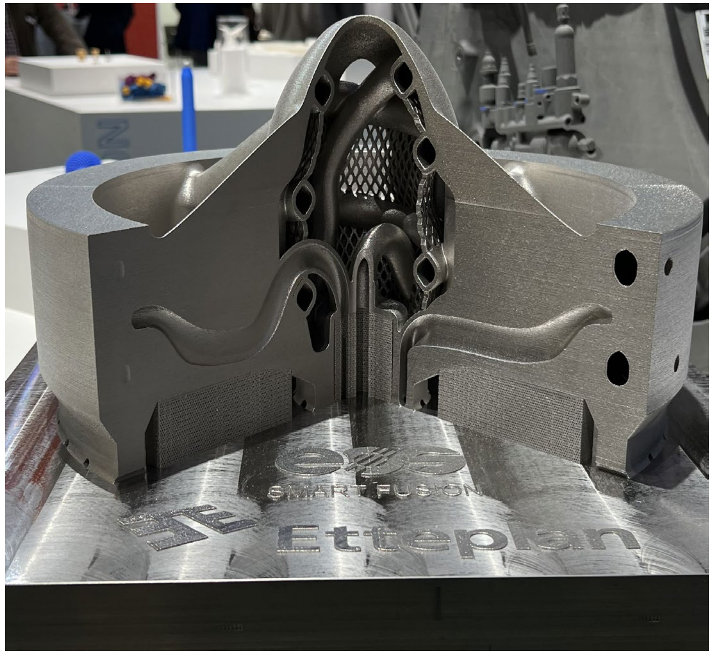


15° angle!

Velo3D





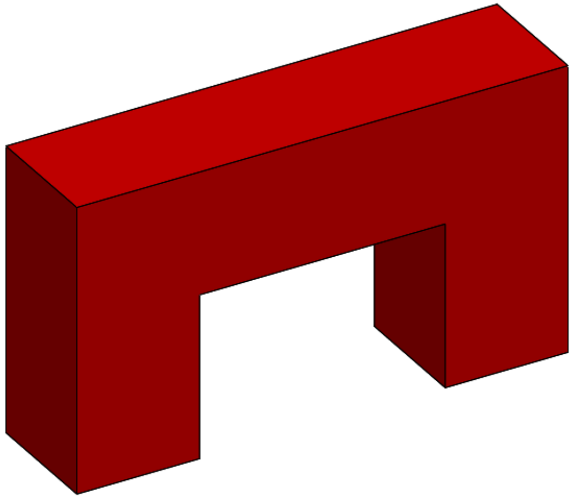


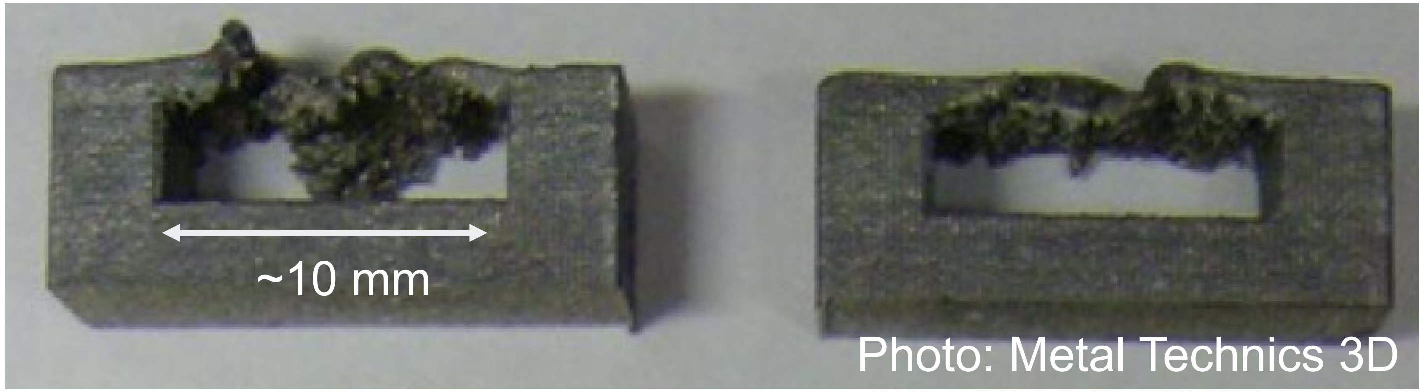
EOS

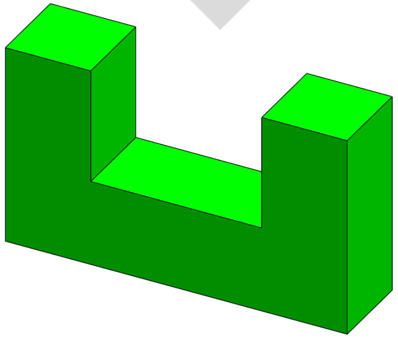
The impeller was produced in an optimized 316L process on an EOS M 290 without internal supports and with a cost reduction of 35% (photo credits: EOS GmbH)

Valmet

Make geometry manufacturable (e.g. get rid of overhangs)

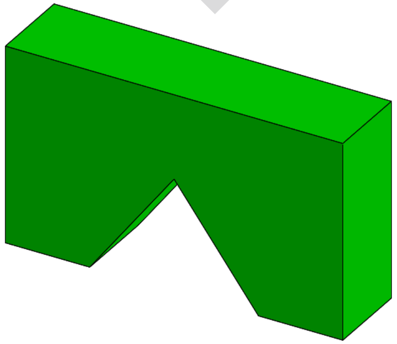






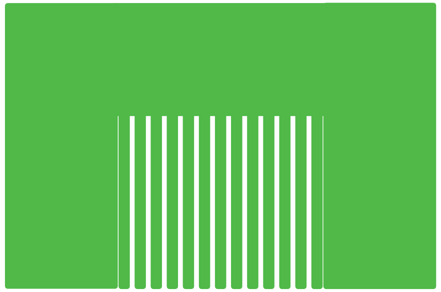
By orientation

OR



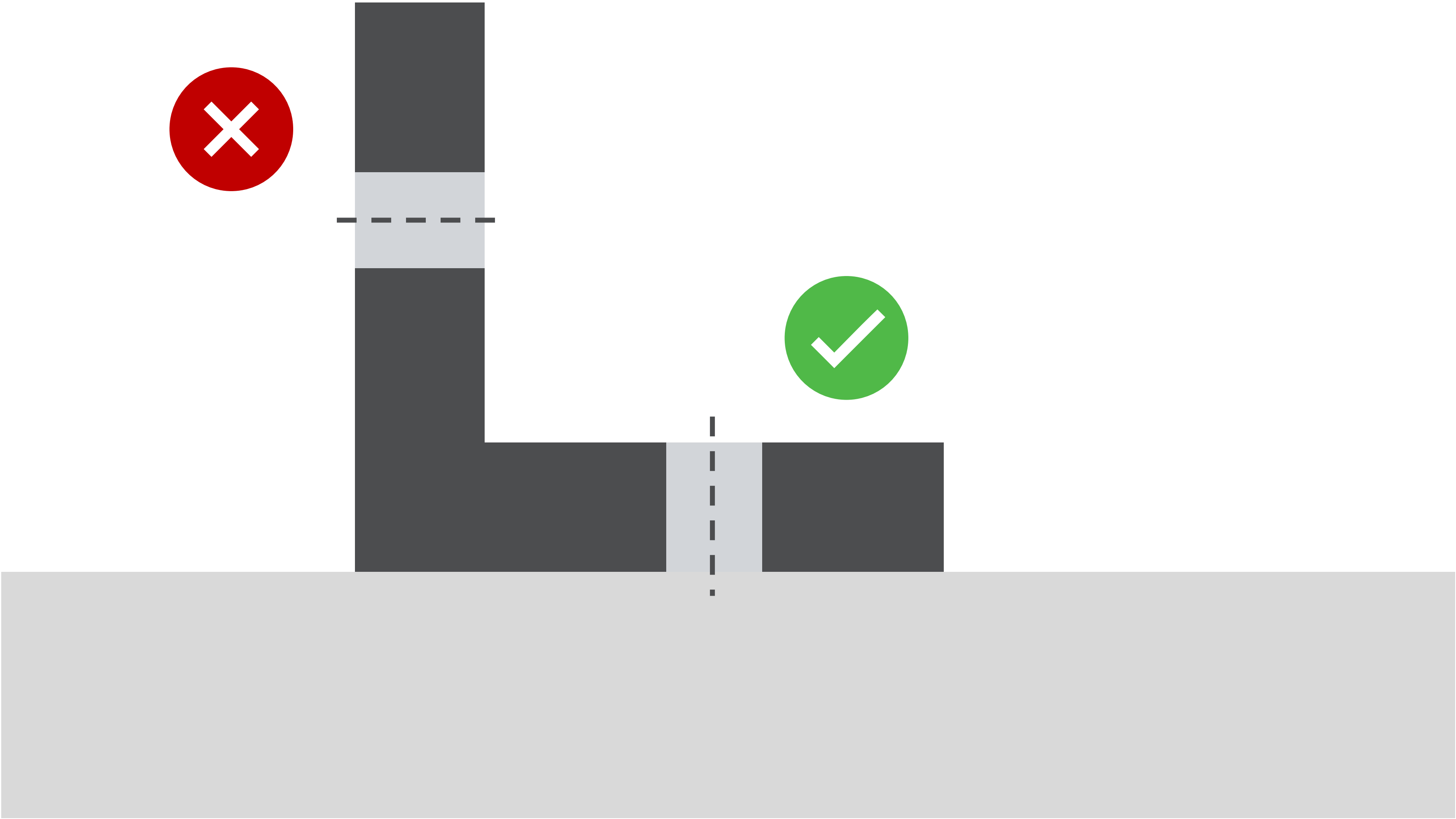
By including supports in design

OR



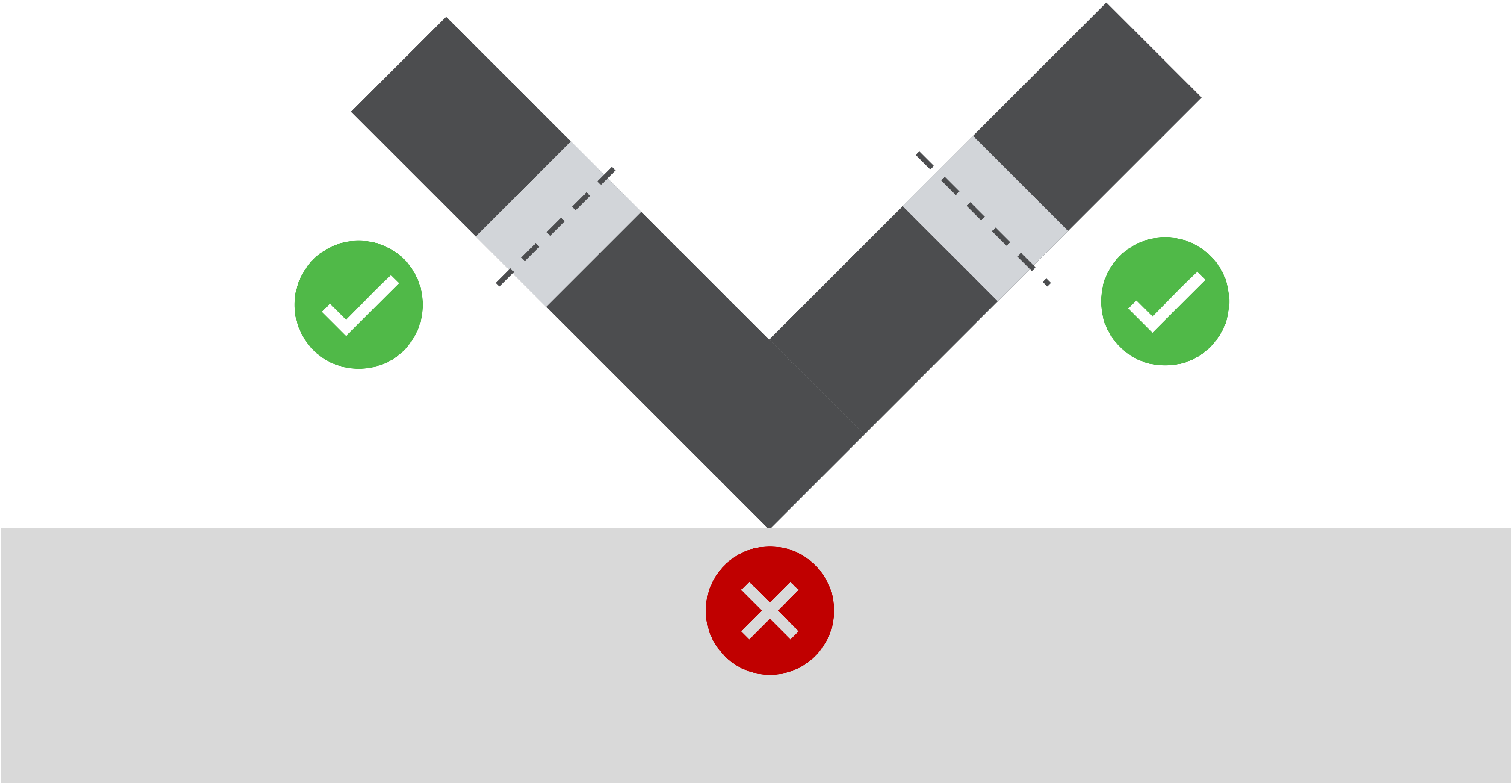
By additional (removable) supports

How to print both holes with good quality?



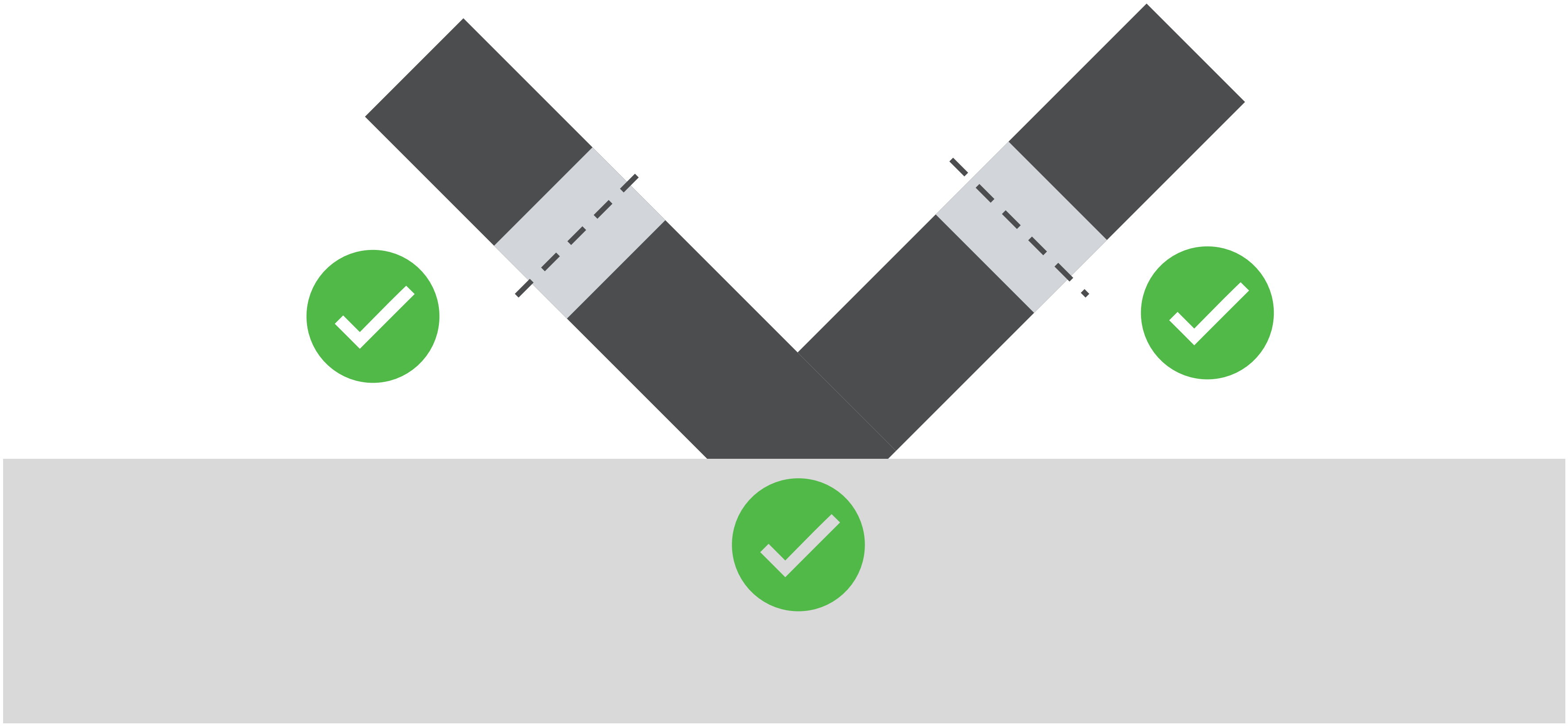
How to print both holes with good quality?

Reorient the part (not sufficient yet)



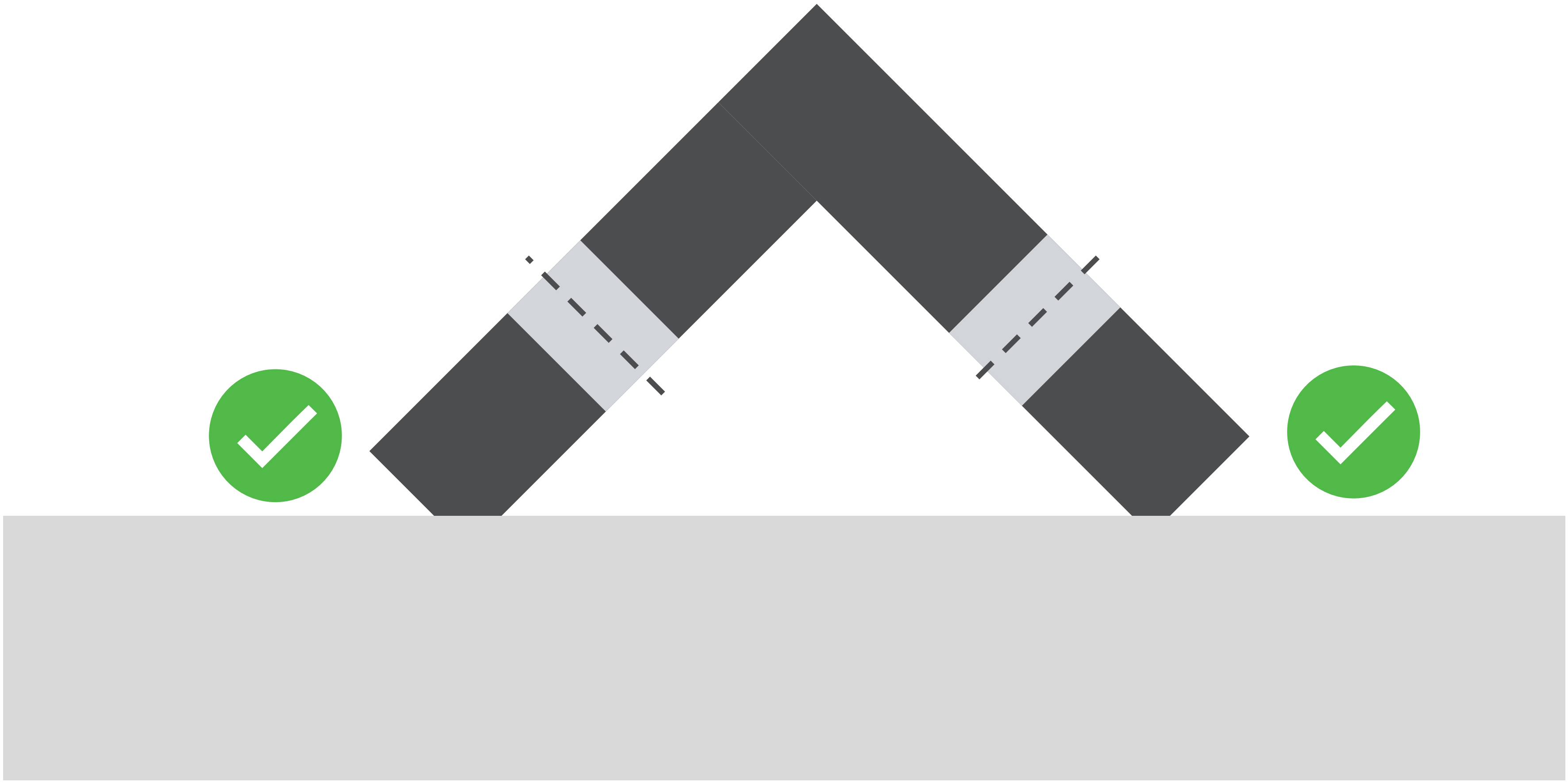
How to print both holes with good quality?

