Learner Centric Advanced Manufacturing Platform

# SELECTIVE LASER SINTERING

WPN° 3 Observatory

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# GLOSSARY AND/OR ACRONYMS

**AI** - Artificial Intelligence

**AM** - Advanced Manufacturing

**Cedefop** - European Centre for the Development of Vocational Training

**CoVE** - Centres of Vocational Excellence

**EAfA** - European Alliance for Apprenticeships

**EC** - European Commission

**ECVET** - European Credit System for Vocational Education and Training

**EntreComp** - The Entrepreneurship Competence Framework

**EQAVET** - European Quality Assurance in Vocational Education and Training

**EQF** - European Qualifications Framework

**ESCO** - European Skills, Competences and Occupations

**ETF** - European Training Foundation

**EU** - European Union

**HE** - Higher Education

**HVET** - Higher Vocational Education and Training

**I4.0** - Industry 4.0

**KET** - Key Enabling Technology

**OECD** - Organisation for Economic Cooperation and Development

**SME** - Small and Medium Enterprises

**SWOT** - Strengths, Weaknesses, Opportunities, Threats

**TVET** - Technical and Vocational Education and Training

**VET** - Vocational Education and Training

**WBL** - Work Based Learning

# CONTENT TABLE

# EXECUTIVE SUMMARY

Advanced Manufacturing (AM) and Higher Vocational Education and Training (HVET) need to update training, implement new technologies, and get quick access to data.

The causes behind these needs are technological factors (Industry 4.0), factors conditioned by education systems and education methodologies, social factors and environmental factors (the European Green Deal with its emphasis on the greening industry).

Under the CoVE initiative, the LCAMP project aims to support regional skill ecosystems and various stakeholders in providing new skills and implementing new or updated technologies in VET centres. LCAMP will tackle this by incorporating a permanent European Platform of Vocational Excellence for Advanced Manufacturing.

By collaborating across borders, LCAMP's goal is to support and empower regional Advanced Manufacturing CoVEs to become more resilient, innovative, and better equipped to train, upskill, and reskill young and adult students, to successfully face the digital and green transitions. We will help European regions and countries grow and be more competitive through their VET systems.

Therefore, the LCAMP OBSERVATORY is one of the services in the LCAMP platform. The observatory is led by the French cluster *Mecanic Vallée* and the French VET provider *Campus des Métiers et des Qualifications d'Excellence Industrie du Futur*.

This present document details the first results of the LCAMP Observatory, through the methodology that the LCAMP consortium used to set up and run the Observatory. We had set up a process cycle for the observation consisting of 5 stages:

- Stage 1: Diagnosis and priority
- Stage 2: Search and information gathering
- Stage 3: Information Analysis
- Stage 4: Creating value. Elaboration of LCAMP reports
- Stage 5: Dissemination and communication.

# 1. INTRODUCTION

The LCAMP observatory is one of the services of the LCAMP platform.

The LCAMP Observatory must be a reliable and easily accessible source of information and data for trainers, VET teachers, and professionals, updated on Digital / Advanced Manufacturing / Smart Industry, delivered through a multimedia and interactive platform -LCAMP platform-, that can be customized according to individual interests (Work in progress in WP8).

This observatory must feed other Work packages (WP), for instance, WP 5 on Learner Centric Training, or Open innovation Community in the WP4.

In a first document about methodology, are set up a process cycle for the observation consisting in 5 stages:

- Stage 1: Diagnosis and priority
- Stage 2: Search and information gathering
- Stage 3: Information Analysis
- Stage 4: Create value. Elaboration of LCAMP reports
- Stage 5: Disseminate-communicate.

Following this process cycle, are detailed the main aspects of the observation methodology:

- Identify reliable sources that we can find in Europe about Advanced Manufacturing.
- Classify and filter data gathered from different sources.
- Present several ways to collect data and to analyse them.
- Define the methods for the creation of annual reports.
- Validate process for those reports.

