Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

WP3 – Observatory

Learner Centric Advanced Manufacturing Observatory

Co-funded by the European Union

The European Commission’s support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

LCAMP partners:

TKNIKA – Basque VET Applied Research Centre, CIFP MIGUEL ALTUNA Centro Integral de Formación Professional; DHBW Heilbronn – Duale Hochschule, Baden-Württemberg, Curt Nicolin High School, AFM – Spanish Association of Machine Tool Industries, EARLALL – European Association of Regional & Local Authorities for Lifelong Learning, FORCAM, CMQE: Association Campus des Métiers et des Qualifications Industrie du Future, MV: Mecanic Vallée, KIC: Knowledge Innovation Centre, MADE Competence Centre Industria 4.0; AFIL: Associazione Fabbrica Intelligente Lombardia, SIMUMATIK AB; Association HVC Association of Slovene Higher Vocational Colleges; TSCMB:Tehniški šolski center Maribor, KPDoNE: Kocaeli Directorate of National Education; GEBKİM OIZ and CAMOSUN College.

Document summary

Document type:	Public Report
Title	Analysis of the evolution of jobs in advanced manufacturing
Author	Pascal Pichoutou *Mecanic Vallée,* Hervé Danton *Mecanic Vallée*
Co-authors	Unai Ziarsolo, Esther Trebolazabala, Metehan Güllü, Miha Zimšek, Alicia Miklavčič, Mikel Ayani, Volkan Alparslan Kilic, Hasan Burçin Menteş, Firat Arslan Haldun Toygarli, Sude Gülün, Gökberk Çelikel, Nisa Yilmaz, Jan Stenzel, Klaus-Dieter Rupp, Eda Ipek, Samuel Nazzareno Monaco, and Ralf Steck.
Contributors	AFIL, AFM, CMQEIf, DHBW, KIC, KPDoNE, *Mecanic Vallée,* Simumatik, TKNIKA
Reviewers	Camille Leonard, *CMQEIf,* Diana Miceli, *KIC*
Date	June 2024
Document status	9.0
Document level	Confidential until its publication
Document description	This document describes the main features of the evolution of jobs related to advanced manufacturing in 5 European countries.
Cite this deliverable as:	LCAMP (2024) Analysis of the impacts and evolution of jobs in advanced manufacturing (LCAMP4.0 Deliverable D3.2M24) retrieved from https://lcamp.eu/
Document level	Public

Version Management

Version	Date	Action
0.1	2023-02-29	Draft version
0.5	2023-03-30	Version for revision
0.6	2024-06-04	Reviewed by Hervé Danton, Camille Léonard
0.7	2024-06-06	
0.8	2024-06-07	Final version reviewed
0.9	2024-06-12	Final version validated with conclusion

ACRONYMS

ACBC - Autonomous Community of the Basque Country

AFDET - French Association for the Development of Technical Education

AFM - Asociación de Fabricantes de Máquina Herramienta- Machine Tool Manufacturers Association

AFNOR - French association for standardisation

AI - Artificial Intelligence

AKF - Ablative Keyhole Fusion

AR - Augmented Reality

AGV - Automated Guided Vehicles

B2B - Business to Business

B2C - Business to Consumer

CAD – Computer Aided Design

CEX-FA - Centros de Excelencia en Fabricación Automatizada - Spanish Network of Centres of VET Excellence on Automated Manufacturing

CMQEIf - Campus des Métiers et des Qualifications d'Excellence Industrie du futur

CNC - Computer Numerical Control

CAM - Computer-Aided Manufacturing

DLS - Digital Light Synthesis

DLP - Digital Light Processing

DT - Digital Twin

EICT - Electronics, Information, and Communication Technologies

EQF - European Qualification Framework

ERP - Enterprise Resource Planning

ESCO - European Skills, Competences, Qualifications and Occupations

FDM - Fused Deposition Modelling

FEM - Finite Element Method

HMI - Human Machine Interfaces

HVET - Higher Vocational Education and Training

IoT - Internet of Things

IT - Information Technology

IUT - University Institute of Technology

IVAF-EEI - Instituto Vasco de Aprendizajes Futuros para la FP -Basque Institute of Future Learnings for VET

LCAMP - Learner-Centric Advanced Manufacturing Platform

LCD - Liquid Crystal Display

M2M - Machine to Machine Communications

MV - Mecanic Vallée

OEE - Overall Equipment Effectiveness

PLC - Programmable Logic Controller

PLM - Product Life Management

SAT - Technical Assistance Service -

SCARA - Selective Compliance Assembly Robot Arm

SLA - Stereolithography

SLS - Selective Laser Sintering

SME - Small and Medium-sized Enterprises

TKNIKA - Centre for Applied Research in Vocational Training in the Basque Country.

TAS - Technical Assistance Service -

VET-LH-FP - Vocational Education and Training-Lanbide Heziketa-Formación Profesional

VR - Virtual Reality

WP - Work Package

CONTENT TABLE

EXECUTIVE SUMMARY

The LCAMP (Learner-Centric Advanced Manufacturing Platform) project under the CoVE initiative aims to enhance regional skill ecosystems in Advanced Manufacturing.

LCAMP plans to establish a European Platform of Vocational Excellence for Advanced Manufacturing, promoting resilience and innovation across regions through collaboration.

This report is a result of the LCAMP Observatory, which is one of the services the LCAMP platform will make available for the final users. The Observatory is led by the French cluster *Mecanic Vallée* and the French VET centre CMQEIf.

During this second year of work, the Observatory Work Package 3 launched an analysis on the impacts of digital and green transitions trends on jobs and skills of the workforce in the advanced manufacturing industry. The analysis focused on a selection of jobs occupied mainly by people qualified by European Qualification Framework (EQF) 3-6 studies.

These analyses are detailed in each regional / national sub-reports written by five countries (the Basque Country, France, Germany, Italy and Turkey) on 28 jobs in the advanced manufacturing industry.

Despite some variations in study methods and presentation of results, this year has established a shared methodological approach and a standardised format for reporting findings, paving the way for further progress.

Drawing from literature review and interviews conducted with companies in the field, several key findings have emerged.

In terms of Collaborative Work Process:

- **Methodology:** Each country relied on its own network of experts, with their differences
- In terms of areas of expertise and availability.
- **Frame:** A detailed presentation, described within a structured database, allows quick cross analysis, based on different axis: trends, skills, jobs/tasks.
- **Results:** Major tendencies of digital and green transition trends, impact on jobs, and required skills have been identified as a result of this analysis.
- **Year 3:** To obtain complete, usable, and certified results going forward, it will be necessary to combine efforts on common analyses. This could result in analysing the impacts of common jobs and reporting in a harmonized framework.

In terms of Impact Analysis and Job Evolutions:

- **Dynamic Job Landscape:** Jobs in advanced manufacturing are undergoing significant transformations due to the digital and green transitions within companies.
- **Influence of Industrial Context:** The evolution of jobs is intricately linked to various factors including company size, digital maturity, production types, business strategies, organisational culture, and regulations.
- **Variability in Job Evolution:** The evolution of specific jobs varies significantly depending on the individual company, highlighting the nuanced nature of workforce changes.
- **Digital Transformation Focus:** Digital transformation initiatives primarily aim at enhancing company performance, with less emphasis placed on individual well-being as the primary driver of change.
- **Versatile Workforce Requirements:** Companies prioritise versatile workers with a flexible mindset towards change, a keen interest in learning, effective communication skills, and problem-solving abilities.
- **Limited Identification of New Jobs:** Few new job roles have been identified, with data analytics positions being predominantly mentioned, particularly in larger companies.
- **Changes in Specific Roles:** Maintenance, Technical Assistance Services (TAS), and automation roles have undergone significant changes in certain cases.
- **Climate Emergency Measures:** Larger companies are more actively implementing climate emergency measures, such as automating carbon footprint calculations and enhancing energy efficiency. However, this process is still in its nascent stages.
- **Specialised Profile Demands:** Companies seek highly specialised profiles tailored to their manufacturing processes. This specialisation is often developed through in-house training and work experience, complementing foundational knowledge acquired from VET schools.
- **Call for Proficiency in Transversal Skills:** VET profiles are expected to possess a solid understanding of fundamentals, proficiency in IT/digital skills and languages, along with holistic transversal skills to meet the demands of advanced manufacturing occupations.

In conclusion, the report underscores the dynamic nature of jobs in advanced manufacturing, driven by digitalisation, greening, and industrial contexts. Companies are increasingly seeking versatile, specialised, and proficient individuals equipped with a blend of technical and transversal skills to thrive in this evolving landscape.

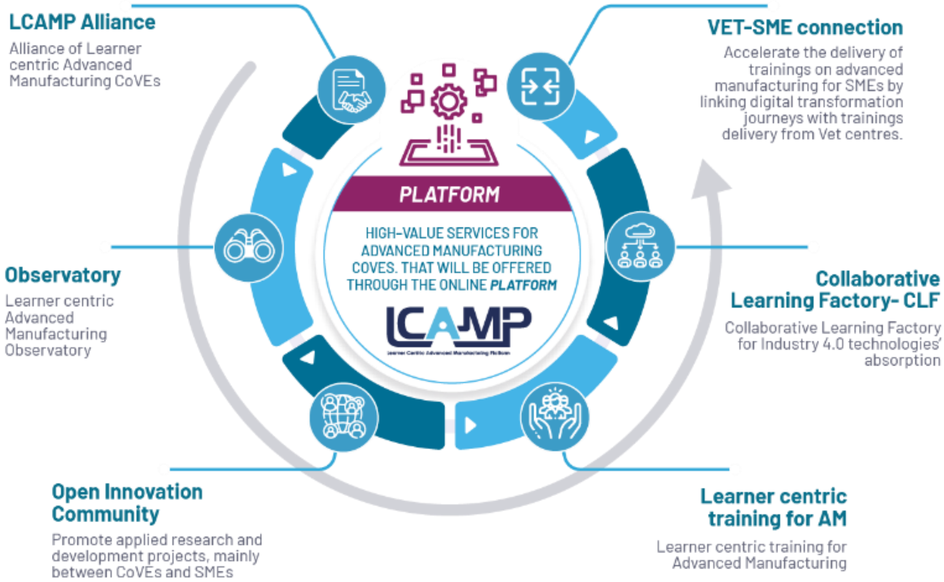

Figure 1 : Outputs and services to be delivered by the LCAMP platform

1. INTRODUCTION

The LCAMP Observatory will serve as an easily accessible source of information for VET centres, authorities in charge of curricula, companies, clusters and other associations through a digital platform. Throughout the LCAMP project, the Observatory will issue periodic reports covering technology trends, labour market changes, skill requirements, and occupations in Advanced Manufacturing.

The following publication of yearly reports is expected:

- Report 1: June 2023, D3.2 – M12 (https://lcamp.eu/wp-content/uploads/sites/53/2023/07/D3.2-Observatory_reportN1-2.pdf)
- Report 2: June 2024, D3.2 – M24 (this year's focus)
- Report 3: June 2025, D3.2 – M36

These reports are complemented with regional and national sub reports that will be periodically distributed in the platform and by conventional dissemination channels.

Each of these conclusions are described within all written sub-reports.

In this report, the Observatory work package analyses the impact of digital and green transitions on the competences of the workforce in the advanced manufacturing industry.

It focuses on a selection of jobs occupied mainly by people qualified by European Qualification Framework (EQF) levels 3-6 studies, that make up a significant part of the current demand in industrial companies located in the Autonomous Community of the Basque Country (ACBC), France, Italy, Germany and Turkey, impacted by the digital and green transition (see job selection criteria in section “3.1.1 Fields & Areas of observation”).

The information gathered and the conclusions reached are the basis for the development of other activities under the LCAMP Project (https://lcamp.eu/). In addition, the contents of this report may be analytical material for some stakeholders to develop activities in their respective fields, such as VET Centres, clusters and business associations, companies, etc. These stakeholders will find basic information for the development of activities such as the integration of technology in VET centres, the revision of content (curriculum) and learning methodologies, the updating of continuous training, the design of VET specialties, among others.

The combination of desk (analysis of reports published on the subject in the last years) and field (direct analysis of the job positions selected, conducted through interviews with managers of companies) research activities followed in the elaboration of the report converges in the detailed description of the 28 selected jobs. The elements derived from the general analysis have been combined with elements conditioned by the context of companies, revealing specific results in relation to the 28 jobs.

In term of project management and collaborative work, this year aimed to validate how to describe a job's impact and related skills and validate the frame to allow other work packages to use such Observatory results.

2. OUTCOMES

Year 2 study delivery is constituted by the sub-reports below:

Table 1 : List of sub-reports

WRITER	SUB-REPORT REFERENCE	SUB-REPORT SCOPE	CONCAT	OBJECTIVES
FR	D3.2 - M24 - A	Methodological sub-report	D3.2 - M24 - A Methodological sub-report	Describe objectives, outcomes, scope, and the methodology to produce Sub-reports.
BC	D3.2 - M24 - B	Basque Country sub-report	D3.2 - M24 - B Basque Country sub-report	The purpose of each sub-report is to present how jobs selected, tasks and related skills are impacted by Advanced Manufacturing Digital Technologies and the Green Transition.
FR	D3.2 - M24 - F	French sub-report	D3.2 - M24 - F French sub-report	
GE	D3.2 - M24 - G	Germany sub-report	D3.2 - M24 - G Germany sub-report	
IT	D3.2 - M24 - I	Italy sub-report	D3.2 - M24 - I Italy sub-report	
TR	D3.2 - M24 - T	Turkey sub-report	D3.2 - M24 - T Turkey sub-report	
FR	D3.2 - M24 - S	Synthesis of all D3.2 - M24 sub-reports.	D3.2 - M24 – S Synthesis of all D3.2 - M24 sub-reports.	Provides a synthesis of all D3.2 - M24 reports.
FR	D3.2 - M24 - C	Consolidated report	D3.2 - M24 - C - Consolidated report	Gathering of all sub-report

D3.2 outcomes are the imputs of other LCAMP services, mainly:

- Learner Centric Training for Advanced Manufacturing WP5, which manages skills and curricula data base.
- LCAMP Platform (n.d.) WP8 and Impact Assessment (WP8 which develops the Platform).

These Sub-reports' list in table 1 was defined following to the first stage of the methodology described here after.

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - A Methodological sub-report

Co-funded by
the European Union

3. METHODOLOGY OF THE D3.2-M24 OBSERVATORY REPORT

To build up the database and keep it up to date, the Observatory's operating methodology comprises a five-stage process, which takes place on a regular basis.

- Stage 1: Diagnosis and Priority - Set up Priorities and Fields to Observe.
- Stage 2: Search and Information Gathering
- Stage 3: Information Analysis
- Stage 4: Create value. Development of LCAMP Reports
- Stage 5: Disseminate-Communicate.

In this section, the structure of the LCAMP Observatory is explained, focused for this 2024 year, on trends impacts description on selected jobs.

That structure follows the process cycle as shown in Figure 2 below:

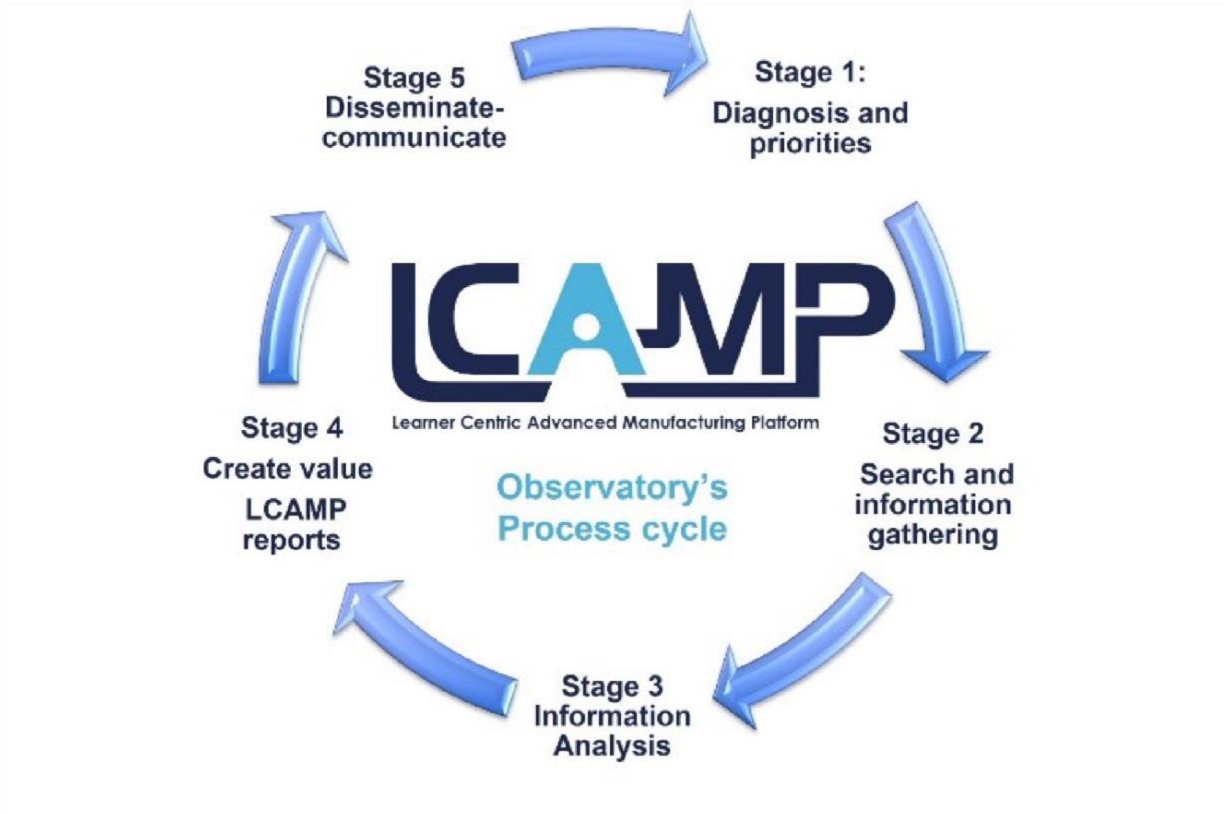

Figure 2 : Process cycle for the observatory

3.1. STAGE 01 DIAGNOSIS AND PRIORITIES

Before advancing to the analysis of job impacts and objectives for subsequent phases, the diagnostic stage began by addressing key questions. These questions are designed to consistently align with the goals, tasks, and processes necessary for producing the expected deliverables:

1. What is expected from the Observatory D3.2 - M24?
2. What do those outcomes do?
3. What are the outcomes of the Observatory Report 2: June 2024, D3.2 –M24?

Hereafter, are the answers to the above questions:

1. Describe how jobs are impacted by Advanced Manufacturing Digital Technologies and the Green Transition and the related knowledge/skills to be developed.
2. D3.2 outcomes are the inputs of other LCAMP services, mainly:
    - Learner Centric Training for Advanced Manufacturing (WP5)
    - Platform (WP8) and Impact Assessment
3. The Sub-reports are detailed in the above paragraph 2-Outcomes.

3.1.1. FIELDS & AREAS OF OBSERVATION

To define the scope / areas of observation, the following process took place:

- **First statement:** this Report describes which digital and green transition trends identified in D3.2 – M12 (LCAMP, 2023), are impacting a selection of jobs, instead of describing how each digital and green transition trend is already impacting jobs.
  Based on this statement and because it was not possible to analyze all the industrial jobs, the analysis focuses on a list of jobs selected by each country.

- **Second statement:** it was decided not to select new jobs, during the "research phase". The job to select already exists in industry.

  Each country has selected a list of relevant jobs based on the following 5 criteria:

  1. **Industry sectors:** the selected job is to be included in the LCAMP industry sector scope.
  2. **Jobs Impacted:** it has been verified that the jobs related to the digital and green transitions are impacted by the new trends previously identified in–D3.2 – M12;
  3. **Employability:** evaluate the employability / demand within industry.
  4. **Smart Specialisation Strategy** (https://s3platform.jrc.ec.europa.eu/): jobs must belong to industrial sectors included in the regional Smart Specialisation Strategies.
  5. **Education level:** it is validating that VET and high VET jobs - I4.0-centred Qualifications are delivered at EQF (European Qualification Frame) level 3 to 6.
     To facilitate harmonisation, each job is listed in the following tables with the corresponding ESCO occupation name and code. This enables the identification of

jobs that are common across countries and those that are country specific. These are classified into three groups:A – Job selected by 3 countries and more.
B – Job selected by 2 countries.
C – Job selected only by one country.

- The initial global list was condensed to shorten the report's length; each country submitted a brief list of jobs for analysis.

From these submissions, selected jobs were approved for further examination in the Sub-reports. Industry Sectors

With regard to the sectors, the jobs chosen are included in the list below, representing the areas of greatest interest for observation by the LCAMP:

- Machine tools (Mechanical Engineering)
- Automotive
- Aerospace
- Electric and Electronic Industries
- Transport
- Maritime.

Sectors defined by the EU Commission (EU commission, 2022).

Jobs Impacted

Analysis is built by analysing which and how tasks are impacted by the Digital and Green transition trends identified in previous Report (lcamp.eu/wp-content/uploads/sites/53/2023/07/D3.2-Observatory_reportN1-2.pdf) (Danton-a, 2023). Below is the reviewed list:

Table 2 : list of transition trends

TREND REF	DIGITAL TRANSITION TRENDS
1-1	Internet of Things (IoT) / Smart Sensors / 5G technology
1-2	Artificial Intelligence (AI) / Machine learning / Big Data Analytics
2-1	Virtual and Augmented Reality
2-2	3D scanning
3-1	Cybersecurity
3-2	Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing
4-1	3D Printing/Additive Manufacturing

4-2	Robotics and Automation
4-3	Collaborative Robots (Cobots)
4-4	Digital Twins
4-5	Adaptive Manufacturing Systems
4-6	Predictive Maintenance
TREND REF	**GREEN TRANSITION TRENDS / SUSTAINABLE MANUFACTURING**
5-1	Renewable Energy Integration
5-2	Circular Economy
5-3	Energy Efficiency
5-4	Waste Reduction
5-5	Green Logistics and Supply Chain
5-6	Sustainable Material Innovation
5-7	Carbon Footprint Management
5-8	Eco-friendly Packaging
5-9	Biomimicry in Design
5-10	Sustainable IT Infrastructure
5-11	Environmental Monitoring and Reporting
5-12	Corporate Social Responsibility (CSR) Initiatives

Employability

Based on common European reports, available regional reports, regional surveys, and other regional methodologies (refer to the following tables), it has been verified that the selected jobs are in high demand and/or experiencing rapidly increasing demand.