Reorient the part and alter the geometry



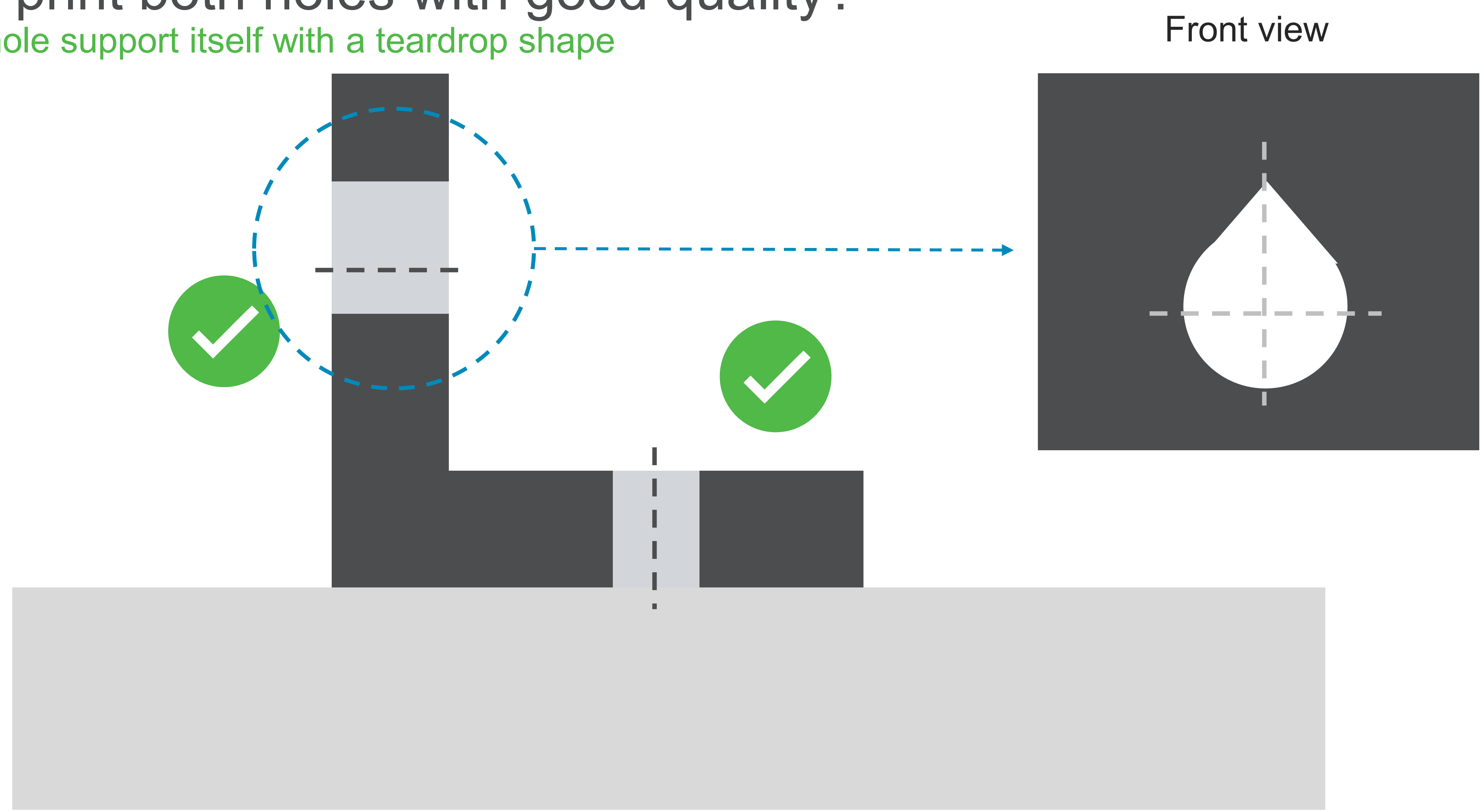
How to print both holes with good quality?

Reorient the part, option 2



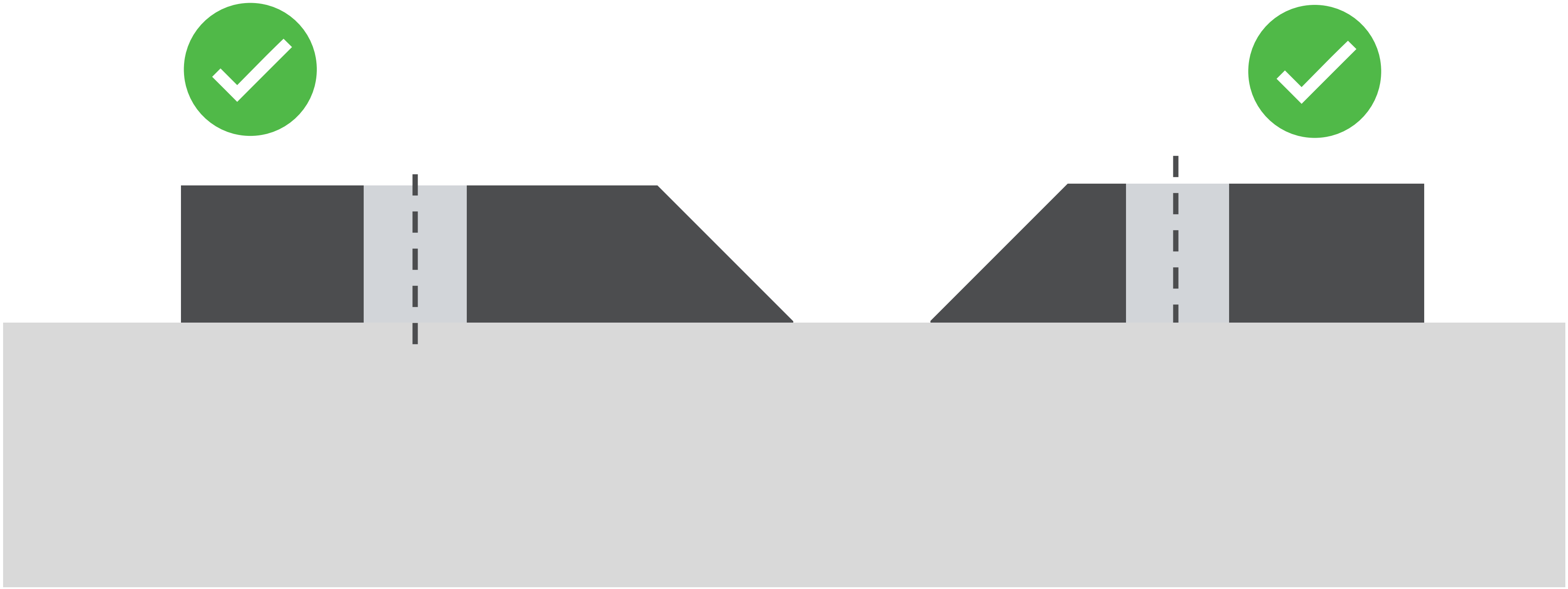
How to print both holes with good quality?

Make the hole support itself with a teardrop shape



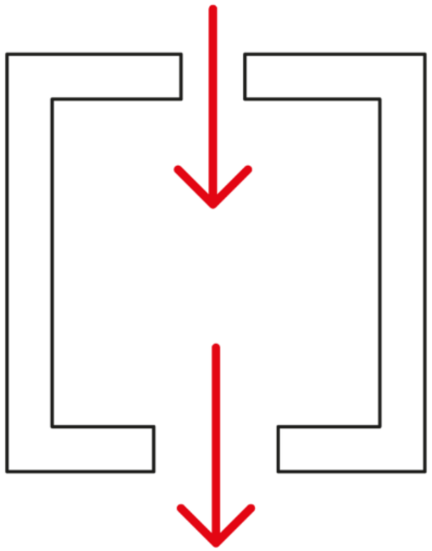
How to print both holes with good quality?

Divide the part into two



Escape holes

- Escape holes are needed to get rid off the trapped powder in hollow structures
- Two holes are recommended: one to blow air and other for powder exit
  - For metal one hole is okay
  - For plastic, holes should be on opposite sides



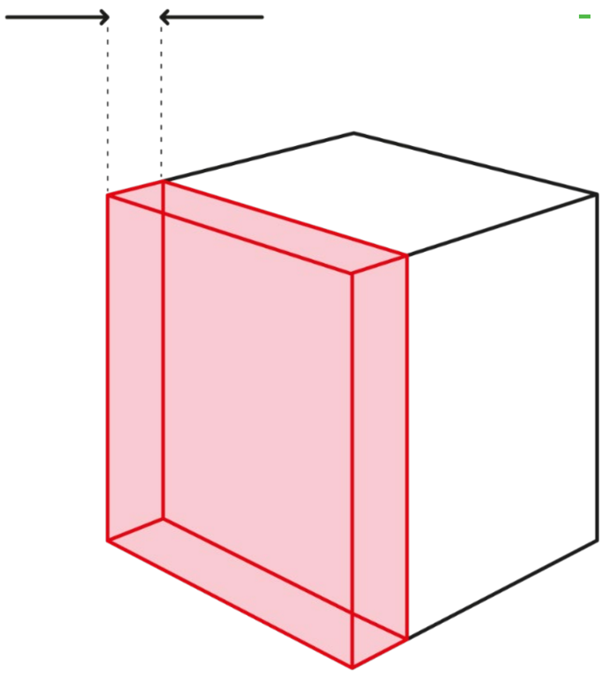
- Laser Powder Bed Fusion (LPBF)
  - Ø 2-5 mm
- Selective Laser Sintering (SLS)
  - Min Ø 4 mm

Trapped powder (especially metal) is a **safety risk!**

Valmet

Tolerances / Accuracy

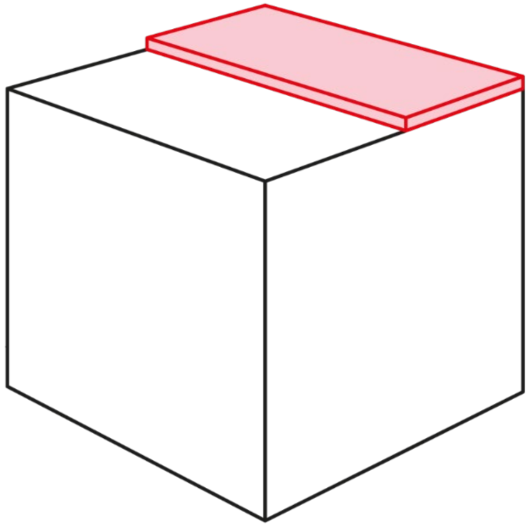
- Laser Powder Bed Fusion (LPBF)
  – Accuracy depends on part orientation, material and part size
  – Typically, ± 0.2 % (± 0.1–0.2 mm up to 100 mm size)
- Fused Deposition Modelling (FDM)
  – Typically, ± 0.15 % (lower limit ± 0.2 mm)



- Selective Laser Sintering (SLS)
  - PA2200 / PA3200 / PA2241FR / PA2210FR / Alumide: ± 0.2 % (min. ± 0.2 mm)
  - TPU: ± 0.2 % (min. ± 0.3 mm)
  - PA11 ESD: ± 0.3 % (min. ± 0.4 mm)

Machining allowance

- Often, the part is not ready right after printing, but machining or other post-processing is needed
- From machining point of view, additive manufacturing is essentially producing a “blank"
- In AM, the added material is only what is needed for the end part



Remember to account for machining!

- Typically, 0.5 mm machining allowance is enough
  - Sometimes more might be needed so remember to consult your print service provider / machinist!

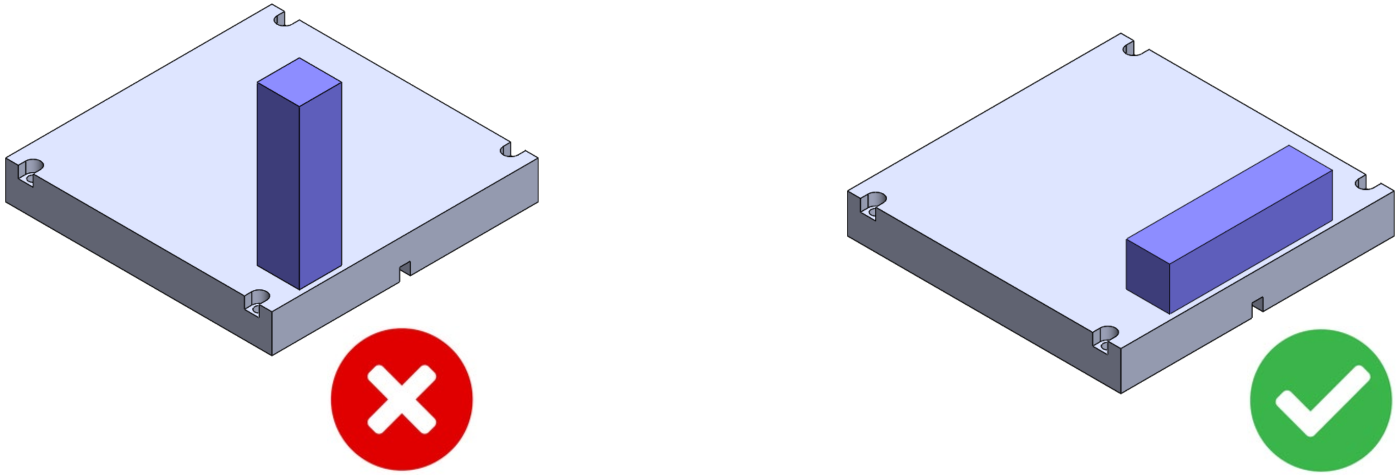
Valmet

INTERNAL

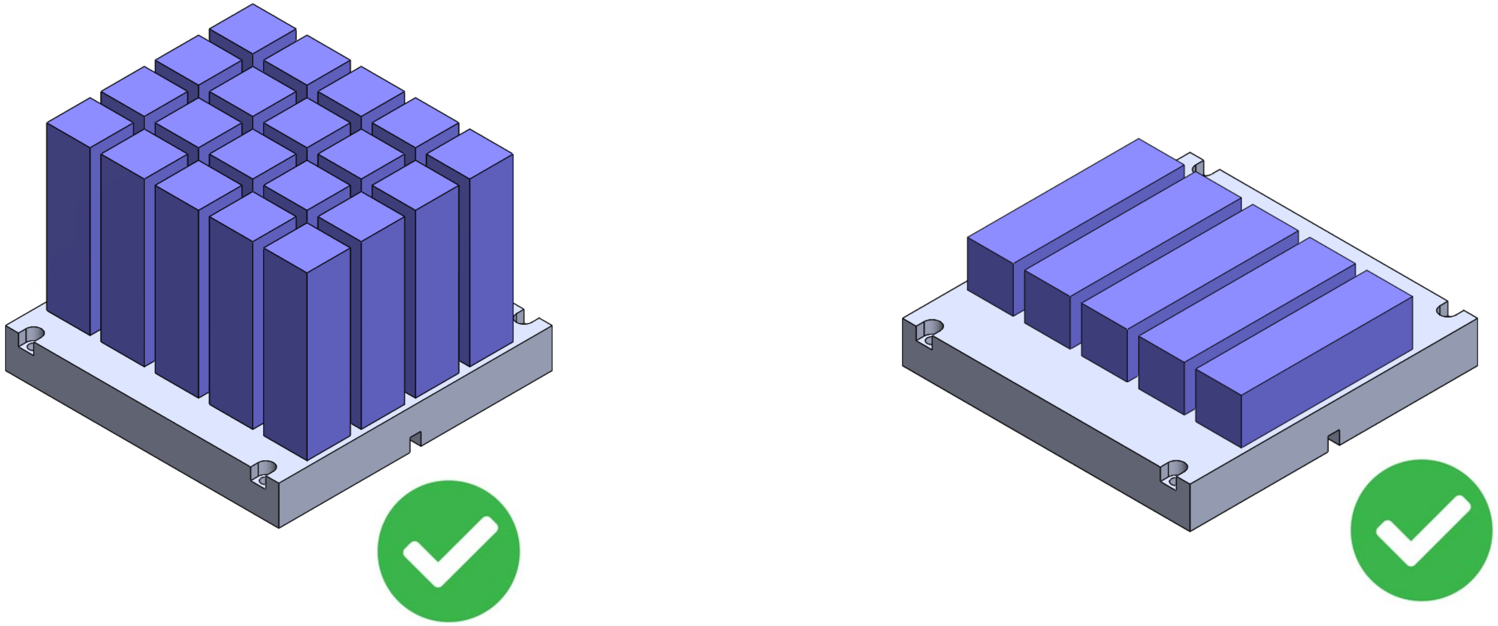
Nesting & orientation
(Metal LPBF)

Standing tall | Laying flat

Single component



As many parts produced as possible



Design for stacking (maximizing the use of build volume)

Laser Powder Bed Fusion (LPBF)

SLS / MJF / MBJ / EBM

Valmet

Real-life case from Valmet

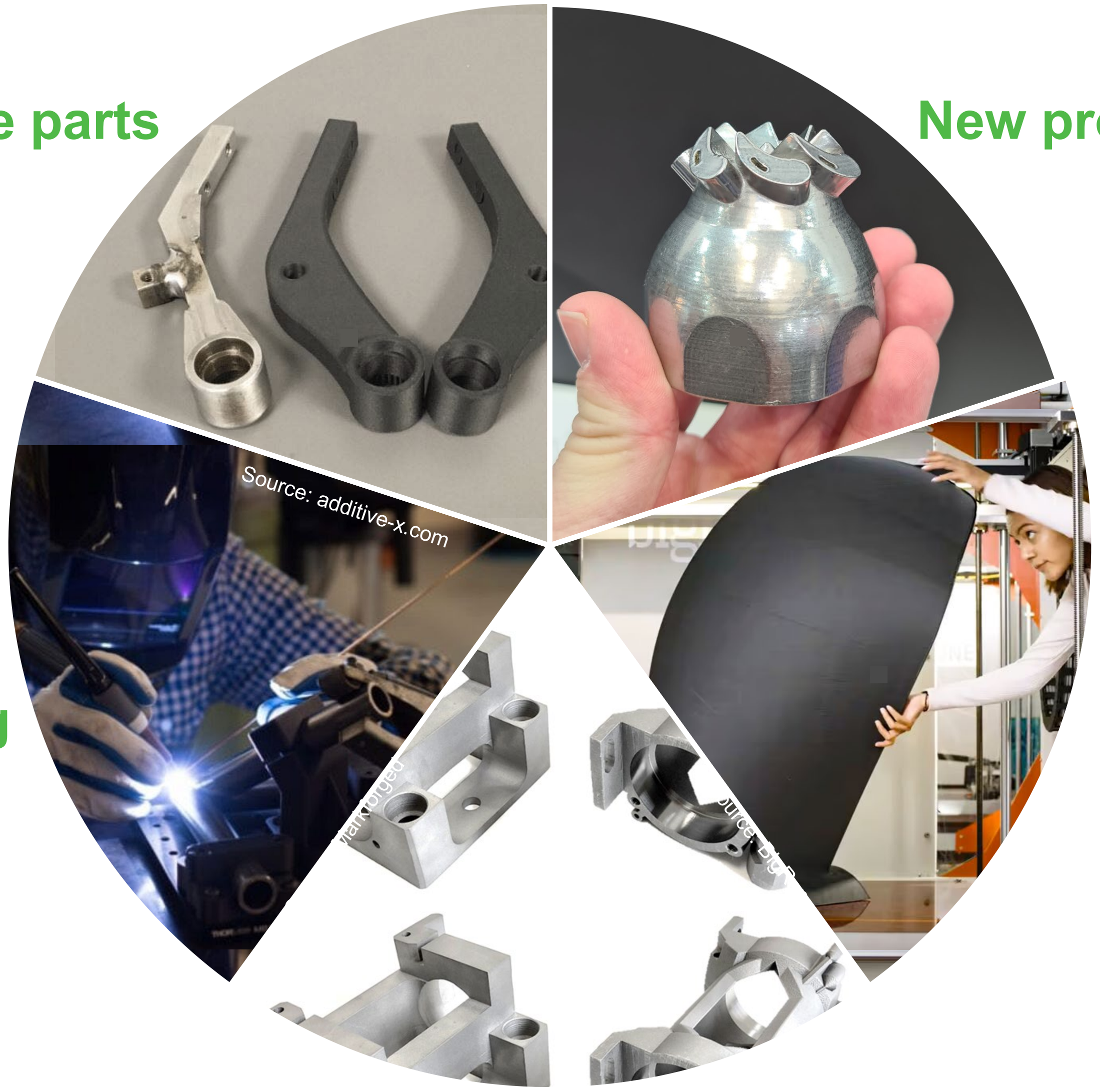
What are the typical application areas for AM?