The observatory will publish periodical reports for VET and HVET target audiences about technology trends, labour market changes, skill needs, and occupations in Advanced Manufacturing. It is expected that SMEs, industry clusters and other associations will also find valuable information in the observatory.

The publication of a yearly report is planned.

- Report 1: June 2023,
- Report 2: June 2024,
- Report 3: June 2025.

This first annual report is gathering sub-reports written by around twenty different writers, from the main partners involved in the LCAMP project. 39 Topics were determined, and 22 TOPICS were analysed and worked on during this first period.

# 2. SELECTIVE LASER SINTERING

The purpose of this chapter is to present some of the development areas related to AM.

These are topics that concern all or some of the stakeholders

- CoVEs and VETs: teachers, trainers and heads of VET schools;
- Learners: students, active workers, job seekers;
- Companies;
- Policy makers and other stakeholders

## 2.1 INTRODUCTION

What is digital selective laser sintering?

Laser sintering is a sub-segment or a type of additive manufacturing.

### 2.1.1 ADDITIVE MANUFACTURING

Additive manufacturing is a process of creating a three-dimensional object by successive layers of material, most commonly plastic or metal.[1] [2]

Additive manufacturing, also known as 3D printing, is a process of producing a three-dimensional object from a digital model. The process involves successive layers of material being built up to form a physical object, usually from metals or plastics. This process can be used to create products from a wide variety of materials, from plastic to metal, and is often used for rapid prototyping and parts production.[3] [4]

### 2.1.2 TYPES OF ADDITIVE MANUFACTURING:

- Fused Deposition Modeling (FDM)
- Selective Laser Sintering (SLS)
- Direct Metal Laser Sintering (DMLS)
- Stereolithography (SLA)
- Binder Jetting (BJ)

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[1] « Additive Manufacturing Solutions | Prima Additive », s. d., https://www.primaadditive.com/en/additive-manufacturing-solutions?gclid=Cj0KCQjwlumhBhClARIsABO6p-ym0nMqRetErSvck2MzfLuMVzuyMZ7qaVMuBdYf_k-v1taW8tb1aEcaAilgEALw_wcB.

[2] « What Is Additive Manufacturing? (Definition & Types) », s. d., https://www.twi-global.com/technical-knowledge/faqs/what-is-additive-manufacturing.aspx.

[3] Ibid

[4] « Selective Laser Sintering (SLS) », MakerVerse, s. d., https://www.makerverse.ai/technologies-sls.

- Electron Beam Melting (EBM)
- Laminated Object Manufacturing (LOM)
- Digital Light Processing (DLP)
- Material Jetting (MJ)
- High-Speed Sintering (HSS)

### 2.1.3 SELECTIVE LASER SINTERING

Selective Laser Sintering (SLS) is a 3D printing technique that uses a laser to heat and fuse powdered material (such as plastic, metal, ceramic, or glass) layer by layer to create a three-dimensional object.[5] [6] [7]

Selective Laser Sintering (SLS) is an additive manufacturing process that uses a laser to selectively join powdered material by sintering to create a three-dimensional object. The laser selectively fuses the powdered material together one layer at a time, creating the desired 3D shape without the need for support structures. SLS is suitable for a range of materials, including metals, plastics, and ceramics, and is often used to create complex geometries and hollow parts.[8] [9] [10]