Smart Specialisation Strategy

It was necessary to confirm that the selected jobs are relevant to the Smart Specialisation Strategy (European Commission, n.d.) in the respective country.

Education Levels

LCAMP is focused on advanced manufacturing for the European VET and HVET Education systems. According to the European Qualifications Framework (EQF) (Europass, 2017), education levels from EQF3 to EQF6 are covered by VET and Higher VET Education systems.

Then it is validated that selected jobs can be performed at EQF (European Qualification Frame) 3 to 6 level.

3.2. STAGE 02 AND 03 SEARCH & INFORMATION GATHERING AND ANALYSIS

Consortium partners employ various methodologies within the Technology Surveillance and Competitive Intelligence systems. The information gathering strategy outlined in the Observatory incorporates the best practices from these methods. It adapts their use according to the observation targets, as detailed in the D3-1 Observatory Methodology document. (Danton-b, 2023).

In this section, the methodologies and tools to be used by partners are described. There are also some software and IT applications that could be used by the project, if tailored to LCAMP requirements: The section classifies as follows:

- Different methodologies, how they are used.
- Software or other tools used in each methodology (if any).
- When each methodology or combination of those are used.

During this second year of the project, and specifically its analysis phase, the Observatory is based mainly on secondary research activities, to do desk research activities, which have a predominant role in the Observatory.

1. Web Scraping, “Real time” information.
2. Publications, Professional magazines, clusters’ reports, etc.
3. EU project’s results review.

Desk research activities were conducted at the national level in the LCAMP partner countries of France, Germany, Italy, Slovenia, Spain, and Turkey. Based on these regional and national desk research efforts, national reports were produced. This forms part of Stage 04: Extracting Value & Report Creation.

3.2.1. EXTRACT VALUE & REPORT CREATION

It is proceeded in two steps:

- **Step 1:** Sum-up all jobs' impacts within the following document:

Table 3 : Tasks and skills impacted related to occupation.

OCCUPATION REFERENCE	OCCUPATION TITLE	TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Code of the occupation in ESCO	Specify the Occupation title (Preferred Term)	Name of task	Reference s from « D3.2 M12 » reviewed (see table provided below)	Main impacts identified on this task	If Skill available in ESCO data base: ESCO Skill name.	Code of the occupation in ESCO	Skill/ knowledge	L4 (Expert) Bloom descriptors: (create, evaluate, analyse, apply, understand, remember) L3 (Intermediate+) Bloom descriptors: evaluate, analyse, apply, understand, remember) L2 (Intermediate) Bloom descriptors: (analyse, apply, understand, remember) L1 (Basic/Beginner) Bloom descriptors: (apply, understand, remember)	If Skill availa ble in ESC O data base: http:// dxxx	If Skill available in ESCO data base: ESCO Skill description. If not indicate skill description.

- **Step 2:** Write the relevant sub-report with all the detailed information.

3.2.2. VALIDATION PROCESS

The validation process assures the quality of the reports generated within the Observatory.

The process of validation of the results of the analyses carried out by the Observatory must be very exhaustive. The credibility of the results published is based on three pillars.

1. The contrasted quality of the sources used.
2. The transparency of the process of analysis of information.
3. The validation of the conclusions by authorities with expertise in the relevant fields.

Considering the high relevance of the validation process, it is carried out on 3 levels:

1. Internal validation at a thematic team level and/or at regional level.
2. Validation at consortium level.
3. External validation carried out by panels of experts.

Internal Validation

The Observatory's steering group approves the reports. The final internal evaluation is led by the Observatory leader and co-leader, that are *Mecanic Vallée* (MV).

The internal validation is a prerequisite to call the panel of experts and continue with the external validation steps.

Panel of Experts

An international panel of experts was created during the first year of the project. This panel has to approve the conclusion and finding to be included in the reports elaborated in the LCAMP Observatory.

Composition, duties, frequency and timing of the panels of experts was already described in the D3-1-Observatory Methodology" (https://lcamp.eu/wp-content/uploads/sites/53/2023/07/D3-1-Observatory-Methodolgy-Final-version-1.pdf) document (Danton-b, 2023).

Once the research teams of the LCAMP Observatory established the main conclusions and findings to be included in the reports of the observatory, and after the validation of those reports by the Observatory's steering group, the regional panel of experts met and approved the findings.

Each panel decided the format of their meetings and the methodology.

The reports by the LCAMP partners () documented the findings and conclusions from the panel discussions. The respective partner prepared the final regional report to be submitted to the observatories' steering committee. To enhance communication, stimulate collaboration, and collect feedback for final validation, each country was encouraged to adopt a review process using shared tools that facilitate the examination of documents and statements.

3.3. STAGE 05 COMMUNICATION

All sub-reports are shared with Work Packages 5 and 8 (WP5 and WP8). They are designed to be practical and structured for use by WP5 and WP8. The subsequent tables titled "Tasks and Skills Impacted Related to Occupation" (e.g., Table 12), which summarize the impacts on all jobs, serve as a database for both WP5 and WP8.

3.4. LOCAL SPECIFICITIES

Due to the unique context of each country, the general methodology was clarified and/or adjusted as needed. These modifications are detailed in the respective sub-reports. Below is a summary of these adjustments.

In the Basque Country the research methodology combines a) an analysis of regional reports; b) a selection of jobs for the analysis; c) interviews with companies.

In Italy and France, a combination of these specificities / clarification was applied.

In Germany, the analysis follows a mixed academic approach that aims to combine different methods. AI was used to identify a trend and provide supporting data. Business surveys were conducted to confirm the results and gain further insights. This comprehensive approach allows a broad understanding of the issue to be developed and sound conclusions to be drawn.

In Turkey, the development of the report follows a methodology that is in line with other partners' approach. In terms of selecting the jobs, the Smart Specialisation Strategy for Turkey was considered as the main source while the outline of the jobs inspected in this report were decided after discussions and distribution among other project partners from different countries.

Analysis of the impacts were carried out by the Turkish project partners from different backgrounds and occupations, trying to cover as much variety as possible and consider each and every aspect.

The emerging report was validated by experts from the advanced manufacturing sector by sharing the draft version and gathering feedback / using a Survey Tool where individual statements from the report are converted into a survey to make the validation process easier for the experts.

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - B Basque Country sub-report

Co-funded by
the European Union

4. BASQUE COUNTRY: JOB'S IMPACT ANALYSIS

4.1. OVERVIEW OF THE IMPACT IN THE BASQUE COUNTRY

4.1.1. ADVANCED MANUFACTURING IN THE BASQUE COUNTRY

Basque Companies are in a constant change to maintain national and international competitiveness and to survive. Important drivers of change are new technology adoption (WOF, 2023), sustainability and social wellbeing (Orkestra, 2024), digitalisation (Cecimo, 2023), increase the added value of their products by enhancing their competencies for design, prototyping, validation and advanced manufacturing (ACICAE, 2024).

Identifying the success of new technology adoption strategies in the region is difficult. The lack of common indicators and data available make it difficult to assess the extent to which the digital and green transitions are being deployed in different types of industrial companies. According to the data published by EUSTAT (Basque Institute of Statistics), the adoption of Industry 4.0 technologies is heterogeneous (see table below).

Table 4 : Indicators of Industry 4.0 in the industrial establishments of the Basque Country, according to employment stratum (% of establishments) 2022. Date July 12, 2023. Source: (EUSTAT, 2023)

INDICATORS FOR INDUSTRY 4.0	ESTABLISHMENTS	
	Total (%)	10 or more employees (%)
Use of computer services "in the cloud"	26,6	50,2
Use of the internet of things (IoT)	13,6	25,6
Cybersecurity activities	20,8	47,7
Analysis of aggregate (Big Data)	12,2	25,9
Use of artificial intelligence systems	4,9	8,4
Use of 3D printers	2,6	8,7
Use of Robotics	2,3	12,9

4.1.2. SKILLS FOR ADVANCED MANUFACTURING (GLOBAL)

The impact analysis of the digital and green transition on specific jobs and workforce skills started with a review of existing literature. While there are sectorial reports and technology-specific analyses, they lack details on changes in specific advanced manufacturing jobs. Additionally, global reports on skills for Industry 4.0 do not provide context-specific data or break it down by variables such as company size, sector, type of production, nor do they detail the impact on specific jobs or tasks. Despite these limitations, the most significant findings are summarized below. According to insights from the World Economic Forum (WEF, 2023, p. 7) regarding the skills necessary for Industry 4.0:

- "Employers estimate that 44% of workers' skills will be disrupted in the next five years (until 2028)"
- "Six in 10 workers will require training before 2027, but only half of workers seem to have access to adequate training opportunities today".
- "The skills that companies report to be increasing in importance the fastest are not always reflected in corporate upskilling strategies".
- "Respondents express confidence in developing their existing workforce, however, they are less optimistic regarding the outlook for talent availability in the next five years".
- "Investing in learning and on-the-job training and automating processes are the most common workforce strategies which will be adopted to deliver their organisations' business goals".
- "Forty-five percent of businesses see funding for skills training as an effective intervention available to governments seeking to connect talent to employment".

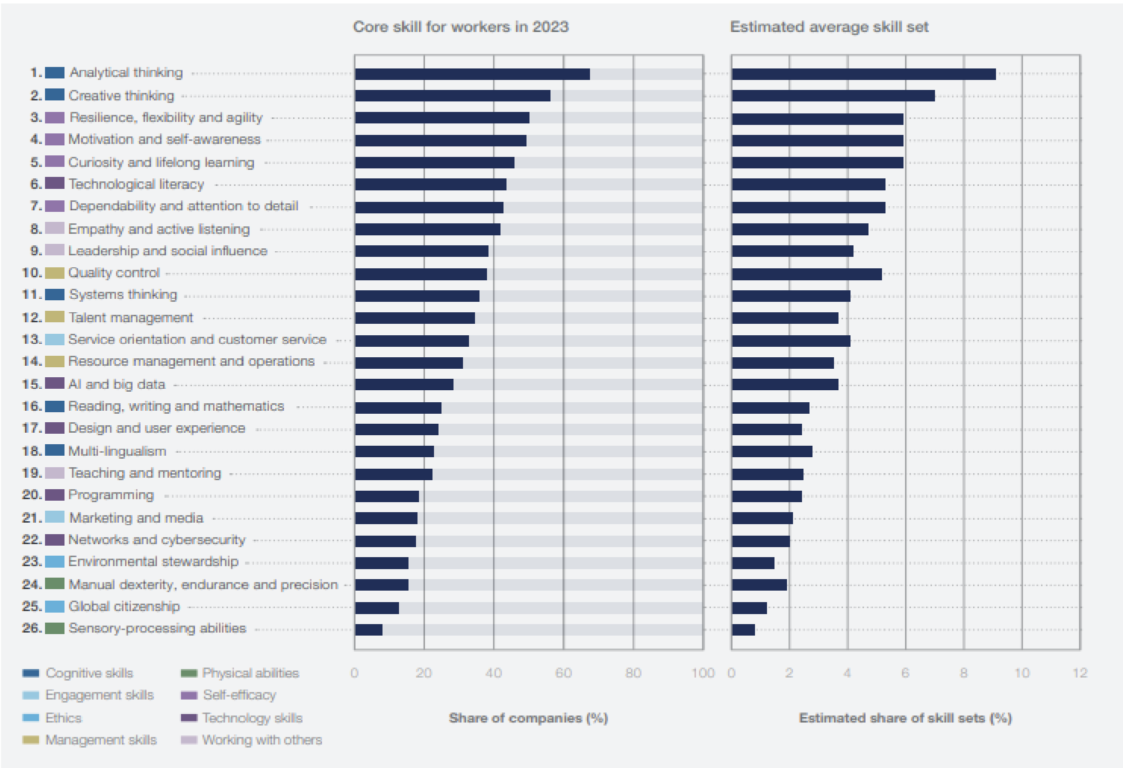

Figure 3 : Share of organisations surveyed which consider skills to be core skills for their workforce Source World Economic Forum, Future of Jobs Survey 2023 (WOF, 2023, p. 38).

The OECD (2023), in "Skills for a Resilient Green and Digital Transition", offers generic information on the skills evolution with special emphasis on Artificial Intelligence. There are no segregated details on skills for advanced manufacturing.

Cecimo (2024) in the report "From survey to strategy. Understanding Skills Trends in Advanced Manufacturing" provides an overview on the skills required for the machine tool industry.

The European Commission funds numerous interesting initiatives for the digital and green transition, such as:

- The Digital skills and jobs platform (European Commission, n.d.) helps to enhance digital capacity-building.
- The "Skills for Industry" initiative supports national efforts within the EU and contributes to a shared long-term strategy on skills for industry in Europe. Selected publications include:
    - "Skills for smart industrial specialisation and digital transformation" (Pedersen, Probst, Wenger, & Cracan, 2019)
    - "Skills for industry curriculum guidelines 4.0, Future-proof education and training for manufacturing in Europe 2019" (Dervojeda, 2019).
    - "Skills for SMEs, Cybersecurity, Internet of things and big data for small and medium-sized enterprises 2020" (Capgemini Invent; European Digital SME Alliance; Executive Agency for Small and Medium-sized Enterprises (European Commission), 2020).

Finally, in analysing the adoption of Industry 4.0 technologies in companies and their impact on jobs, it is essential to bear in mind that the incorporation of technological innovations depends heavily on the context and organisational aspects of the companies (Oeij., et al., 2023).

4.1.3. REGIONAL REPORTS ON SKILLS AND JOBS

At regional level, the analysis is focused on four reports about job profiles and skills for advanced manufacturing:

- Report of the Spanish Ministry of Education, Vocational Education and Training and Sport, coordinated by the Network of Centres of VET Excellence on Automated Manufacturing focus on the **identification of training needs for the preparation of job profiles in the automated manufacturing sector** (Homs, 2023). This report was developed by the 8 centres of the Network of VET Excellence centres of Automated Manufacturing in Spain. The aim was to identify the training needs of relevant job profiles in the automated manufacturing sector throughout Spain, including regional specificities. For the case of the Basque Autonomous Community, the study included interviews with 8 companies in the region.

- Report of the Spanish cluster of machine tool manufacturers (AFM) about **the future of work in advanced manufacturing. New challenges, roles, and competencies** (AFM 2022).AFM represents 90% of machine tool and advanced manufacturing technology companies in Spain. The report contains studies on the future of employment and future employment in the Advanced manufacturing field. The study was conducted among 19 companies from the Machine Tool Sector in 5 critical jobs, including Machining (EQF5), Industrial Maintenance (EQF5-6), SAT technician (EQF 5-6), Data Analyst (EQF 6) and IT experts (EQF 6). Technical or functional, social, methodological and personal competencies of these profiles were analysed (AFM, 2022).

- Report of the Basque Innovation Agency (Innobasque) about the **technologies and professional skills 4.0 Analysis of business demand** (Innobasque, 2019). Study carried out before the COVID pandemic including 19 companies from 5 sectors (Machine tool, Automotive, Energy, Aeronautic, EICT (Electronics, information, and communication technologies).

- Report of the Basque Employer Association (Confebask) about the **employment and qualification needs of Basque companies 2022** (Confebask, 2022). It gathers information from 600 companies on the types of profiles required, the qualification and training needs they demand and the difficulties they have in finding qualified workforce. The information in the Manufacturing, Construction and Services sectors.

These reports provide insights into the job profiles in demand within the Basque industry, offering a general overview of both specific technical skills and broader, cross-functional skills associated with various occupations.

4.1.4.LEVERS OF CHANGE

Homs (2023) claims that “the speed of change in the current framework marks the transition towards the consolidation of new productive forms of networked companies, marked by the emergence of new technologies and a new type of worker adapted to the new times (…). This brings with it the insertion of changes in the organisation of work, in processes and the inclusion of innovative changes and improvements in products”. In the field of work and its relation to job profiles, the main **levers of change** are:

- The automation of production.
- The digitisation of productive and social activity.
- The fight to control the crisis and the climate emergency.
- The ageing population.
- The reorganisation of geo-strategic balances on a global scale.
- The reorganisation of territorial criteria for the location of economic activity.
- The fight against the gender gap in the labour and social spheres.

According to AFM (2022) the levers of change for companies in the machine tool sector are, on the one hand, **productivity / efficiency improvement** and **process improvement** (Figure 4).

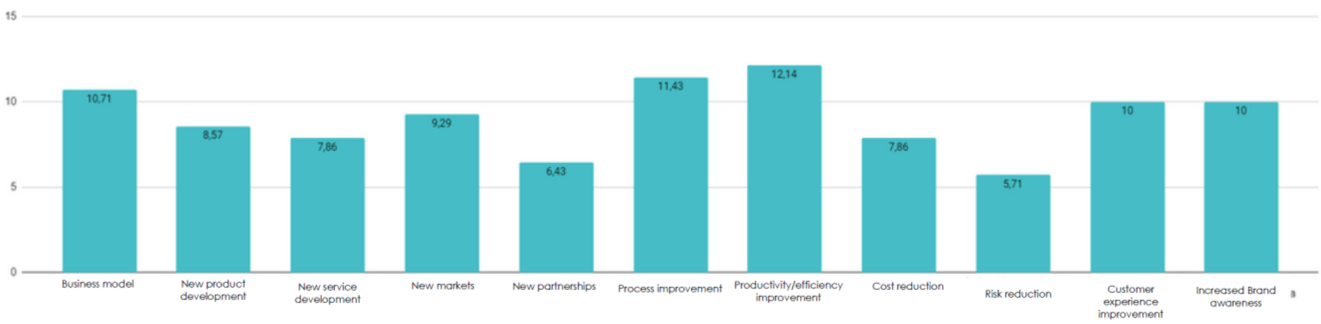

Figure 4 : Transformation priorities/challenges in which companies are currently preoccupied with Source (AFM, 2022)

On the other hand, the main directions where companies from the sector are moving are a) **developing differentiated products and services** and b) **finding growth opportunities for existing products and services** (Figure 5) (AFM, 2022).

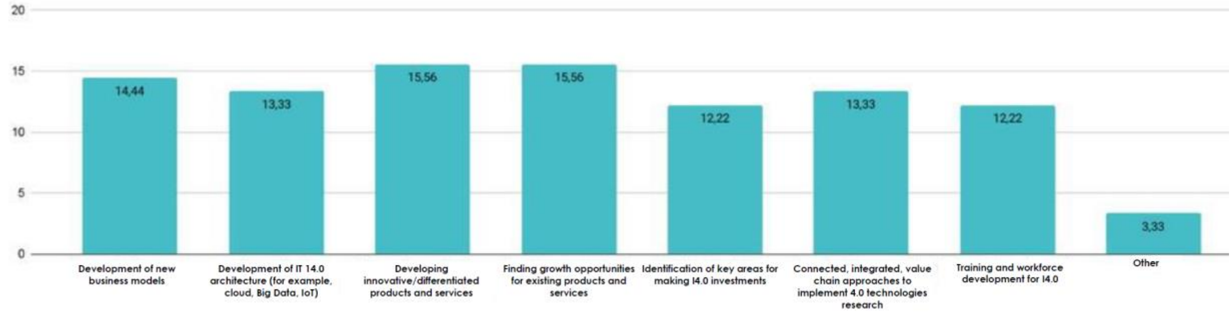

Figure 5 : Digital transformation initiatives and priorities/challenges in which companies are moving towards Industry 4.0 (AFM, 2022)

4.1.5.ORGANISATIONAL CHANGES

Digitalisation and automation in the sector have reshaped work organisation. **Organisational factors have the highest effect on skills development of the workforce** (Homs, 2023)**.** Roles have shifted from direct machine operation to team-based interaction, focusing on integrated production processes like programming and control. Each company adopts unique organisational models based on concrete production characteristics, resulting in varying task specialisation and career paths for employees. This entails different qualification requirements for their staff, ranging from models with greater segmentation to others with greater versatility.

According to AFM, considering the future importance of **organisational aspects**, over 60% of the surveyed companies believe that the relationship between people management and industry 4.0 are relevant, levers include: well-being, new working methods, compensation and benefits, or new models of organisational design. (AFM, 2022)

According to Homs (2023), factors such as sector, company size, production type, business strategies, organisational strategies, and regulations significantly influence technology adoption and, consequently, the skills required from the workforce.

4.1.6.PRIORITY TECHNOLOGIES

The literature review shows a variety of ways to analyse the priority technologies that drive transformation in companies. While some reports present an exhaustive list of technologies (Innobasque, 2019), others avoid explicit references (AFM, 2022), (Homs, 2023) (Confebask, 2022). Alongside artificial intelligence, the technologies identified as priorities by companies in the Basque Country according to Innobasque (2019) are mainly:

- Hybrid and/or multi-tasking machines / equipment.
- Flexible, intelligent and connected production systems.
- Agile human-machine interfaces.
- Communication system between equipment of consecutive production processes.
- Monitoring of equipment and processes and implementation in production processes.
- Data collection, visualisation and management systems.

- Intuitive and Multimodal Programming.
- Virtual systems for simulation and control of plant processes.
- Inspection and measurement systems integrated in the production process and connected online.
- Monitoring systems during the entire life cycle.
- Predictive maintenance systems and models for production systems.
- Efficient manufacturing processes for advanced materials.

4.1.7.NEW PROFILES / NEW JOBS

Concerning the creation of new jobs because of the digital and green transformations, the analysed reports refer more to show an evolution of jobs rather than the creation of jobs. That evolution is referred towards jobs based on workers' functions instead of jobs based on concrete tasks, mostly in SMEs (AFM, 2022) (Homs, 2023). Jobs tend to be modified rather than being destroyed or created.