Spare parts

New products

Tooling

Prototyping



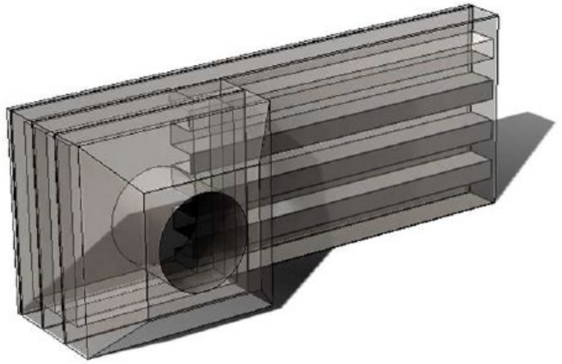
Manufacturing shift

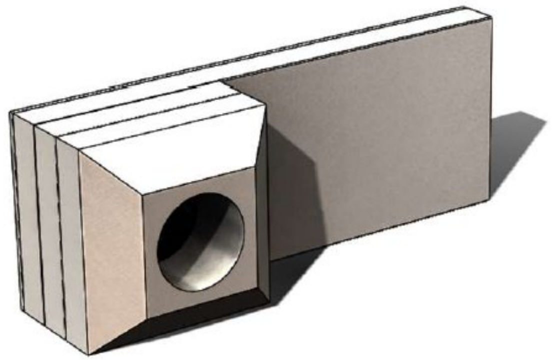
Real-life new product development case: Headbox Edge Flow

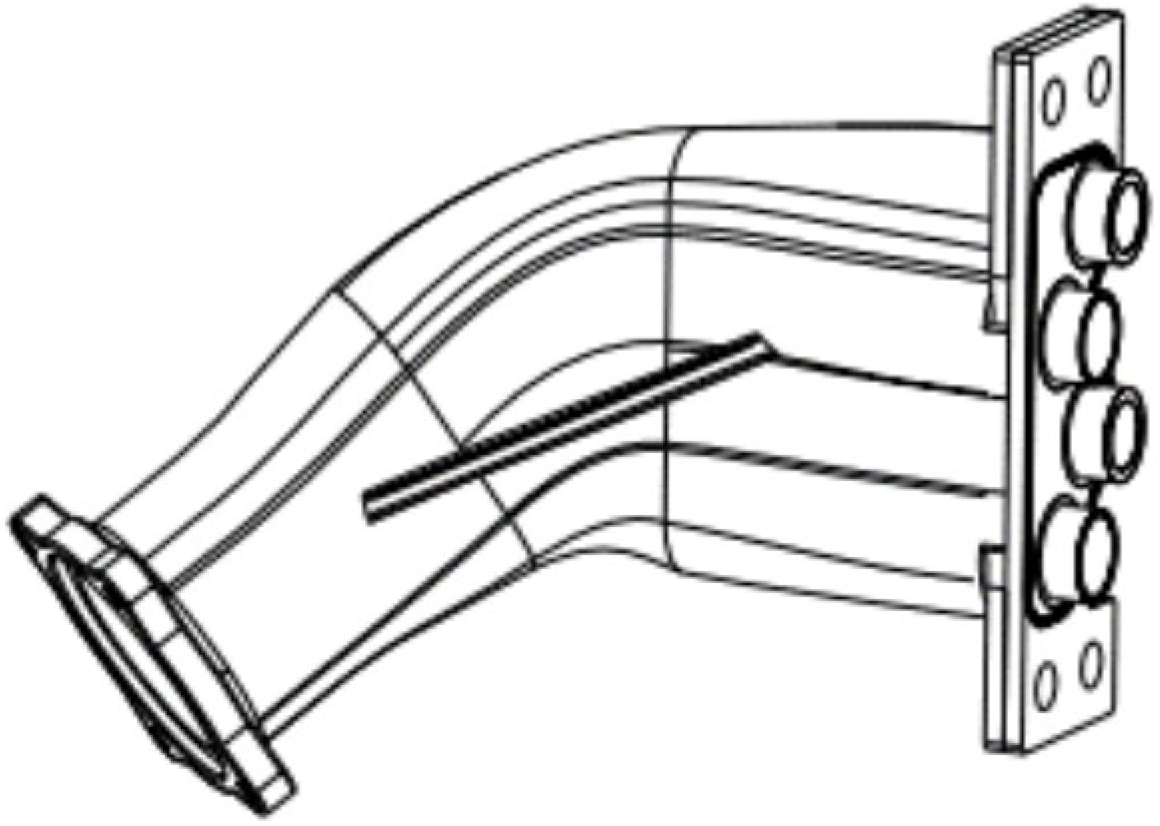
Valmet

- One of the first, if not the first, application of metal AM-parts at Valmet. This application was identified and first designed as part of a mechanical engineering thesis from JAMK published 2018.
- Design for AM included a) the use of build plate as an integral part of the construction and b) nesting optimization for printing several parts at the same time
- Old design
  - Multi-part assembly from milled parts
  - Previously it had poor manufacturability and considerable amount of welds
  - This resulted into high cost
- Flow properties were also poor with 90-degree sharp corners
- AM approach is to machine a base plate and print on top the geometry that makes sense to be printed
- Benefits
  - Part consolidation: 7 -> 2
  - Improved flow: -60% power loss
  - Cost reduction: -30%
  - Enabled a modular product

Old design pictured below (new design censored)







Some of the first sketches of the new design (Kuikka 2018)

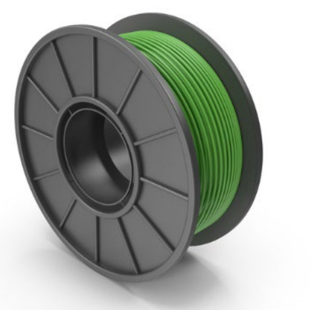
Jasperi Kuikka’s mechanical engineering thesis (2018)

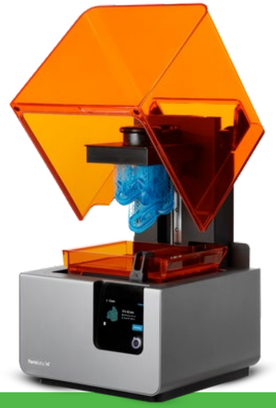
[Slides with further Valmet product examples removed from this version of the presentation]

Summary

- AM is one group of manufacturing methods that you should be somewhat familiar with – not the only one, not always the best, but among those that should be considered alongside methods such as tooling with milling and turning machines, casting, sheet metal work, and welding.
- A plethora of methods of AM exist. For starters, these are sufficient:
  - FDM (Fused Deposition Modeling) – Traditional desktop 3D-printing. Get one, make your own projects, and learn the basics through it. Supports are needed in FDM prints. Designing and printing such objects can be useful in understanding also metal-AM design.
  - SLA (Stereolithography) / resin-based – Elso desktop printing viable for customers, intricate details, mechanically not very viable.
  - SLS (Selective Laser Sintering) – Professional 3D printing with polymers.
  - Metal AM – A lot of different methods (laser powder bed fusion, binder jetting, direct energy deposition, etc.) exist. Supports are needed.
- AM allows for increasingly complex design with localized mechanical properties, complex internal geometries, etc. – at some point, humans won’t be able to keep up in designing such pieces. From there, cloud-based computing and automated, iterative design such as generative shape design step in.

AM cheat sheet – what you need to know / should remember for now





FDM

- Polymer printing
- Your typically hobby / desktop printer
- Very good for prototyping and getting familiar with the technology
- Needs supports but not escape holes
- Good mechanical properties can be achieved
- If you have an excuse – just buy one (or use the ones at your school)

SLA

- Polymer printing
- Very cheap machines but bad odors/chemicals
- Allows for extremely intricate details and the surface quality is very good – extremely suitable for visual prototypes
- Common for hobbyists as well (small figures, scale models etc.)
- Generally bad mechanical properties
- Needs supports and escape holes

SLS

- Polymer printing
- Your typically hobby / desktop printer
- Probably the most typical industrial application of polymer printing

AM

- Especially interesting field of technologies professionally, but probably learning the basics is easier through polymer methods.
- Escape holes and supports are needed

Images: Pixelsquid, Formlabs, xometry.eu, 3dvector.com

Other materials

- Breaking AM video series by Huld:
- https://www.youtube.com/playlist?list=PL3uWv4yEVZNQUFLsYPJ1_tYIdDl5FojYT

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

C6 – Manufacturing Technology

L2 – Solder Paste Printing Process

P5 - Robert Bosch SRL

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union

Solder Paste Printing Process

The purpose of the lab is:

1) Understanding the PCB paste printing process;
2) Establishing a technological itinerary for PCB manufacturing;
3) Identifying possible factors that can lead to paste printing errors;
4) Becoming familiar with specialized terminology;
5) Understanding the importance of intermediate product quality control/gate.

Content

- Introduction – Surface Mount Technology Area
- Topic 1 – Solder Paste Printing – Process definition;
- Topic 2 – Offset Printing Exercise;
- Topic 3 – Solder Paste Printing issues;
- Printing Application;

Introduction – Surface Mount Technology Area

Co-funded by
the European Union

Introduction – Surface Mount Technology Area

Abbreviations and Definitions

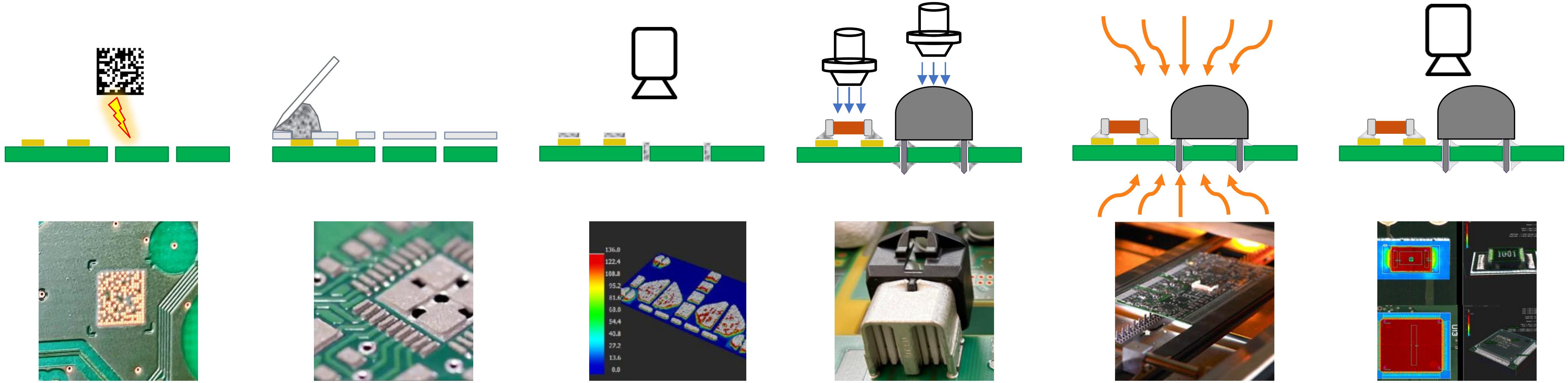
SPP	**S**older **P**aste **P**rinting
SPI	**S**older **P**aste **I**nspection
AOI / SJI	**A**utomatic **O**ptical **I**nspection / **S**older **J**oint **I**nspection
AWP	**A**rrow **W**ith **P**olarity
SMT	**S**urface **M**ounted **T**echnology
PCB	**P**rinted **C**ircuit **B**oard
SMD	**S**urface **M**ounted **D**evices
THRS	**T**rough **H**ole **R**eflow **S**oldering
DMD	**D**ivision **M**anufacturing **S**ystem
Fiducial	Reference point used by automated assembly machines to ensure accurate alignment and placement of components during the assembly process.
Pad	Is a metallized area that allows for the connection and attachment of the electrical terminals of electronic components
Aperture	An opening or shape used in the stencil design that controls the application of solder paste onto the pads of the board.
Quality gate	A quality gate in the SMT industry is a checkpoint where products are inspected to ensure they meet standards, identifying defects early to maintain quality and prevent downstream issues.

Co-funded by the European Union

Introduction – Surface Mount Technology Area

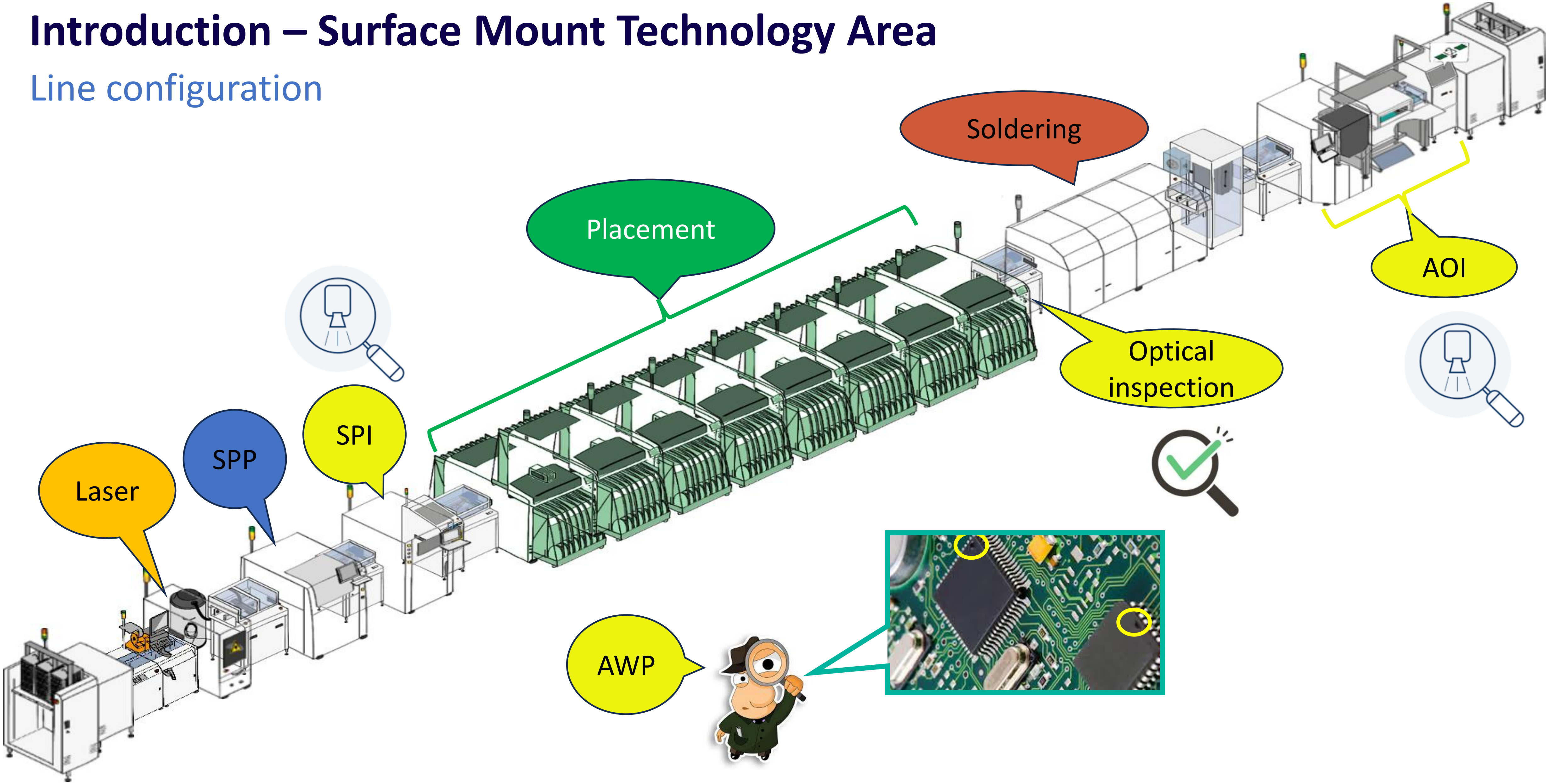
Process flow for Surface Mount Technology (SMT)

DMC Engraving	Solder Paste Printing	Solder Paste Inspection	Components Placement	Reflow Soldering	Automated Optical Inspection



Introduction – Surface Mount Technology Area

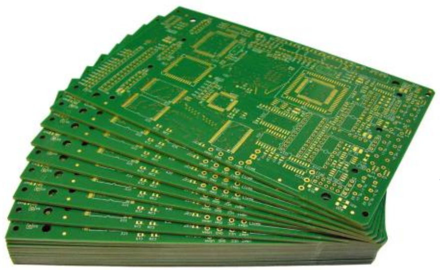
Line configuration



Co-funded by the European Union

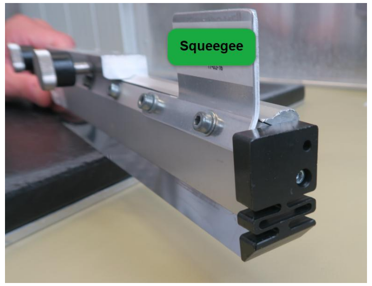
NextGEng

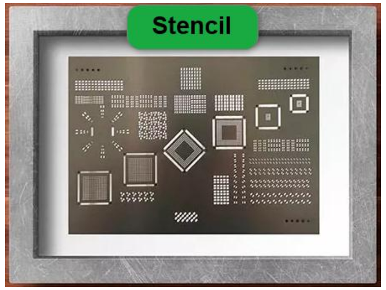
Printed Circuit Board (PCB)