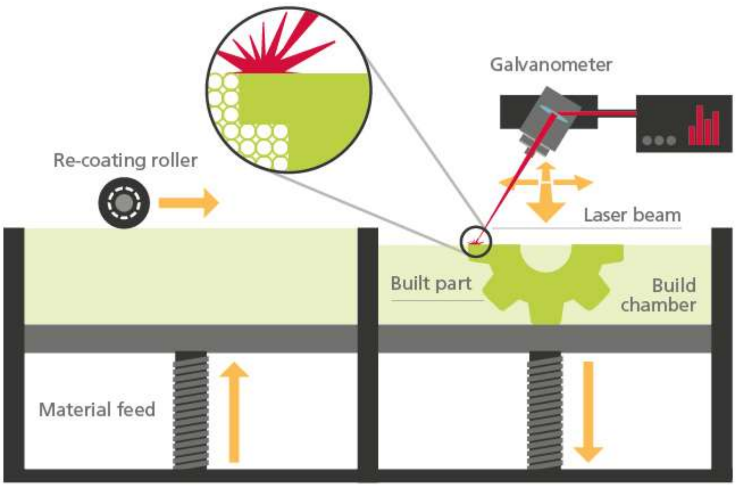


*Figure 1 SLS - how it works - rapid prototyping*

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[5] « What Is Selective Laser Sintering (SLS)? », s. d., https://www.protolabs.com/resources/design-tips/designing-for-selective-laser-sintering/.
[6] Mahbub Hassan et al., « 3D Printing of Biopolymer Nanocomposites for Tissue Engineering: Nanomaterials, Processing and Structure-Function Relation », *European Polymer Journal* 121 (décembre 2019): 109340, https://doi.org/10.1016/j.eurpolymj.2019.109340.
[7] « Selective Laser Sintering (SLS) ».
[8] « What Is Selective Laser Sintering (SLS)? »
[9] Hassan et al., « 3D Printing of Biopolymer Nanocomposites for Tissue Engineering ».
[10] « Selective Laser Sintering (SLS) ».

## 2.2 CONTEXTUALISATION

Selective Laser Sintering (SLS) is likely to be the most widely utilized additive manufacturing technology in the future, due to its versatility and affordability. SLS is capable of producing highly detailed parts and components with strong physical properties, and its cost-effectiveness makes it ideal for large-scale production. Additionally, SLS technology is being increasingly used in a variety of industries, from medical to automotive to aerospace.[11]

The trend of SLS is currently expanding due to its increasing affordability, flexibility and accuracy. This technology has the potential to revolutionize production processes and enable mass customization of products.

Selective laser sintering (SLS) 3D printing is trusted by engineers and manufacturers across different industries for its ability to produce strong, functional parts.[12] [13] [14] [15]

### 2.2.1 POSITIVE IMPACTS OF SLS ON INDUSTRY

- Increased speed of production: SLS is a rapid prototyping technology which allows for quicker production and testing of products, saving time and money.

- Increased flexibility: SLS has the capability to fabricate complex geometries with intricate details and customize the final product to meet specific needs.
- Increased accuracy: SLS is able to produce highly accurate parts with a high degree of precision, eliminating the need for costly post-processing.
- Reduced costs: SLS eliminates the need for tooling and can reduce the cost of production, as well as lead times.[16] [17]

### 2.2.2 NEGATIVE IMPACTS OF SLS ON INDUSTRY

- Limited materials: Currently, SLS only works with a limited number of materials, such as nylon and polycarbonate.

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[11] « Selective Laser Sintering (SLS) ».
[12] « Guide to Selective Laser Sintering (SLS) 3D Printing », Formlabs, consulté le 22 mai 2023, https://formlabs.com/eu/blog/what-is-selective-laser-sintering/.
[13] « Selective Laser Sintering (SLS) ».
[14] Adrian Korycki, « Study of the selective laser sintering process : materials properties and effect of process parameters », 2020, https://oatao.univ-toulouse.fr/27651/1/Korycki_Adrian.pdf.
[15] E.O. Olakanmi, R.F. Cochrane, et K.W. Dalgarno, « A Review on Selective Laser Sintering/Melting (SLS/SLM) of Aluminium Alloy Powders: Processing, Microstructure, and Properties », *Progress in Materials Science* 74 (octobre 2015): 401-77, https://doi.org/10.1016/j.pmatsci.2015.03.002.
[16] Korycki, « Study of the selective laser sintering process : materials properties and effect of process parameters ».
[17] Olakanmi, Cochrane, et Dalgarno, « A Review on Selective Laser Sintering/Melting (SLS/SLM) of Aluminium Alloy Powders ».

