

# Additive manufacturing using metal pilot line

## MANUELA

Innovation Action 2018-2022 (48 Months)

Grant no: 820774

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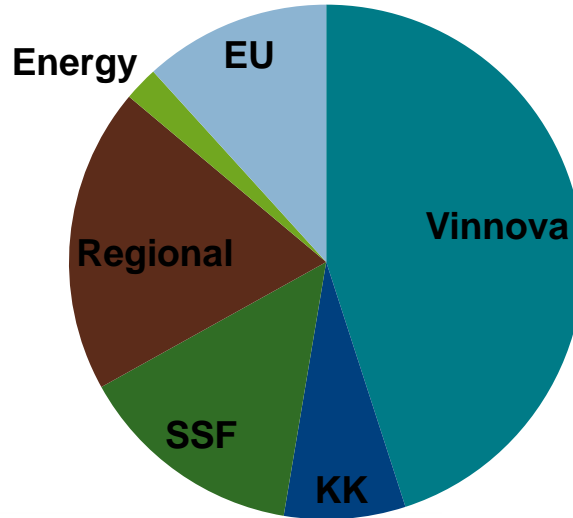
# Some Background

# Additive Manufacturing in Sweden

## Industry involved in AM

- Siemens Industrial Turbomachineri
- GKN Aerospace
- Arcam/GE Additive
- SAAB
- Sandvik
- Höganäs
- Uddeholm
- Erasteel
- Carpenter Powder Products
- Volvo
- Volvo Cars
- Scania CV
- ABB
- Epiroc
- Husqvarna
- Electrolux
- Wärtsilä
- Stora Enso
- Quintus Technologies
- Aga/Linde
- AIM Sweden
- LHS Lasertech
- 3DMetPrint
- Brogrens Industries
- 3DMetPrint

## **Funding for Metal AM 2012-2022** **511 MSEK total**



National Roadmap, RAMP-UP PROJECT, Strategic Innovation  
Programme Metallic Materials, *Spring 2018 status*

## Important RTD organisations with AM R&D

- Chalmers
- RISE IVF
- Swerim (former Swerea KIMAB)
- Univ. West
- KTH
- UU
- LiU
- LU
- LTU
- KaU
- RISE
- **Amexci (private entity)**
- Örebro Univ.
- ...

Note: not a complete list, but indication of strong involvement



## Technical strengths of Sweden

- Materials and metal powder
- Manufacturing of high-end products
- Digitilization and automation
- Software and design
- EHS
- Hardware

## Mindset

- Early adopters of new technology
- Innovation capacity
- Industry-University-Institute co-operation

## West Sweden

- Dominant share of running public R&D in Sweden (Chalmers, RISE IVF, Univ. West)

Sweden has 25% of the world powder production



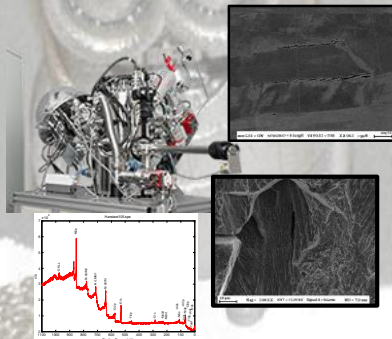
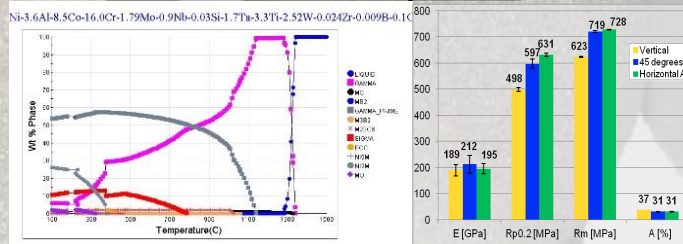
**<5% of the powder for AM!**

# AM@Chalmers

## Powder Assessment and Materials Development

## Surface Science

## Process optimization/ process monitoring



## Role in Swedish AM R&D ecosystem:

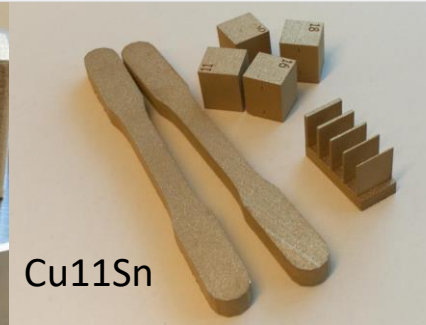
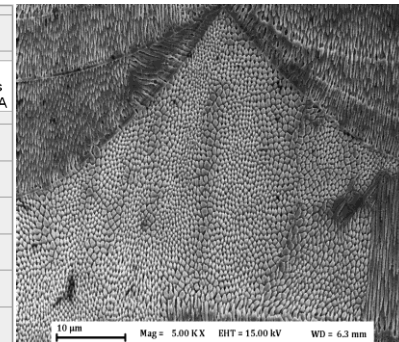
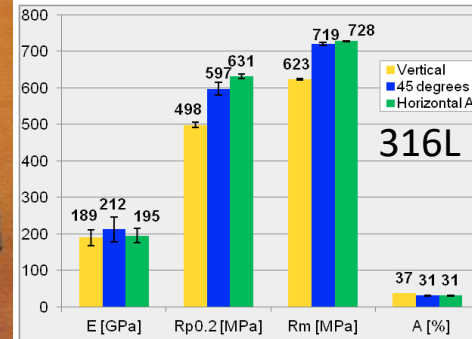
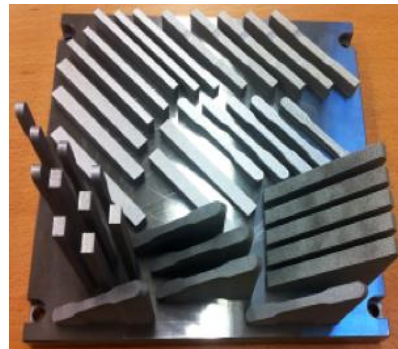
- **Vinnova Excellence Centre CAM<sup>2</sup>:** 112MSEK (40MSEK Vinnova) (1st stage: 2017-2021)
- (5 RTD partners, 26 industry partners (whereof 9 SMEs))
- **MANUELA co-ordinator:** European pilot line (powder-bed fusion), 15.6 MEUR total budget
- **16 R&D additional funded projects** approx. half co-ordinated by Chalmers
- Founded in AoA Production and AoA Materials Science, Chalmers
- **MSc course** additive manufacturing (80 students)
- **BSc course** additive manufacturing (from 2020, 30 students)