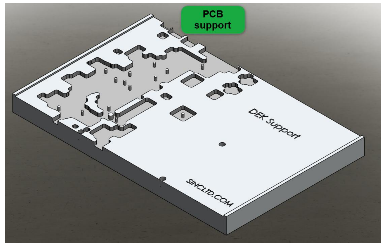
Parameters:

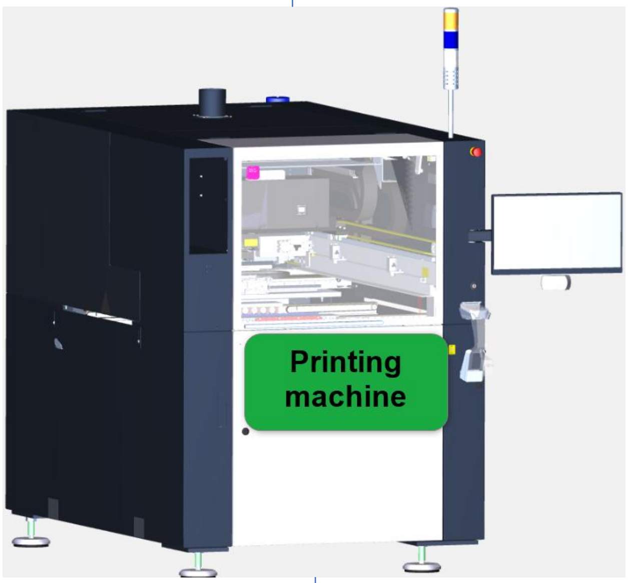
- Printing speed
- Printing pressure
- Cleaning cycle
- Stencil separation speed



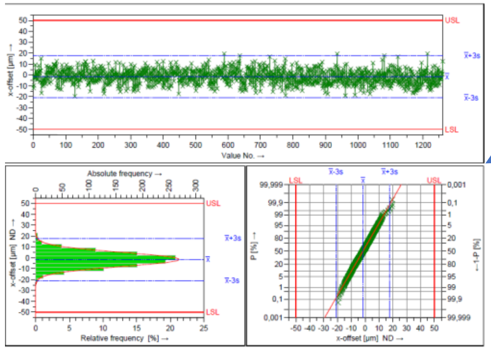


Tools





Machine Capability Index (CMK)



DMD

Environment

Temperature **Humidity**

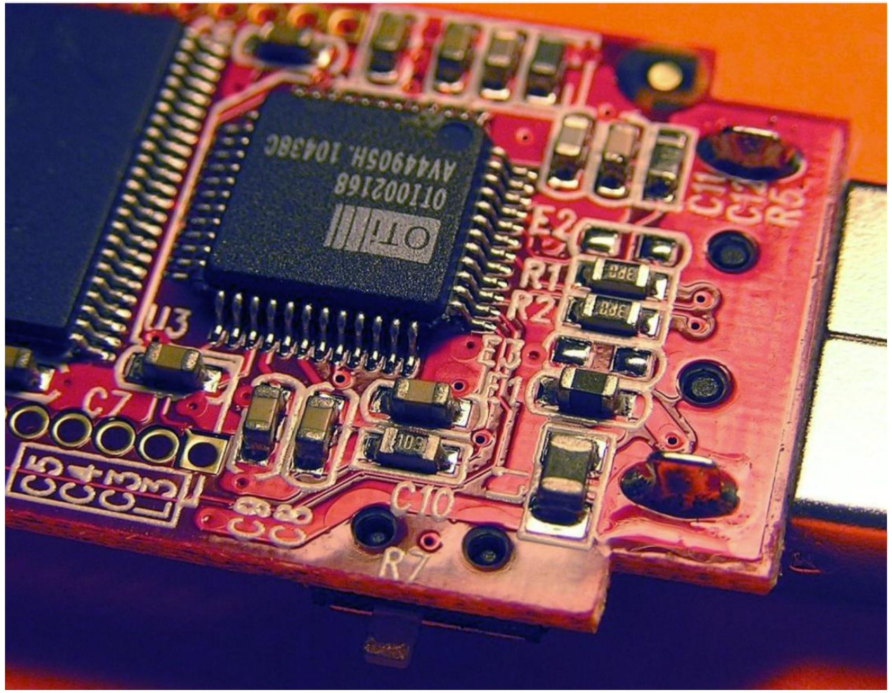
Co-funded by
the European Union

NextGEng

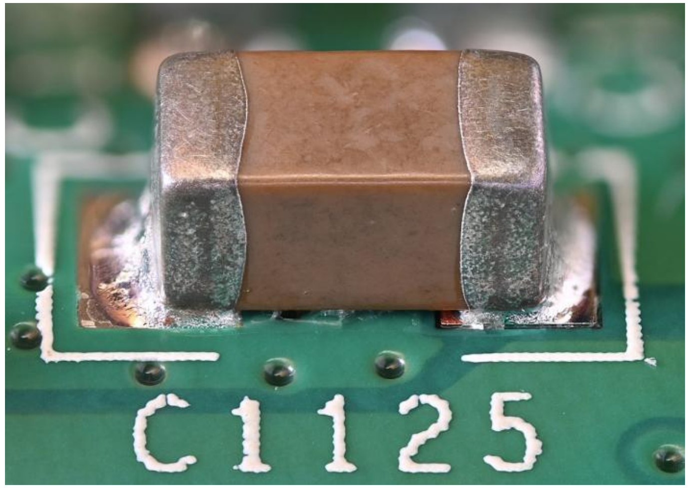
Introduction - Tools used for Printing Process

Factors which can influence the printing process

Solder paste printing involves applying solder paste to the pads of a printed circuit board (PCB) through a stencil.



- **Stencil Design:** The size, shape, and thickness of stencil apertures must be optimized for different PCB designs and component sizes.
- **Paste Quality:** The viscosity, particle size, and flux activity of the solder paste must be suitable for the application and the printing equipment.
- **Environmental Conditions:** Temperature and humidity can affect solder paste performance and should be controlled in the printing environment.
- **Printer Calibration:** Regular calibration and maintenance of the printing machine are essential to maintain accuracy and repeatability.



Co-funded by the European Union

NextGEng

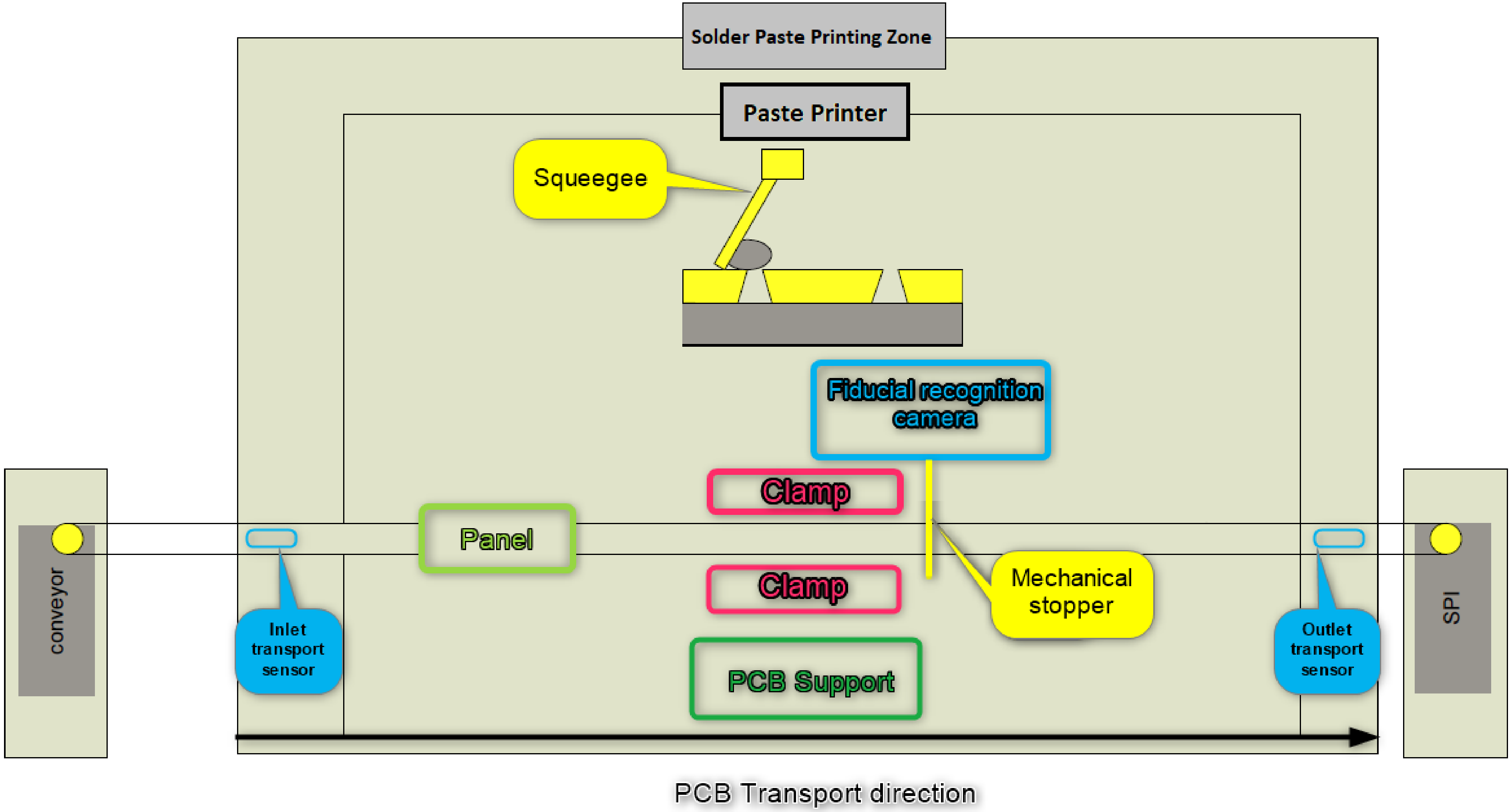
Topic 1 - Solder Paste Printing - Process Definition

Co-funded by
the European Union

NextGEng

Solder Paste Printing – Process Definition

Process inside of printing machine



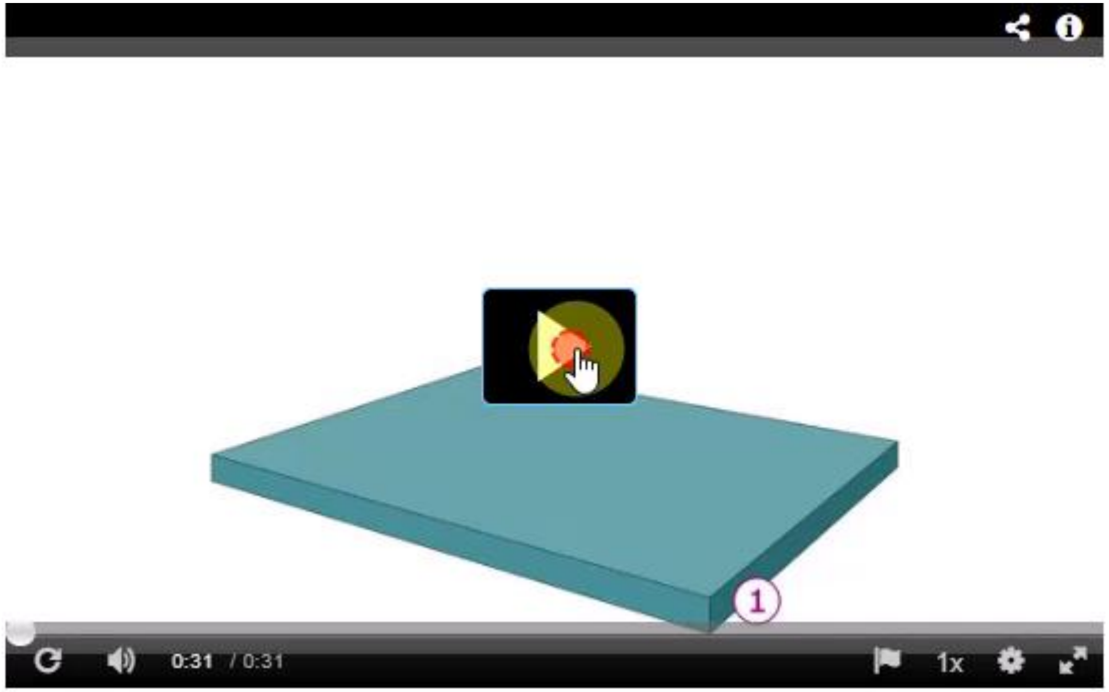
Co-funded by the European Union

NextGEng

Solder Paste Printing – Process Definition

Printing process concept

Step	Description
1	The PCB arrives at the inlet of the printer and enters the solder paste printer via transport belt.
2	The printing table with the PCB support lifts up the PCB from below. Afterwards the clamping is closing.
3	The PCB is lifted up against the stencil.
4	The squeegee pushes the solder past-roll, which is in front of the squeegee, over the stencil.
5	The solder paste is pressed into the apertures of the stencil and smoothly peeled off.
6	The PCB will be separated from the stencil by lowering the printing table.
7	When the PCB is back on the transport belt, the clamp will be released and the printed PCB moves out of the printer.

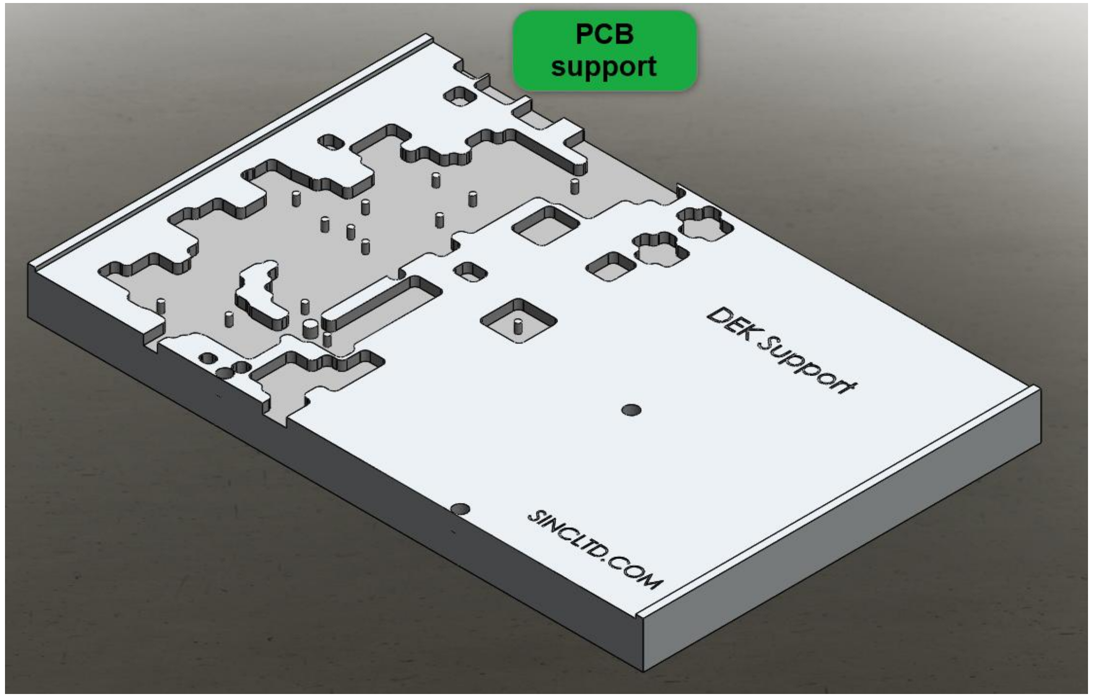


Element	Name
1	PCB Support
2	Stencil
3	PCB with Copper Pads
4	Squeegee
5	Solder Paste

Solder Paste Printing – Process Definition

PCB support

- **Support:** PCB support provides a stable and flat surface for the PCB during the solder paste printing process. The main functions and importance of PCB support are:
  - Stabilization - Is essential for ensuring accurate alignment between the stencil and the PCB pad;
  - Preventing Bending and Warping - Thin or large PCBs can bend or warp under the pressure applied by the squeegee, and support fixture helps to hold the PCB flat.
  - Alignment Assistance - PCB supports often include features that assist in the precise alignment of the PCB with the stencil.



Solder Paste Printing – Process Definition

Solder paste

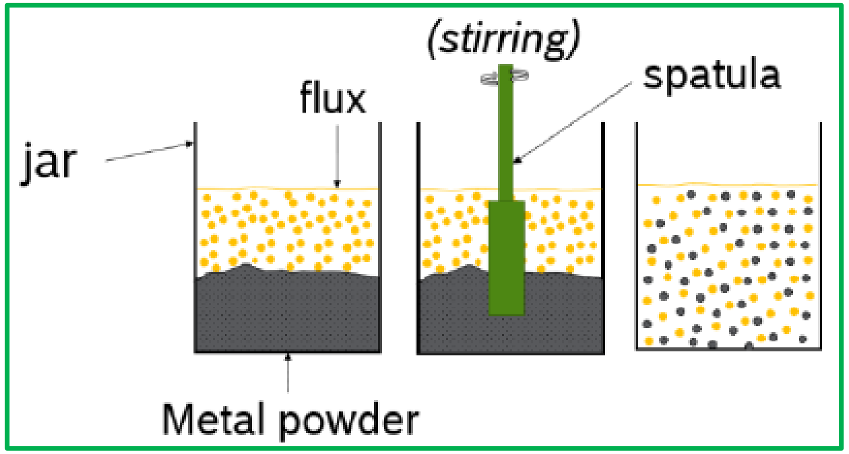
- **Solder paste:** Solder paste is a mixture of powdered solder (typically an alloy of tin, lead, or lead-free alternatives) and a flux medium.