In large companies there are a few new positions for data analytics or similar. The creation of departments or working groups to manage the digital transition is also mentioned for large companies. In SMEs, those functions are assigned to existing positions such maintenance staff, production managers or engineering departments. AFM (AFM, 2022) considers the Data Analyst profile as new.

4.1.8.RECRUITMENT

Two out of the four reports give information about expected recruitment, (AFM, 2022) (Confebask, 2022). The former states that within the expected requirements for the next 5 years (until 2027) among the 19 companies surveyed, assembly technicians, mechanical engineers and automation technicians will likely be the most demanded. (AFM, 2022)

Table 5 : Expected recruitment for the next 5 years among the 19 companies surveyed (AFM, 2022)

JOBS	% TOTAL REQUIREMENTS	QUALIFICATION LEVEL EQF5	QUALIFICATION LEVEL EQF6-7
Assembly technicians	27%	100%	0%
Mechanical engineers	18%	34%	66%
Automation technicians /electronics	17%	27%	73%
CNC Machining technician	13%	100%	0%
IT specialists	11%	0%	100%
TAS technicians	5%	27%	73%
Data analyst	2%	0%	100%
Maintenance	1%	100%	0%
Others	6%	36%	64%
TOTAL	100%	55%	45%

New recruitment is due to an increase in activity (57%), retirement (31%) and new activities (11.5%) (Confebask, 2022). By 2024, an increase of one point (58%), a decrease in the proportion of retirements (25%) and an increase in the number of new activities (17%) are expected. (Confebask, 2024)

This requires a direct recruitment process, via the Internet and, increasingly, through the job banks of educational centres. By departments, the most in demand are Production, Assembly and Maintenance (43%), Engineering and Quality Control (27%) and Marketing, Sales and Marketing (14.7%). As regards new recruitment and focus on the industrial sector, mechanical manufacturing (41.6%), electricity and electronics (18.1%), installation and maintenance (10.3%), chemistry (5.9%) and information technology (5.9%) are in first place, with a slight downward trend in mechanical manufacturing and installation and maintenance and an increase in chemistry, information technology and communications and transport and vehicle maintenance (Confebask, 2022).

4.1.9.COMPETENCIES

The 4 reports analyse different professional profiles, which make any comparison difficult. In addition, a common taxonomy to describe skills and competencies linked to professional profiles or jobs, beyond the distinction between technical / transversal or hard / soft skill, is non-existent.

AFM (2022) provides the necessary competencies clustered by technical, methodological, personal and social for 5 profiles (CNC machining technicians, Maintenance technicians, TAS technicians, Data analysts, IT specialists), together with the qualifications required for these jobs. Innobasque (2019) clusters competencies by: strategic, structural, activity related and transversal. The table below summarizes four recurrent aspects:

- **The organisational dependencies** of the functions linked to the jobs, as underlined in section 3.3.2, influence in the set of skills required for occupations.
- **Technical professional competencies form the core of the occupations:** the trend is towards higher demands on professional skills (Homs, 2023). Companies expect a strong technical base from VET graduates that will further specialize either in the job training or by Lifelong Learning courses or both. For the technical competencies, due to the changes towards more function-based jobs, IT skills and analytical skills are aggregated to almost all job categories.
- **Transversal competencies** are highly valued. It is remarkable that the three out of four reports mention similar transversal skills: problem solving, communication, collaborative work, creativity and innovation, data analysis and interpretation, attitude for learning and languages (AFM, 2022) (Innobasque, 2019) (Homs, 2023).
- **Systemic strategies** for talent management are proposed (AFM, 2022).

4.2. INTERVIEWS WITH COMPANIES

4.2.1. LIST OF JOBS SELECTED

12 jobs were selected based on the data collected through job vacancies offered by Miguel Altuna LHII (2024) and JOIND platform (2024) being considered relevant for VET graduates in the field of advanced manufacturing in the Basque Country. The employment exchange service from Miguel Altuna LHII covers information about job vacancies for VET graduates for the period 2017-2021. Information based on DUAL training from Miguel Altuna is also considered for the selection. The JOIND platform, on the other hand, is the employment exchange service from AFM. The data gathered in that platform covers the period June 1st, 2022, to December 31st, 2023.

The criteria to select the jobs was established by the LCAMP Observatory:

- Jobs where advanced manufacturing technologies are used.
- Jobs that are changing due to twin transition.
- Jobs with high rates of employability in the region.
- Jobs from sectors considered strategic in the region.
- Jobs with EQF5 requirements.

Table 6 : List of jobs analysed in the report.

Nº	SELECTED JOBS	VET LEVEL
1	CNC technician (Operator + programmer)	EQF5
2	Maintenance Operator (electrical, mechanical and others)	EQF5
3	After Sales Service technician-TAS operator (electrical, mechanical and other)	EQF5
4	Technical Office assistant (mechanical, electrical, product development and other)	EQF5
5	Automation technician & Robotics	EQF5
6	Quality Control assistant	EQF5
7	Assembly operator	EQF5
8	Industrial Assembly Supervisor	EQF5
9	Cold forging operator	EQF5
10	Welder	EQF5
11	Technical Sales representative	EQF5
12	Moulding machine technician	EQF5

4.2.2. COMPANIES INCLUDED IN THE ANALYSIS

Jobs vary significantly across companies; the tasks that workers perform and the skills they require can differ widely. To assess how context influences jobs, the analysis considered three main variables:

- **Size:** large companies (more than 250 employees), medium (between 50-250 employees) small (less than 50 employees).
- **Type of production**: customised short production batches, serial production, automated production. As companies with *own product* have shown singular characteristics, it is considered as a variable.
- **Sectors**: automotive, machine tool manufacturers, components manufacturers, equipment manufacturing, electric, biotechnologies, multisector.

The **relevance of the analysed jobs within the value chain** in the companies has also been considered. Not all jobs have the same weight in the value chain, therefore the priorities for their digitalisation may vary.

4.2.3.DIGITAL MATURITY

Company digitalisation levels vary, with company size being the primary differentiator more so than the type of sector or production. Smaller companies tend to have lower levels of digitalisation and integration of Industry 4.0 enabling technologies. However, it is important to note that the small companies surveyed are prepared to make significant technological advancements, as evidenced by their machinery, short-term investments, and strategic plans.

The table below provides more information about these companies:

Table 7 : List of companies participating in the study.

COMPANY	Nº OF EMPLOYEES	ACTIVITY	SECTOR
BIDEGAIN	47	Valves manufacturing	Multisector (wood, metal, building automotive r
BIELE GROUP	250	Turnkey solutions for production plants	Multisector
DOMOTEK	10	Manufacturing machinery for 3D bio printing	Additive Manufacturing
DS AUTOMATION	22	Maintenance and Industrial Automation Solutions.	Automation
ECENARRO	71	Manufacture of fasteners and special parts by cold forging	Automotive
GAMESA GEARBOX	55	Design, manufacture and supply of wind power transmissions	Energy
GH CRANES&COMPONENTS	240	Manufacture and design of cranes, and other lifting equipment.	Multisector

GOIMEK	85	Precision machining	Machine tool
HAIZELUR	33	Precision machining	Multisector
KENDU	28	Manufacturing of tools	Machine tool
KSB	200	Design and manufacture of pumps, valves and services for fluid transfer applications	Multisector
LEMU-Ibarra	123	Manufacture of paper converting solutions	Multisector
MAIER	902	Manufacture of plastic parts and technical subassemblies for industry	Automotive
ORMAZABAL	583	Manufacture of equipment for electrical distribution and control	Electric
P4Q ELECTRONICS	232	Manufacture of electronic equipment	Multisector
TECUNI	288	Electrical works and maintenance and electrical infrastructure	Electric
URUMEA MEKANIZATUAK	27	Machining	Multisector

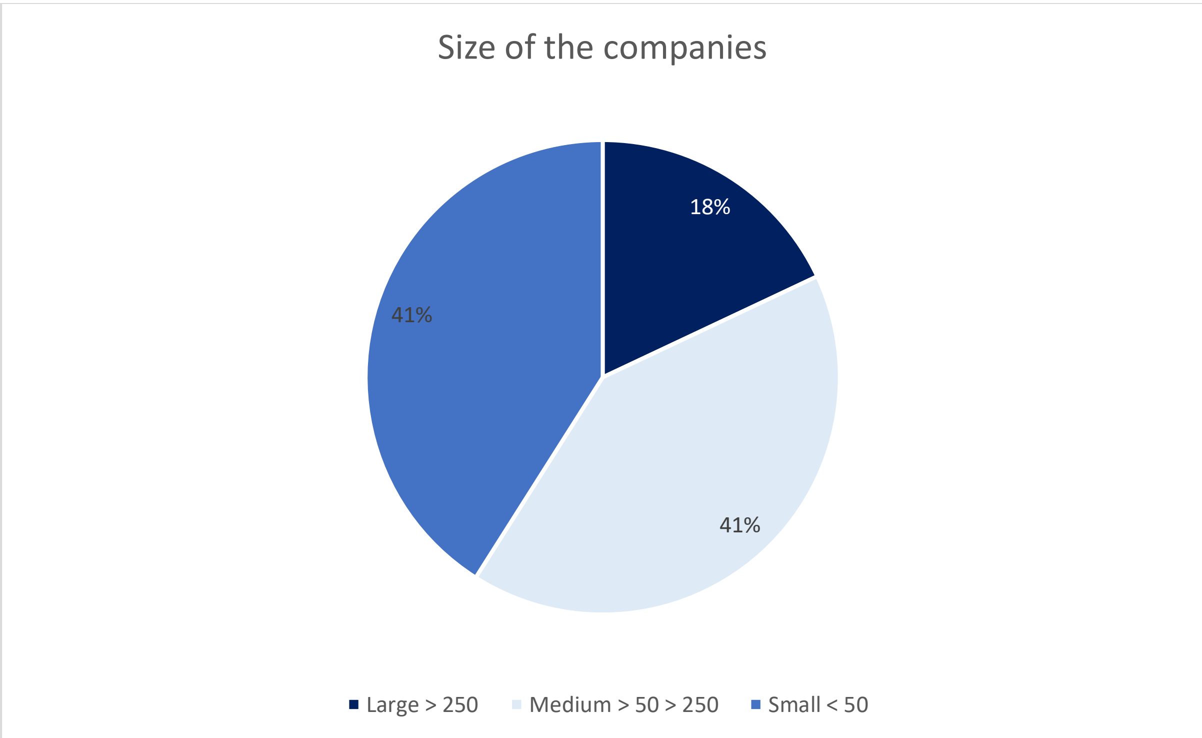

Figure 6 : Size of the companies.

4.2.4. METHODOLOGY FOR THE INTERVIEWS

Interviews were conducted with 15 teachers from 10 Basque VET centres and representatives from 17 companies. In most cases, the interviews were held face-to-face and involved two representatives from each company, typically a human resources manager and a production manager. Each interview lasted between 1.5 and 2 hours.

Table 8 : List of VET Centers involved in the study.

VET CENTRE	LOCATION
CIFP Armeria Eskola LHII	Eibar
Goierri Eskola	Ordizia
CIFP IMH LHII	Elgoibar
CIFP Miguel Altuna LHII	Bergara
CIFP Tartanga LHII	Erandio
CIFP Tolosaldea LHII	Tolosa
Politeknika Txorierri	Derio
CIFP Zornotza LHII	Zornotza
CPIFP Egibide LHIPI	Vitoria-Gasteiz
CIFP Usurbil LHII	Usurbil

Figure 7 : VET centres involved in the analysis.

The interviews covered three main aspects as shown in Figure 8.

- Analysis of changes the company undergoing and their impact on tasks and jobs.
- The identification of competencies arising from the changes for such jobs.
- The identification of the needs of the target workforce.

Figure 8 : Interview's process

4.3. JOB'S CHANGE ANALYSIS IN COMPANIES

This section examines how the 12 selected jobs are evolving within the companies interviewed and their impact on the workforce. As previously discussed, factors such as job context, company size, sector, and type of production are crucial for understanding and assessing the extent of these impacts. Additionally, an analysis of the drivers behind these changes reveals several common characteristics across most companies. Before delving into the specifics of each job, the following outlines these general features:

Context

The analysis takes a sample of 17 companies from different sectors with diverse industrial activities (see *Table 7 : List of companies participating in the study.* And Figure 6 : Size of the companies.). 41% are small sized companies, 41% medium and 18% large.

The **size of the company** is one of the variables that makes a difference in the rhythm and level of digitalisation. The automation and digitalisation levels are higher in large companies. Small companies are still in an early digitalisation stage. Another substantial difference is given by the companies with own product, where the customisation of products and services is leading to significant changes. The main **lever of change** that affects multiple jobs is to improve production efficiency. Other factors mentioned are environmental aspects, market driven factors such digitalisation of entire value chains or added value services.

4.3.1. GENERIC FEATURES FOR THE DIGITAL AND GREEN TRANSITIONS

4.3.2. DATA ACQUISITION SYSTEMS ARE THE BASIS FOR FURTHER INNOVATIONS.

The modernisation of Enterprise Resource Planning (ERP) systems connected with data acquisition systems are impacting in most of the jobs of those companies. Workers interact with Manufacturing Execution Systems (MES) and Human Machine Interfaces (HMI) in many analysed jobs. Similarly, data management and document management systems for (process) documents i.e. plan and control sheets, create a relevant impact in many jobs.

The process is progressive, some companies that are in the early stage of change (around 18%) start with machine retrofitting and data acquisition systems to move towards paperless production processes where still the interaction of the workers with the systems is very present, whereas others (53%), normally large companies, show more sophisticated data collection systems, introduction of IoT infrastructures and the use of Big Data for well-defined purposes (improvement of preventive maintenance, analysis of set-up times of machining machines, improvement of performance in the manufacture of milling tools).

In any case. it is seen that, as digitisation progresses, companies are integrating the collected data within other digital systems in the company for its subsequent analysis for the implementation of improvements.

4.3.3.MONITORING OF EQUIPMENT AND PROCESSES

In companies where machining is a relevant activity (precision machining, tools and dies manufacturing) data is collected directly from the machines. Manufacturing Intelligence systems are used to calculate Overall Equipment Effectiveness (OEE), manufacturing incidences and other relevant data. The direct acquisition of data from the machines is seen also in other activities besides the machining such as cold forging, injections and others. In some companies, data is also collected in assembly lines with relatively digitalized, workplaces although there are still a lot of manual operations carried out by workers.

The monitoring of data also facilitates the traceability of goods, components to understand the main process variables and their effects on products. For instance, in the **automotive sector** Original Equipment Manufacturers (OEMs) are requesting to the suppliers the availability of data related to their products in open and collaborative data space (Catena-X Automotive Network e.V., n.d.). A Similar request is also observed in other sectors. This requirement is forcing companies to speed up the establishment of data acquisition systems.

In all these **cases there is a clear change of the worker's role**. Workers, in addition to producing products, often become responsible for the data associated with these products. Promoting data culture is becoming a necessity in the automotive industry. The data collection requirements encompass the traceability of the full value chain, from raw materials to shipping, where multiple production and control parameters are requested.

4.3.4.AUTOMATION OF PROCESSES

Large companies show a clear trend towards automation. In small and medium companies even if the tendency is palpable, automation is still not so perceptible, it is limited to more specific operations such as the inclusion of a welding robot or one or more assembly operations.

Specifically, among companies engaged in machining activities, which accounts for 71%, there is a widespread trend towards investing in state-of-the-art machinery. This includes flexible, hybrid, or multitasking machines equipped with Human-Machine Interfaces (HMIs) and data acquisition systems, along with a high degree of automation. Palletized feeding systems that enable 24x7 production are on the agenda for nearly all these companies.

Regarding intralogistics, warehouses, and material supply, 12% of the companies have already digitized warehouse control, and 6% have digitized the supply to production lines, with plans to expand digitisation efforts. Others are planning to undertake such digitisation soon. Automated warehouses for products and tools are now commonly used. Additionally, three companies have disclosed plans to digitize the control of spare parts and machining tools in the near future.

Among other technologies mentioned in the interviews, already operative in some cases and foreseen in the near future, are findings of automated measurement, control systems by artificial vision, quality control integrated in processes and Automated Guided Vehicles (AGV).

4.3.5. COMPANIES WITH OWN PRODUCT

Among the companies that produce their own products, representing 29%, a clear driver of change is the integration of technology into their products. This innovation causes the products to evolve, thereby creating demand for new technologies and knowledge. Some companies are developing digital and online customer services such as advanced predictive maintenance, product configuration, and online monitoring of manufacturing orders. The leading companies are discussing further innovations, such as applying AI to products, incorporating their own embedded IoT systems, and using big data to monitor and control their products to optimize end-user operations. Companies, with their own product mark these milestones as being of paramount importance. It leads to the need for organisational changes that respond to production in discontinuous cycles on the one hand and to an increase in product customisation on the other. In addition to organisational changes, these trends are leading to more specialized professional profiles with greater technical knowledge of the product, processes and capital goods. In turn, there is a need for greater versatility between jobs within the same production section and even between different ones. It is worth mentioning that versatility is a general comment, not only by the companies with own product.

4.3.6. ENVIRONMENTAL SUSTAINABILITY

Changes in regulations and an increase in the environmental awareness among companies is leading to adopt changes related to environmental aspects within the companies. Once again, the adoption rate of environmental measures vary from company to company, with the larger companies leading. Companies with own product are adopting environmental measures for their products such as the elimination of certain greenhouse gases, modification of their product designs, generation of new products and new manufacturing lines. Companies have also shown awareness for sustainability due to regulations in their supply chains.

The calculation of the carbon footprint and greenhouse gas emission reduction commitments are present in around 35% of the interviewed companies. Actions such as calculation of the carbon footprint, waste treatment, energy efficiency in equipment, lines and buildings, installation of solar panels are observed.

There is a clear cultural shift to address sustainability issues.

4.3.7. ARTIFICIAL INTELLIGENCE, VIRTUAL REALITY, ROBOTICS, DIGITAL TWINS, 3D PRINTING

Among the interviewed companies, those at the forefront of digitalisation consider AI as the natural progression for data analysis. Despite widespread recognition of AI's potential, most interviewed companies are not actively pursuing AI projects. However, three companies have included AI in their short-term agendas.

In terms of AR and VR initiatives, three companies, one medium-sized and two large, have expressed their intention to integrate these technologies in the near future.

Regarding robotics, the companies surveyed generally have limited use due to their specific production requirements. Two companies employ robotic cells for automated welding, while one medium-sized company has successfully implemented AGVs. Although the current use of cobots is limited, there are plans to incorporate them soon.

One notable mention in the realm of 3D printing is a company specializing in manufacturing 3D printing machines for biotechnology. However, large-scale 3D printing component manufacturing is not prevalent among the interviewed companies.

The adoption of Digital Twins as a short-term strategy was mentioned by just one company.

4.3.8.ORGANISATIONAL CHANGES

There is a **widespread belief that job profiles are evolving**, shifting from traditional blue-collar roles to management positions. This reflects a broader definition of tasks and jobs, supporting findings from (Homs, 2023) and (AFM, 2022), which indicate a move from defining roles by specific tasks to broader "workers' functions". Workers are increasingly linked to functions rather than tied to specific machines.

Companies emphasise the need for adaptability to changing market and customer specifications. They highlight not just the necessity for flexible production that can tailor products to customer needs, but also the critical adaptability skills workers must possess to facilitate these changes.

Organisational transformations are anticipated as a result of digitalisation, aiming to provide greater autonomy at all company levels. A strong push towards data-driven management is evident, with new working methods and organisational models being adopted.

Increasingly, companies value a systemic understanding of the entire organisation and the interconnectedness among jobs. Versatility, or the ability of individuals to perform multiple roles or tasks within the production line or process, is recognized as a highly valuable trait for workers. This versatility allows workers to adapt to various responsibilities or positions as needed, thereby enhancing the manufacturing environment's efficiency, adaptability, and productivity.

4.3.9.GENERIC COMPETENCIES AND SKILLS

The changes in competencies brought about by the digital and green transitions, companies often cite technical skills enhancement focused on deeper knowledge of the technologies used in their specific work environment.

Essential technical skills that they aim to improve include **data management, digital literacy, familiarity with internal procedures, and proficiency in management tools**.

Companies emphasize the vital role of **basic technical knowledge** acquired in VET centres, viewing it as a strong foundation for specific technology expertise.

Interdisciplinary skills are increasingly valued, with roles traditionally focused on mechanical expertise now incorporating electronics or IT skills, especially in maintenance positions. Transversal (soft) skills such as problem-solving, decision-making, in collaboration, leadership and effective communication are consistently highlighted.

Proficiency in foreign languages, particularly English, is crucial due to the rising need for interaction with international stakeholders.

Companies often set up in-house training related to the functioning and program of existing and forthcoming new machines. Training of workers as external courses (lifelong learning) are also widely used, being VET centres the principal providers of such trainings. Technology providers (machine, equipment, engineering solutions or software vendors) are also recurrent training providers.

The interviewed companies have well-established **onboarding systems**, typically involving a learning period before employees become autonomous, especially with complex machinery. Internal training programs are therefore, crucial. Such programs would need to be updated according to the evolution of the worker's competencies.

Defined **career paths** to reach certain positions are common, offering progression to positions of greater complexity or responsibility. Many intermediate managerial roles, such as line managers and quality control technicians, are filled by VET graduates with extensive experience and comprehensive knowledge of products, processes, and machines. For instance, in a company producing its own products, progression may involve starting as a machine operator, advancing to CNC machine programming, then to roles like production manager or even area manager overseeing work teams and continuous improvement. These pathways are long-term and can take several years to complete. Personalized learning programs for workers are established in a few companies although it is not the most common strategy.

DUAL training systems and internships are frequently used to develop candidates' technical competencies specific to the company.

Table 9 : Jobs analysed in companies.