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## MATERIALS FOR AM – ON-GOING R&D AT CHALMERS:

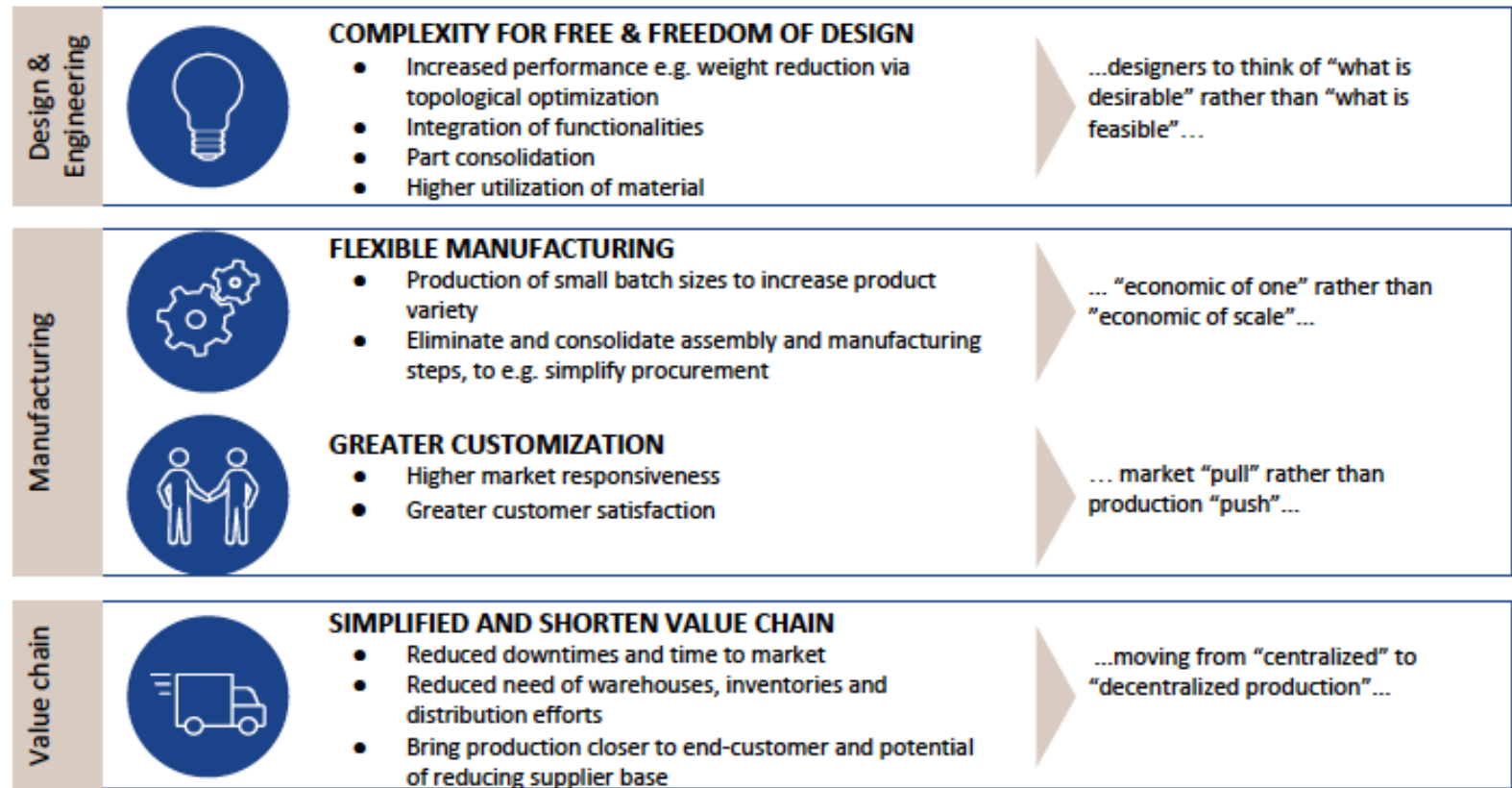
- Ni-base alloys
- 316L
- Cu-base alloys
- High entropy alloys
- Tool steel
- High strength steel
- Al-alloys
- Ti-alloys



Cu11Sn

Density: >99.9%  
Small spread  
Rp: 350±5 MPa  
Rm: 410±3 MPa  
A(%): 3.1±0.1





Karlström, Bengtsson, MSc thesis, 2017

Industries	Use of AM	System level	Main drivers (own interpretation)
<b>Medical &amp; Dental</b>	<ul style="list-style-type: none"> <li>Reached <b>large-scale industrial manufacturing</b>.</li> <li>Numerous applications are being used for standard as well as customized products.</li> </ul>	<ul style="list-style-type: none"> <li>AM have established a strong basis and become a major/sole manufacturing technology to <b>enable mass customization</b></li> </ul>	Value creation and cost reduction by: <ul style="list-style-type: none"> <li>- Complex design</li> <li>- Manufacturing flexibility</li> <li>- Supply chain flexibility</li> </ul>
<b>Aerospace</b>	<ul style="list-style-type: none"> <li>Started to <b>manufacturing non-critical components</b></li> <li>Market trends are that a larger number of parts are to be AM-produced, including more critical ones</li> </ul>	<ul style="list-style-type: none"> <li>Moving into more critical parts and redesigning components.</li> </ul>	Value creation and cost reduction by: <ul style="list-style-type: none"> <li>- Lightweight</li> <li>- Functionality</li> <li>- Manufacturing flexibility</li> </ul>
<b>Engineering/Manufacturing</b>	<ul style="list-style-type: none"> <li>Case studies and <b>prototyping</b> for "direct to use parts"</li> </ul>	<ul style="list-style-type: none"> <li>Individual non-critical components with existing design</li> </ul>	Increase know-how through inhouse applications
<b>Automotive</b>	<ul style="list-style-type: none"> <li>Mostly <b>prototyping</b> and field testing</li> </ul>	<ul style="list-style-type: none"> <li>Individual non-critical components with existing design</li> </ul>	Increase know-how through inhouse applications