- Prone to defects: SLS is prone to defects caused by material shrinkage during the sintering process.
- Environmental concerns: SLS produces hazardous fumes and dust, which can be harmful to the environment.
- High cost: SLS can be expensive due to the cost of materials, equipment, and post-processing.[18] [19]

### 2.2.3 MARKET INSIGHTS

According to a report by MarketsandMarkets, the SLS market is expected to reach USD 2,890.4 million by 2023.

According to a report by Global Market Insights, the selective laser sintering (SLS) market is expected to reach a market size of USD 3,269.2 million by 2025, and USD 4,977.9 million by 2030.[20] [21] [22]

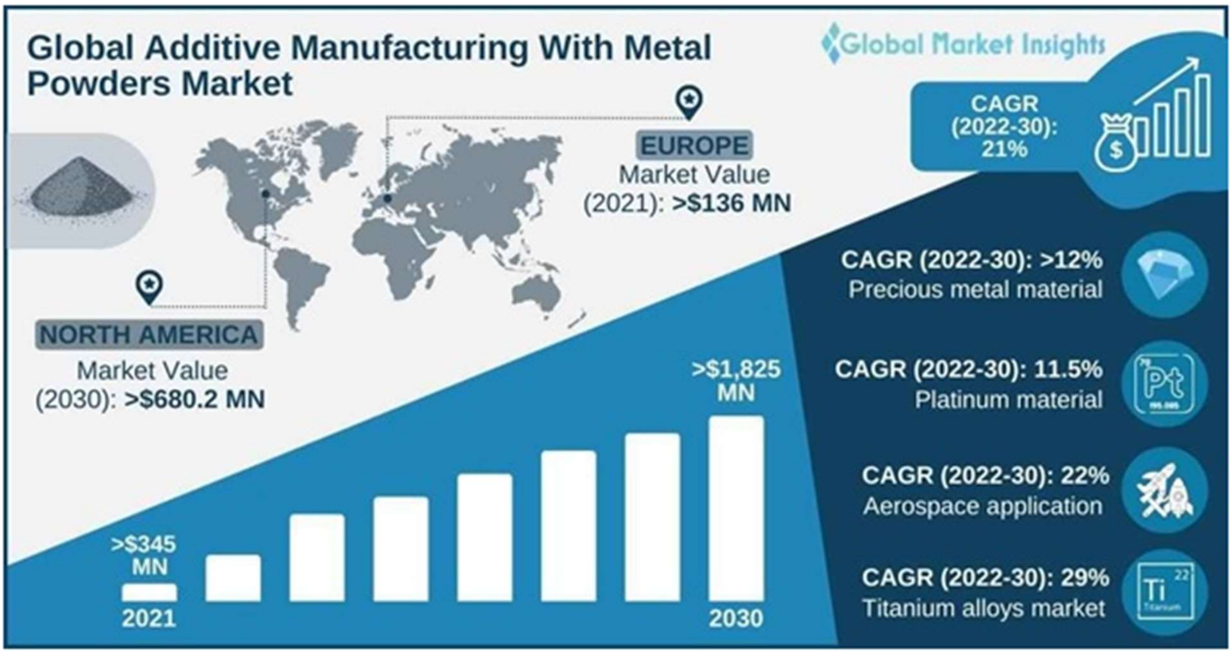


*Figure 2 Additive manufacturing global market [23]*

[18] Karel Kellens et al., « Environmental impact modeling of selective laser sintering processes », *Rapid Prototyping Journal* 20 (20 octobre 2014): 459-70, https://doi.org/10.1108/RPJ-02-2013-0018.
[19] Dayton Horvath, « The Hidden Promise and Challenges of Selective Laser Sintering for Plastic 3D Printing », 3D Printing Industry, 29 août 2017, https://3dprintingindustry.com/news/hidden-promise-challenges-selective-laser-sintering-plastic-3d-printing-120596/.
[20] Korycki, « Study of the selective laser sintering process : materials properties and effect of process parameters ».
[21] Horvath, « The Hidden Promise and Challenges of Selective Laser Sintering for Plastic 3D Printing ».
[22] « Additive Manufacturing with Metal Powders Market Statistics – 2030 », Global Market Insights Inc., s. d., https://www.gminsights.com/industry-analysis/additive-manufacturing-with-metal-powders-market.
[23] ibid.