COMPANY	#01	#02	#03	#04	#05	#06	#07	#08	#09	#10	#11	#12	#13	#14	#15	#16	#17	
Vet centre interviewing	Goierri Eskola	Goierri Eskola	Miguel Altuna	Miguel Altuna	Miguel Altuna	P. Txorierri	Tolosaldea	Tolosaldea	Zornotza	Zornotza	IMH	Tartanga	Tartanga	Egibide	Armeria	Usurbil	Usurbil	% present
Size (Small, Medium, Large)	S	M	M	S	M	S	M	L	L	L	M	L	M	S	M	S	S	
JOBS																		
CNC operator	●	●	●	●	●	●	●	●	●		●					●	●	71%
Maintenance Operator	●		●	●	●			●	●		●	●	●			●	●	82%
TAS operator		●			●	●	●	●	●				●			●		53%
Technical office assistant	●	●		●	●	●	●	●	●		●					●		65%
Automation technician		●				●			●				●	●				35%
Quality control assistant	●	●	●	●	●	●			●		●		●			●	●	65%
Assembly operator		●	●	●	●	●	●	●	●	●					●	●		65%
Industrial assembly supervisor/ team leader	●				●		●		●	●	●					●	●	65%
Cold forging operator			●															6%
Welder		●			●	●			●							●	●	35%
Injection moulding machine operators									●									6%

4.3.10. CNC OPERATOR

4.3.11. GENERAL DESCRIPTION

CNC operator (ESCO 7223.4) ESCO description: **"**Computer numerical control machine operator's set-up, maintain and control a computer numerical control machine, in order to execute the product orders. They are responsible for programming the machines, ensuring the required parameters and measurements are met while maintaining the quality and safety standards" (ESCO, n.d.).

Although the job is identically named in all the selected companies, the related job competencies can vary depending on the company context. The definition given by ESCO is a well-accepted, general function of the operator which includes tasks related to quality control and maintenance of CNC machines.

On the other hand, to maximize productivity rates, CNC programming are made outside the actual production machines, normally carried out by specialized workers in technical offices with knowledge of CAM. Operator in machine made the adjustments of the programs or set up of certain parameters. The subcontract of the programming of complex machining processes have been observed in one company where machining is not their main activity.

Also, tasks based on data analysis and problems solving are derived to operators.

Presence in Sectors

71% of the companies interviewed include CNC operators in the study. 67% of those consider the machining activity as relevant activity for their company. Furthermore, such jobs are occupied by VET graduates. All the sectors represented in the study include CNC operators' jobs.

4.3.12. LEVERS OF CHANGE

A CNC operator is valued as a changing job by most of the companies (60%). The most recurring levers of change identified are the following:

- **Investment in state-of-the-art machinery:** flexible, hybrid or multi-task machines equipped with HMIs and data acquisitions systems.
- There is a generalized trend of` **monitoring the data from CNC** machines. It goes from the implementation of Management Intelligence systems to exploit data from CNC machines to IoT and Big data technologies. Usually, the aim is the improvement of Overall Equipment Effectiveness (OEE).
- The **workplace is connected to MES and ERP** systems.
- **24x7 running machines** with palletising systems or automatized feeding systems.
- **Tailored** production, and **Small production batches**.

Looking for short-term trends, the following existing levers will remain:

- More automation of CNC machines (palletisation eta and inclusion of sensors to improve safety functions, automatized measurement).
- Big Data and AI applied to the predictive maintenance of CNC machine.
- Product customisation.
- Inclusion of sensors to improve the control of spare parts.
- Traceability of tools, automated warehouses for tooling.
- Automated inspections and/or measurement systems in the workplace.
- Machine Learning to improve efficiency and quality.

4.3.13. SKILLS AND COMPETENCIES

Changes in technologies entail the evolution of both technical and transversal competencies. A general comment for CNC operators is that the organisation of the job is changing with a development of workers' autonomy in the workplace, greater involvement in the production processes and higher interaction for the systems.

Concerning the **technical skills,** the increase of complexity of products, increasing demands for precision and quality, the complexity of the machine's requests to higher knowledge in Computer Aided Manufacturing (CAM) processes, digital skills, data analytics and languages, especially English.

More concrete requirements mentioned for CNC operators in some companies (60%):

- Interactions with MES and ERP systems.
- Computer-Aided Design (CAD)/CAM programming skills.
- Predictive maintenance.
- Complex drawing's interpretation and spatial vision.
- 5S, lean manufacturing.
- Cybersecurity in OT systems.

Regarding the transversal competencies, the companies agree on the need of the aforementioned soft skills related to CNC operators i.e. involvement, problem solving, decision making, interdisciplinarity, interest in learning, communication.

Other characteristics observed for this job are **adaptability to production needs, versatility, mind-set for data culture**. High **knowledge on the product's functionalities** is also highly valued for CNC operators.

Qualification requested for this job:

- Production Scheduling in Mechanical Manufacturing EQF5.
- Machining technician EQF 4.
- Specialisation program on precision machining EQF 5.

4.3.13.1. APPROACHES FOR UPSKILLING AND RESKILLING

100% of the interviewed companies have training processes for CNC operators in place. From onboarding trainings to very specific high-tech trainings. Internal trainings and on the job trainings are the main training methods used. VET centres are important training providers for CNC operators in Lifelong Learning (LLL) programs related to CNC. Also, technology provider companies.

As has happened over the years, CNC workers have moved to more complex positions as they have gained experience, always reinforcing their knowledge with external training actions. A typical pathway would be operators start working on simpler two-axis or cylindrical machines and over time move to 5 and 6-axis machines. In many companies the professional progression leads to positions such as Tooling Design Technician, CAD CAM process technician, Quality, warehouse supervision and purchasing and so on.

It is observable the relevance of LLL programs and external training providers to assists those paths.

For CNC, operator **versatility** is more and more requested, at least among machines with similar characteristics. The requires adapting to changes, and attitudes toward LLL.

4.3.14. MAINTENANCE OPERATOR

4.3.15. GENERAL DESCRIPTION

In the interviews with companies the *maintenance operator* job's definition varies, depending on the type of company. The definitions found corresponds to the following:

- **Industrial Maintenance Supervisor** (ESCO 3515.1.6) ESCO description: "Industrial maintenance supervisors organise and supervise the activities and maintenance operations of machines, systems and equipment. They ensure inspections are done according to health, safety and environmental standards, and productivity and quality requirements" (ESCO, n.d.).
- **Electrical Maintenance Operator** (ESCO 7411.1) ESCO description: "Electricians fit and repair electrical circuits and wiring systems. They also install and maintain electrical equipment and machinery. This work can be performed indoors as well as outdoors, in nearly every type of facility" (ESCO, n.d.).
- **Industrial Machinery Mechanic** (ESCO7233.7) ESCO description: "Industrial machinery mechanics work on new machinery and equipment in operation. They set up for the specific application and build accessories if necessary, perform maintenance and repair, and run diagnostics to find faults in systems or parts that need replacing" (ESCO, n.d.).

According to interviewed companies the *maintenance operator* job is changing substantially. Depending on the sector, size and type of product, the **functions for maintenance operators** are specified in different ways.

There are companies where the maintenance operators are responsible for preventive and corrective maintenance of equipment and for the automations and improvements in production lines. Due to automation and digitalisation, job profiles that used to involve purely mechanical and/or purely electrical maintenance tasks, nowadays are complemented with mechatronics and

IT related tasks. New functions such as PLC programming, maintenance of data acquisition systems, communications between machines and systems and security regulations are more and more affecting this job.

There are different strategies to carry out maintenance tasks. It is often the operators themselves who carry out preventive maintenance tasks at their workstations, and in some cases even simple corrective maintenance tasks (67%).

Given the increasing complexity of machines, equipment and manufacturing lines, and also due to the lack of personnel with sufficient knowledge, different options are observed among the companies interviewed. Some opt to subcontract part of the maintenance to the technical services of the machine brands and outsource repairs and periodic repairs. In other cases, given the complexity of the tasks, the entire maintenance service is outsourced to specialists in advanced technologies, while the management tasks remain with the parent company.

Presence in Sectors

This job is present in all the sectors and manufacturing plants considered in this study with the exception of one small company. 82% of the interviewed companies included this job in the analysis. In 53% of cases, due to the inclusion of complex machines, such as 5-axis CNC machine, or the inclusion of AGVs, the maintenance of these specific elements becomes an external process, i.e. an outsourced service.

4.3.16. LEVERS OF CHANGE

Medium and large size companies consider maintenance operator position as a changing job. Due to the twin transitions the complexity of the technologies implemented in production lines have brought a change in the functions of maintenance operators. It is common for maintenance operators to be in charge of implementing and maintaining the automation in productions lines.

The most recurring levers of change identified for maintenance operators are the following:

- Automation of production lines or integration of complex machinery, including retrofitting of existing machinery.
- Development of advanced predictive maintenance based on data collection.
- Organisational changes that integrate the simple maintenance operations to production under the supervision of the machinery operators.
- Evolution in the maintenance monitoring system due to the outsourcing of periodic and corrective maintenance of equipment in case of complex machines. This evolution is driven by the need to meet control requirements mandated by tool and equipment manufacturers for certification and legal compliance.
- Participation in interdisciplinary teams to implement improvements in the manufacturing processes. The improvements can have different origins, can be proposed by both engineering and machine staff.
- Higher collaboration with technical departments.

Some companies mention a trend toward the use of AI for predictive maintenance in a short future, which will obviously have an impact on the skill needs for maintenance operators.

4.3.17. SKILLS AND COMPETENCIES

Technical skills identified as new in the interviews are listed below. Note that the term "new" could be subjective, what is new for some companies can be mature in other.

- Implementation and maintenance of machine-to-machine communications systems.
- Data capture from manufacturing equipment.
- Industrial communications.
- For those companies with a more advanced level in machine-to-machine communications, there is an evolution of the competencies towards industrial IT maintenance profiles.
- Multi-brand robot programming (the mention was made for welding robots).
- Multi-brand PLC programming.
- Artificial vision systems.
- Alignment of tools by laser.
- Alignment of tools by laser.
- Big data and IA skills are mentioned in the most digitalized companies, still a minority.
- Cybersecurity.

With reference to **transversal competencies,** companies focus on the development of analytical skills and increased organisational, planning and management skills.

Qualification requested for this Job

- Industrial Mechatronics EQF 5.
- Automation & Industrial Robotics EQF 5.
- Double qualifications or Qualification + specialisation courses are very much valued i.e.:
  - Production Scheduling in Mechanical Manufacturing EQF5 + Automation & Industrial Robotics EQF 5.
  - Industrial Mechatronics EQF 5 + Specialisation Course in Digitalisation of Industrial Maintenance.
  - Industrial Mechatronics EQF 5 + Specialisation Course in Smart Manufacturing.
- Mechanical Engineering EQF 6.
- Electronic engineering EQF 6.

4.3.18. TAS OPERATOR

4.3.19. GENERAL DESCRIPTION

Electrical eta Mechanical TAS Operator-After-Sales Service Technician (ESCO 2433.1) ESCO description: **"***After-sales service technicians provide after-sales service support to customers, such as the installation, maintenance and repair of the sold products. They take corrective actions to ensure customers' satisfaction"* (ESCO, n.d.).

Depending on the company, a distinction may be made between commissioning after-sales service and technical support.

TAS operators require in-depth knowledge of the operation of the products as well as its components for both commissioning of products and diagnosing and resolving problems at the customer's premises. Furthermore, for technical services in addition to corrective maintenance, their functions may also include remote predictive maintenance with the monitoring of installed equipment.

Presence in Sectors

Among the interviewed companies 53% have TAS services. Usually, the TAS operator job appears on those companies with own product (57%). 43% claimed that it also appears as the main activity of the company as the automation of third-party production lines or machines.

This job requires, - besides advanced technical competencies - languages proficiency and availability for travel and/or flexibles working times.

4.3.20. LEVERS OF CHANGE

The companies rated the change level for TAS operators as the highest among the jobs included in this study. The following are some of the reasons for the transformation of tasks for this job:

- Integration of digital elements into the operation of the product that provide new safety functions, operation monitoring capabilities and extended operating functions in critical environments.
- Installation or export of automated processes, integrating HMIs, IoT systems or robots to other plants.
- The transformation of products following environmental legislations, requires the electrification of those to remove fossil fuel-based technologies.
- Increased security requirements lead to non-outsourcing of installation services becoming functions for TAS operators.
- Remote support services to solve customers' problems without the displacement of the technicians.
- Increased environmental legal requirements such as handling certain gases or hazardous materials.

According to one company an important lever of change in the near future will be the integration of AI for monitoring and preventive maintenance of products installed in customer's facilities.

4.3.21. SKILLS AND COMPETENCIES

New skills requirements for TAS operators were identified:

- Development of sensorics knowledge.
- Remote maintenance systems.
- Data analysis.
- Big data and AI.
- Cybersecurity.
- Identification of emerging technologies.

With regard to transversal skills, the companies that have analysed this job emphasise on the need for: communication, networking, analytical thinking and problem-solving skills.

Qualification requested for this Job

To promote this job, work experience is required, however, the background could be vary in nature:

- Production Scheduling in Mechanical Manufacturing EQF5.
- Industrial Mechatronics EQF 5.
- Automation & Industrial Robotics EQF 5.
- Double qualifications are very much valued:
  - Production Scheduling in Mechanical Manufacturing EQF5 + Automation & Industrial Robotics EQF 5.
  - Industrial Mechatronics EQF 5 + Specialisation Course in Digitalisation of Industrial Maintenance.

4.3.22. TECHNICAL OFFICE ASSISTANT

4.3.23. GENERAL DESCRIPTION

The job covered in this section is Technical Office Assistant (mechanical, electrical, product development and other). Depending on the type of organisational structure of the company, this job therefore corresponds to various definitions:

- **Mechanical Engineering Drafter** (ESCO 118.3.11) ESCO description: "*Mechanical engineering drafters convert mechanical engineers' designs and sketches into technical drawings detailing dimensions, fastening and assembling methods and other specifications used for example in manufacturing processes*" (ESCO, n.d.).
- **Electrical Drafter** (ESCO 3118.3.6) ESCO description: "*Electrical drafters support engineers in the design and conceptualisation of electrical equipment. They draft, with the support of specialised software, the specifications of a varied number of electrical systems such as voltage transformers, power plants, or energy supply in buildings*" (ESCO, n.d.).
- **Product Development Engineering Drafter** (ESCO 3118.3.12) ESCO description:**:** **"***Product development engineering drafters design and draw blueprints to bring new concepts and products to life. They draft and draw detailed plans on how to manufacture a product*" (ESCO, n.d.).

Other functions not included in ESCO definitions are observed in the interviewed companies. Functions such as support in the selection of materials and components, project monitoring and assistance to preparation of budgets.

In some companies, in addition to preparing drawings for production, functions such production programming and numerical control programming are carried out by Technical Offices.

Therefore, although the job position Technical Office Assistant is commonly regarded for all the interviewed companies, its functions vary from firm to firm.

Presence in Sectors

This job position is present in 65% of the companies covered by this study. It is currently considered as essential given the growing demand for personalized projects. The Technical office assistants are defined as contributors with specialized knowledge and with a strong vocation for innovation to translate the needs of the client into innovative and functional technical solutions. Its ability to apply new and creative solutions to product design and development challenges is critical to competitiveness in a demanding market.

General Comments

Functions vary based on products, technologies, and company size. In small companies, these roles may involve drafting plans, programming numerical control machines. Depending on the organisation is some of those small company, multifunctional profile that integrates the purchase of raw materials, warehouse control, preparation of offers and dealing with the customer is also observed.

The professionals in this job position with a VET background are highly experienced workers, usually with extensive experience in production that promote to the technical office.

In own product companies, product development and process engineering are separate departments, with technical office assistants typically aligned with product development. For companies where the main activity is to develop manufacturing and automation processes, the profile is related to these activities.

4.3.24. LEVERS OF CHANGE

This job position is classified as changing. The factors contributing to the change identified are the following:

- Product customisations, modifications and evolutions (own products).
- Product’s complexity, increase of challenges for their manufacture.
- Evolution of ERP systems. Increase of IoT, M2M communication and data acquisition systems.
- Introduction of automations in the workstations.
- Inclusion of multifunctional machines, in the case of machining, involving more complex numerical control programming.
- New manufacturing lines that include advanced technologies in their design.
- Related to sustainability, robotisation of the calculation of the carbon footprint and subsequent reduction actions.

- Increase the expansion to international customers. Higher interaction with customers.
- Systemic view of the process.
- Working in multidisciplinary or interdepartmental teams.

4.3.25. SKILLS AND COMPETENCIES

The emerging technical skills mentioned in the interviews for this job are the following:

- Analysis of production data, for those technical office also in charge of production management.
- Advanced CAD design. In some cases, including (FEM) simulation of processes.
- CAM systems for those technical office in charge of production management in machining companies.
- Product Life Management (PLM) systems.
- Energy efficiency of equipment.
- Calculation and reduction of carbon footprint.
- Cybersecurity.
- Languages, mainly English and sometimes others such as French.

The transversal competencies match the general ones already mentioned, with special focus on communication skills, problem solving, including quick response to the customer.

Qualification requested for this Job

Usually, to promote this job, work experience is a mandatory request. The background may vary:

- Mechanical Manufacturing Design EQF5.
- Production Scheduling in Mechanical Manufacturing EQF.
- Double qualifications or Qualification + specialisation courses are very much valued i.e.
    - Mechanical Manufacturing Design EQF 5 + Specialisation Course in Smart Manufacturing.
- Mechanical Engineering EQF 6.
- Electronic engineering EQF 6.
- Production management engineering EQF6.

4.3.26. AUTOMATION TECHNICIAN

4.3.27. GENERAL DESCRIPTION

Numerical Tool and Process Control Programmer (ESCO 2514.4) ESCO description: "*Numerical tool and process control programmers develop computer programs to control automatic machines and equipment involved in manufacturing processes. They analyse blueprints and job orders, conduct computer simulations and trial runs"* (ESCO, n.d.).

This job position in related to the professionals that implement automations in productions lines or machinery to automate tasks and or to acquire data coming from the equipment for its later processing. They also install the IoT systems and communication networks, integrating the automation with MES and ERP systems.

The functions assigned to automation technician overlaps with maintenance operator in many of the companies interviewed whereas in others those functions are carried out by personal in technical offices. In the analysed companies, Robot programming is part of the tasks of those professionals.

Presence in Sector

The functions of automation are becoming relevant in all company interviews. However, the automation technician job position is present in only 40% of the companies interviewed, which are typically large companies with high levels of digital maturity. In the remaining companies, automation functions are integrated into other roles such as maintenance technicians or process engineering. In companies with proprietary products, automation embedded within the product is also handled by automation technicians.

According to one interviewed company, the key to the growth of this role is the cross-interrelation between processes, products, IT, and data acquisition. This job appears in companies that manufacture automotive parts, those that design automated processes, and those that integrate automation into their end-customer products.

This profile is increasingly present in factories. Sometimes it is linked to the product itself, which includes automations, and sometimes to the manufacturing process within the maintenance or process engineering function.

General Comments

In certain companies, this role is associated with maintenance, where the electrical and electronic components are becoming increasingly significant. The profile for this position is highly versatile, hence the analysis encompasses broad and general aspects.

4.3.28. LEVERS OF CHANGE

The main drivers of change for this job are the mentioned in section 4.3.1. Other aspects identified that may be very specific for concrete companies are:

- Development of specialized software for parameter setting.
- Development of intelligent systems to reduce risks and facilitate product operation.
- Incorporation of elements linked to data acquisition, communications and digitalisation.
- Automation of present manufacturing processes, at different levels such as improvements including a welding robot, inclusion of AGVs, collaborative robotics, or entire manufacturing lines.

In the near future, companies plan to continue along the same lines and focus on:

- Evolving to more automation suppliers.
- Opening up to new markets such as aeronautics.
- Increasingly complex and interconnected manufacturing systems.

4.3.29. SKILLS AND COMPETENCIES

The technical skills required for this profile are highly representative of advanced manufacturing:

- Design of automated systems.
- Integration of IoT systems and systems management in digital environments.
- Systems commissioning and start-up.
- Knowledge in sensorics and industrial communication.
- HMI, M2M communications.
- PLC programming.
- Robot programming.
- Artificial vision.
- Optimisation of processes using Artificial Intelligence.
- Data analytics.
- Assistance technologies for digital workplaces.
- Cybersecurity.

The transversal competencies match the general ones mentioned in 4.3.9 with a special focus on continuous learning for constant updating in response to technological advances and problem-solving.

Qualification requested for this Job

Usually, to promote to this job, work experience is mandatory. The background may vary:

- Production Scheduling in Mechanical Manufacturing EQF5.
- Industrial Mechatronics EQF 5.
- Automation & Industrial Robotics EQF 5.
- Double qualifications or Qualification + specialisation courses are very much valued i.e.:
    - Automation & Industrial Robotics EQF 5 + Specialisation Course in Smart Manufacturing.
    - Automation & Industrial Robotics EQF 5 + Specialisation Course in Artificial Intelligence and Big Data.
- Mechanical Engineering EQF 6.
- Electronic engineering EQF 6.
- Production management engineering EQF6.

4.3.30. QUALITY CONTROL ASSISTANT

4.3.31. GENERAL DESCRIPTION

Product Quality Controller (ESCO 7543.9): "*Product quality controllers check the quality of manufactured products. They work in manufacturing facilities where they perform basic inspection and evaluation of products before, during or after the production*" (ESCO, n.d.).

Presence in Sectors

Quality control assistant roles are prevalent in nearly all the manufacturing companies interviewed, accounting for 65%. However, these positions are not observed in companies that specialize in automation.

This position is particularly relevant in so far as it relates to product quality and hence, knowledge on the product, customer's specifications, and sectorial standards.

General Comments

Although the role is not new, new functions are emerging as a result of digitalisation. Furthermore, functions traditionally carried out by the quality control department are switched to machine or line operators. A trend to integrate the control operations in all the companies as a part of the manufacturing operations was observed. This allows the traceability of data related to critical components and operations. In such cases, where the control process is being automated, final human supervision remains necessary.