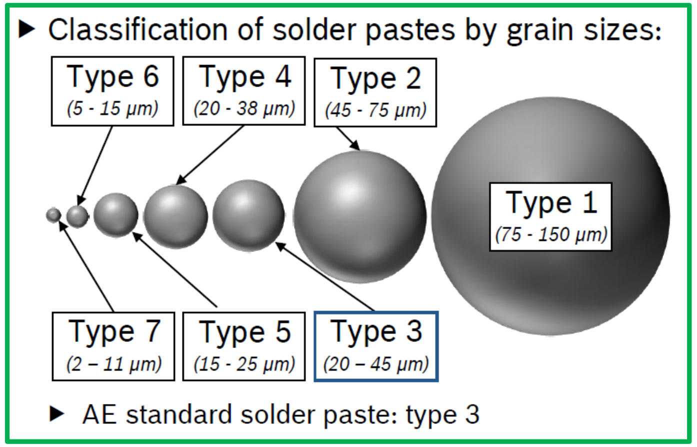
Once applied and reflowed, the solder in the paste melts and forms solid, electrically conductive joints between the PCB pads and the component leads. Besides electrical conductivity, solder paste secures components to the PCB, ensuring they remain in place during the operational life of the device, even under mechanical stresses like vibration or thermal cycling.

https://www.youtube.com/watch?v=1JFoh4TppDM

De interes Sec 14-20

- **Ingredients:**
  - Metal powder of tin, lead, cooper;
    - ➔ Electronic connection between components and PCB
  - Flux consisting solid and fluid particles:
    - ➔ Removing the oxide layer of pads, holding SMD components on PCB





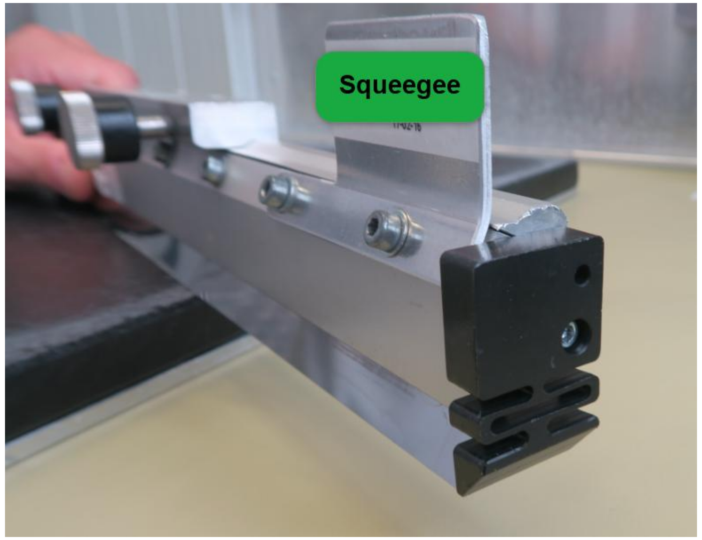
Co-funded by the European Union

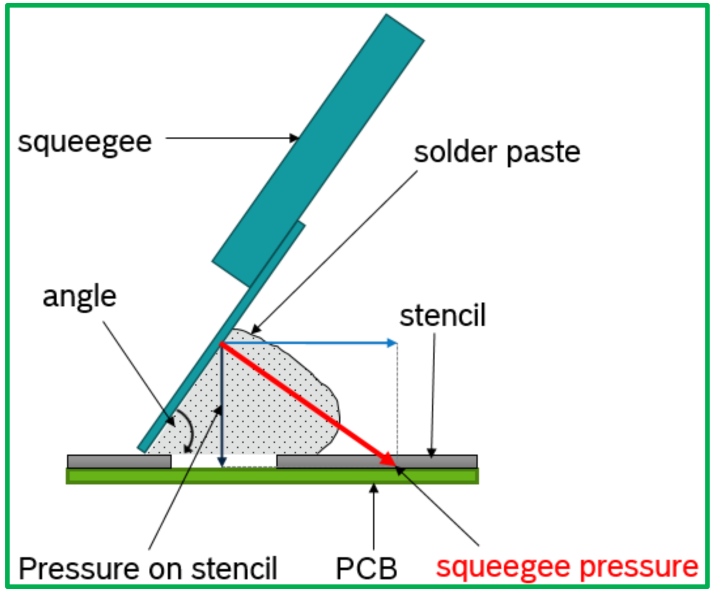
NextGEng

Solder Paste Printing – Process Definition

Squeegees

- **Squeegees:** The primary role of the squeegee is to apply solder paste uniformly across the stencil's surface.
  - Paste Application - By moving the squeegee over the stencil, it forces the paste through the stencil apertures onto the PCB pads.
  - Paste Distribution - The squeegee ensures an even distribution of solder paste across the entire stencil. This uniformity is essential for consistent deposition of paste on all the pads, which is critical for the quality and reliability of the solder joints.
  - Pressure Control - The squeegee applies the necessary pressure to push the solder paste through the stencil apertures.
  - Angle and Speed - The angle and speed at which the squeegee moves are carefully controlled to optimize paste deposition.





Co-funded by
the European Union

NextGEng

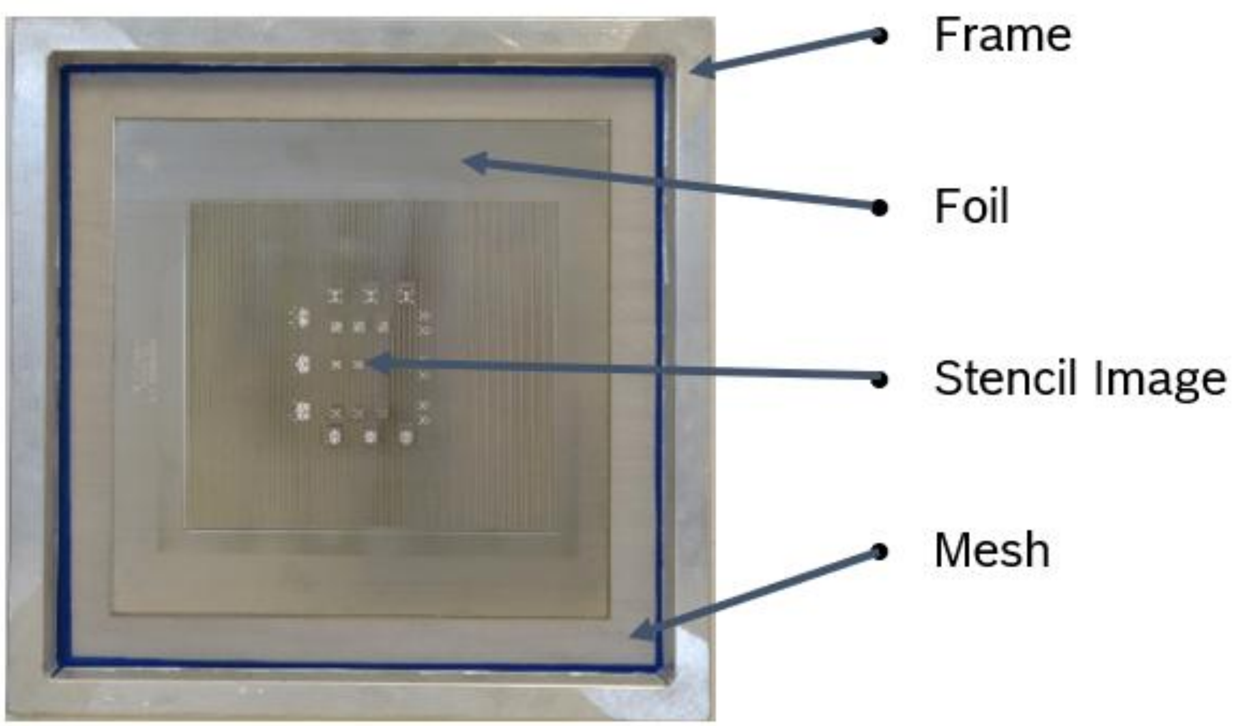
Solder Paste Printing – Process Definition

Stencil

➢ **Stencil Design:** The size, shape, and thickness of stencil apertures must be optimized for different PCB designs and component sizes.

The apertures of a stencil used in solder paste application for a printed circuit board (PCB) are intentionally designed to be slightly smaller than the pads on the PCB. This design choice serves several important purposes:

- Solder paste control - Smaller apertures help to control the amount of solder paste deposited on the PCB pads;
- Paste spread - Solder paste tends to spread slightly after being deposited;
- Stencil wear - Stencils are subjected to mechanical wear during the printing process;
- Improved Adhesion - By depositing a slightly smaller volume of solder paste, the paste can better adhere to the pad during the reflow process.

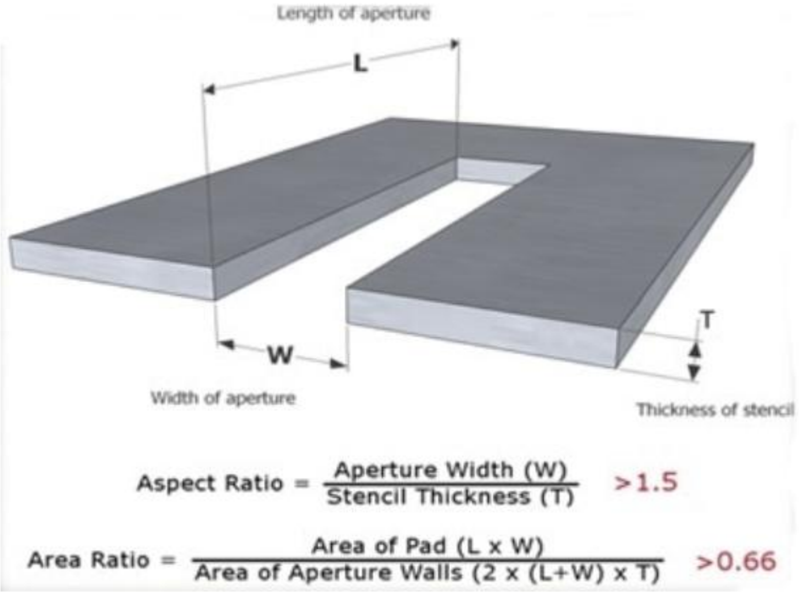


Co-funded by the European Union

NextGEng

Solder Paste Printing – Process Definition

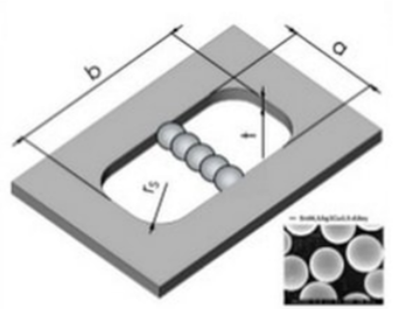
Stencil



The release of solder paste from the apertures of the stencil is also affected by the particle size of the selected solder paste. Below are the types and particle sizes available:-

Particle size in microns

Type	Less than 0.5% larger than	10% Max. between	80% Min. Between	10% Max. Less than
1	160	150-160	75-150	75
2	80	75-80	45-75	45
3	60	45-60	25-45	25
4	50	38-50	20-38	20
5	40	25-40	15-25	15
6	25	15-25	5-15	5
7	15	11-15	2-11	2



5 Solder Ball Rule

There is a rule of thumb which says ideally a minimum of 5 solder particles should span the width of the smallest aperture.

https://www.surfacemountprocess.com/a-guide-to-effective-stencil-design.html

Topic 2 – Alignment between pads and apertures

Co-funded by
the European Union

Alignment Between Pads and Apertures

Offset printing

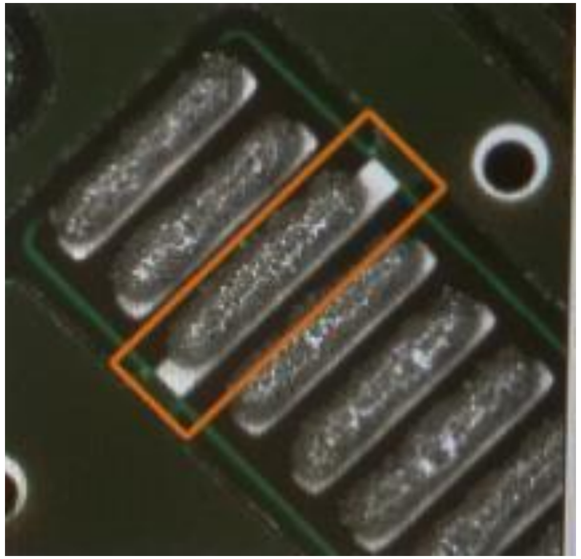
Offset printing: In SMT, solder paste offset detected by SPI poses major quality risks for automotive products due to strict reliability standards.

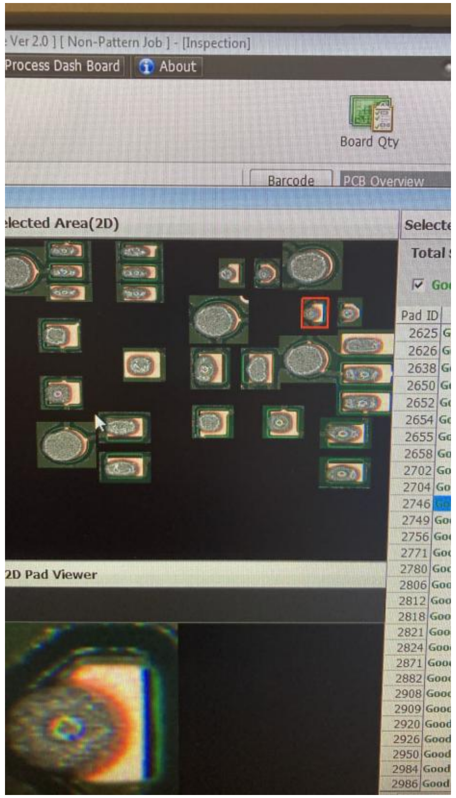
Possible causes:

- **Stencil Misalignment**: The stencil is not properly aligned with the PCB, leading to incorrect paste deposition;
- **PCB Warpage**: The PCB is warped, causing uneven contact with the stencil.
- **Improper Machine Setup**: Incorrect programming of the solder paste printer or poor clamping of the PCB;
- **Stencil Damage or Wear**: A damaged stencil may result in uneven paste deposition.
- **Squeegee Issues**: Worn-out or improperly adjusted squeegees can cause inconsistent paste application.
- **Environmental Factors**: Temperature, humidity, or contamination in the printing environment can affect paste consistency and placement.

Containment actions:

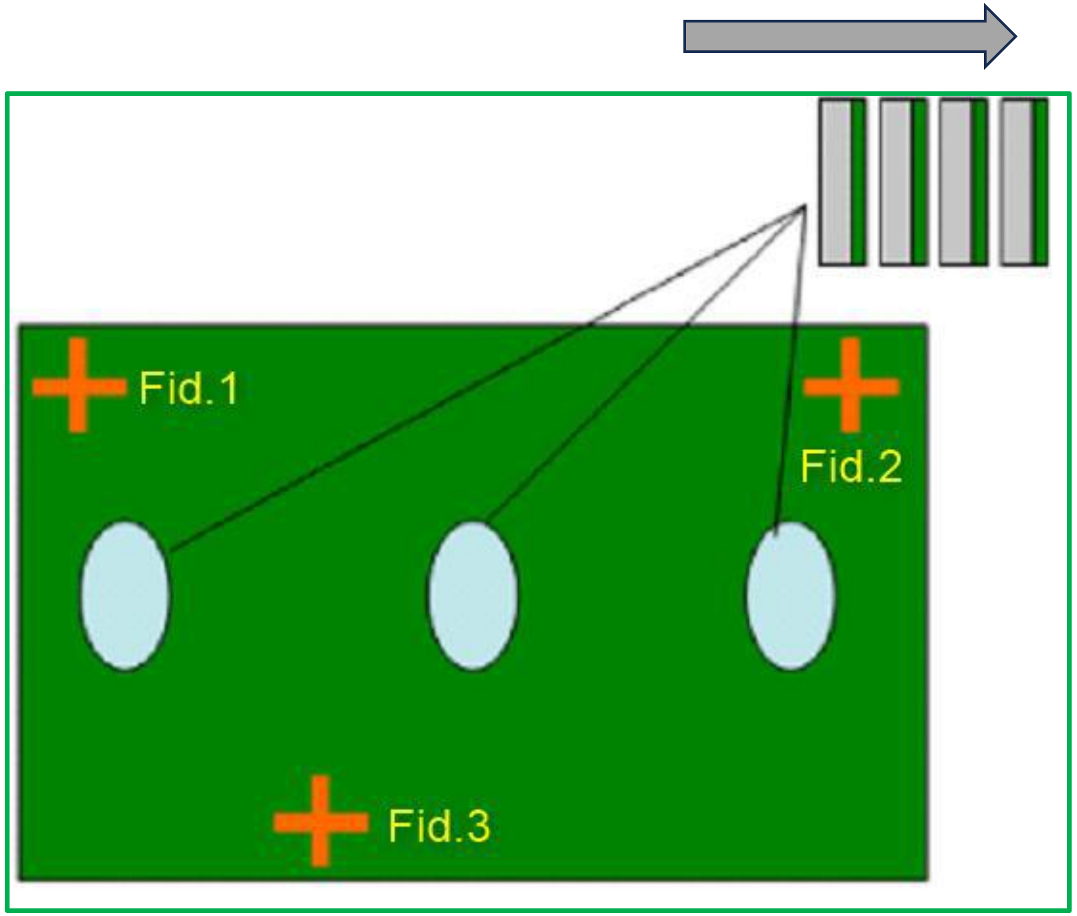
- Apply offset on the SPP machine;





Alignment Between Pads and Apertures

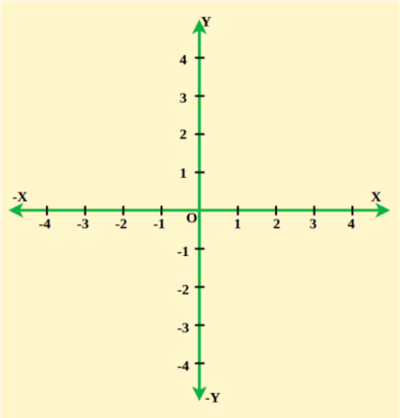
Exercise Nr.1



1. Offset printing over the entire PCB to the left side.

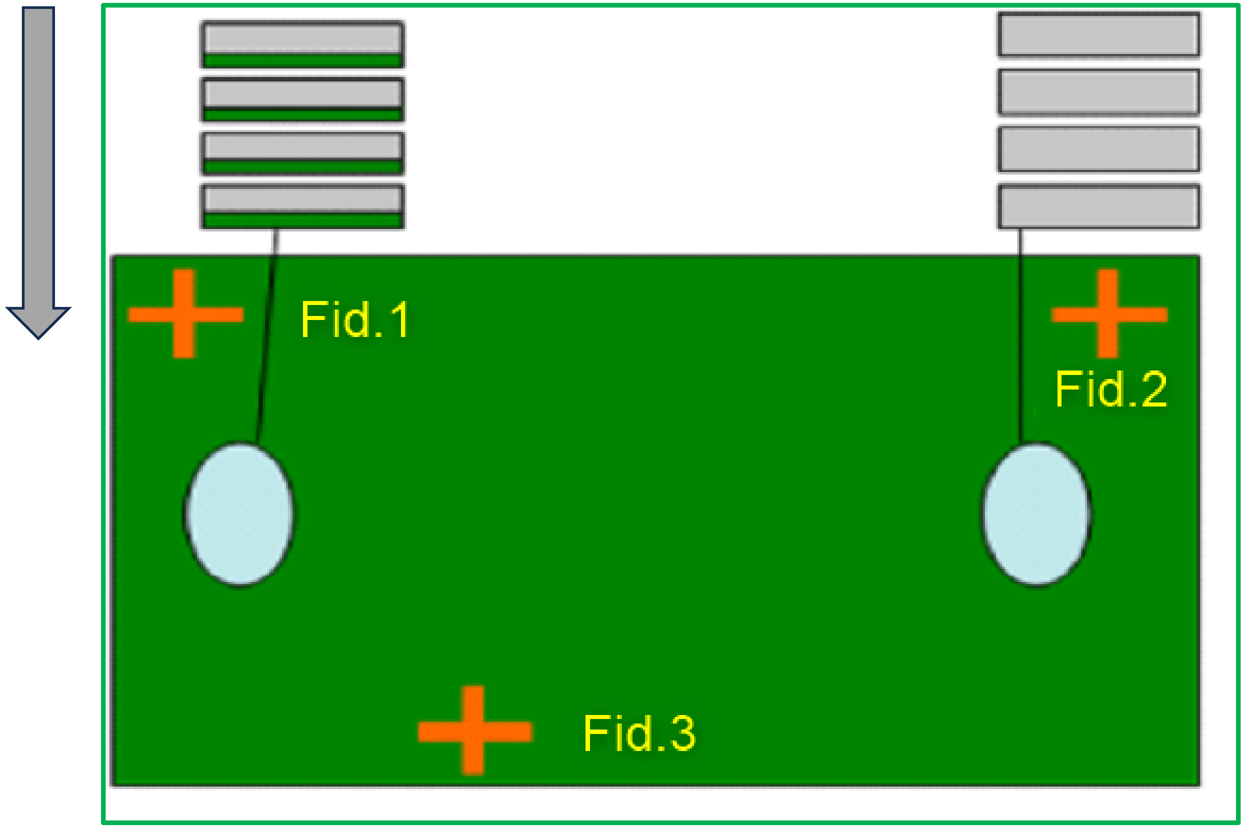
On which fiducial point should I apply the correction, and with what sign (plus or minus) to properly align the printing?