## 2.2.4 IMPACTS OF SLS ON THE JOB MARKET

Selective laser sintering (SLS) is a 3D printing technology that is becoming increasingly popular in the manufacturing industry. It is a process that uses a laser to fuse small particles of plastic, metal, ceramic, or glass powder into a 3D-shaped object. As a result, it is being used in a variety of industries and occupations, from automotive to medical, to create complex and custom parts.

The industrial use of SLS is growing rapidly, which is resulting in a rise in job opportunities and training programs. SLS engineers and technicians are in high demand, and companies are beginning to offer advanced training in order to keep up with the technology.

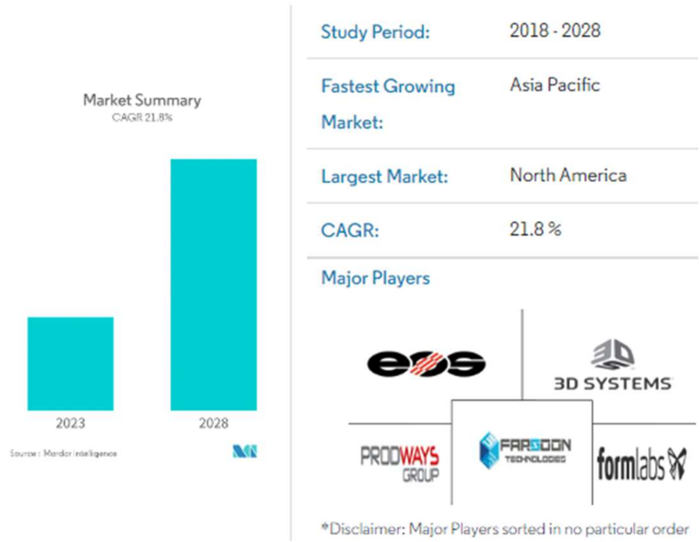


*Figure 3 SLS market size [24]*

Vocational schools and universities are also offering SLS-specific classes and programs. These courses teach students the fundamentals of the technology, such as the equipment, software, and processes. They can also go more in depth and learn how to design, build, and optimize SLS parts.

The demand for SLS technicians and engineers is also driving the development of online courses and tutorials. These resources provide a convenient way to learn the basics of SLS and help those who are interested in the technology get up to speed quickly.

In addition, the growing use of SLS is making it easier for professionals to get certified. Companies and organizations such as the American Society of Mechanical Engineers (ASME) and the National Institute for Metalworking Skills (NIMS) offer certifications in SLS, which can

[24] « Selective Laser Sintering Market Size & Share Analysis - Industry Research Report - Growth Trends », s. d., https://www.mordorintelligence.com/industry-reports/selective-laser-sintering-market.

help professionals demonstrate their knowledge of the technology and gain an edge in the job market.[25] [26] [27]

Overall, the trend of selective laser sintering is one of growth and development. As the technology becomes more widely used, it is creating new job opportunities and providing more educational resources for those interested in learning more about it.

However, it also has the potential to cause job losses in the short-term, particularly in the areas of manual labour and traditional machining. Furthermore, this technology requires specific skills and knowledge to operate, which could require retraining of existing staff in order to remain employable.[28] [29]

The shift to automated manufacturing processes such as SLS can also have an impact on vocational training. This technology requires specific skills and knowledge, which may not be fully addressed in existing curricula. Furthermore, the presence of automated manufacturing processes could lead to a reduced demand for traditional vocational training and skills.[30] [31]

# 2.3 OBJECTIVES / RESEARCH QUESTION / PROBLEM STATEMENT

## 2.3.1 OBJECTIVES

Within this document, we try to offer some insight into shifts in the jobs market and how VETs and SMEs can adapt to the effects selective laser sintering will have on the manufacturing segment.