4.3.32. LEVERS OF CHANGE

The changes affecting the role were already mentioned in 4.3.1 Generic features for the digital and green transitions:

- The implementation of more complex machines integrated into the company's data systems increases the number of controllable parameters.
- Capture of manufacturing parameters and their subsequent analysis. This requires knowledge of the complete process and in the analysis to establish the cause-effect relationship.
- Increased data collection for product traceability.
- Introduction of sensors in the manufactured products to automate their operation in automatic and autonomous environments.
- Evolution of the manufactured products, digitalisation of the monitoring of the products.
- New markets, new standards, new legislations, e.g. the manufacture of prostheses.
- Implementation of automatic measurements by machine vision systems.

4.3.33. SKILLS AND COMPETENCIES

Besides the skills linked to quality control assistant, other technical competencies have been observed being company dependant:

- Digital and management competencies.
- General knowledge of lean manufacturing and 5S.
- Data analytics and business intelligence systems.
- Use of (digital) verification tools (3D scanners, artificial vision machines etc.).
- Cybersecurity.
- Languages, especially English.

The transversal competencies match the general ones mentioned in Section 4.3.9 Generic competencies and skills with a special focus on communication skills to express ideas clearly and effectively, involvement and problem solving.

When asked about the training to be reinforced in new recruits, more general aspects appear, such as the interpretation of complex drawings, digital skills for data analysis, languages, communication and some specific methodological problem solving (8D, 5Why, Isikawa).

Qualification requested for this Job

To promote to this job opportunity, work experience is compulsory. The background may vary:

- Production Scheduling in Mechanical Manufacturing EQF 5.
- Industrial Mechatronics EQF 5.
- Mechanical Engineering EQF 6.
- Electronic Engineering EQF 6.
- Production Management Engineering EQF 6.

4.3.34. ASSEMBLY OPERATOR

4.3.35. GENERAL DESCRIPTION

The assembly operator job-position addresses both assembly line staff and machine assembly staff, depending on the company.

Industrial Machinery Assembler (ESCO 8211.2) ESCO description: *Industrial machinery assemblers manufacture industrial equipment such as industrial robots, assembly line machines, and labelling machines. They use hand tools and computer-controlled machines.*

In this study, the assembly operator's role varies based on the company's organisation, encompassing mechanical assembly, component assembly, adjustment and testing, as well as 'interior, exterior, and electrical and electronic brain assembly'.

Presence in Sectors

The position is identified in 65% of the companies in the study and is valued as changing.

4.3.36. LEVERS OF CHANGE

It is observed that in companies engaged in the automation of operations and production lines, this profile has a very close relationship with the automation and maintenance profiles. Thus, the levers for assembly-automation- maintenance would be related to each other. Hereafter the levers related only to the assembly of the equipment are included. For the cases of automated equipment assembly other levers should also be considered.

- Automation of existing manufacturing processes, at different levels such as improvements including robots, inclusion of AGVs, collaborative robotics, or entire manufacturing lines.
- Digitalisation of assembly workplaces, digital assembly instructions.
- Implementation of assistance technologies, AR.
- Digitisation and monitoring of products to be assembled and programmed.
- Changes in environmental legislation (implication on recyclability).

More specific to assembly lines:

- Data collection in the assembly process.
- New assembly processes according to equipment customisation.
- Digitalisation of work environment including assistive technologies such as AGV and collaborative robots, new production lines.
- Lean manufacturing.

4.3.37. SKILLS AND COMPETENCIES

The evolving technical skills identified for the assembly operator are generic:

- Digital competencies.
- Lean manufacturing.
- Ability to operate and understand assembly and control systems.
- Identify and resolve technical obstacles either from the product or from the means of production that may arise during the manufacturing process.

For machine assembly staff:

- PLC programming, robot programming.
- Complex drawing interpretation.
- Knowledge in sensorics and industrial communication.
- HMI, M2M communications.

The transversal competencies match the general ones mentioned in, with a special focus on communication skills, autonomy, problem solving and working in a collaboratively way with other team members to ensure smooth execution of the scheduled work.

Qualification requested for this Job

- Industrial Mechatronics EQF 5
- Automation & Industrial Robotics EQF 5
- Double qualifications or Qualification + specialisation courses are very much valued i.e.
    - Automation & Industrial Robotics EQF 5 + Specialisation Course in Smart Manufacturing.

4.3.38. INDUSTRIAL ASSEMBLY SUPERVISOR - TEAM LEADER

4.3.39. GENERAL DESCRIPTION

Industrial Assembly Supervisor (ESCO 3122.3) ESCO description: **"***Industrial assembly supervisors are in charge of organizing, planning and coordinating assembly operations. They keep track of all the work activities and manage the process for efficient functioning in order to tackle problems such as production loss. They answer to the industrial production and the manufacturing manager"* (ESCO, n.d.).

According to the interviews, in addition to the assembly line manager, the role of work team's coordinator is added to those included in the ESCO definition. This entails leading the execution of strategies within an area and implementing actions for its continuous improvement.

Presence in Sectors

This job position is present in 65% of the companies. The team leader plays a key role in the efficient and cost-effective operation of the company to maintain high quality standards, meet delivery times and control production costs.

General Comments

The position is linked to the production department. The study of this position has focused on individuals with Vocational Training (EQF5) qualifications who begin their work as operators and progress to expert level. Additionally, the competencies listed in this section should be considered.

4.3.40. LEVERS OF CHANGE

It is defined as a highly evolved position. The levers of change are linked to organisational level transformations, production challenges, and the demands of planning including the use of ERP/MES systems and data collection. In addition to the mentioned in section 4.3.1 Generic features for the digital and green transitions, the following are included as the most influential:

- Increased levels of versatility.
- Increased autonomy in functions.
- Increased customisation of the products or equipment manufactured.
- Participation in the implementation of improvements and in multi-purpose teams.
- Inclusion of more complex technologies in the area.

4.3.41. SKILLS AND COMPETENCIES

The technical competencies of this profile include:

- Expert knowledge of the product and the manufacturing process.
- Highly skilled in responding to changes in technology.
- Knowledge of lean manufacturing.
- Languages, especially English.
- Cybersecurity in OT systems.

The transversal competencies match the general ones mentioned in Section 4.3.9 Generic competencies and skills, with a special focus on leadership and management skills due to the relevance of the position.

Qualification requested for this Job

Usually, to promote this job opportunity, work experience is compulsory. The background may vary:

- Production Scheduling in Mechanical Manufacturing EQF5.
- Industrial Mechatronics EQF 5.
- Automation & Industrial Robotics EQF 5.
- Double Qualifications or Qualification + specialisation courses are very much valued.
- Mechanical Engineering EQF 6.
- Electronic Engineering EQF 6.
- Production Management Engineering EQF6.

4.3.42. COLD FORGING OPERATOR

4.3.43. GENERAL DESCRIPTION

The closest definition found in the ESCO database for this job is s*tamping press operator*

Stamping Press Operator (ESCO 7223.21) ESCO description: "*Stamping press operators set up and tend stamping presses designed to form metal workpieces in their desired shape by applying pressure through the up and down movement of a bolster plate and a die attached to a stamping ram on the metal, resulting in the die producing smaller metal parts of the workpiece fed to the press"* (ESCO, n.d.).

The definition above refers to sheet metal forming technology, whereas cold forging operators work with bar or wire. This job appears only in one company interviewed but it serves as a representative for a big concentration of cold forging companies placed in the Basque Country. Cold forging press operators set up multistage high speed progressive presses to produce complex part in up to 6 strokes by metal forging at room temperature including the preparation of the tooling sets.

The main sector for these companies is automotive. The digital transition is bringing the connections of machines and implementation of data acquisitions systems, integrating the machines production data with ERP systems. Servo drive presses and/or transfers systems are also contributing to increase the complexity of forming processes.

4.3.44. LEVERS OF CHANGE

The following are the levers of change:

- Increase in the complexity of produced parts.
- Retrofitting of presses
- Data acquisitions systems integrate to high-speed progressive presses.
- Change in standards in the automotive sector as example traceability of produced components, high level of cleanliness, strict dimensional tolerances, zero errors.
- Trends toward the prognosis of tool break based on effort curves analysis by means of big data analysis.

4.3.45. SKILLS AND COMPETENCES

Cold forging press operators usually are trained in house being the work experience the key to get skilled operators.

Technical skills derived from digitalisation are listed below:

- Data management, digital literacy, HMI interactions.
- Relation between physical phenomena and digital signals.
- Traceability of components.
- Artificial vision systems for components control.
- Cybersecurity in OT systems.
- Knowledge on the full process.

The mind-set change is considered vital. Cold forging operators, in addition to producing components become responsible for the data associated with these products.

The transversal competencies match the general ones mentioned in 4.3.9 Generic competencies and skills, with a special focus of problem solving.

Qualification requested for this Job

- Production Scheduling in Mechanical Manufacturing EQF5.
- Industrial mechatronic EQF 5.
- Double qualifications or Qualification + specialisation courses are very much valued:
    - Production Scheduling in Mechanical Manufacturing EQF5 + specialisation program in cold forging.

4.3.46. OTHERS

This section focuses on job profiles mentioned by fewer companies but still considered relevant.

4.3.47. WELDER

Welder (ESCO 7212.3) ESCO description: **"***Welders operate welding equipment in order to join metal workpieces together. They can use fusion welding processes based on different techniques and materials. They also perform simple visual inspection of welds"* (ESCO, n.d.).

In companies where welders are employed in-house, their primary role involves working with large parts or structures, which includes handling loads.

Levers of Change

This job has seen minimal changes over the past five years and is currently found in 35% of companies.

It requires specialised skills, interpretation of drawing and quality assurance for each weld. Companies follow a certification procedure that allows them to ensure, together with a recognised qualification, to demonstrate technical and professional capacity.

The main lever of change is the incorporation of welding robots, foreseen in two companies.

Skills and Competencies

Among the technical competencies listed for the welder profile, there are some more specific competencies such as the integration of laser welding and others that comprise more general aspects such as:

- Adaptation to new measurement and verification systems.
- Use of digital equipment for drawing interpretation.
- Emphasis on quality and accuracy.
- Human-robot interaction.

Transversal skills encompass the development of communication abilities and active involvement.

4.3.48. TECHNICAL SALES REPRESENTATIVE

Technical Sales Representative (ESCO 2433.6) ESCO description: "*Technical sales representatives act for a business to sell its merchandise while providing technical insight for customers"* (ESCO, n.d.).

Level of Change

The drivers of change are linked to staying current with technological advancements in the market and the product customisation associated with the technification of job profiles. A

s customer service roles expand, positions typically held by vocational education and training (VET) graduates are increasingly requiring competencies akin to those of a project manager.

Levers of Change

Manufacturing new products and the inclusion of advanced technologies influences the job profile and attributes to it a strong need for knowledge to establish the reliability of equipment.

Skills and Competencies

Technical competencies related to the specific profile:

- High technical knowledge of the process about and the ability to understand and communicate technical and advanced aspects of manufacturing products or services, as well as their applications and benefits to customers.
- Customer-centric attitude, with the ability to understand the specific needs and challenges of each customer in the advanced manufacturing sector and deliver customised solutions that add value to their business.
- Focus on innovation and continuous improvement.

The competencies defined are related to transversal competencies and have an impact on analytical and problem-solving skills communication and languages.

4.3.49. INJECTION MOULDING MACHINE OPERATOR

Moulding machine technician ESCO 7233.12: "*Moulding machine technicians service machinery used in the casting and moulding of plastics and other materials. They calibrate the equipment, perform maintenance activities, examine finished products and repair faults"* (ESCO, n.d.).

In addition to the ESCO functions, mould changing, and injection moulding parameter control are also required.

Levers of Change

- Automation and integrated robotics to improve efficiency and productivity. This includes the integration of robots for part handling, automatic assembly and material loading and unloading.
- Advanced process control allowing greater control over the moulding process. This includes the ability to monitor and adjust parameters such as pressure, temperature and injection speed in real time, ensuring greater accuracy and quality of moulded parts.

Skills and Competencies

Technical competencies related to the specific profile:

- Understanding of the control systems and being able to adjust parameters to optimise the manufacturing process.

Regarding transversal competencies, emphasis is placed on adaptability. continuous learning and problem solving.

4.4. EXPERTS' VALIDATION

The findings of the report were discussed with a committee of expert in fields related to advanced manufacturing and/or VET. This section summarised the comments and suggestion given by the groups during a face-to-face workshop held on 29 April 2024 at Tknika.

Participants

- **Rikardo Lamadrid**, Basque Education Ministry, Director of Technologies and Advanced Learning.
- **Iñigo Araiztegui**, Director of Internationalisation Department, Tknika.
- **Susana Espilla**, Project Manager at the Internationalisation Department, Tknika.
- **Mikel Albizu**, Researcher at Orkestra, Basque Institute of Competitiveness.
- **Josune Irazabal** Expert on Basque VET, Manager of Digitalisation at CIFP Miguel Altuna.
- **Josu Riezu** Director of People Department. AFM, Cluster of Spanish Machine Tool Manufactures
- **Ricardo Alberdi**, representant of Ikaslan Bizkaia. Association of Basque Public VET Centres
- **Isidro Zaldua** representant of Ikaslan Gipuzkoa. Association of Basque Public VET Centres
- **Uribarri Goikuria,** Project Manager at Innobasque, Basque Innovation Agency
- **Oriol Homs,** Expert on Spanish VET, Sociologist, author of one of the reports based on Skills and Jobs (see 4.1.3)

About the Study Methodology

The analysis methodology and the sample used are considered appropriate. To add quality and representativeness to the sample, it is recommended to:

- Include leading companies with high levels of digitalisation maturity.
- Include technological companies or start-ups.
- Consider other sources of information, such as the data from the public employment and training body of the Basque Country (Lanbide).

On the other hand, the difficulty of conducting comparative analyses considering the difference in digitalisation levels among companies is reaffirmed. Consequently, analysing occupations that are highly dependent on these levels of digitalisation is complex. The same issue arises at the European level when discussing competencies and skills.

It is suggested that in the policy briefs of LCAMP, a recommendation be drafted to the European Commission regarding the need to define standards, both for skills and digitalisation

Digital and Green Transformations

The report mentions:

- The dependency on organisational factors for the competencies attributed to each position.
- The heterogeneity in the pace of transformation.

With reference to how occupations and vocational training titles are related, several comments arose:

- These factors often result in a lack of direct correlation between vocational training titles and job positions. Therefore, creating curricula that specifically match certain positions is very complex. Typically, companies hire individuals with a range of skills and versatility, and then, after internal training, they are assigned specific roles / positions according to their abilities. Additionally, there is rotation to other positions. This situation raises questions about the value of generating specific curricula for particular positions. What does appear relevant is understanding the competencies required for occupations in different types of companies and what factors influence those competencies.

With reference to the pace of digitalisation, it is noted that industries are at the beginning of the digital transformation. Companies (in general) view the digital transition as an opportunity to improve profitability and/or management. However, sustainability is perceived in many cases as a "regulatory imposition" that creates difficulties, especially when competing with companies not subject to similar regulations. This difference in perception also affects how both transformations are approached and, consequently, the competencies of individuals.

Technology Adoption

The standard digitalisation sequence identified, which consists of data capture, equipment and process monitoring, and automation, aligns with the experience of the focus group members.

Additionally, the assertion that the difference in transformation level is mainly marked by company size, the focus group confirms this finding from other studies. The relevance of proprietary products is also noted, with customers often driving innovation in these cases.

Evolution of Job Positions

The conclusions of the report on the evolution of occupations are corroborated by the focus group: traditional occupations are not disappearing, although they are being assigned functions that were traditionally assumed by other profiles. Versatility is established as a very important attribute in all occupations.

The changes undergone by the analysed job positions in the sample companies, maintenance technicians and Technical Assistance Service (SAT) technicians have been the most impacted. The focus group participants viewed these comments positively.

The report highlights the limited use of technologies such as artificial intelligence (AI), virtual and augmented reality (VR/AR), digital twins, 3D printing, and robotics in the positions analysed.. Several comments have emerged in response to this assertion:

- Technologies like AI, VR, DT, etc., may be present in newly established technological companies that require such profiles.

- A possible reason for companies not recognising the need for new profiles in AI, VR, DT, etc., could mean that these functions are outsourced.
- It is possible that some of the more technologically advanced functions (such as AI, digital twins, and data analytics) are performed by roles not covered in this study, such as those in Engineering or R&D departments.

The group of experts confirms the existence of high-level technology service providers in AI, DT, VR, data analytics, etc., who work for advanced manufacturing companies and indeed require qualified individuals. It seems reasonable to think that as manufacturing companies internalise these types of functions, the need for such competencies will increase.

Competences

Interesting comments emerged as follows:

- The process of professionalisation is changing, and the relationship between competencies acquired in VET centres and in companies is also evolving. Specialisation occurs within the company, while a strong technological foundation is expected from VET centres.
- The balance between basic competencies and specialisations is key. There is a debate about what should be taught in the basic part, to what extent centres specialise, and how professionalisation is structured throughout life, whether within the company or in collaboration with training centres.
- Specialisations can also have levels, for example, basic specialisation in AI, advanced specialisation in AI, etc.
- Standardising curricula is mentioned as an obstacle since in a transition where each company progresses at its own pace. However, non-standardisation is very complex. Standardisation to a certain extent with flexibility to adapt to different realities is an option worth exploring.

Regarding how VET centres are perceived as Providers of Specialised Profiles

Companies are demanding high levels of specialisation for their processes, but often do not see VET centres as providers of such specialisations. This is a gap in vocational training: VET centres offer specialisation courses, but companies still do not identify those specialised profiles with vocational training. VET students do not (yet) cover such profiles, often due to unawareness of the capabilities of these students. There is work to be done by the vice-Ministry, the centres, and the companies in this regard.

Furthermore, the report notes discrepancies in terminology between companies and educational institutions, and even among educational systems in different countries. Consequently, accurately defining competencies does not fully address the issue of perception discrepancies. There is a misunderstanding about the actual capabilities associated with specific qualifications. For instance, some companies may over-qualify positions by selecting engineers for roles intended for vocational education and training (VET) graduates.

4.4.1. Report Relevance

VET- Ministry, Policy Makers

This study enhances our understanding of professional profiles and their development over time. It is crucial to delve deeper into the reasons behind the phenomena discussed here, such as the perception of specialisations within certain companies. Additionally, organising forums to discuss these reports—segmented by regions, sectors, and stakeholders—could prove valuable. Such discussions can help draw conclusions and support decision-making in areas like curriculum development and more.

Vocational Training Centres

- The findings ground our understanding of realities beyond our immediate surroundings, aiding in decision-making and verifying the accuracy of information from various sources.
- Engaging in critical analysis and sharing insights in forums can help compare findings across numerous reports, enriching our collective knowledge.
- The report provides educators with a clearer picture of company situations, enhancing the relevance of their teaching.
- It assesses whether current strategies align with actual needs and if adaptations made to courses are effective.

This report is invaluable for sparking discussions among educational centres, businesses, social organisations, and institutions. It fosters reflection and development on necessary changes within the vocational training system.

Additional Considerations

The study mentions that, in the sample studied, the main driver for companies' digitalisation is increased competitiveness, ahead of employee well-being. In response to this assertion, it is noted that regional studies underline the central role of people in business development. Therefore, this could be a point of reflection.

The study shows a context where a cultural and organisational change is required ahead of purely technological change.

Another suggestion is to include the opinions of social agents and unions in these types of studies. Some companies or groups of companies' may choose to lobby to prioritise curricula related to their particular activities. However, there is a growing need for more versatile profiles in vocational training.

A key aspect would be to give VET centres greater autonomy to adapt the curriculum according to their regional context, as allowed by law. This type of measure would allow for the creation of non-standardised specialisation courses, tailored to the demands of companies with well-contrasted quality criteria (timing, format, etc.), with more flexible contents.

Finally, there is a broad consensus that discussions involving groups of experts, like the current one, are highly valuable for addressing important issues related to vocational training and its stakeholders.

Jobs analysed related to VET Titles

Following a comment from one of the participants, the table below outlines the relationship between the jobs featured in the report and the most commonly requested vocational education and training (VET) qualifications for these positions.

Note: The table does not account for specialised courses, as defining such relationships requires a more detailed description of job functions. This aspect remains open for future analysis.

Table 10 : Analysed jobs and related VET titles

Used nomenclature:
1= First choice
2= Second choice
3= work experience compulsory
*= preferably with specialisation programs

	VET Titles / JOBS	EQF 5 Production Scheduling in Mechanical Manufacturing	EQF 5 Industrial Mechatronics	EQF 5 Automation & Industrial Robotics	EQF 5 Design in Mechanical Manufacturing	EQF 5 Metallic constructions	EQF 4 Machining technician	EQF 4 Electro mechanical maintenance	EQF 4 Welding
1	CNC technician (Operator + programmer)	1	2		2		1		
2	Maintenance Operator (electrical, mechanical and others)	2	1	1				1	
3	After Sales Service technician-TAS operator (electrical, mechanical and other)	1 + 3	1 + 3	1 + 3	2 + 3				
4	Technical Office assistant (mechanical, electrical, product development and other)	2	2	2	1				
5	Automation technician & Robotics	2	1	1	2				
6	Quality Control assistant	1	1	2	1				
7	Assembly operator	1	1	2	2		1	1	
8	Industrial Assembly Supervisor	1	1	1	2				
9	Cold forging operator	1*	2*		1*				
10	Welder					1			1
11	Technical Sales representative	1 + 3	1 + 3	1 + 3	1 + 3				
12	Moulding machine technician	1			1				

Figure 9 : Workshop with the Basque validation groups with representatives of industry, education and government.

4.5. BASQUE COUNTRY CONCLUSIONS

This study examines the progression of advanced manufacturing employment within the Basque country, spurred by digital transformation. Data pertaining to the evolution of 12 job categories across 15 companies have been compiled. Augmenting this primary research endeavour are findings from other organisations' studies conducted within advanced manufacturing enterprises between 2019 and 2023. Notably, insights gleaned from reports by AFM (surveying 19 companies in 2022), CEX-FA (interviewing 8 companies in 2023), and Innobasque (surveying 19 companies in 2019) have significantly contributed to this paper, with data from a cumulative 57 companies being integrated.