A correction will be applied for all fiducials in the positive +X direction (ex. 0.40µm).
No correction is applied in the Y direction.



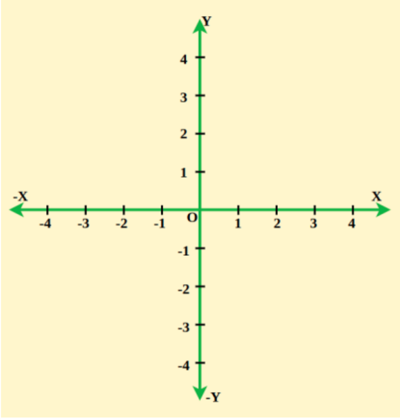
Alignment Between Pads and Apertures

Exercise Nr.2



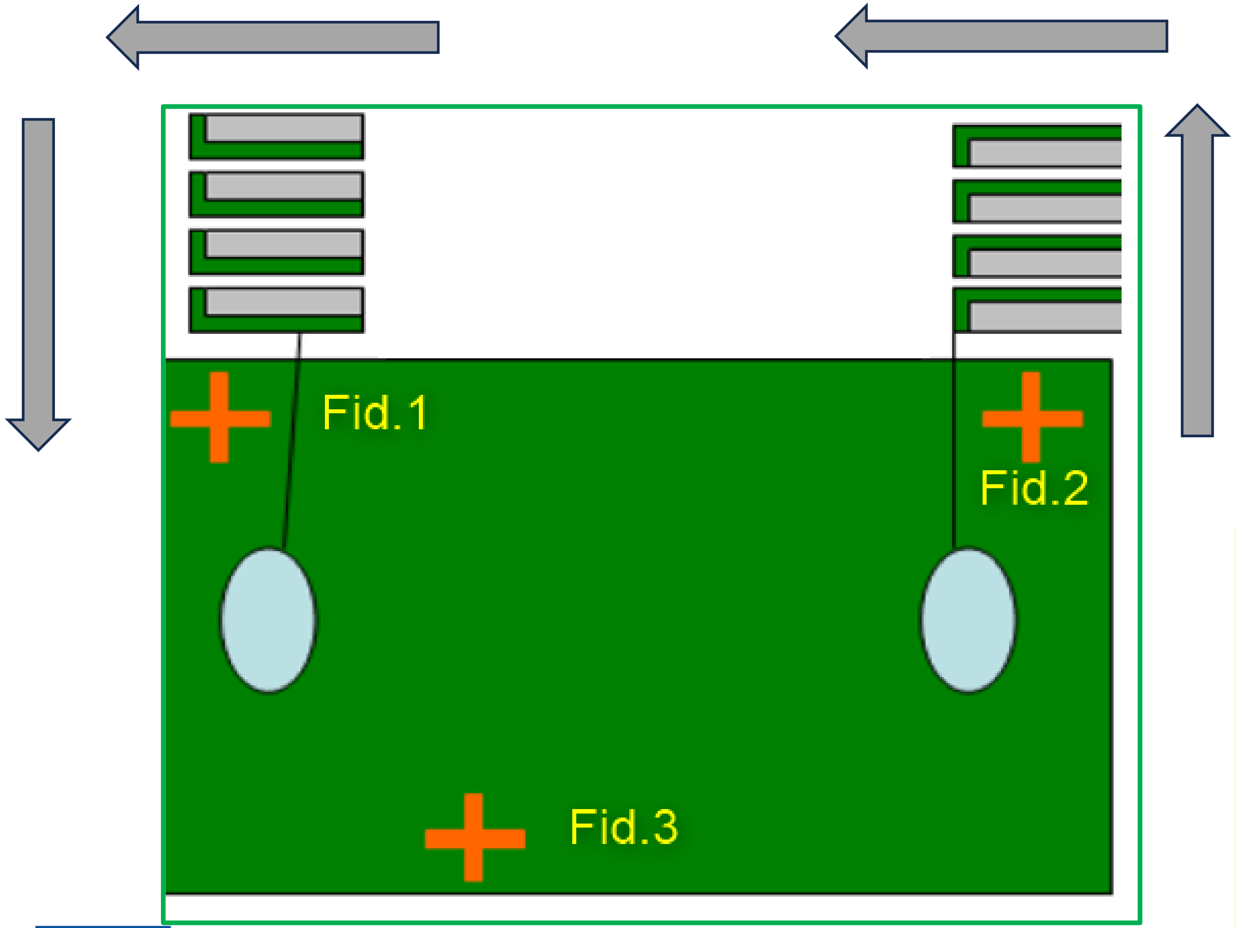
2. Offset printing to the left corner only on 1st fiducial.

A correction is applied to the first fiducial in the -Y direction (ex. 0.40µm).
No correction is applied in the X direction.



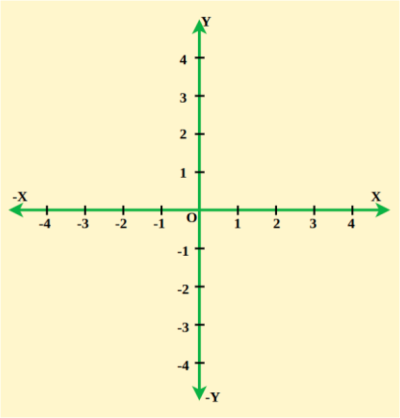
Alignment Between Pads and Apertures

Exercise Nr.3



3. On 1st fiducial is an offset printing into the right and upward direction;
On 2nd fiducial is an offset printing into the right and downwards direction;

On 1st fiducial will be applied on –Y and –X.
On 2nd fiducial will be applied on +Y and –X.



Topic 3 – Solder Paste Printing – Printing issues

Co-funded by
the European Union

Solder Paste Printing – Printing Issues

Tools influences – PCB support

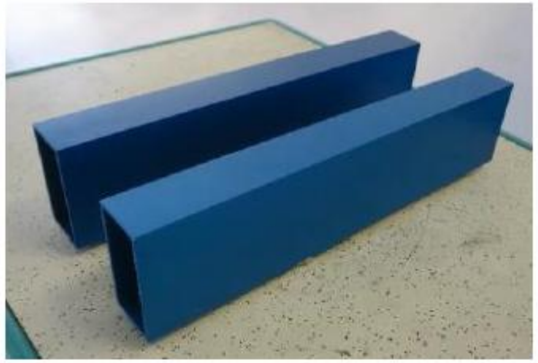
PCB - Support:

- Purpose:

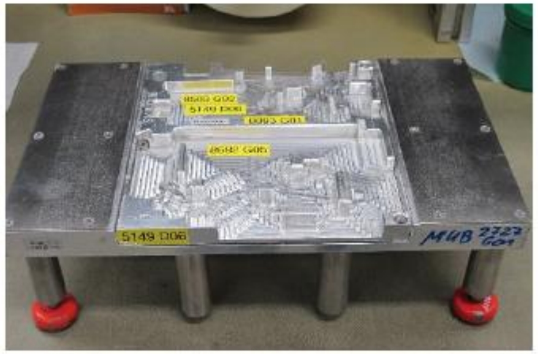
Supports PCB against squeegee pressure to avoid a critical bending

- Usage:
  - Universal: for unpopulated PCBs
  - Product specific: for populated PCBs
- Handling:
  - Check PCB support surface for damages and contamination (e.g., Dry solder paste, bumps, worn out) before and after usage

Universal support



Product specific support



Co-funded by the European Union

Solder Paste Printing – Printing Issues

Tools influences - Squeegees

Squeegee:

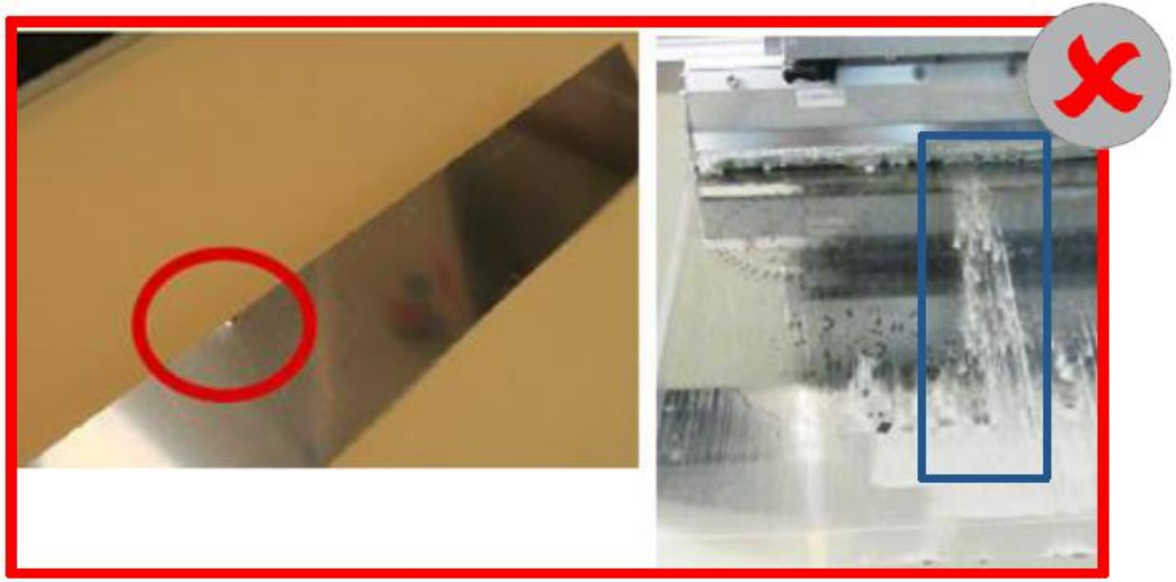
- Purpose:

Strokes solder paste over stencil and into apertures

- Usage:

Only for specific solder paste to avoid contamination

- Handling:
  - Check before and after usage for
    - Blocked apertures
    - Bulges
    - Cracks in wire cloth
    - Foreign particles
    - Scratches



Solder Paste Printing – Printing Issues

Tools influences – Stencil

Stencil:

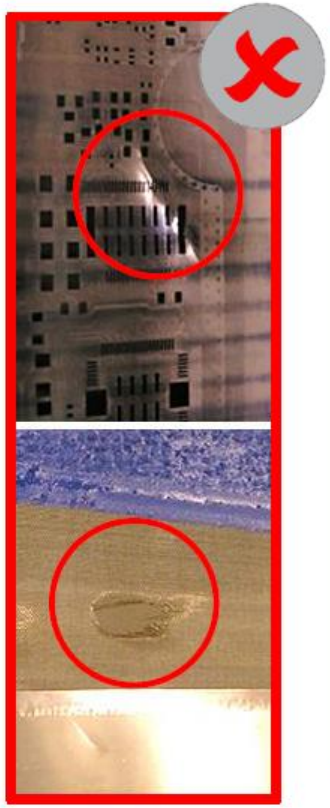
- Purpose:

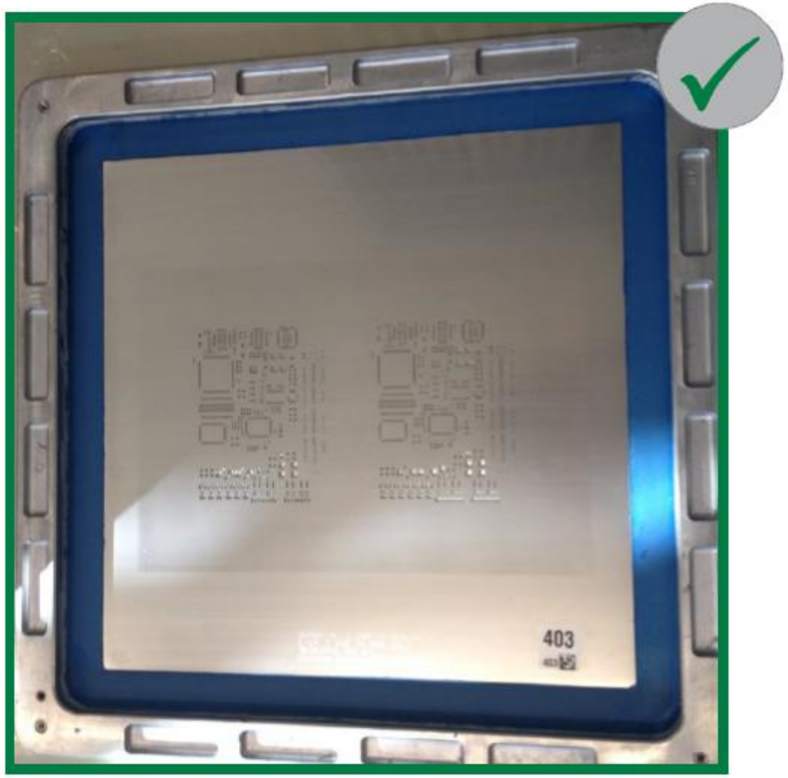
Defines locations on PCB where solder paste is printed at

- Usage:

Only for specific layout of PCB

- Handling:
  - Do not touch any apertures
  - Check before and after usage for
    - Blocked apertures
    - Bulges
    - Cracks in wire cloth
    - Foreign particles
    - Scratches





Co-funded by
the European Union

NextGEng

Solder Paste Printing – Printing Issues

Insufficient Printing

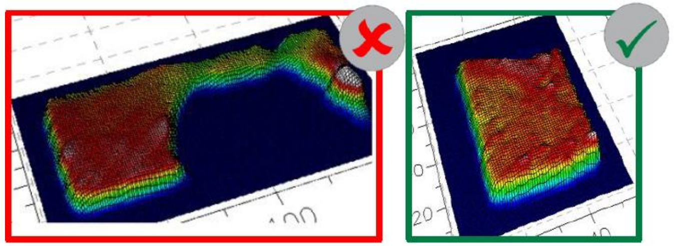
- **Insufficient Paste:** Paste deposits that are below the allowed limits can result in poor solder joints. Ensuring consistent printing parameters and stencil cleanliness helps address this problem.

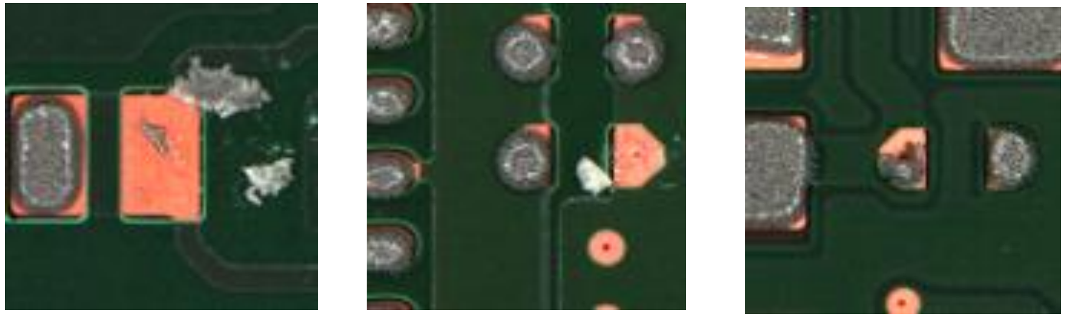
Possible causes:

- ➢ Clogged apertures;
- ➢ Exposure and mixing paste;
- ➢ Quality of the raw material;
- ➢ Dirty or damaged tools;
- ➢ Improper cleaning process inside of the printing machine;
- ➢ Wrong settings on SPI machine;
- ➢ Contaminations;
- ➢ Environment;

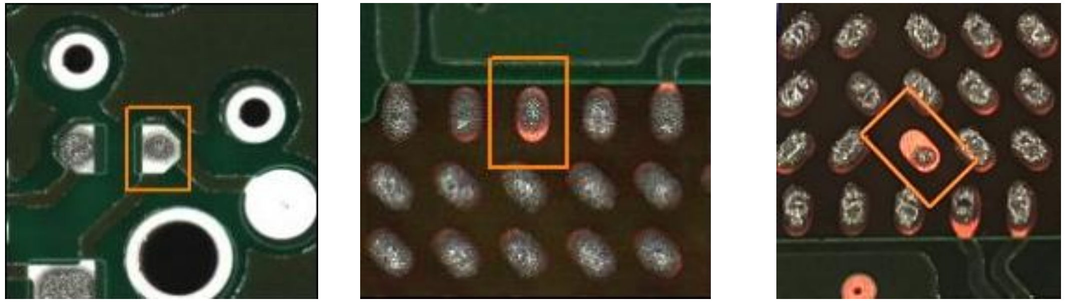
Corrective actions:

- ➢ Check printing parameters
- ➢ Check stencil and PCB support





Insufficient due to contamination



Real defect

Co-funded by
the European Union

Solder Paste Printing – Printing Issues

Excessive Printing

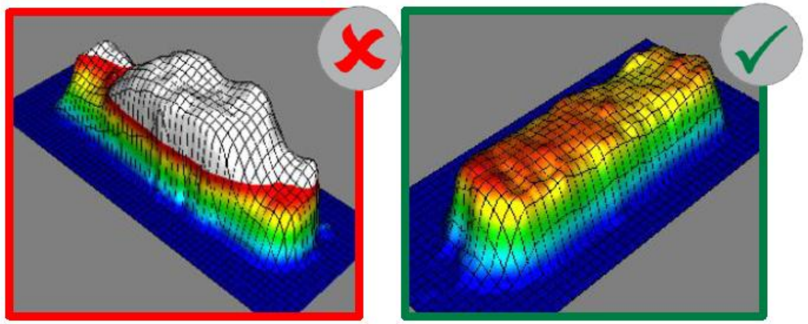
- **Excessive paste:** Paste deposits that are over the allowed limits can result in non-conform solder joints.