[http://www.metalliskamaterial.se/globalassets/3-forskning/rapporter/2016-03898---state-of-the-art-for-additive-manufacturing-of-metals-2\\_1.pdf](http://www.metalliskamaterial.se/globalassets/3-forskning/rapporter/2016-03898---state-of-the-art-for-additive-manufacturing-of-metals-2_1.pdf)

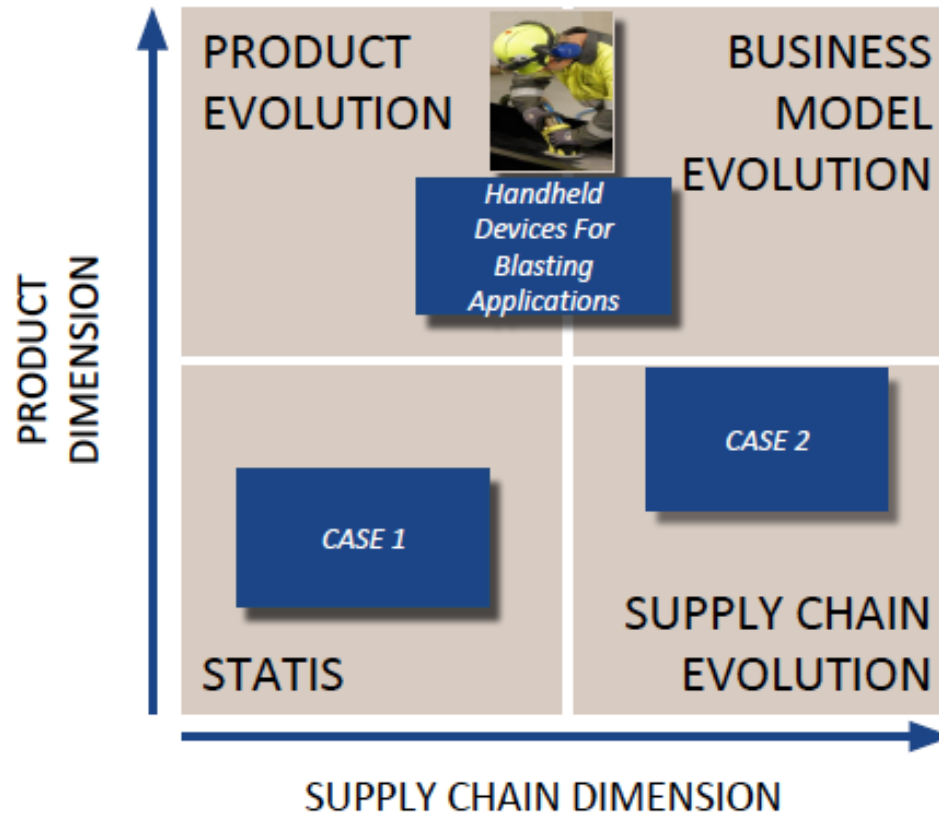
Karlström, Bengtsson, MSc thesis, 2017





## CLUSTERING AM INITIATIVES....

Product evolution or  
Supply chain evolution...



Karlström, Bengtsson, MSc thesis, 2017

# MANUELA

Additive Manufacturing using Metal Pilot Line

2019-04-24



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# Additive Manufacturing Using Metal Pilot Line

H2020-NMBP-TR-IND-2018-2020

DT-FOF0-4-2018 Innovation Action

Project duration: 48 months

Start: 1 Oct.

Co-ordinator: Lars Nyborg, Industrial and Materials Science, Chalmers  
University of Technology

Total budget: 15.6 Meuro (EU contribution: 12.5 Meuro)  
(whereof 35% to Sweden)