While equally as important, SLS and other additive manufacturing technologies will have environmental impacts as well, it is not the focus of the LCAMP project.

## 2.3.2 RESEARCH QUESTION

- How will selective laser sintering impact the existing jobs market?

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[25] Digital Growth, « The Ultimate Guide to Selective Laser Sintering (SLS) 3D Printing », Quickparts, 12 avril 2023, https://quickparts.com/the-ultimate-guide-to-selective-laser-sintering-sls-3d-printing/.
[26] « Laser Sintering Jobs, Employment | Indeed.com », s. d., https://www.indeed.com/jobs?q=Laser+Sintering&from=mobRdr&utm_source=%2Fm%2F&utm_medium=redir&utm_campaign=dt&vjk=9b2bdd0673d7e86d.
[27] « Offres d'emploi "9 Laser Sintering" - États-Unis », 2 avril 2023, https://www.linkedin.com/jobs/laser-sintering-jobs.
[28] Alexandrea P, « The Complete Guide to Selective Laser Sintering (SLS) in 3D Printing », 3Dnatives, 18 juin 2022, https://www.3dnatives.com/en/selective-laser-sintering100420174/.
[29] Growth, « The Ultimate Guide to Selective Laser Sintering (SLS) 3D Printing ».
[30] « 2023 Global Selective Laser Sintering (SLS) Technology for 3D Printing Market: An In-Depth Analysis and Forecast of Industry till 2028 », MarketWatch, 2023, https://www.marketwatch.com/press-release/2023-global-selective-laser-sintering-sls-technology-for-3d-printing-market-an-in-depth-analysis-and-forecast-of-industry-till-2028-2023-04-12.
[31] P, « The Complete Guide to Selective Laser Sintering (SLS) in 3D Printing ».

- Which competencies and skills will be needed for selective laser sintering related jobs?
- How can SMEs and VETs adapt to cater to the needs of people that wish to learn selective laser sintering?

### 2.3.3 PROBLEM STATEMENT

Additive manufacturing and selective laser sintering have the potential to revolutionize the manufacturing industry. However, this technology could also have a significant impact on existing jobs in the manufacturing segment. This potential disruption raises the question of which jobs in the manufacturing segment will be replaced by additive manufacturing and selective laser sintering, and what new jobs will be created in their place.

One of the biggest challenges of additive manufacturing and in particular selective laser sintering is the potential disruption of existing jobs in the manufacturing industry. This technology is capable of producing components with a much higher degree of complexity than traditional manufacturing methods, requiring fewer manual labour and production costs. This could lead to a decrease in the demand for skilled labour, as well as a shift in the skillset required for manufacturing jobs.

Vocational training institutions may also experience changes due to the introduction of additive manufacturing. As this technology requires new skillsets, there may be a need to shift vocational training courses to fit the new requirements. Additionally, institutions may need to provide training on the use of the new technology, as well as how to design products that can be created using it.

Small and medium-sized companies may also be affected by the use of additive manufacturing. Due to the high cost of the equipment, and the need for specialized skillsets to operate it, SMEs may find it difficult to take advantage of this technology. This could lead to SMEs being unable to compete with larger companies, who have access to the necessary resources.

Overall, additive manufacturing and in particular selective laser sintering have the potential to cause significant changes in the existing jobs and the manufacturing industry. This technology has the potential to reduce the demand for skilled labour and to shift the skillset required for manufacturing jobs. Vocational training institutions may need to shift their courses to meet the new requirements, and SMEs may find it difficult to take advantage of the technology due to the high cost of the equipment and the need for specialized skillsets.[32] [33] [34] [35]

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[32] « Additive Manufacturing Solutions | Prima Additive ».
[33] « What Is Additive Manufacturing? »
[34] Horvath, « The Hidden Promise and Challenges of Selective Laser Sintering for Plastic 3D Printing ».
[35] P, « The Complete Guide to Selective Laser Sintering (SLS) in 3D Printing ».