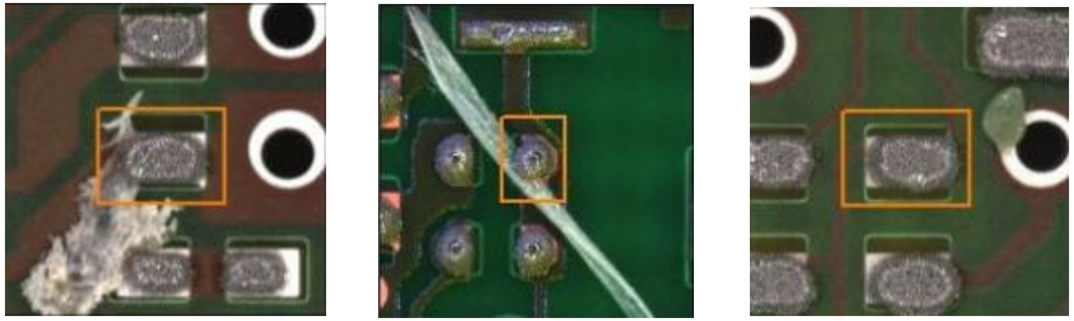
Possible causes:

- ➢ Worn out or damaged squeegees;
- ➢ Exposure and mixing paste;
- ➢ Environment;
- ➢ Dirty or damaged tools;
- ➢ Gap between PCB and Stencil;
- ➢ Improper cleaning process inside of the printing machine;
- ➢ Contaminations;

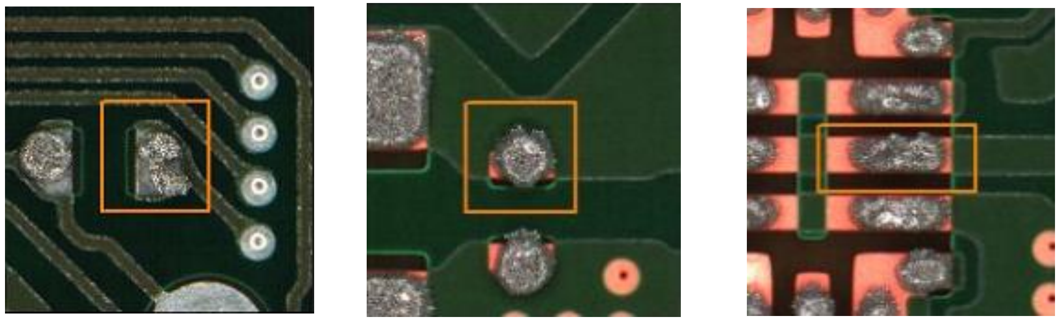
Corrective actions:

- ➢ Check printing parameters
- ➢ Check stencil and PCB support
- ➢ Check PCB warpage





Excessive due to contamination



Real defect

Solder Paste Printing – Printing Issues

Bridging Printing

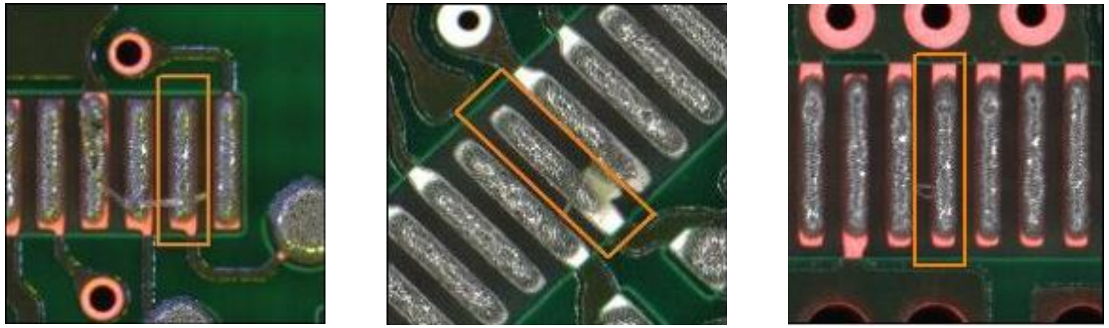
- **Bridging:** Excessive solder paste can lead to bridging between adjacent pads. Proper stencil design and paste selection can mitigate this issue.

Possible causes:

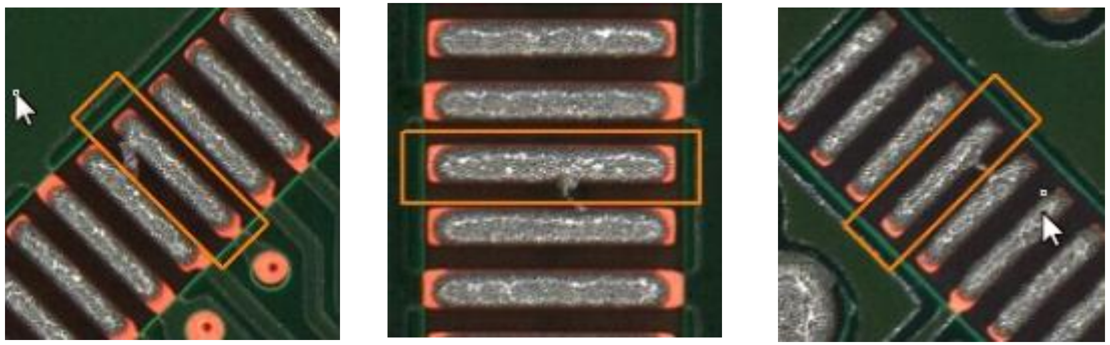
- Worn out or damaged squeegees;
- Exposure and mixing paste;
- Environment;
- Dirty or damaged tools;
- Gap between PCB vs Stencil;
- Improper cleaning process inside of the printing machine;
- Contaminations;

Corrective actions:

- Check stencil bottom side
- Check cleaning frequency
- Check stencil position
- Check solder paste



Bridging due to contamination



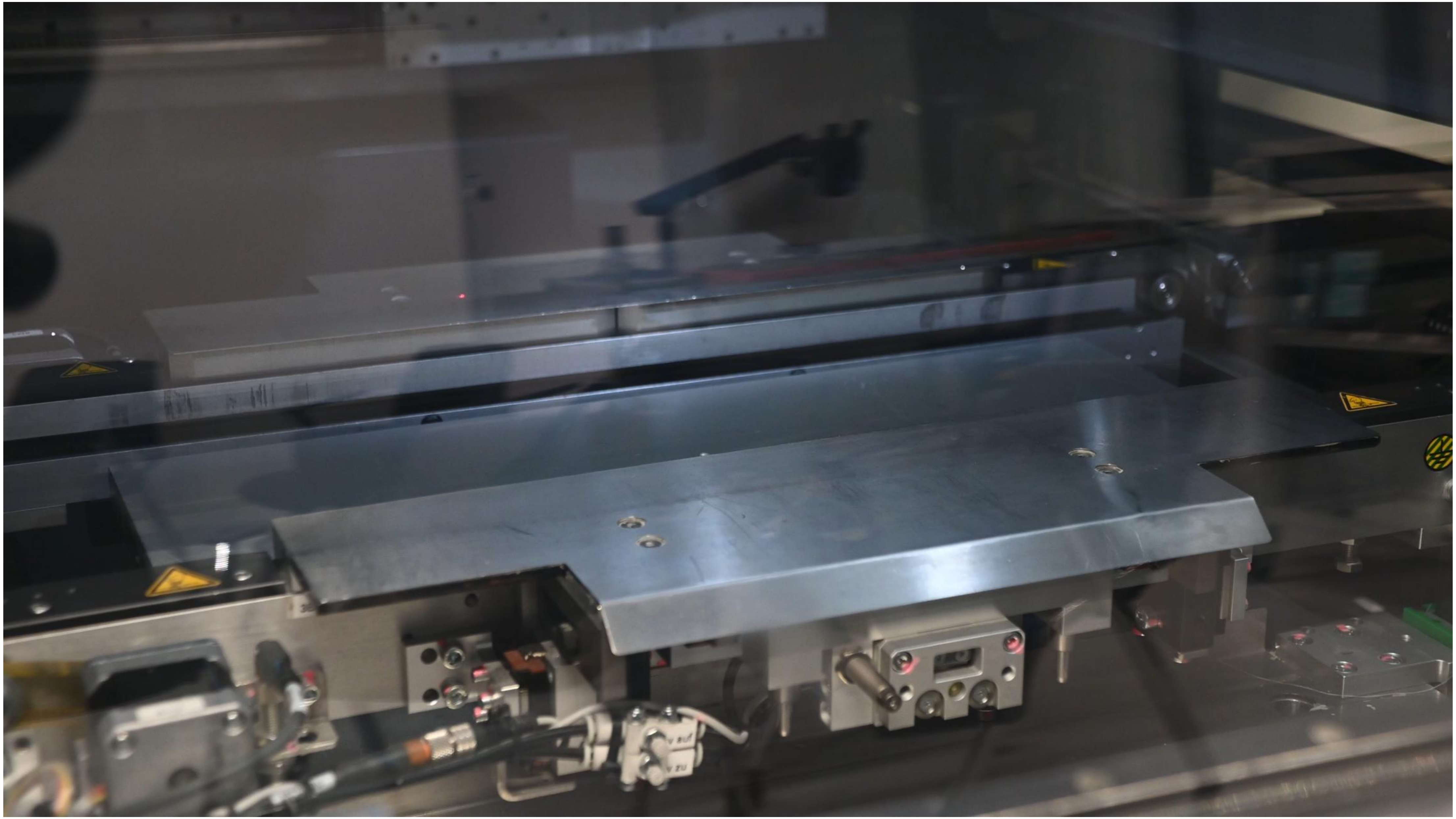
Real defect

Co-funded by
the European Union

NextGEng

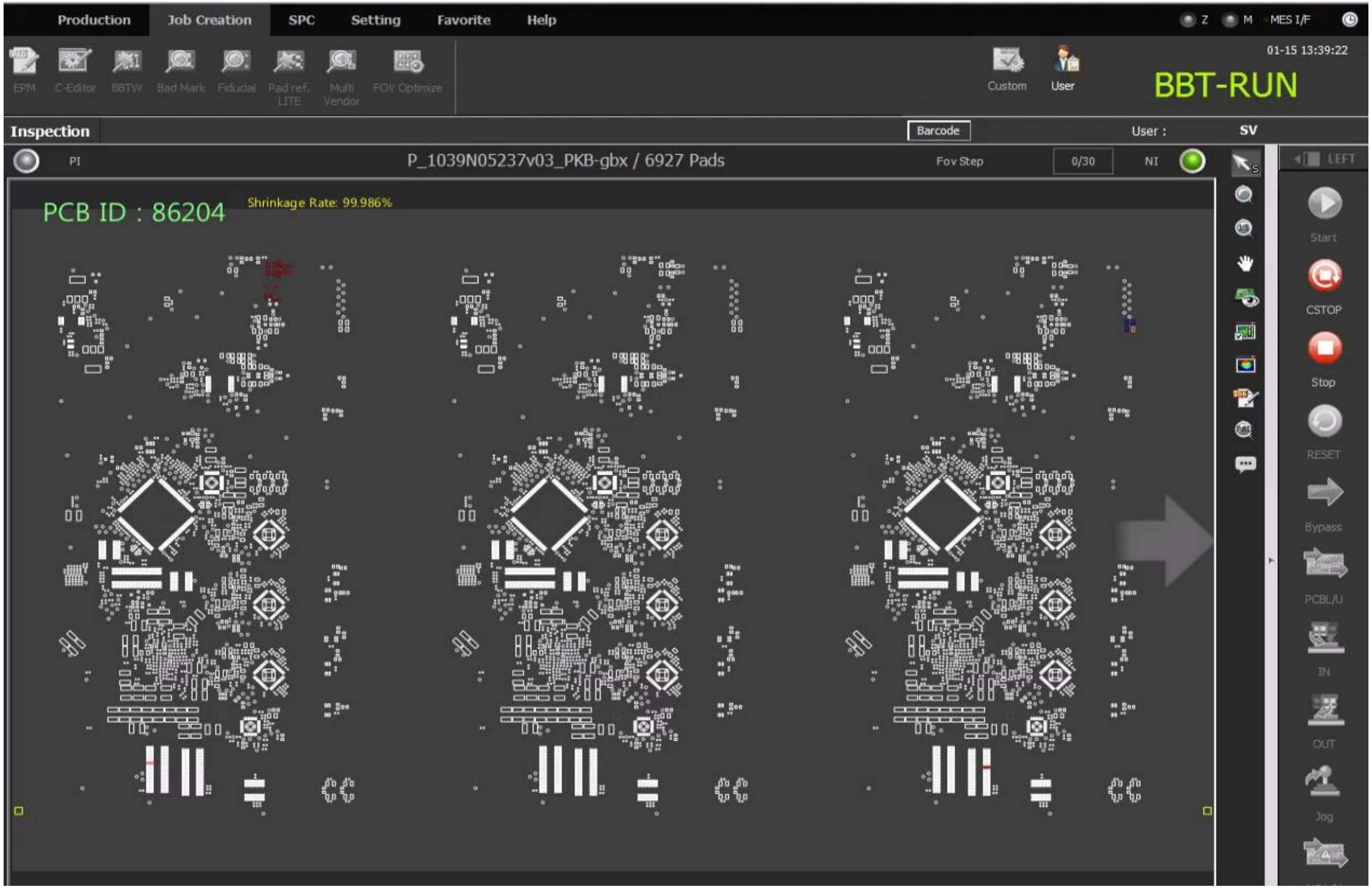
Printing Application

Co-funded by
the European Union



Co-funded by
the European Union

NextGEng

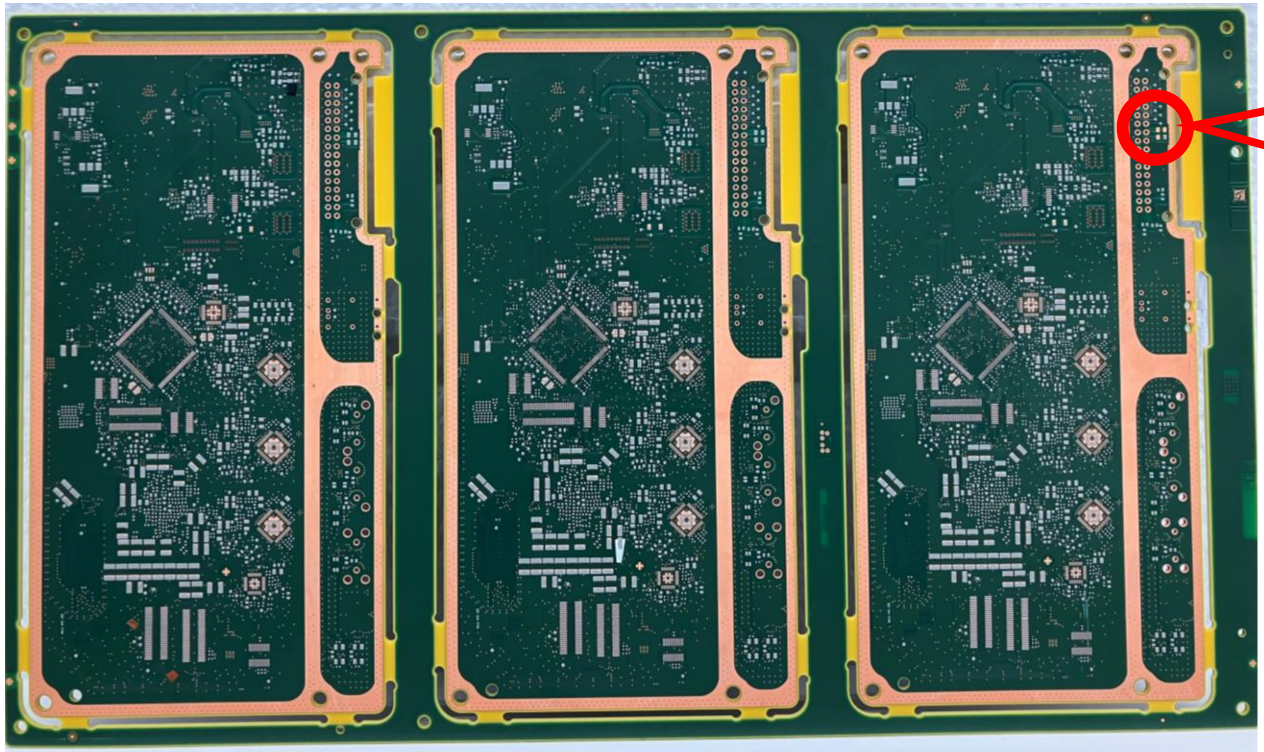


Co-funded by
the European Union

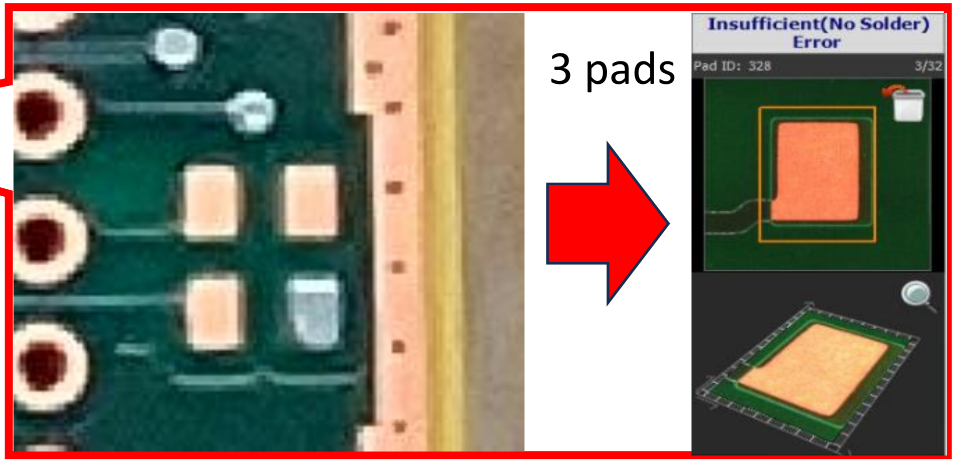
NextGEng

Printing Application

Insufficient printing



Real image SPI image



Possible causes:

- Clogged aperture due to paste deposit or contamination;

Corrective actions:

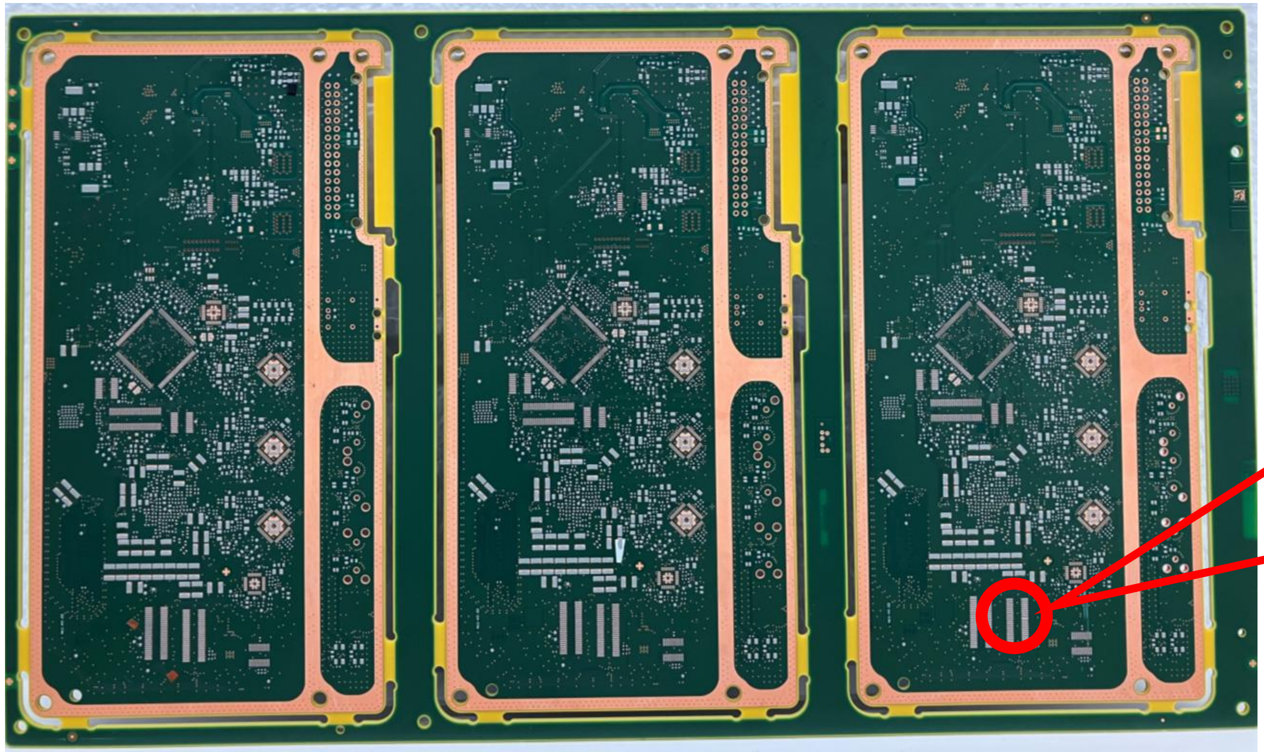
- Scrap the PCB;
- Clean the stencil;
- Check the equipment;