Focus: powder-bed processing

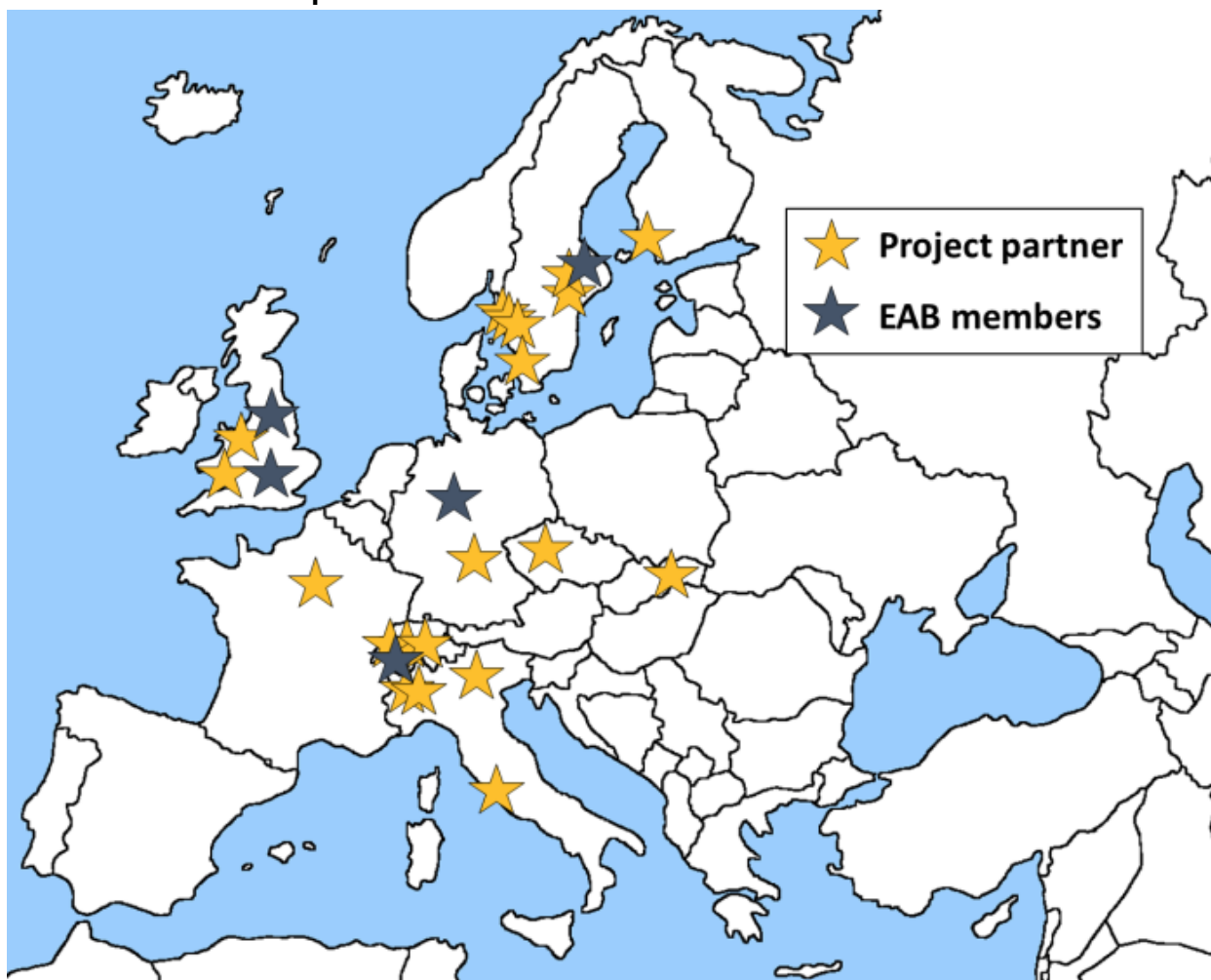
Grant: 820774

Consortium: 20 partners

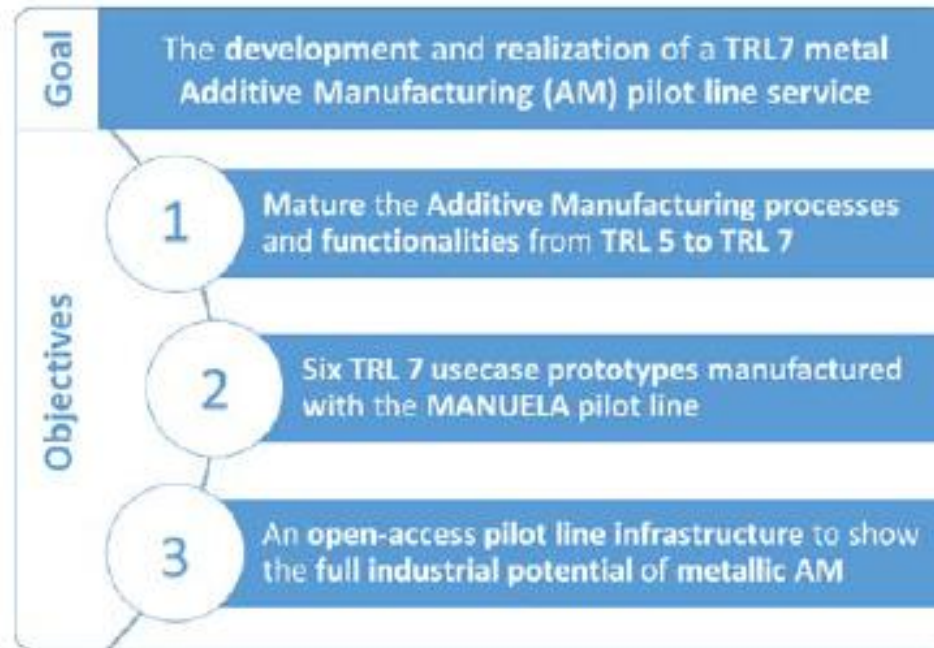
Public website: <http://www.manuela-project.eu>