# 2.4 FINDINGS

## 2.4.1 JOBS THAT WILL LIKELY BE GRADUALLY REPLACED BY ADDITIVE MANUFACTURING AND SELECTIVE LASER SINTERING

- **Traditional machinists**: Additive manufacturing, particularly selective laser sintering, will replace traditional machinists with more specialized roles such as **3D printing technicians and 3D printing engineers**.

- **CNC Machinists**: Additive manufacturing will replace CNC machinists with **3D printing technicians and 3D printing engineers**.

- **Designers**: Additive manufacturing will replace designers with **3D designers, 3D printing engineers, and 3D printing technicians**.

- **Welders**: Additive manufacturing will replace welders with **3D printing technicians, 3D printing engineers, and 3D designers**.

- **Toolmakers**: Additive manufacturing will replace toolmakers with **3D printing technicians, 3D printing engineers, and 3D designers**.

- **Mold makers**: Additive manufacturing will replace mold makers with **3D printing technicians, 3D printing engineers, and 3D designers**.

- **Assembly line workers**: Additive manufacturing will replace assembly line workers with **automated lines, robots, 3D printing technicians, 3D printing engineers, and 3D designers**.

- **Manufacturers**: Additive manufacturing will replace manufacturers with **3D printing technicians, 3D printing engineers, additive manufacturing experts**.

- **Data entry clerks:** Additive manufacturing will replace data entry clerks with **various ML and AI programs and interfaces**.

- **Quality control inspectors**: Additive manufacturing will replace quality control inspectors with **additive materials experts, 3D printing engineers**

- **Material handlers**: Additive manufacturing will replace material handlers with 3D printing technicians, 3D printing engineers, and 3D designers.

- **Logistics experts:** Additive manufacturing will replace logistics experts with 3D printing technicians, 3D printing engineers, and 3D designers.

- **Prototype makers**: Additive manufacturing will replace prototype makers with 3D printing technicians, 3D printing engineers, and 3D designers.

- **Machine operators**: Additive manufacturing will replace machine operators with 3D printing technicians, 3D printing engineers, and 3D designers.

- **Fabricators**: Additive manufacturing will replace fabricators with **3D printing technicians, 3D printing engineers, and 3D designers**.

- **Patternmakers**: Additive manufacturing will replace patternmakers with **3D designers**.

- **Model makers**: Additive manufacturing will replace model makers with **3D printing engineers, and 3D designers**.

- **Quality engineers**: Additive manufacturing will replace quality engineers with **advanced materials engineers, additive manufacturing engineers, 3D printing technicians, 3D printing engineers, and 3D designers**.

- **Production planners**: Additive manufacturing will replace production planners with **automation experts, additive manufacturing experts, 3D printing technicians, 3D printing engineers, and 3D designers**.

- **Casting technicians**: Additive manufacturing will replace casting technicians with **3D printing technicians, 3D printing engineers, and 3D designers**.

### 2.4.2 MANUFACTURING JOBS REPLACED BY ADDITIVE MANUFACTURING AND SELECTIVE LASER SINTERING

1. Metal Fabricator

2. Metal Caster

3. Tool and Die Maker
4. Machine Operators
5. Mold Maker
6. Machinist
7. Welder
8. Laser Technician
9. CNC Machine Operator
10. Sheet Metal Worker
11. Die Maker
12. Punch Press Operator
13. Electronics Assembly Worker
14. Pattern Maker
15. Prototype Maker
16. Assembly Worker
17. Press Operator
18. Plastic Injection Mold Maker
19. Metal Worker
20. Metal Spinner
21. Metal Fabricator
Technician
22. Tool Grinder
23. Sheet Metal Worker
24. Production Technician
25. Foundry Worker
26. Assembly Line Worker
27. Painter
28. Machine Maintenance Technician
29. Sheet Metal Worker
30. Injection Molding Technician
31. Industrial Machinery Mechanic
32. Quality Control Technician
33. CNC Programmer
34. Metal Finisher
35. 3D Printer Operator
36. Laser Cutting Technician
37. Laser Engraver
38. Metal Stamping Technician
39. Metal Shaper
40. Metal Forming