Co-funded by the European Union

NextGEng

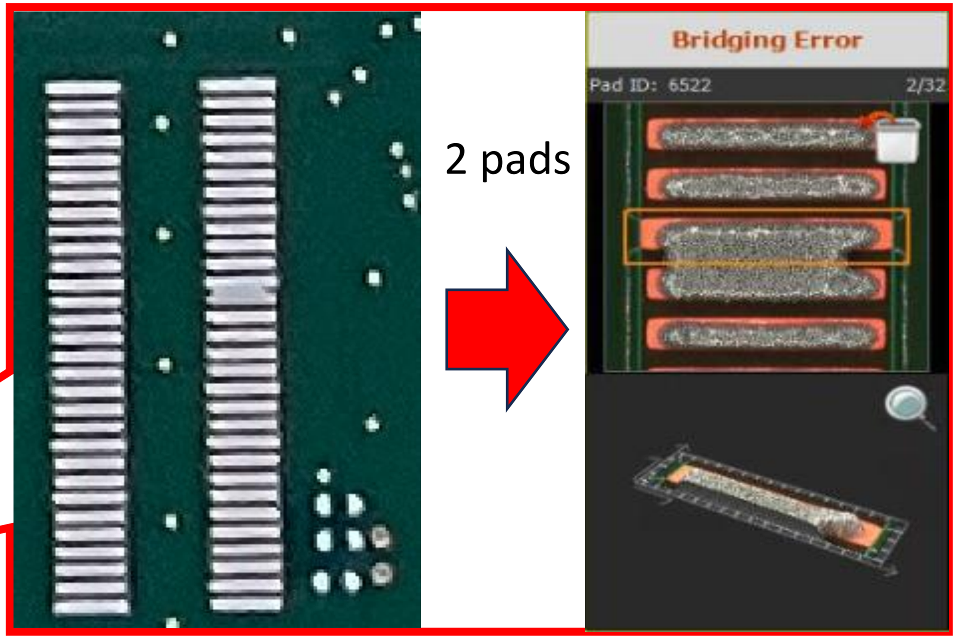
Printing Application

Bridging



Real image

SPI image



Possible causes:

- ➢ Damaged aperture due to manipulation or worn out;

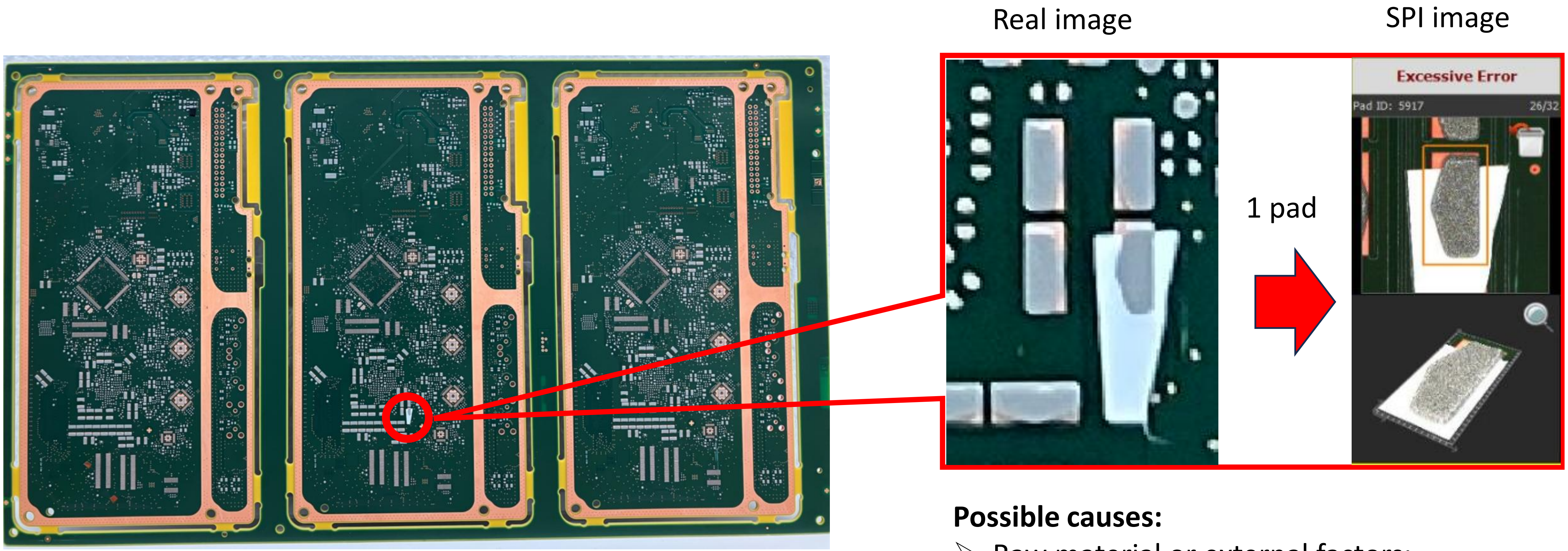
Corrective actions:

- ➢ Scrap the PCB;
- ➢ Replace the stencil;

Co-funded by the European Union

Printing Application

Excessive printing



Possible causes:

- ➢ Raw material or external factors;

Corrective actions:

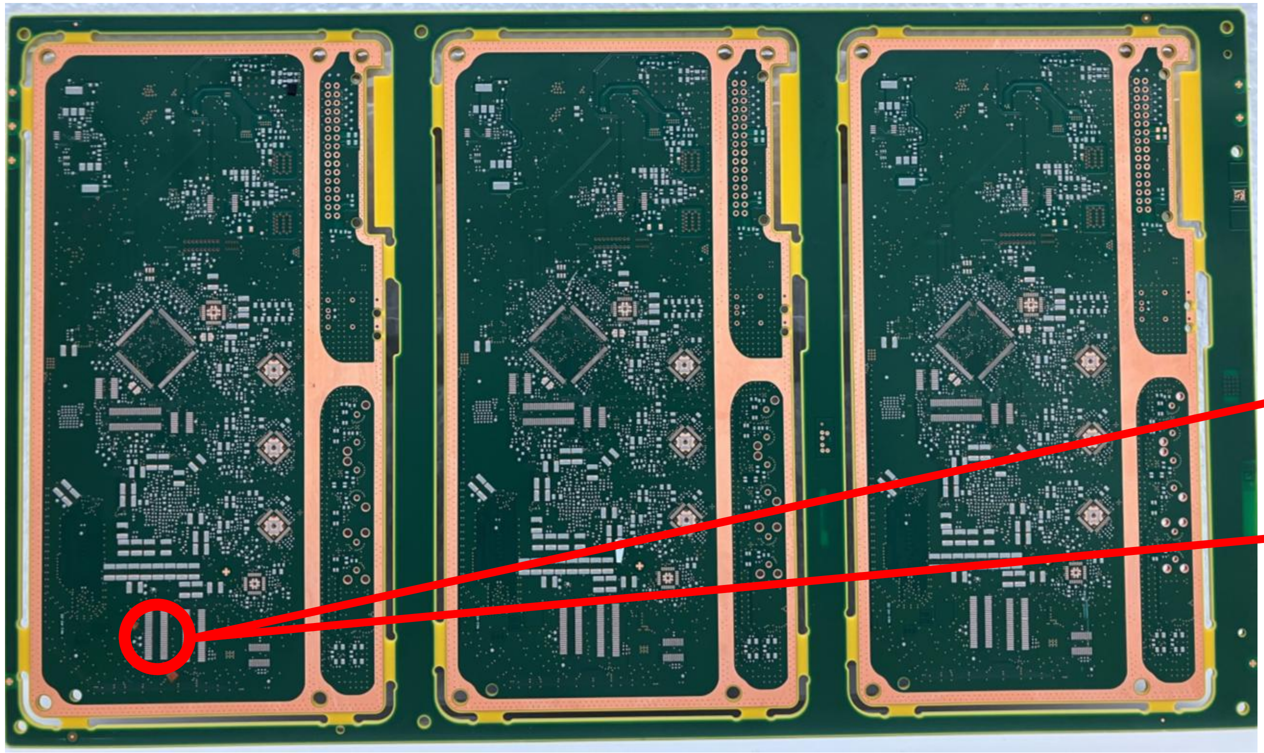
- ➢ Scrap the PCB;
- ➢ Check the cleaning station;
- ➢ Check the equipment;
- ➢ Check the raw material;

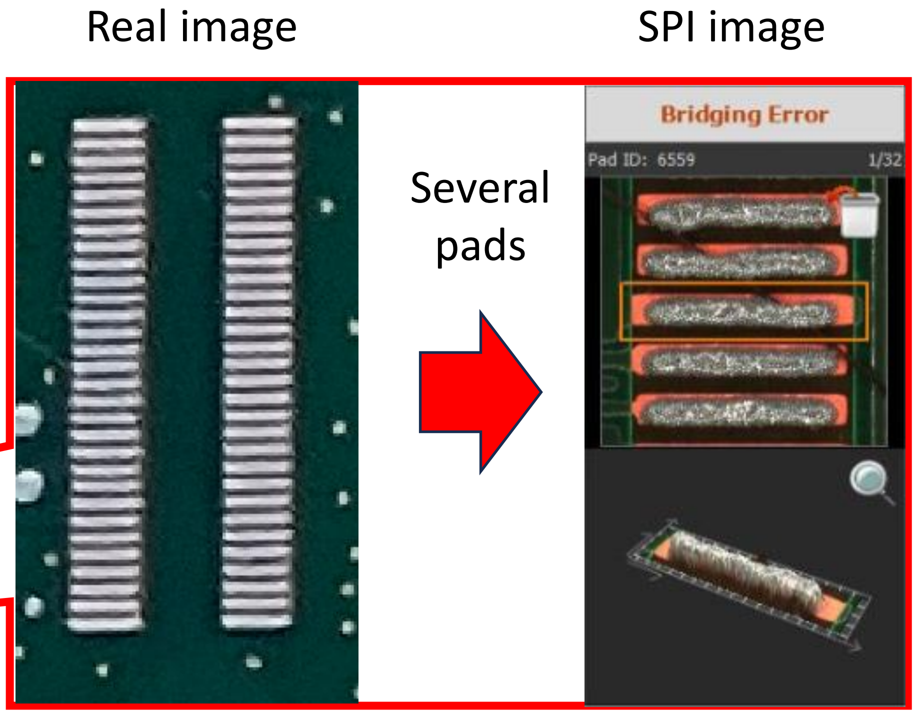
Co-funded by
the European Union

NextGEng

Printing Application

Bridging





Possible causes:

- Raw material or external factors;

Corrective actions:

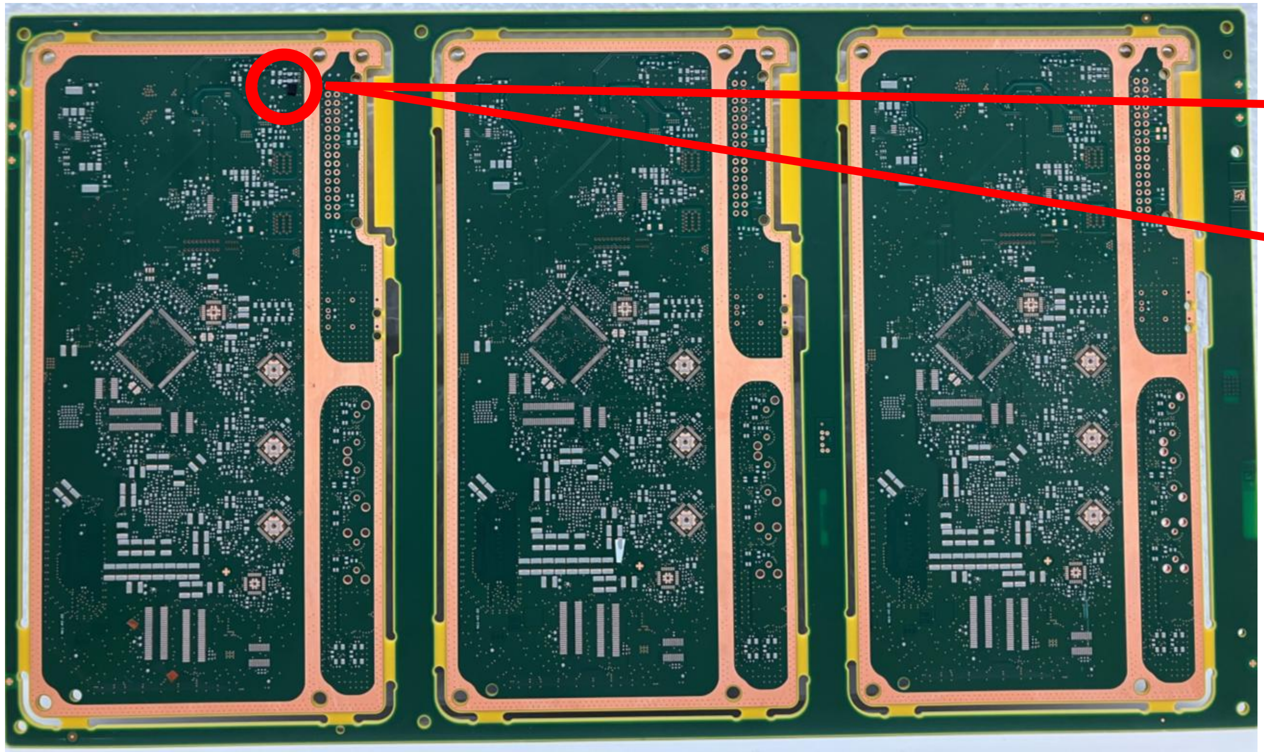
- Scrap the PCB;
- Check the cleaning station;
- Check the equipment;
- Check the raw material;

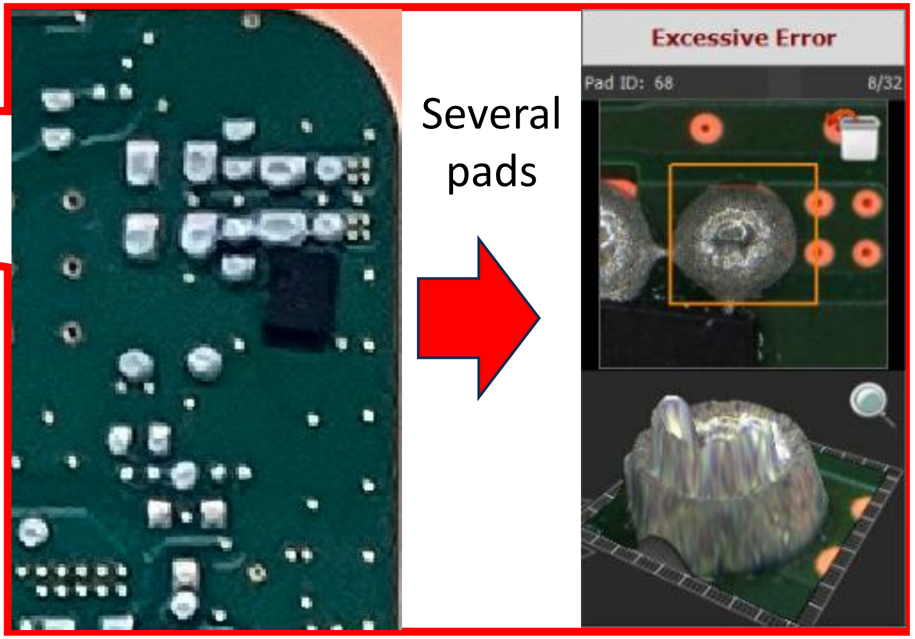
Co-funded by the European Union

NextGEng

Printing Application

Excessive printing





Possible causes:

- Raw material or external factors;

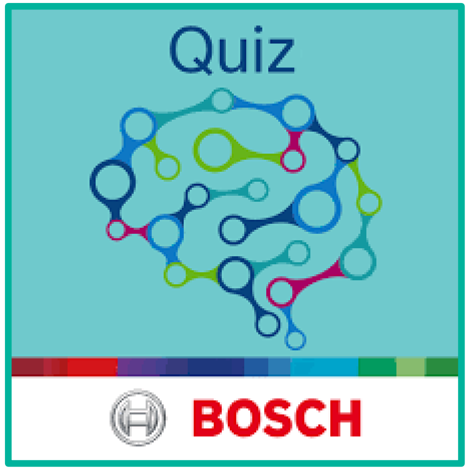
Corrective actions:

- Scrap the PCB;
- Check the cleaning station;
- Check the equipment;
- Check the raw material;

Co-funded by the European Union

NextGEng

Quiz



1. What is a quality gate?

A quality gate in the SMT industry is a checkpoint where products are inspected to ensure they meet standards, identifying defects early to maintain quality and prevent downstream issues.

2. What are the tools used in Solder Paste Printing Process?

- PCB support
- Stencil
- Squeegees
- Solder paste

3. What are common defects in solder paste printing, and their causes?

- Insufficient paste: Caused by blocked stencil apertures or improper squeegee pressure.
- Excessive paste: Due to damaged stencils or too much squeegee pressure.
- Offset printing: Stencil misalignment with the PCB. Solder bridging: Paste spreads between adjacent pads, often due to excessive paste or stencil design flaws.

4. What actions can be taken if an offset printing defect is detected?

Actions include recalibrating the stencil alignment, cleaning and reprinting the affected PCB, and verifying the stencil's condition.

5. What are the critical parameters in the solder paste printing process?

Key parameters include stencil alignment, squeegee pressure, squeegee speed, stencil thickness, and solder paste properties such as viscosity and particle size.

Conclusions

In conclusion, today we've covered the essential elements of the **Solder Paste Printing Process** in the **SMT industry**. We started with a comprehensive introduction to **Surface Mount Technology (SMT)**, outlining the SMT line, the process flow, and the critical parameters that influence solder paste printing quality.

We explored the **Solder Paste Printing Process** in detail, focusing on the working concept of printing machines and the tools used to ensure precise and efficient paste application. Moving on, we emphasized the importance of **Alignment between pads and apertures**, along with a practical exercise on how to apply the correct offset on the machine to achieve perfect alignment.

Finally, we discussed common **Printing Issues** and the factors that can influence them, highlighting the need for constant monitoring and adjustments to prevent defects.

Understanding these key steps and techniques is crucial for ensuring the **quality and reliability** of SMT assemblies, which are essential for high-performance electronic devices. With this knowledge, you are now equipped to address the challenges and optimize the solder paste printing process for better outcomes in future projects.

Thank you for your attention, and I look forward to your questions!

Co-funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Co-funded by the European Union