## European dimension of MANUELA

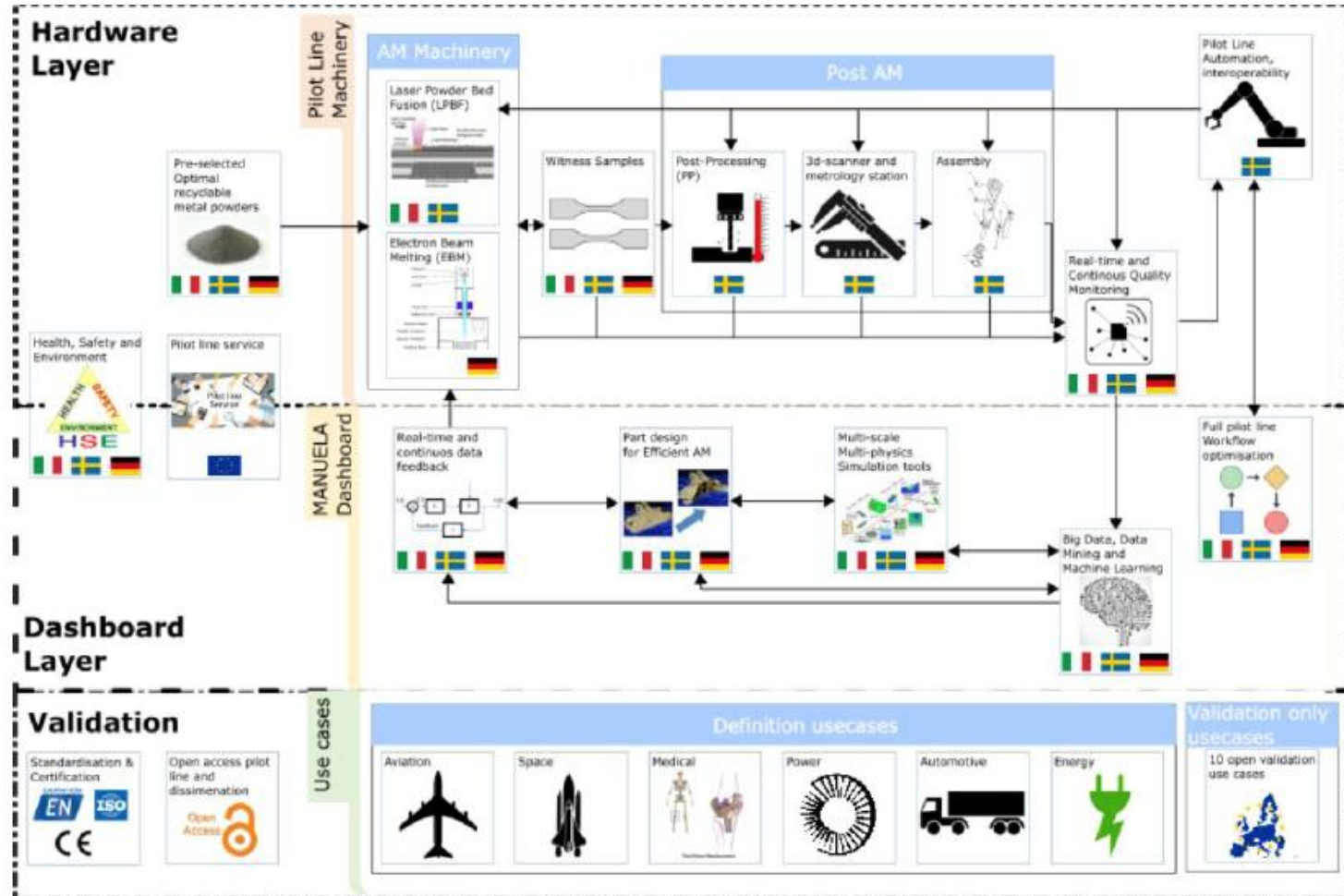


# PILOT LINE INITIATIVE - MANUELA



The “*additive MANUfacturing using mEtaI pilot Line*” (MANUELA) project, is proposed to advance and assure that metal AM will live up to its long-term potential, concentrating on Laser Powder Bed Fusion (LPBF) and Electron Beam Melting (EBM) as the most developed and industrially relevant metal AM technologies at the current state-of-the-art.

# PILOT LINE INITIATIVE - MANUELA





# PILOT LINE INITIATIVE – MANUELA core characteristics

## HARDWARE LAYER

- AM process – EBM
- AM process – LPBF (smaller parts, largers parts)
- Post-AM processing incl. automated workflows
- Quality monitoring (integration of state-of-the-art solutions) and testing

## DASHBOARD LAYER

- Big data, data mining and machine learning
- Multi-scale and multiphysics simulation tools
- Part desing for efficient AM
- Real-time and continuous feedback
- Full pilot line workflow optimization

## VALIDATION

- *Pre-defined use cases*
- *Open call for additional use cases*

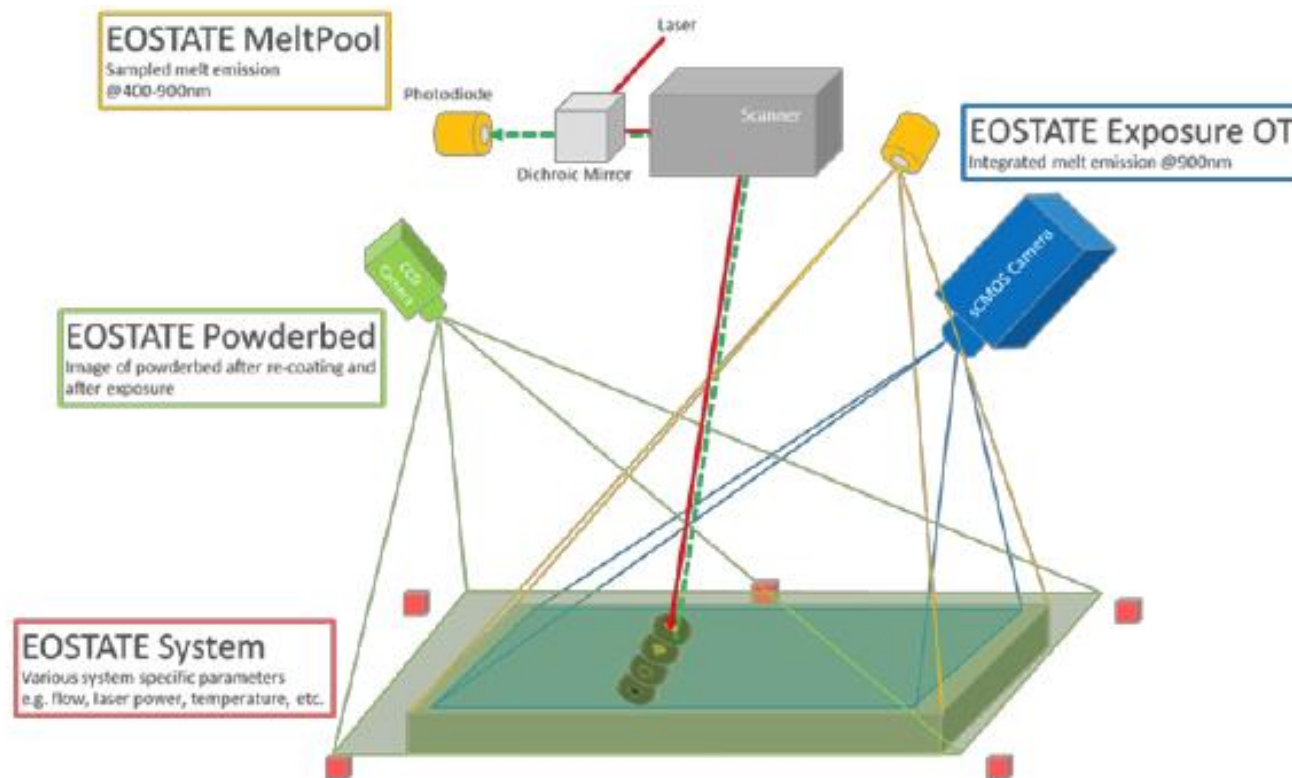
## BUSINESS CONCEPT DEVELOPMENT

Standardisation bodies involved in  
Advisory Board (but not partners)