### 2.4.3 JOBS CREATED BY ADDITIVE MANUFACTURING AND SELECTIVE LASER SINTERING

1. 3D Printing Technician
2. Additive Manufacturing Technician
3. CAD Engineer
4. SLS Operator
5. Rapid Prototyping Technician
6. 3D Printing Engineer
7. Selective Laser Sintering Technician
8. Design Engineer
9. Product Development Engineer
10. Manufacturing Engineer
11. Quality Assurance Technician
12. 3D Modeler
13. CAD Operator
14. Materials Engineer
15. CAD Technician
16. Process Engineer
17. Robotics Technician
18. Automation Engineer
19. Laser Technician
20. Software Engineer

21. 3D Design Engineer
22. Industrial Engineer
23. Process Technician
24. Quality Control Engineer
25. Maintenance Technician
26. Industrial Designer
27. Computer Numerical Control Programmer
28. Automation Technician
29. Mechanical Engineer
30. Manufacturing Technician
31. Production Engineer
32. Quality Engineer
33. Tool and Die Maker
34. Research Engineer
35. Mechanical Design Engineer
36. Mechanical Technician
37. 3D Printing Consultant
38. Robotics Engineer
39. Computer Aided Design Engineer
40. Additive Manufacturing Engineer

# 3. CONCLUSIONS

As with most new ADMA jobs, significant upskilling will be needed – people will need to add new skills to their arsenal in order to be able to fulfil the ADMA needs of the market, additive manufacturing and selective laser sintering might just be a sub-segment of ADMA, but the same rules apply. In order for the right skills to be chosen, the appropriate VET programs and courses to be selected, learning Analytics and Learning Pathways will have to be utilized to get the best possible options, customized to each person's education portfolio, abilities, circumstances and needs.

The broad additive manufacturing, but in particular selective laser sintering, which will likely represent the highest portion of additive manufacturing, will require a shift to a different set of skills. Below are some of the skills and competencies that VETs and SMEs should focus on in the future, to be able to fulfil the needs of the manufacturing segment.

- 3D Design Skills: People transitioning from traditional manufacturing jobs to selective laser sintering should learn 3D design skills such as CAD, CAM and 3D modelling. Sources:
- Laser Sintering Knowledge: People transitioning from traditional manufacturing jobs to selective laser sintering should learn about the laser sintering process, including materials, design and post-processing considerations. Sources:
- Problem-Solving Skills: People transitioning from traditional manufacturing jobs to selective laser sintering should develop problem-solving skills to be able to address any issues that arise during the process. Sources:

Other skills and competences that VETs and SMEs should focus on to meet the additive manufacturing / selective laser sintering needs:

## 3.1 SKILLS TO LEARN TO TRANSITION TO ADDITIVE MANUFACTURING AND SELECTIVE LASER SINTERING:

1. CAD Design [36]

2. 3D Printing [37]

3. Computer Aided Manufacturing (CAM) [38]

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[36] « Fusion 360 | 3D CAD, CAM, CAE, & PCB Cloud-Based Software | Autodesk », s. d., https://www.autodesk.com/products/fusion-360/overview.

[37] « The Free Beginner's Guide », 3D Printing Industry, 14 mars 2023, https://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/.

[38] Bob Warfield, « The Secrets of CAM for Beginners », CNCCookbook: Be A Better CNC'er, 29 septembre 2014, https://www.cnccookbook.com/every-beginner-know-cam/.

4. Machine Programming [39] [40]
5. Machining [41]
6. Material Selection [42]
7. Quality Assurance [43]
8. Process Documentation [44]
9. Troubleshooting [45]
10. Robotics and Automation [46]

## 3.2 COMPETENCES TO LEARN TO TRANSITION TO ADDITIVE MANUFACTURING AND SELECTIVE LASER SINTERING

1. Cost Analysis
2. Time Management
3. Critical Thinking
4. Problem Solving
5. Teamwork
6. Communication
7. Leadership
8. Creativity
9. Negotiation
10. Adaptability

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