The results of LCAMP's study closely align with those of the analysed reports, occasionally offering supplementary insights, duly acknowledged. The analysis underscores the transformative impact of digitalisation and sustainability initiatives on job roles within companies. The study corroborates the findings of the other analysed reports. Consequently, conclusions are drawn, regarding the nature of this transformation.

Transformation of Jobs

The evolution of jobs is intricately tied to the industrial context, influenced by various factors such as company size, digital maturity, production types, business strategies, organisational culture, regulations, and more. This aligns with the notion that "organisational factors exert the greatest influence on workforce skill development" (Homs, 2023). Indeed, the analysis reveals that the evolution of certain jobs can vary significantly depending on the company. The pace of digitalisation distinctly shapes the extent of job transformation.

Primarily, digital transformation aims to enhance company performance, with less emphasis placed on the well-being of individuals as the primary driver of change. However, it's widely acknowledged that the involvement of people is crucial in implementing these changes.

The impact of transformation extends across all job categories examined in this report, albeit with varying degrees of significance. Only in rare instances, substantial shifts are found, where the very nature of tasks linked to a job undergoes complete transformation. Generally, digitalisation reshapes job structures or specific tasks within them, consequently influencing staff functions in alignment with CEX-FA and AFM. Moreover, this evolution introduces new responsibilities to workers who previously did not encounter them. All companies agree that the workers should be versatile, with a flexible mentality to change, with an interest in learning, ability to communicate effectively and solve problems.

Not many new jobs have been identified, and those mentioned are those related to data analytics in large companies. The jobs that have undergone major changes are maintenance (in some cases), TAS and automation (in some cases).

Drivers for Transformations

Generally, the primary goal of digital transformation is to enhance company performance. While the well-being of individuals is seldom cited as a main driver of change, the critical importance of people in implementing these changes is universally acknowledged. As companies recognize the essential role of their workforce in the success of digital transformations, new organisational models are emerging. However, there are few mechanisms in place to empower the workforce and enhance their involvement in these processes.

Organisational Changes

Organisational changes are expected as a result of digitalisation, to provide more autonomy to all the levels within the company. Data-driven management is being strongly promoted. New working methods and organisational models are taking place.

The companies interviewed, encouraged by digitalisation, demonstrate a trend towards market adaptation and the customisation of products and services to enhance competitiveness. In some cases, they notably include emerging markets with reference to renewable energies and, to a lesser extent, to health. These trends coincide with AFM's assertions.

Technologies

Data collection and system integration are the basis for change in jobs. The most widespread technologies are related to machine and process monitoring, integration of MES and ERP systems. As well as access to data associated with inspection and measurement systems, i.e. the incorporation of systems aimed at monitoring and traceability of the entire value chain of the product. The integration of these systems is accelerated by the introduction of multifunctional machines, retrofitting of existing machines and automation of production lines.

There is also a growing demand for process data collection and for making it available to customers both on the product being manufactured and after the product has been delivered to the customer. These assertions are aligned with the technologies identified as priorities by companies in the Basque Country, according to Innobasque (Innobasque, 2019).

Interviewed companies, regardless of their size, mention ongoing projects using language that encompasses intelligent systems, manufacturing process automation, digitalisation, data collection, IoT systems, and, looking ahead, they delve into the realm of AI and augmented reality (although the latter is less prevalent currently). These trends align with the findings of the report "Identification of training needs for the preparation of job profiles in the automated manufacturing sector" (Homs, 2023).

Remarkably, companies with proprietary products encompass a broader scope of Industry 4.0 technologies. Digital transformation is not only applied to their production processes but is accentuated by endowing their products with digital features / functions and by offering digital services related to their operations. Endowing products and services with such characteristics demand a substantial technological leap for these companies, consequently requiring an enhancement in the competencies of individuals. Functionalities associated with IoT systems, communications, and data use provide opportunities to monitor product operations and enhance preventive maintenance. Some companies are evaluating the use of augmented reality and virtual systems to facilitate remote learning and work.

Artificial intelligence, 3D printing, digital twins and the use of robots deserve special mention: Although AI remains a topic of discussion, it has yet to be fully integrated into the companies under study, although short-term implementation plans for AI have been observed. 3D printing is recognized as a task associated with other roles within the companies. Regarding the use of robots, despite the automation trend detected within the analysed companies, there is less emphasis on incorporating robots directly. The interviewed companies have not yet adopted digital twins. The level of adoption of these technologies reflects a similar pattern to the data provided by Eustat (EUSTAT, 2023).

Sustainability

Climate emergency measures are more prevalent in large companies, including actions such as automating the calculation of carbon footprints, improving the energy efficiency of manufacturing equipment and buildings, and eliminating certain greenhouse gases. It is noted that this process is in its early stages and that there is still a long way to go.

Competences

Companies seek highly specialised profiles tailored to their manufacturing processes. This specialisation is developed through in-house training and work experience, built upon the foundational knowledge acquired by individuals from VET schools. Thus, VET profiles are expected to possess a solid understanding of the fundamentals, along with proficiency in IT / digital skills and languages, complemented by strong transversal skills. Among these, the most frequently mentioned include problem-solving abilities, analytical thinking, a proactive learning attitude, effective communication, and a strong sense of engagement.

As observed in the study, VET industrial programs are the main source for the analysed jobs, notably leading to higher-level degree programs (EQF5) such as mechanical manufacturing, mechatronics, industrial automation and robotics, and manufacturing design. Versatility is a highly valued attribute that emerges frequently in many interviews. In terms of versatility, individuals with dual qualifications, such as mechanical manufacturing coupled with automation and robotics, are regarded favourably. Specialisation courses within VET have also received positive evaluations in the instances.

Training programs within the company are widespread among the interviewed firms. Typically, these initiatives are focused on addressing immediate production requirements, signifying a gradual progression rather than a disruptive change. With regard to the training content, while companies appreciate both personal and technical competencies, they give precedence to technical skill development. Companies aim for individuals to possess personal skills inherently, considering them as foundational.

Dual training and internships, developed in collaboration with VET centres, are highly regarded as valuable resources. On the one hand, companies provide students with hands-on training tailored to their specific processes, complement official learning programs. On the other hand, this approach enables companies to attract and retain talent while also assessing students' suitability for future roles.

Dual and in-Company Training

In terms of hiring, companies have difficulty attracting talent. It should be noted that in some companies interviewed, due to the shortage of personnel, automation is conceived not only as a means to increase performance but also to reduce the need for personnel.

Regarding the aging population, its impact is particularly negative for small businesses, as younger individuals tend to seek out more technologically advanced environments and more comfortable working conditions.

The gender gap persists as a significant issue. Among the companies interviewed, 73% provided data regarding their workforce segregated by gender. Women constitute 27% of the total number of VET graduates among their staff.

4.6. REFERENCES

ACICAE. (2024, 03 01). The Basque Automotive Sector. Retrieved 2024, from Acicae.es: https://www.acicae.es/en/the-basque-automotive-sector/#:~:text=The%20automotive%20sector%20is%20feeling,changes%20in%20its%20business%20model

AFM. (2022). El futuro del trabajo en fabricación avanzada. Nuevos retos, roles y competencias. Donostia. Retrieved from https://www.afm.es/es/descargas

Capgemini Invent; European Digital SME Alliance; Executive Agency for Small and Medium-sized Enterprises (European Commission). (2020). Skills for SMEs – Cybersecurity, Internet of things and big data for small and medium-sized enterprises. Publications Office,. doi: https://data.europa.eu/doi/10.2826/708138

Catena-X Automotive Network e.V. (n.d.). Open data ecosystem for the automotive industry designed to create data chains that will enhance your value chain. Retrieved 03 03, 2024, from Catena-X: https://catena-x.net/en/

Cecimo. (2023). Transformation of Manufacturing: Embracing Digital and Green Skills. Retrieved 02 02, 2024, from https://www.cecimo.eu/wp-content/uploads/2023/07/Final-Skills-Paper-1.pdf

Cecimo. (2024). From survey to strategy. Understanding Skills Trends in Advanced Manufacturing. Retrieved 03 22, 2024, from https://www.cecimo.eu/publications/from-survey-to-strategy-understanding-skills-trends-in-advanced-manufacturing/

Confebask. (2022). Necesidades de empleo y cualificaciones de las empresas vascas 2022. Retrieved from https://www.confebask.eus/sites/default/files/2022-05/Necesidades%20Empleo%20y%20Cualificaciones%202022_0.pdf

Dervojeda, K. K. (2019). Skills for industry curriculum guidelines 4.0 – Future-proof education and training for manufacturing in Europe,. European Commission, Executive Agency for Small and Medium-sized Enterprises,. European Commission Publications Office. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/75478035-56b9-11ea-aece-01aa75ed71a1/language-en

European Commission. (n.d.). Digital Skills and Jobs Platform. Retrieved from https://digital-skills-jobs.europa.eu/en/about/digital-skills-and-jobs-platform

EUSTAT. (2023, 12 1). EUSTAT.eus. Retrieved 01 12, 2024, from Euskal Estatitiska Erakundea-Instituto Vasco de Estadística: https://en.eustat.eus/elementos/ele0020000/ti_indicadores-de-la-industria-40-en-los-establecimientos-industriales-de-la-ca-de-euskadi-segun-estrato-de-empleo--sobre-establecimientos-2022-/tbl0020003_i.html

Homs, O. (2023). Detección de necesidades de formación de perfiles del sector de fabricación automatizada. Report for the Spanish Network of Centres of VET Excellence on Automated Manufacturing, Ministerio de Educación, Formación Profesional y Deportes., Madrid, Spain.

Innobasque. (2019). Tecnologías y competencias profesionales 4.0-Análisis de la demanda empresarial. Retrieved from https://www.innobasque.eus/publicaciones/tecnologias-y-competencias-profesionales-4-0-analisis-de-la-demanda-empresarial/

JOIND. (2024, 03 01). Plataforma de empleo para la industria. Retrieved from https://joind.es/

MIGUEL ALTUNA LHII. (2024, 03 01). www.maltuna.eus. Retrieved from https://www.maltuna.eus/en/services/students-and-ex-student/job-listing/

OECD. (2023). Skills Outlook 2023: Skills for a Resilient Green and Digital Transition,. Paris: ECD Publishing. doi: https://doi.org/10.1787/27452f29-en

Oeij., P., Rhijn, G. v., Wietse van Dijt, F. K., Dickinson, P., Chris Warhust, Johnsen, H. C., . . . Rhomberg, W. (2023). Conceptual framework of Industry 5.0 to study workforce skills (BRIDGES 5.0 deliverable D1.1. Leiden: BRIDGES 5.0. Retrieved from https://bridges5-0.eu/wp-content/uploads/2023/12/BRI_WP1_-D1-1-Framework-report-Industry-5.0-and-skills_2023.pdf

Orkestra. (2024). Basque Country Competitiveness report 2023. doi: https://doi.org/10.18543/YJLS9838

Pedersen, B., Probst, L., Wenger, J., & Cracan, R. (2019). Skills for industry – Skills for smart industrial specialisation and digital transformation. European Commission, Executive Agency for Small and Medium-sized Enterprises. European Commission, Executive Agency for Small and Medium-sized Enterprises, Publications Office. Retrieved from https://data.europa.eu/doi/10.2826/69861

WOF. (2023). Future of Jobs Report. World Economic Forum. Retrieved from https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - F French sub-report

Co-funded by
the European Union

5. FRANCE: JOB'S IMPACT ANALYSIS

This section deals with the analysis of the selected 6 jobs. As mentioned in the Methodology of the D3.2 M24 Observatory Report (section 3), an analysis of the changes faced by companies is carried out to identify the **levers of those changes** affecting the specific jobs; then, the **changes in skills and knowledges** detected in the analysis, are described.

5.1. LIST OF SELECTED JOBS

Going through the 5 main criteria to evaluate (seen on above 3.1.1 Fields, Areas of observation), here is after the short list of jobs to be analysed in France:

Table 11 : List of jobs selected

ESCO CODE	ESCO OCCUPATION	1 - INDUSTRY SECTORS	2 - DIGITAL AND GREEN TRANSITIONS NEW TRENDS IMPACTING	3 - EMPLOYABILITY	4.RELEVANCE FOR THE SMART SPECIALISATION STRATEGY – AT REGIONAL/COUNTRY?	5 - EDUCATION LEVEL.
3139.2	Industrial Robot Controller	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-1 Virtual and Augmented Reality, 3-1 Cybersecurity, 4-1 3D Printing / Additive Manufacturing, 4-4 Digital Twins, 4-6 Predictive Maintenance, 5-12 Corporate Social Responsibility (CSR) Initiatives	November 2023 - France: Robotics technician: 3090 job offers https://candidat.pole-emploi.fr/offres/recherche?motsCles=technicien+robotique&offresPartenaires=true&range=0-19&rayon=10&tri=0	10 regions among the 21 FR regions consider this generic job among the priorities: FR10; FRC2; FRD1; FRF3; FRG0; FRH0; FRJ2; FRK1; FRK2; FRL0	EQF6
7543.9	Product Quality Controller	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D Scanning, 3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-2 Robotics and Automation	Novembre 2023 - France: QA engineer: 1639 job offers https://candidat.pole-emploi.fr/offres/recherche?motsCles=ing%C3%A9nieur+testeur&offresPartenaires=true&range=0-19&rayon=10&tri=0	12 regions among the 21 FR regions consider this generic job among the priorities: FRD1 ; FRE1 ; FRF2 ; FRF3 ; FRG0 ; FRH0 ; FRI3 ; FRJ1 ; FRJ2 ; FRK1 ; FRK2 ; FRL0	EQF 6

3118.1	3D Printing Technician	Maritime, Electric, and electronic Industries, Aerospace, Automotive, Transport	3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-4 Digital Twins, 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-4 Waste Reduction, 5-6 Sustainable Material Innovation	In 2022, more than 900 job offers for 3D printing roles were published across the French, English, Spanish, Italian, and German sites of 3Dnatives. This number represents more than double the offers published in the previous year.	10 regions among the 21 FR regions consider this generic job among the priorities: FRC2; FRE1; FRF1; FRF2; FRF3; FRG0; FRH0; FRI2; FRJ2; FRK1	EQF 5
2152.1.13	Predictive Maintenance Expert	Machine tools (Mechanical Engineering), Automotive, Aerospace, Transport, Electric and electronic Industries, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D scanning, 3-1 Cybersecurity, 5-2 Circular Economy		13 regions among the 21 FR regions consider this generic job among the priorities: FRC2; FRD1; FRD2; FRE1; FRE2; FRF1; FRF3; FRG0; FRH0; FRJ2; FRK1; FRK2; FRL0	EQF 6
2163.1	Industrial Designer	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-1 Virtual and Augmented Reality, 2-2 3D scanning, 3-1 Cybersecurity, 4-1 3D Printing / Additive Manufacturing, 4-6 Predictive Maintenance, 5-2 Circular Economy, 5-4 Waste Reduction, 5-6 Sustainable Material Innovation	November 2023 - France: 17852 job offers - Product designer: 712 offers (4%) https://www.glassdoor.fr/Emploi/france-product-designer-emplois-SRCH_IL.0,6_IN86_KO7,23.htm	18 regions among the 21 FR regions consider this generic job among the priorities: FR10; FRC2; FRD1; FRD2; FRE1; FRE2; FRF1; FRF2; FRF3; FRG0; FRH0; FRI2; FRI3; FRJ1; FRJ2; FRK1; FRK2; FRL0	EQF 6
3114.1.10	Sensor Engineering Technician	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 4-1 3D Printing / Additive Manufacturing, 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-10 Sustainable IT Infrastructure, 5-11 Environmental Monitoring and Reporting		18 regions among the 21 FR regions consider this generic job among the priorities:	EQF 5

5.2. INDUSTRIAL ROBOT CONTROLLER

5.2.1. JOB DESCRIPTION AND SCOPE

Job Description

Industrial Robot Controller (ESCO 3139.2) ESCO description: *"Industrial robot controllers operate and monitor industrial robots used in automation processes to perform various manufacturing activities such as lifting, welding and assembling. They ensure that the machines are working correctly and in sync with other industrial robots, maintain and repair defective parts, assess risks and perform tests".* (ESCO, n.d.).

Business Area

This job typically falls within the broader field of automation and robotics engineering. Professionals in this role are responsible for programming, operating, and maintaining industrial robots which are used in a variety of manufacturing and production processes. Here are some of the key industries within scope that employ industrial robot controllers (Bill, n.d.).

- **Automotive Manufacturing:** This industry is one of the largest employers of industrial robot controllers. Robots are used extensively in assembling cars, welding, painting, and handling materials.
- **Electronics and Semiconductors:** Industrial robots are employed for assembling electronic devices, from smartphones to computers and televisions. They are used for tasks that require high precision, such as placing tiny components on circuit boards.
- **Aerospace:** The aerospace industry uses robots for assembling parts of aircraft and spacecraft. This includes drilling, riveting, and welding tasks, all of which require high levels of precision and reliability.
- **Metals and Machinery Manufacturing:** Robots are used in the metal industry for welding, cutting, bending, and assembling metal parts. They are also involved in machinery manufacturing, helping to construct complex machines.
- **Logistics and Warehousing:** Although not manufacturing, this sector increasingly employs robots for picking, packing, and goods. Controllers are needed to manage these robotic systems.

Industrial robot controllers are essential in these industries, ensuring that robots operate efficiently, safely, and effectively. Their work involves programming robots to perform specific tasks, troubleshooting any issues that arise, and performing maintenance to keep robots in optimal condition. As technology advances, the demand for skilled robot controllers is likely to increase across these and other industries (https://www.bls.gov/). (U.S. Bureau of Labor Statistics, 2024)

5.2.2. CONTEXT AND LIMITATIONS

Insights from the Global and European industrial robotics markets can provide useful context to understand the potential demand of industrial robot controllers in France.

The global industrial robotics market is experiencing significant growth, driven by technological advancements and the integration of AI and the Internet of Things (IoT) into robotics. These advancements are enhancing the capabilities of robots, including Selective Compliance Assembly Robot Arm (SCARA) and collaborative robots "cobots", making them more adaptable, efficient, and suitable for a wider range of applications. The increasing adoption of robotics in manufacturing and production processes indicates a growing demand for professionals skilled in controlling and maintaining these systems, including industrial robot controllers.

Furthermore, the robotics market is witnessing a surge in the development and application of collaborative robots designed to work alongside humans. This trend is particularly notable in small and medium-sized enterprises (SMEs) due to cobots' cost-effectiveness and flexibility. The push towards Industry 5.0, which aims to harmonise human creativity and craftsmanship with robotic efficiency, underscores the importance of advanced safety features and human-robot interaction enhancements.

While specific data on France's demand for industrial robot controllers was not directly available, the European robotics market's overall growth trajectory suggests that France, as a significant industrial player in Europe, is likely experiencing similar trends. The robotics industry's expansion in Europe, coupled with initiatives to promote automation and digital transformation within the industrial sector, implies a positive outlook for job opportunities in robotics control and maintenance.

Given the global push towards automation and the strategic importance of robotics in manufacturing and other sectors, professionals with skills in programming, operating, and maintaining industrial robots are likely to find increasing opportunities in France as well. The emphasis on safety, efficiency, and the integration of new technologies into robotics points to a need for skilled controllers to manage these complex systems effectively.