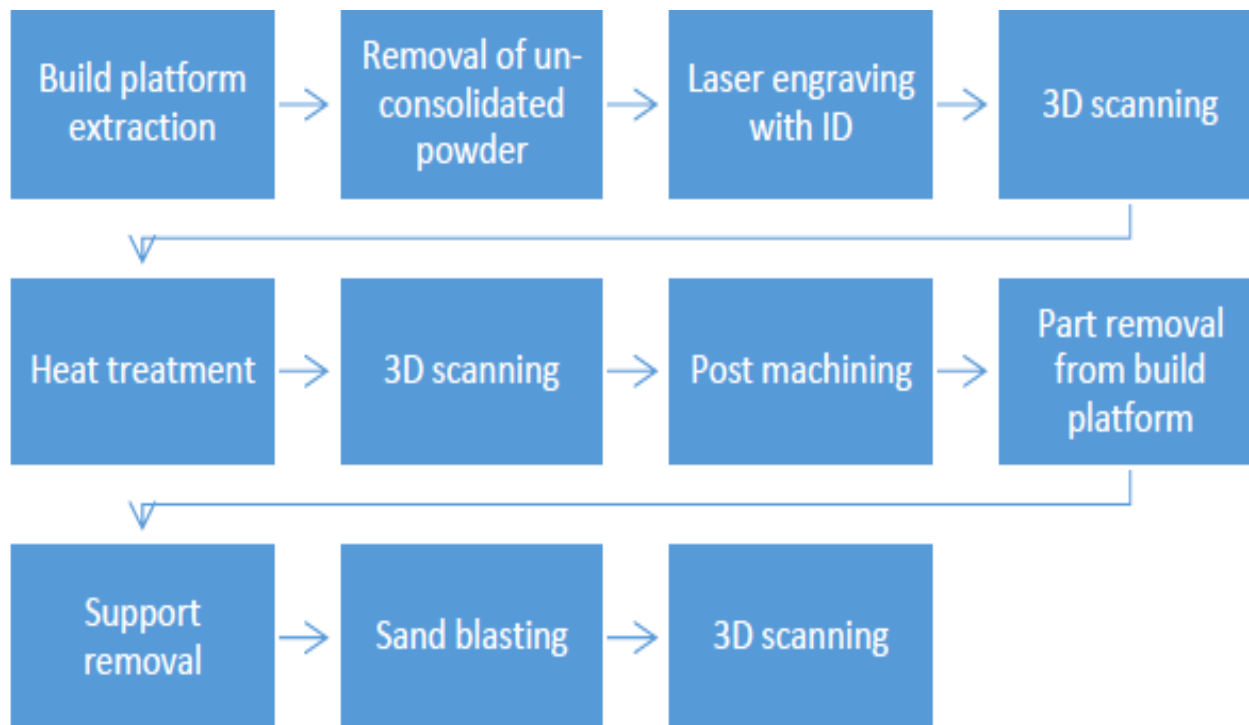
# PILOT LINE INITIATIVE – MANUELA core characteristics

## On-line process monitoring – first part right



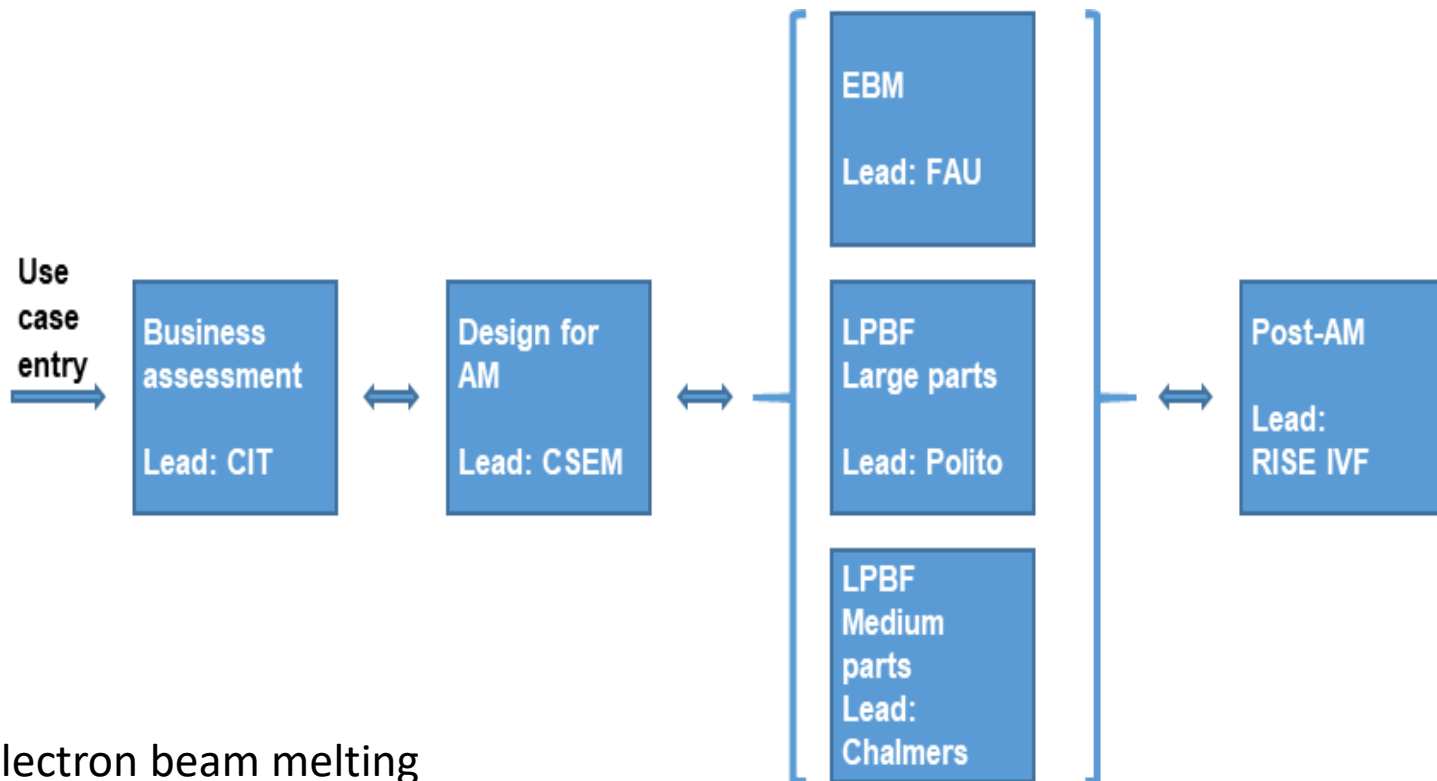
# PILOT LINE INITIATIVE – MANUELA core characteristics

Generic post-AM processing for basically all cases of powder bed fusion



# PILOT LINE INITIATIVE – MANUELA core characteristics

Manufacturing workflow for the processing of demonstrator parts for use cases



EBM = Electron beam melting  
LPBF = Laser powder bed  
fusion (also called SLM, etc)