5.2.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 12 : Tasks and skills impacted related to Industrial robot controller occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Operate and Monitor Industrial Robots	**2-1 Virtual and Augmented Reality**	Improve operation efficiency by using VR and AR technology for real-time guidance.	**Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety.** **Augmented Reality**	+	**Skill**	L3	**http://data.europa.eu/esco/skill/abdc7ac8-151f-40c6-bc1a-1e9b4b073290**	The process of adding diverse digital content (such as images, 3D objects, etc.) on surfaces that exist in the real world. The user can interact in real-time with the technology by using devices such as mobile phones.
			Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety. **Virtual Reality**				**http://data.europa.eu/esco/skill/5da42cfd-1da8-4e4f-b68e-4f821d005fc5**	The process of simulating real-life experiences in a completely immersive digital environment. The user interacts with the virtual reality system via devices such as specifically designed headsets.
	3-1 Cybersecurity	Ensuring secure operations of interconnected robotic systems. Protecting sensitive industrial data and robot control systems from cyber threats.	**Skills in cybersecurity**		**Knowledge**		**http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44**	The methods that protect ICT systems, networks, computers, devices, services, digital information, and people against illegal or unauthorised use.
	4-4 Digital Twins	Using digital twins for simulation, testing, and optimisation of robotic systems.	**Use of digital twins for optimisation**		**Skill**		**FR01**	Use of digital twins for monitoring optimisation

Optimize industrial robot processes	**4-1 3D Printing/Additive Manufacturing**	Create custom tools and jigs for industrial robots, Produce lightweight and durable tooling for precision manufacturing	**Be aware about 3D printing abilities to propose efficient and flexible solutions in day-to-day Robots usage.**		**Knowledge**		**http://data.europa.eu/esco/skill/2afb2b59-c9a3-4cf3-b1dd-1a2fad51e583**	The process of reproducing 3D objects by using 3D printing technologies.
	5-X All Green Transition Trends / Sustainable Manufacturing	Sustainable manufacturing practices that reduce environmental impact.	**Knowledge of sustainable manufacturing principles, energy efficiency techniques and standards, and their impact on industrial robot processes.**		**Skill**	L4	**FR02**	Ability to optimize industrial robot processes in line with sustainable manufacturing principles, reducing environmental impact and improving resource efficiency.
Participate in robotics strategies development	**5-12 Corporate Social Responsibility (CSR) Initiatives**	Aligning the integration of robots with key CSR objectives, including ensuring that robotic operations meet high safety and quality standards to protect both employees and the public. This involves rigorous testing and compliance with current regulations and standards.	**CSR initiative participation, Ethical operation understanding**		**Knowledge**	L2	**http://data.europa.eu/esco/skill/66db424f-2abe-420d-8e5b-186607266b61**	The handling or managing of business processes in a responsible and ethical manner considering the economic responsibility towards shareholders as equally important as the responsibility towards environmental and social stakeholders.
	5-X All Green Transition Trends / Sustainable Manufacturing	Incorporate Green Transition Trends / Sustainable Manufacturing practices.	**knowledge of Green Transition Trends / Sustainable manufacturing principles**				**FR03**	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries
		Increase efficiency of communication and collaboration with Engineering, Technical, and Stakeholder Teams to integrate Digital and Green Transition Trends in efficient and sustainable Manufacturing practices.	**collaborate with all stakeholders' teams**		**Skill**	L3	**http://data.europa.eu/esco/skill/d52382fe-f236-421f-95fe-34fe69d48dbd (à modifier)**	Communicate and collaborate with all stakeholder teams to improve manufacturing processes

Troubleshoot and maintain industrial robots	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Enhance predictive maintenance capabilities: increase data collection from connected robots - Real-time monitor of robot performance and health.	**Knowledge of IoT device communication.**		**Knowledge**	L4	**http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51**	The general principles, categories, requirements, limitations, and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
			Knowledge of sensors technology.				**http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b**	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Use advanced analytics and AI tools for predictive maintenance and fault detection.	**Programming skills - AI concepts**			L3	**http://data.europa.eu/esco/skill/e465a154-93f7-4973-9ce1-31659fe16dd2**	The artificial intelligence theories, applied principles, architectures, and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies, and cognition theories.
			Programming skills - machine learning concepts				**http://data.europa.eu/esco/skill/3a2d5b45-56e4-4f5a-a55a-4a4a65afdc43**	The principles, methods and algorithms of machine learning, a subfield of artificial intelligence. Common machine learning models such as supervised or unsupervised models, semi- supervised models and reinforcement learning models.
			Technical skills - analyse big data			L4	**http://data.europa.eu/esco/skill/47a49cd6-097d-457a-9f7b-c290c14930d5**	Collect and evaluate numerical data in large quantities, especially for the purpose of identifying patterns between the data.
	4-6 Predictive Maintenance	Use predictive analytics for timely maintenance and reducing downtime.	**Understand predictive maintenance principles, data analysis, and their application in industrial automation.**				**http://data.europa.eu/esco/skill/7d913551-e17a-40ba-baf7-48d0c3b12e50**	The use of data analytics and mathematical calculation to manage and monitor the conditions of machines and production processes.
Learn and simulate maintenance procedures	**2-1 Virtual and Augmented Reality**	Improve training and maintenance simulation by using VR and AR technology.	**Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety.**		**Skill**		**FR04**	

5.2.4. IMPACTS ON SKILLS

Here after the description of new skills identified, following ESCO format “ESCO template for new Skill description”

Table 13 : Industrial robot controller’s impact on skills

SKILL REFERENCE (LOCAL CODIFICATION)	CONCEPT NAME	DESCRIPTION	ALTERNATIVE LABELS/ SYNONYMS	SKILL TYPE	SKILLS REUSABILITY LEVEL	ESSENTIAL SKILL OF	OPTIONAL SKILL OF	HIERARCHY
FR01	Digital Twin Monitoring Optimisation	Use of digital twins for monitoring optimisation	Twin Monitoring Improvement Digital Replica Optimisation	S	Cross-sectoral	Industrial Engineers Manufacturing Engineers Process Engineers Automation Engineers Data Analysts/Scientists in Manufacturing	Operations Managers Production Supervisors Quality Control Inspectors Logistics Coordinators Maintenance Technicians	
FR02	Sustainable Industrial Robot Process Optimisation	Ability to optimize industrial robot processes in line with sustainable manufacturing principles, reducing environmental impact and improving resource efficiency.	Sustainable Robotics Improvement Green Process Optimisation	S	Sector specific	Robotics Engineers Manufacturing Engineers Process Engineers Industrial Engineers Sustainability Engineers	Safety Coordinators Manufacturing Technicians	
FR03	Renewable Energy Automation Integration	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries	Renewable Energy Integration Green Automation Incorporation	S	Sector specific	Renewable Energy Engineers Automation Engineers Electrical Engineers specializing in renewable energy systems Control Systems Engineers Energy Systems Analysts Sustainability Managers	Renewable Energy Project Managers Energy Consultants	

FR04	VR/AR Robot technologie**s**	Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety.	Virtual / Augmented Reality Robotics Immersive Robotics	S	Cross-sectoral	Robotics Engineers Virtual Reality (VR) Engineers Augmented Reality (AR) Engineers Software Developers specializing in VR/AR Robotics Programmers Simulation Engineers Human-Computer Interaction (HCI) Specialists	Graphic Designers	

5.3. PRODUCT QUALITY CONTROLLER

5.3.1. JOB DESCRIPTION AND SCOPE

Job Description

Product Quality Controller (https://www.aia-aerospace.org/) (ESCO 7543.9): "*Product quality controllers check the quality of manufactured products. They work in manufacturing facilities where they perform basic inspection and evaluation of products before, during or after the production process"* (ESCO, n.d.). They track production problems and send inferior or malfunctioning items back for repair (Aerospace Industries Association, 2023).

Business Area

The role of Product Quality Controller is critical across various industries where maintaining high standards of product quality is essential. These professionals are responsible for inspecting and testing products to ensure they meet established quality standards, regulatory compliance, and customer satisfaction. Here are some of the key industries (https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview) within scope that employ Product Quality Controllers (Aerospace Industries Association, 2023):

- **Manufacturing:** This is one of the largest sectors employing Product Quality Controllers. They work in different manufacturing industries, including automotive, electronics, consumer goods, textiles, and machinery, ensuring products are manufactured to specifications and quality standards.
- **Aerospace and Defence:** Given the critical nature of products in the aerospace and defence industry, Product Quality Controllers ensure that components, systems, and final products meet strict quality and safety standards.
- **Construction Materials:** In the construction industry, Product Quality Controllers ensure that materials like cement, steel, and glass meet required quality standards and specifications for safety and durability.
- **Technology and Electronics:** Product Quality Controllers in the technology sector work with electronic devices, software, and hardware products to ensure they meet quality standards, functionality, and user experience requirements.

Across these industries, Product Quality Controllers use a variety of tests and inspection methods to ensure products meet quality standards, including visual inspections, performance tests, durability tests, and regulatory compliance checks. Their work is essential for protecting consumers, maintaining brand reputation, and ensuring the long-term success of products in the market.

5.3.2. CONTEXT AND LIMITATIONS

The general trends and importance of quality control and assurance roles across various industries provide useful insights. Quality controllers ensure products meet specifications and quality standards, a critical function in manufacturing and production processes. Their roles encompass monitoring manufacturing processes, ensuring compliance with standards, maintaining quality documentation, evaluating and maintaining quality management systems, and more.

The skillset for quality control roles has evolved, with an increased emphasis on technical skills, problem-solving, and familiarity with industry standards like ISO and IEC deliverables. Demonstrating precision, consistency, analytical skills, and a practical approach to problem-solving is essential. These trends suggest a growing need for skilled professionals in quality control and assurance, reflecting the broader demand for roles that support operational excellence and product integrity.

Related skills and roles of “Product Quality Controller” in industrial sectors indicate the importance of quality control functions. These sectors are significant employers of quality control expertise to maintain product standards and compliance. Thus, individuals with experience in quality control and a deep understanding of industry-specific regulations are likely to find opportunities in France's diverse industrial landscape.

5.3.3. FROM CURRENT SITUATION TO ONGOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 14 : Tasks and skills impacted related to Product Quality Controller occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Analyze product performance data from sensors	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Integration of sensors into products for real-time performance monitoring and quality control, providing insights beyond traditional inspections.	**Understand sensor data, data analysis techniques, and quality control principles in industrial contexts.**	+	**Skill**	L4	**FR13**	Ability to analyze industrial sensor data related to product performance and identify quality issues.
Perform destructive and non-destructive testing	**4-2 Robotics and Automation**	Automation of repetitive, hazardous, or high-volume testing procedures using robots, improving efficiency and consistency.	**Understand robotic systems, industrial testing procedures, and quality control standards.**				**FR14**	Ability to operate and utilize robotic systems for industrial product testing and quality control.
Maintain accurate and complete quality control records	**3-1 Cybersecurity**	Implementation of robust cybersecurity measures to protect sensitive quality control data, including production information and intellectual property.	**Cybersecurity principles - Vulnerability assessment and penetration testing skills - Network security protocols, standards, and best practices**		**Knowledge**	L3	**http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44**	The methods that protect ICT systems, networks, computers, devices, services, digital information, and people against illegal or unauthorised use.

Perform Visual Inspection		Automatize visual inspections using image and video analysis for defect detection with high accuracy and speed.	**Understand AI principles, image/video analysis techniques, and quality control standards.**				**FR15**	
Perform Non-destructive Testing	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	AI analysis of X-ray or other non-destructive testing data for internal defect identification.	**Understand AI principles, data analysis techniques, and non-destructive testing methods and standards.**				**FR16**	
Perform Surface Quality Inspection		AI-powered analysis of surface images for scratch, crack, or imperfection detection.	**Understand AI principles, image analysis techniques, and surface quality standards.**		**Skill**		**FR17**	
Perform Inspect products for visual and dimensional defects	**2-2 3D scanning**	Use of 3D scanning for automated, high-precision inspection and defect detection, including complex geometries.	**Understand new tools of 3D scanning technology, data analysis, and defect identification in industrial settings.**				**FR18**	Ability to use 3D scanners for industrial product inspection, analyze data, and identify defects.
Assess product customisation and personalisation	**4-1 3D Printing/Additive Manufacturing**	Adapt quality control practices to evaluate variations and ensure quality in customized and personalized 3D printed products.	**Understand of 3D printing principles, design for additive manufacturing (DfAM) guidelines, and customized product quality standards.**		**Knowledge**	L4	**http://data.europa.eu/esco/skill/2afb2b59-c9a3-4cf3-b1dd-1a2fad51e583**	The process of reproducing 3D objects by using 3D printing technologies.
Conduct advanced testing with 3D-printed tools		Think, ask, and Integrate 3D-printed jigs, fixtures, and testing tools for specialized and efficient quality control procedures.	**Understand 3D printing capabilities for creating custom testing tools, knowledge of relevant testing procedures, and data analysis skills.**			L2	**FR19**	

Analyze manufacturing processes performance data from sensors	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Integrate sensors into production tools for real-time performance monitoring, improving process control through predictive maintenance and quality defect detection, reducing waste, and increasing efficiency.	**Understand sensor data, data analysis techniques, and quality control principles in industrial contexts.**		**Skill**	L4	**FR12**	Ability to analyze industrial sensor data related to product performance and identify quality issues.
Analyze manufacturing processes performance data from sensors	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	Integrate sensors into production tools for real-time performance monitoring, improving process control through predictive maintenance and quality defect detection, reducing waste, and increasing efficiency.	**Understand AI principles, data analysis techniques, and non-destructive testing methods.**		**Skill**	L4	**FR11**	Ability to analyze industrial sensor data related to product performance and identify quality issues.

5.3.4. IMPACTS ON SKILLS

Here after the description of new skills identified, following ESCO format “ESCO template for new Skill description”

Table 15 : Product Quality Controller’s impact on skills

SKILL REFERENCE (LOCAL CODIFICATION)	CONCEPT NAME	DESCRIPTION	ALTERNATIVE LABELS/SYNONYMS	SKILL TYPE	SKILLS REUSABILITY LEVEL	ESSENTIAL SKILL OF	OPTIONAL SKILL OF	HIERARCHY
FR10	Sustainable Automation Development	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries	Sustainable Automation Progress Eco-Friendly Automation	S	Sector specific	Sustainability Engineers Automation Engineers Industrial Engineers Manufacturing Engineers Process Engineers	Energy Consultants Operations Analysts	

5.4. 3D PRINTING TECHNICIAN

5.4.1. JOB DESCRIPTION AND SCOPE

Job Description

3D Printing Technician (Prior, 2023), (ESCO 3118.1) ESCO description: *"3D printing technicians assist in the designing and programming of products, ranging from prosthetic products to 3D miniatures. They may also provide 3D printing maintenance, check 3D renders for customers and run 3D printing tests. 3D printing technicians can also repair, maintain and clean 3D printers"* (ESCO, n.d.).

LCAMP job description: 3D printing technicians, also known as additive manufacturing technicians or specialists, are responsible for operating and maintaining 3D printing equipment and processes to create three-dimensional objects from digital models.

Here after the ***ESCO table for reviewing an existing Occupation*** filled to propose a change on the description:

Table 16 : 3D Printing technician occupation definition

OCCUPATION URI	OCCUPATION TITLE	COMMENTS ON THE PREFERRED TERM	NEW DESCRIPTION OF AN EXISTING OCCUPATION	ALTERNATIVE LABELS TO BE REMOVED/MODIFIED	ESSENTIAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE	OPTIONAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE
3118.1 **http://data.europa.eu/esco/occupation/4cf7be91-fed9-47a7-9ca9-e74c7eb6becb**	3D printing technician	Description ESCO should now contain "operating 3D printers"	3D printing technician is now part of serial production processes, not only focused on design phase and prototype production	N/A	N/A	N/A

Business Area

Hereafter are the industries engaging in this role:

The business area of a 3D print operator can vary widely, depending on whether the focus is on business-to-consumer (B2C) or business-to-business (B2B) markets. In a B2C context, 3D printing can be used to create customised products like collectibles, fashion items, or even personalised earbuds. This area is appealing because it allows for the creation of unique, tailored items that cater to individual consumer preferences.

On the other hand, in a B2B setting, 3D printing services are often geared towards industrial clients and can involve producing prototypes, parts for manufacturing processes, and even functional products in various industries like engineering, automotive, aerospace, and medical. In this area, the focus is more on providing solutions that meet specific industrial needs, such as creating prototypes for testing or producing specialised components that might be too complex or costly to manufacture using traditional methods.

In both B2C and B2B contexts, the ability to customise and rapidly prototype offers significant advantages. However, the level of investment, the type of 3D printers needed, and the business model can differ substantially between these two approaches. For instance, B2C might require less initial investment and can be started even with more affordable desktop 3D printers, whereas B2B services often demand higher-end equipment, more significant investment, and a deeper understanding of industrial requirements.

Thus, the business area for a 3D print operator can range from consumer-focused product creation to providing specialized manufacturing and prototyping services for various industries. The choice of area depends largely on the target market, the level of investment, and the specific expertise and capabilities of the operator.

In the Business-to-Business (B2B) sector, 3D printing operators can explore several areas, including:

- **Engineering and Manufacturing:** Providing prototypes and parts for various engineering and manufacturing processes. This includes creating components for machinery, automotive parts, or other manufacturing tools.
- **Medical Industry:** Production of prosthetics, orthotics, and medical implants. The medical field often requires highly customised parts, which is a key strength of 3D printing.
- **Aerospace Industry:** In the aerospace sector, 3D printing is used for creating lightweight components and parts that need to meet precise specifications.
- **Automotive Industry:** 3D printing is used for both prototyping and the production of final parts in the automotive industry, especially for custom or specialized vehicles.
- **Consumer Goods and Electronics:** Customised components for consumer goods, electronics, and household items.
- **Education and Research:** Providing models and experimental designs for educational purposes and research projects.
- **Tooling and Fixtures:** Producing jigs, fixtures, and other tools that are used in various manufacturing processes.
- **Customised Machinery Parts:** Tailoring parts for specific machinery that might be too expensive or time-consuming to manufacture using traditional methods.
- **Spare parts:** Reproduction of components from old machines or products for which tooling is no longer available. Keeping equipment operational, reducing the resources used to produce new replacement machines, reducing environmental impact.

5.4.2. CONTEXT AND LIMITATIONS

Key Figures

In 2022, more than 900 job offers for 3D printing roles were published across the French, English, Spanish, Italian, and German sites of 3Dnatives. This number represents more than double the offers published in the previous year. The data indicates a significant demand for technical profiles in the 3D printing sector, particularly in industrial fields such as aerospace, automotive, and medical. These sectors are increasingly integrating additive manufacturing into their value chains, showing a growing market and interest in 3D printing skills.

As of 2022 and moving into 2023, the role of a 3D printing technician in the industry has evolved significantly, indicating a shift from a predominantly research-focused phase to an increasingly applied and "live" industry role.

The 3D printing job market in 2022 saw a growing demand for technical roles, with a focus on design, development, production, and methods. This demand reflects the ongoing integration of additive manufacturing into various industrial sectors, such as aerospace, automotive, and medical. The fact that 76% of the job offers in the 3D printing domain were for permanent contracts also underscores a long-term investment in these technologies and confidence in their sustainability and growth within the industry. This transition from research to industry application is evident in the increasing recruitment by large manufacturing companies specializing in these sectors, looking for experts in additive manufacturing to maximise the technology's benefits.

The trend for 2023 continues to show an expansion of 3D printing into mainstream manufacturing processes, with an emphasis on overcoming previous challenges like supply chain issues and the need for more efficient manufacturing processes. There's a strong focus on the development of new technologies, systems, and materials to drive the adoption of additive manufacturing. One notable aspect is the diversification of applications across different sectors, including healthcare and dental, which are particularly well-suited to the benefits of 3D printing.

However, there are challenges that remain, such as concerns about capital budgets for customers, questions about the use of existing systems, and economic factors like inflation. These issues might influence the pace of adoption and integration of 3D printing technologies in various sectors.

Overall, the role of a 3D print technician has firmly established itself in the industry, with significant growth and application across various sectors. The ongoing developments and challenges highlight an industry that is increasingly moving beyond research and prototyping to become a key part of mainstream manufacturing and production processes.

5.4.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 17 : Tasks and skills impacted related to 3D Printing technician occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Ensuring Reliability and Cybersecurity	**3-1 Cybersecurity**	Protect sensitive data and systems from cyber threats	**Cybersecurity**	+	**Knowledge**	L3	**http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44**	The methods that protect ICT systems, networks, computers, devices, services, digital information, and people against illegal or unauthorised use.
Collaborate in Design	**4-1 3D Printing/Additive Manufacturing**	Integrate 3D Printing Technology in Product Design	**collaborate with designer**		**Skill**		**http://data.europa.eu/esco/skill/d52382fe-f236-421f-95fe-34fe69d48dbd**	Communicate and collaborate with fellow designers to coordinate new products and designs
Operate 3D Printers		Enhance flexibility, precision, sustainability, and reliability in production processes.	**Knowledge of 3D printing technologies, materials, and processes.**		**Knowledge**	L4	**http://data.europa.eu/esco/skill/2afb2b59-c9a3-4cf3-b1dd-1a2fad51e583**	The process of reproducing 3D objects by using 3D printing technologies.

Operate and monitor	**4-4 Digital Twins**	Improve oversight and efficiency in 3D printing operations	**Internet of Things**			L3	**http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51**	The general principles, categories, requirements, limitations, and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
Maintain 3D Printers	**4-6 Predictive Maintenance**	Anticipate maintenance failure, reducing downtime.	**predictive maintenance**			L4	**http://data.europa.eu/esco/skill/7d913551-e17a-40ba-baf7-48d0c3b12e50**	The use of data analytics and mathematical calculation to manage and monitor the conditions of machines and production processes.
Implement Sustainability Practices	**5-3 Energy Efficiency**	Reduce waste and energy consumption	**advise on sustainability solutions**		**Skill**	L3	**http://data.europa.eu/esco/skill/dbef5042-4b99-4e6f-b2ed-1d33b07b3ed6**	Advise companies on solutions to develop sustainable production processes, improve material efficiency and reuse and reduce carbon footprint.
Handle Material	**5-6 Sustainable Material Innovation**	Use sustainable materials and components	**Knowledge of sustainable materials, environmental impact assessment**				**http://data.europa.eu/esco/skill/73576419-31c2-4e45-8e30-ab1afec3db4e**	Identify, select environmentally friendly materials and components. Decide on the substitution of certain materials by the one that are environmentally friendly, maintaining the same level of functionality and other characteristics of the product.

5.5. PREDICTIVE MAINTENANCE EXPERT

5.5.1. JOB DESCRIPTION AND SCOPE

Job Description

Predictive Maintenance Expert (ESCO 2152.1.13) ESCO description: *"Predictive maintenance experts analyse data collected from sensors located in factories, machineries, cars, railroads and others to monitor their conditions in order to keep users informed and eventually notify the need to perform maintenance"* (ESCO, n.d.) (Next Move Strategy Consulting, 2024).

Business Area

Predictive Maintenance Technicians play a crucial role in industries that prioritise equipment reliability to enhance operational efficiency, reduce downtime, and optimise maintenance schedules. Their primary responsibility is to use diagnostic tools and data analysis to predict when equipment might fail and to conduct maintenance to prevent such failures. Here are some key industries that employ Predictive Maintenance Technicians within our scope:

- **Manufacturing:** In manufacturing plants, predictive maintenance is essential for minimizing downtime and ensuring that production lines run smoothly. Technicians monitor machinery and equipment using sensors and data analytics to predict and prevent failures.
- **Logistics:** Shipping, and logistics operations use predictive maintenance to monitor the health of engines, vehicles, and other critical infrastructure. This helps in avoiding delays and reducing maintenance costs.
- **Construction and Heavy Machinery:** Predictive maintenance is critical for monitoring construction equipment and heavy machinery to prevent unexpected breakdowns that can delay projects and increase costs.

These industries value the role of Predictive Maintenance Technicians because they help in reducing operational costs, improving safety, and increasing the lifespan of equipment through timely and data-driven maintenance decisions.

5.5.2. CONTEXT AND LIMITATIONS

The demand for predictive maintenance technicians in France is part of a global trend, towards integrating advanced technologies like IoT and AI for maintenance strategies, significantly impacting various industries. This approach not only enhances operational efficiency but also contributes to cost savings by minimizing unplanned downtime and extending equipment lifespan. While specific figures for France weren't available, the global predictive maintenance market, which France is a part of, is expected to grow substantially, indicating a strong demand for these skills across industries.