# PILOT LINE INITIATIVE – MANUELA core characteristics

## Summary of **pre-defined use cases** and potential solutions

Use case	Material	Dimension	Complexity	Post-AM	Method	Process monitoring
Housing	Al-alloy	Small	High	Yes	LPBF	Benefit
	Possibly need for materials development					
Slip ring	Al-alloy or Cu-alloy	Small	High	Yes	LPBF (Al) EBM (Cu)	Benefit
Implant	Ti-alloy	Medium	Medium	Yes	EBM LPBF	Benefit
Liner and injector	Ni-alloy	Large	Medium	TBD	LPBF (large)	Not possible
Brake bell and rocker	Ti-alloy	Medium	High	Yes	EBM LPBF	Benefit
	Possibly for LPBF need for materials development					
Gas turbine heat shield	Ni-alloy	Medium	High	TBD	LPBF	Benefit

# Delivering on the Promise of Additive Manufacturing:

## MANUELA PILOT LINE

**Karl Lundahl**

**Exploitation Manager and Work Package Leader for WP2 and WP8 in Manuela**

Project Manager, Commercial R&D, Materials Group

Chalmers Industriteknik



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**MANUELA**  
Additive Manufacturing using Metal Pilot Line



# Presentation Outline

1. Chalmers Industriteknik's part in MANUELA
2. How may MANUELA contribute to my company's business?
3. How can my company get access to MANUELA?



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# Manuela in a Nutshell

## Key Facts

Research Topic:	Additive Manufacturing
Start date:	October 2018
End date:	September 2022
Duration in months:	48
Project EU funding:	12.5 million Euro
Project Coordinator:	Chalmers University of Technology



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# Chalmers Industriteknik's part in MANUELA

1. Lead the work towards a **world-class integrated pilot production service**
  - Production Planning
  - Logistics
  - Operations
2. Develop a streamlined and effective **interface towards European Industry**
  - We are setting up and staffing a Customer Engineering Project Office (CEPO)
  - The CEPO will administer customer projects from initial request to final delivery of finished product.
3. Develop a **sustainable business model** that ensures that the Manuela pilot line will continue to exist after project closure
  - Define the legal entity
  - Develop and deploy operations



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# Chalmers Industriteknik's part in MANUELA

## 20 Consortia Members



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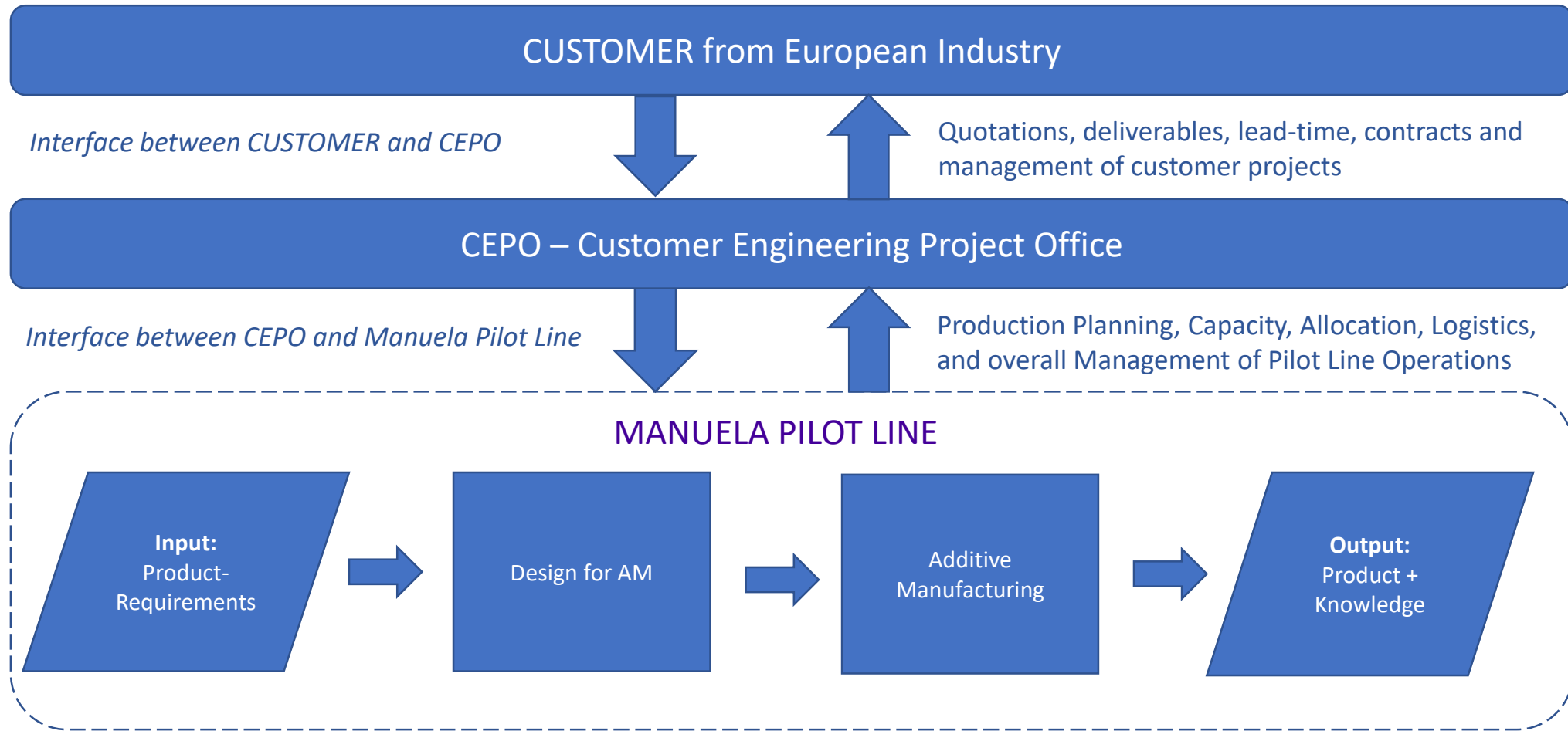
# Chalmers Industriteknik's part in MANUELA

Five Pilot Line Nodes:



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# Chalmers Industriteknik's part in MANUELA



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# Chalmers Industriteknik's part in MANUELA

*Table 11. MANUELA market projection*

MANUELA business projection	2 021	2 022	2 023	2 024	2 025	2 026	2 027
number of small series production	0	0	2	4	8	15	18
number of prototyping	0	10	15	15	25	31	37
training and services	0	1	2	2	4	5	5
revenues (k€)	0	1 005	1 570	1 630	2 760	3 575	4 265
cumulative revenues (k€)	0	1 005	2 575	4 205	6 965	10 540	14 805
MANUELA SEP cost (k€)	MANUELA project		157	163	276	358	427
SEP workforce	1	1	3	3	4	5	6

**Under these assumptions the MANUELA pilot lines will be fully sustainable and it will have capacity to serve to 100 companies for prototyping (mainly SMEs) and 30 companies for showcase pre-industrial production, incl. testing (mainly for large enterprises). Many of them are expected to enter to the large volume production after 1-2 years from the MANUELA service. This will boost the whole European industrial ecosystem and consequently the European industrial leadership in Additive Manufacturing.**

**The accumulated revenue at 2027 from pilot line operations is projected to be in the range of 15 million Euros.**



# How may MANUELA contribute to my company's business?

- **Open calls** for 10+ business development cases.
- The business development cases will be **co-funded by the Manuela project**.
- **1 million euro** of the total project budget is allocated for co-funding the business development cases
- **Any company within EU can apply** to utilize the Manuela Pilot Line service to produce a part or product as a Business development Case



# How may MANUELA contribute to my company's business?

- Formalized application procedures for the open calls will be established during 2019
- However:
- We encourage companies to **get in contact with us immediately** if you are planning to apply for the open calls – or if you would like to get more information about MANUELA
- **Production** for European customers **will commence during Q2 2021**



# How can my company get access to MANUELA?

[manuela@chalmersindustriateknik.se](mailto:manuela@chalmersindustriateknik.se)

[www.manuela-project.eu](http://www.manuela-project.eu)

**...or come talk to us at booth A08 at Advanced Engineering!**



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**MANUELA**  
Additive Manufacturing using Metal Pilot Line

# Thank you for your attention!

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[manuela@chalmersindustrietechnik.se](mailto:manuela@chalmersindustrietechnik.se)

[www.manuela-project.eu](http://www.manuela-project.eu)

Discuss more about  
Manuela in Chalmers  
Industrietechnik's  
**Booth A:08**

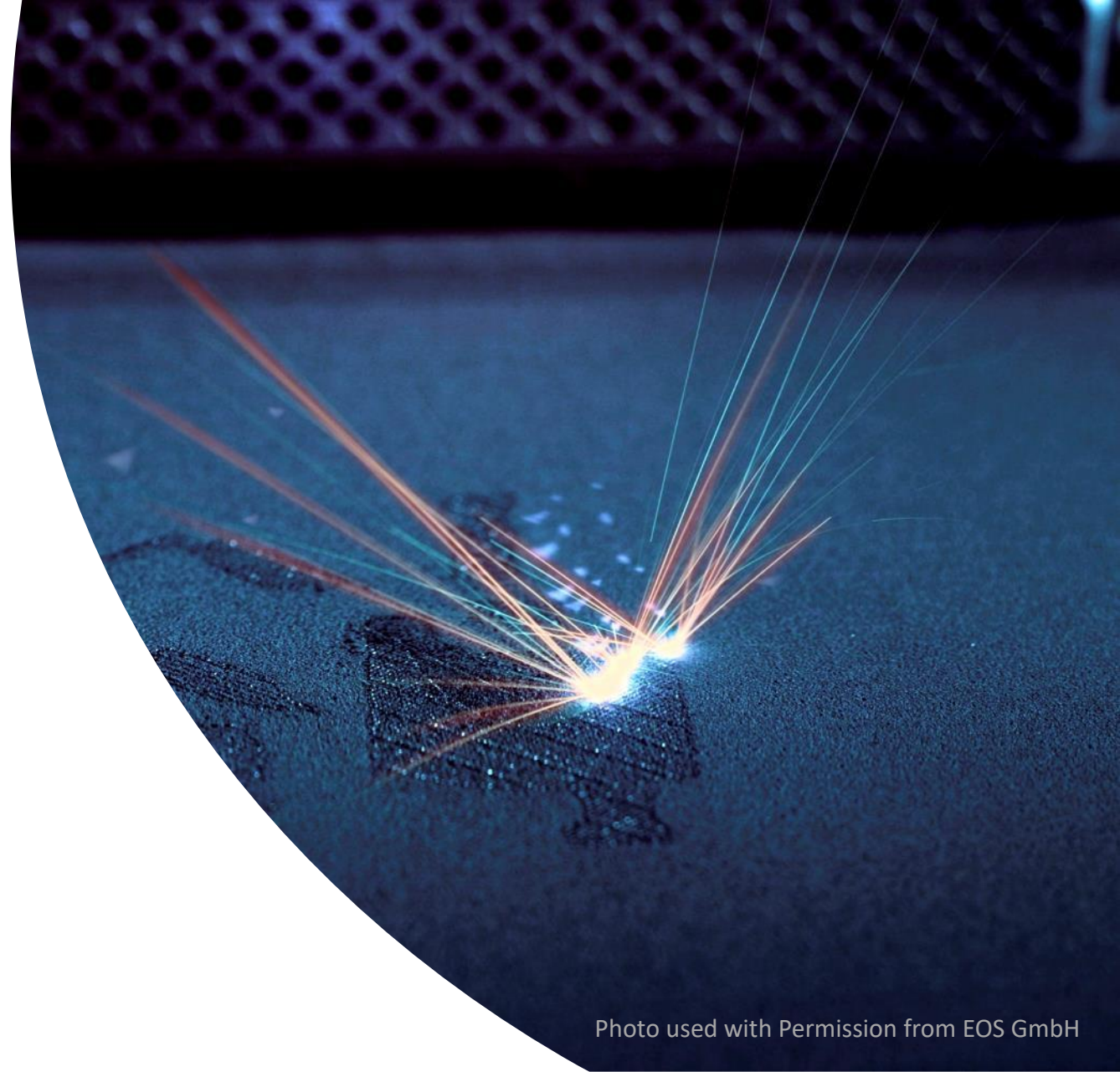


Photo used with Permission from EOS GmbH



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