5.5.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 18 : Tasks and skills impacted related to Preventive maintenance expert occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Collect and monitor equipment data in Real-Time and/or delayed for health Equipment analysis	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Enhance real-time and/or delayed data collection and analysis. Need to understand the general principles, categories, requirements, limitations, and vulnerabilities of smart connected devices.	**Knowledge of IoT device communication.**	+	**Know-ledge**	L3	**http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51**	The general principles, categories, requirements, limitations, and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
		Enhance real-time and/or delayed data collection and analysis. Need to understand the general principles, categories, requirements, limitations, and vulnerabilities of sensors technology.	**Knowledge of sensors technology.**				**http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b**	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.

	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Improve prediction accuracy and optimized maintenance schedules. Need to understand the artificial intelligence theories, applied principles, architectures, and systems.	**Programming skills - AI concepts**				**http://data.europa.eu/esco/skill/e465a154-93f7-4973-9ce1-31659fe16dd2**	The artificial intelligence theories, applied principles, architectures, and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies, and cognition theories.
Virtual Training for Maintenance Teams	**2-1 Virtual and Augmented Reality**	Enhanced training experiences with VR/AR	**AR development training design**				**http://data.europa.eu/esco/skill/abdc7ac8-151f-40c6-bc1a-1e9b4b073290**	The process of adding diverse digital content (such as images, 3D objects, etc.) on surfaces that exist in the real world. The user can interact in real-time with the technology by using devices such as mobile phones.
		Increase efficiency of communication and collaboration with VR/AR programmers to enhanced training experiences with VR/AR.	**collaborate with all stakeholder teams**		**Skill**		**http://data.europa.eu/esco/skill/d52382fe-f236-421f-95fe-34fe69d48dbd (à modifier)**	Communicate and collaborate with all stakeholder teams to improve manufacturing processes/maintenance activities.
Improve identification of dimensional wear in equipment	**2-2 3D scanning**	Use of 3D scanning for automated, high-precision inspection and defect detection, including complex geometries.	**Understand new tools of 3D scanning technology, data analysis, and defect identification in industrial settings.**			L4	**FR20**	Ability to use 3D scanners for industrial product inspection, analyze data, and identify defects.

Improve data securisation	**3-1 Cybersecurity**	Protect of sensitive maintenance data: need to understand cybersecurity concepts.	**Cybersecurity principles - Vulnerability assessment and penetration testing skills - Network security protocols and best practices**		**Know-ledge**		**http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44**	The methods that protect ICT systems, networks, computers, devices, services, digital information, and people against illegal or unauthorised use.
Sustainable Equipment Lifecycle Management	**5-2 Circular Economy**	Promotion of equipment reuse and recycling.	**Lifecycle assessment, circular economy strategies**			L3	**http://data.europa.eu/esco/skill/22c45bf7-e52b-475f-847b-c32a87f65a5d**	The circular economy aims to keep materials and products in use for as long as possible, extracting the maximum value from them while in use and recycling them at the end of their life cycle. It improves resource efficiency and helps to reduce the demand for virgin materials.

5.5.4. IMPACTS ON SKILLS

Here after the description of new skills identified, following ESCO format "ESCO template for new Skill description"

Table 19 : Preventive maintenance experts impacts on Skills

SKILL REFERENCE (LOCAL CODIFICATION)	CONCEPT NAME	DESCRIPTION	ALTERNATIVE LABELS/ SYNONYMS	SKILL TYPE	SKILLS REUSABILITY LEVEL	ESSENTIAL SKILL OF	OPTIONAL SKILL OF	HIERARCHY
FR10	Sustainable Automation Development	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries	Sustainable Automation Progress Eco-Friendly Automation	S	Sector specific	Sustainability Engineers Automation Engineers Industrial Engineers Manufacturing Engineers Process Engineers	Energy Consultants Operations Analysts	

5.6. INDUSTRIAL DESIGNER

5.6.1. JOB DESCRIPTION AND SCOPE

Job Description

Industrial Designer (ESCO 2163.1) ESCO description: *"Industrial designers work out ideas and develop them into designs and concepts for a wide variety of manufactured products. They integrate creativity, aesthetics, production feasibility, and market relevance in the design of new products"* (ESCO, n.d.) (World Economic Forum, 2023).

Business Area

Industrial designer technicians and technologists find employment across a range of sectors, mainly focusing on manufacturing and related fields where their skills in design, efficiency improvements, and production optimisation are highly valued.

The largest sectors in scope employing industrial engineering technologists and technicians include:

- **Manufacturing:** This sector is the most significant employer, engaging a considerable portion of professionals in roles that focus on enhancing manufacturing processes, product quality, and production efficiency. They might work on planning, testing, and custom-making industrial products to improve manufacturing outcomes.
- **Computer and Electronic Product Manufacturing:** Here, technicians and technologists contribute to the development and production of electronic goods, playing crucial roles in designing workflows, machinery layouts, and improving production methods.
- **Transportation Equipment Manufacturing:** In this sector, professionals may work on designing and improving the manufacturing process of transportation equipment, ensuring products meet quality and efficiency standards.
- **Professional, Scientific, and Technical Services:** This broad category includes firms providing advice and assistance in areas such as engineering, design services, and other technical disciplines, where industrial design skills can be applied to a variety of projects.
- **Machinery Manufacturing:** Professionals in this sector work on designing, improving, and optimising the production of various machinery and equipment, ensuring they meet specified standards and efficiency levels.

These sectors highlight the diversity of opportunities available to industrial designer technicians and technologists, reflecting their critical role in enhancing production processes, product quality, and overall efficiency in a wide array of manufacturing environments. Their work often involves collaboration with engineers and other professionals to solve complex problems and implement effective solutions.

5.6.2. CONTEXT AND LIMITATIONS

While specific data on the demand for industrial designer technicians in France was not directly available, insights into the broader field of power engineering and industrial design in France might offer some context for the job market and educational opportunities in related fields. France is recognised for its advanced power engineering sector, hosting nearly 500 power engineering companies and employing over 30,000 engineers and technicians. This indicates a robust engineering sector that could have parallel demand in areas like industrial design.

For those interested in the field of industrial design, France offers a variety of educational programs in industrial design at both undergraduate and postgraduate levels. These programs cover a wide range of topics including design management, engineering design, and sustainable industrial design, preparing graduates for diverse career opportunities in the design field.

Given France's strong emphasis on engineering, design, and innovation, coupled with the presence of specialised design agencies and educational programs, it seems there could be opportunities for industrial designer technicians, albeit indirectly indicated. Those interested in this career path might benefit from focusing on skill development in CAD, product design, and innovation to align with the demands of French industries.

For a more targeted search into the job market or educational programs, visiting specific company websites or educational institution portals could provide further insights into current opportunities and requirements in France.

5.6.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green Transition**, modifications and evolutions of the related needed skills.

Table 20 : Tasks and skills impacted related to Industrial designer occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Conceptualize and design new products	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	AI assists in automating routine tasks, enhancing detail and realism, optimizing designs, speeding up prototyping, predictive modeling, customisation, and error detection in 3D model creation.	**AI proficiency for 3D modeling**	+	**Skill**	L4	**FR06**	Utilize AI tools for enhancing efficiency and precision in 3D model creation.
							FR09	Utilize AI tools for enhancing efficiency and precision in 3D model creation.
	2-1 Virtual and Augmented Reality	Use of VR and AR for product prototyping facilitates design collaboration, and user experience testing.	**Understand VR and AR technologies, their applications in industrial design, and their integration with design tools.**			L3	**http://data.europa.eu/esco/skill/5da42cfd-1da8-4e4f-b68e-4f821d005fc5**	The process of simulating real-life experiences in a completely immersive digital environment. The user interacts with the virtual reality system via devices such as specifically designed headsets.
	2-2 3D scanning	Use of 3D scanning to capture real-world objects for accurate model reproduction. Reverse engineering tool can convert	**Proficiency in 3D scanning technology and software**		**Knowledge**	L4	**FR07**	Skills in operating and interpreting 3D scanning technology

		object scanned into usable object in the CAD tool,	**Proficiency in reverse engineering tool**				**FR08**	Skills in using reverse engineering tool
	4-1 3D Printing/Additive Manufacturing	Use of 3D printing allows for greater design freedom and complexity, rapid prototyping allowing several loops with low costs and time investment.	**Knowledge of 3D printing technologies, materials, and processes.**			L3	**http://data.europa.eu/esco/skill/2afb2b59-c9a3-4cf3-b1dd-1a2fad51e583**	The process of reproducing 3D objects by using 3D printing technologies.
			Collaborate with Machines Operators		**Skill**	L4	**FR05**	Communicate and collaborate with Machines Operators to integrate technologies constraints and possibilities in product designs
	5-2 Circular Economy	Design products for disassembly, reuse, and recycling.	**Understanding of circular design principles**		**Knowledge**		**http://data.europa.eu/esco/skill/22c45bf7-e52b-475f-847b-c32a87f65a5d**	The circular economy aims to keep materials and products in use for as long as possible, extracting the maximum value from them while in use and recycling them at the end of their life cycle. It improves resource efficiency and helps to reduce the demand for virgin materials.
Develop sustainable product designs	**5-6 Sustainable Material Innovation**	Use of sustainable materials, and design principles and standards to reduce the environmental impact of products.	**Knowledge of sustainable materials, design principles, standards, and their application in product design.**		**Skill**		**http://data.europa.eu/esco/skill/73576419-31c2-4e45-8e30-ab1afec3db4e**	Identify, select environmentally friendly materials and components. Decide on the substitution of certain materials by the one that are environmentally friendly, maintaining the same level of functionality and other characteristics of the product.

5.6.4. IMPACTS ON SKILLS

Here after the description of new skills identified, following ESCO format "ESCO template for new Skill description"

Table 21 : Industrial designer's impact on skills

SKILL REFERENCE (LOCAL CODIFICATION)	CONCEPT NAME	DESCRIPTION	ALTERNATIVE LABELS/ SYNONYMS	SKILL TYPE	SKILLS REUSABILITY LEVEL	ESSENTIAL SKILL OF	OPTIONAL SKILL OF	HIERARCHY
FR05	Communication and Collaboration in Product Design	Communicate and collaborate with Machines Operators to integrate technologies constraints and possibilities in product designs	Product Design Cooperation Collaborative Design Communication	S	Sector specific	Product Designers Industrial Designers Design Engineers Project Managers User Experience (UX) Designers User Interface (UI) Designers Design Managers	Manufacturing Technicians Technical Support Technicians	
FR06	AI-Powered 3D Modeling	Utilize AI tools for enhancing efficiency and precision in 3D model creation.	AI 3D Modeling Automated 3D Design	S	Cross-sectoral	3D Modelers CAD Designers Industrial Designers Product Engineers Software Developers specializing in AI and 3D modeling Research Scientists in Computer Vision and Machine Learning Gaming Developers	Product Design Technicians	
FR07	3D Scanning Operation and Interpretation	Skills in operating and interpreting 3D scanning technology	3D Scan Operation Analysis Scan Interpretation Handling	S	Sector specific	3D Scanning Technicians Quality Control Inspectors Metrology Technicians Manufacturing Engineers Reverse Engineers	Manufacturing Technicians Quality Control Inspectors	

FR08	Reverse engineering	Skills in using reverse engineering tool	Product Analysis Retro-Engineering	S	Cross-sectoral	Product Engineers Manufacturing Engineers Design Engineers Quality Control Engineers Industrial Designers Mechanical Engineers Aerospace Engineers	Quality Control Inspectors Manufacturing Technicians Research Scientists	
FR09	AI-Powered 3D Modeling	Utilize AI tools for enhancing efficiency and precision in 3D model creation.	AI 3D Modeling Automated 3D Design	S	Cross-sectoral	3D Modelers CAD Designers Industrial Designers Product Engineers Software Developers specializing in AI and 3D modeling Research Scientists in Computer Vision and Machine Learning	Product Design Technicians	

5.7. SENSOR ENGINEERING TECHNICIAN

5.7.1. JOB DESCRIPTION AND SCOPE

Job Description

Sensor Engineering Technician (ESCO 3114.1.10) ESCO description: *"Sensor engineering technicians collaborate with sensor engineers in the development of sensors, sensor systems, and products that are equipped with sensors. Their role is to build, test, maintain, and repair the sensor equipment"* (ESCO, n.d.) (U.S. Bureau of Labor Statistics, 2023).

Business area

Sensor engineering technicians, falling broadly under the categories of electrical and electronic engineering technologists and technicians, find employment across several key industries. These include engineering services, semiconductor and other electronic component manufacturing, navigational, measuring, electromedical, and control instruments manufacturing, as well as utilities. These professionals play crucial roles in designing, developing, testing, and repairing equipment that is powered by electricity or electric current.

5.7.2. CONTEXT AND LIMITATIONS

While a sensor engineering technician role may involve a significant amount of hands-on work with sensors and related equipment, it may not require the same depth of technical expertise as a sensor engineer or scientist, typically working under the guidance of engineers, often working closely with them, they may have limitations in terms of decision-making authority or responsibility for designing new sensor technologies.

Sensor engineering technicians' responsibilities may include setting up experiments, collecting data, analysing results, and making recommendations for improvements based on their findings, but also installing sensors in various environments and ensuring they are properly maintained and functioning correctly.

Sensor engineering technicians may also need to adhere to strict safety protocols and regulatory requirements. But, they may have limited influence over strategic decisions or broader project goals. Their focus is typically on executing tasks within the parameters set by engineers and project managers.

For a more targeted search into the job market or educational programs, visiting specific company websites or educational institution portals could provide further insights into current opportunities and requirements in France.

5.7.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 22 : Tasks and skills impacted related to Sensor engineering technician occupation.

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Calibrate, test sensors, Troubleshoot and diagnose sensor malfunctions	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Increased use of advanced sensors with complex calibration procedures requiring understanding of data protocols and network connectivity.	**Internet of Things**	+	**Knowledge**	L3	**http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51**	The general principles, categories, requirements, limitations, and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
			Understanding of sensor calibration principles, communication protocols, and data analysis.	=	**Skill**	L4	**http://data.europa.eu/esco/skill/6e34b68e-0d61-49f2-bc4d-571c0326d857**	Test sensors using appropriate equipment. Gather and analyse data. Monitor and evaluate system performance and take action if needed.
		Use of 5G for faster data transmission; implementation of edge computing for localized data processing.	**Understanding of sensor calibration principles, standards, communication protocols, and data analysis.**		**Knowledge**	L3	**http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b**	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic,

								electrochemical, and optical sensors.
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Integration with AI systems for real-time data analysis and adaptive control using sensor data.	**Understanding of AI principles.**	+	**Skill**		**http://data.europa.eu/esco/skill/e465a154-93f7-4973-9ce1-31659fe16dd2**	The artificial intelligence theories, applied principles, architectures, and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies, and cognition theories.
			machine learning concepts				**http://data.europa.eu/esco/skill/3a2d5b45-56e4-4f5a-a55a-4a4a65afdc43**	The principles, methods and algorithms of machine learning, a subfield of artificial intelligence. Common machine learning models such as supervised or unsupervised models, semi-supervised models and reinforcement learning models.
	4-6 Predictive Maintenance	Implementation of predictive maintenance techniques using sensor data to anticipate and prevent sensor failures.	**Understand predictive maintenance principles, data analysis, and their application in industrial automation.**		**Knowledge**	L4	**http://data.europa.eu/esco/skill/7d913551-e17a-40ba-baf7-48d0c3b12e50**	The use of data analytics and mathematical calculation to manage and monitor the conditions of machines and production processes.

Implement sustainable sensor deployment practices	**5-X All Green Transition Trends / Sustainable Manufacturing**	Incorporate Green Transition Trends / Sustainable Manufacturing practices. integration of renewable energy sources for power.	**knowledge of Green Transition Trends / Sustainable manufacturing principles**			L3	**FR10**	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries
Manage sensor data security and privacy	**3-1 Cybersecurity**	Cybersecurity concerns related to sensor data collection, transmission, and storage.	**Understanding of cybersecurity principles, standards, and best practices for protecting sensor data from Cyber threats.**				**http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44**	The methods that protect ICT systems, networks, computers, devices, services, digital information, and people against illegal or unauthorised use.

5.7.4. IMPACTS ON SKILLS

Here after the description of new skills identified, following ESCO format “ESCO template for new Skill description”

Table 23 : Sensor engineering technician’s impacts on skills

SKILL REFERENCE (LOCAL CODIFICATION)	CONCEPT NAME	DESCRIPTION	ALTERNATIVE LABELS/SYNONYMS	SKILL TYPE	SKILLS REUSABILITY LEVEL	ESSENTIAL SKILL OF	OPTIONAL SKILL OF	HIERARCHY
FR10	Sustainable Automation Development	Understand renewable energy technologies, sustainable manufacturing processes, and robotics programming to take part in development and implementation of integrated automation solutions for these industries	Sustainable Automation Progress Eco-Friendly Automation	S	Sector specific	Sustainability Engineers Automation Engineers Industrial Engineers Manufacturing Engineers Process Engineers	Energy Consultants Operations Analysts	

5.8. RESULTS, STATISTICS AND EXPERTS' COMMENTS

Thanks to these impacts analysis, building statistics are obtained, based on:

- Per job, the list of impacting trends and number of tasks impacted.
- From trends impacts, related needed skills to support the changes are identified.

5.8.1. NUMBER OF TASKS IMPACTED PER JOB

The number of tasks impacted per trend are identified below, per occupation.

This table provides a sum-up, per job, of trends which have been identified as impacting, and an idea of number of tasks impacted within jobs.

Table 24 : Number of tasks impacted per job.

OCCUPATION TITLE	1-1 INTERNET OF THINGS (IOT) / SMART SENSORS / 5G TECHNOLOGY	1-2 ARTIFICIAL INTELLIGENCE (AI) / MACHINE LEARNING / BIG DATA ANALYTICS	2-1 VIRTUAL AND AUGMENTED REALITY	2-2 3D SCANNING	3-1 CYBERS ECURITY	4-1 3D PRINTING/ ADDITIVE MANUFACTURING	4-2 ROBOTICS AND AUTOMATION	4-4 DIGITAL TWINS	4-6 PREDICTIVE MAINTENANCE	5-12 CORPORATE SOCIAL RESPONSIBILITY (CSR) INITIATIVES	5-2 CIRCULAR ECONOMY	5-3 ENERGY EFFICIENCY	5-6 SUSTAINABLE MATERIAL INNOVATION	5-X ALL GREEN TRANSITION TRENDS / SUSTAINABLE MANUFACTURI NG
Predictive maintenance expert	2	1	2	1	1						1			
Industrial designer		2	1	2		2					1		1	
Sensor engineering technician	3	2			1				1					1
3D printing Technician					1	2		1	1			1	1	

Industrial robot controller	2	3	3		1	1		1	1	1				3
Product quality controller	2	4		1	1	2	1							

5.8.2. FROM TRENDS IMPACTS TO RELATED NEEDED SKILLS

From trends impacts, related needed skills are identified to support the changes. In order to simplify the analysis, all needed skills identified in 7 groups. Here after are the needed type of skills, are grouped, to support trends impacts.

Table 25 : Needed type of skills, allowing to support trends impacts.

OCCUPATION TITLE	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	INTER-DISCIPLINARY COOPERATION AND PROJECT MANAGEMENT	PRODUCTION AND MANUFACTURING TECHNOLOGIES	DIGITALISATION AND IT SECURITY	TECHNOLOGICAL CORE COMPETENCES	DATA ANALYSIS AND ARTIFICIAL INTELLIGENCE	SUSTAINABILITY AND ENVIRONMENTAL MANAGEMENT	VIRTUAL AND AUGMENTED REALITY
Predictive maintenance expert	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					1		
	2-1 Virtual and Augmented Reality	1						1
	2-2 3D scanning		1					
	3-1 Cybersecurity			1				
	5-2 Circular Economy						1	

industrial designer	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	2-1 Virtual and Augmented Reality							1
	2-2 3D scanning		2					
	4-1 3D Printing/Additive Manufacturing	1	1					
	5-2 Circular Economy						1	
	5-6 Sustainable Material Innovation						1	
sensor engineering technician	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2	1			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	3-1 Cybersecurity			1				
	4-6 Predictive Maintenance					1		
	5-X All Green Transition Trends / Sustainable Manufacturing						1	
3D printing Technician	3-1 Cybersecurity			1				
	4-1 3D Printing/Additive Manufacturing	1	1					

	4-4 Digital Twins			1				
	4-6 Predictive Maintenance					1		
	5-3 Energy Efficiency						1	
	5-6 Sustainable Material Innovation						1	
Industrial robot controller	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					3		
	2-1 Virtual and Augmented Reality							3
	3-1 Cybersecurity			1				
	4-1 3D Printing/Additive Manufacturing		1					
	4-4 Digital Twins		1					
	4-6 Predictive Maintenance					1		
	5-12 Corporate Social Responsibility (CSR) Initiatives						1	
	5-X All Green Transition Trends / Sustainable Manufacturing	1					2	

product quality controller	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				2			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					4		
	2-2 3D scanning		1					
	3-1 Cybersecurity			1				
	4-1 3D Printing/Additive Manufacturing		2					
	4-2 Robotics and Automation		1					

The gathering of skills per type of skills is available in Annex 14.1. Gathering of Skills per Type of Skills.

5.9. EXPERTS' COMMENT

The results of the French report were approved by a panel of French experts composed of:

- **Matthieu Merciecca**: French Ministry of Education, Head of Mission Economy-Education Campus.
- **Landry Bourguignon**: French Ministry of Education, Academy Inspector and Regional Education Inspector.
- **David Krupka**: AFNOR (French association for standardisation), "Engineering, Equipment, Materials and Industry 4.0" Development Manager.
- **Eric Fernandez** : Effi'Cairn, Manager.
- **Pierre Carillo**: IUT du Limousin, Head of Business Partnerships, Mechanical and Production Engineering Department.
- **Stephane Blanchard**: Agence Ad'occ (Economic development agency for the Occitanie region),
- **Ali Guerroui:** AFDET (French Association for the Development of Technical Education), Board Member.

Hereafter the results of a survey shared with participants involved during the LCAMP Conference in Aalen (Germany, May 2024). It corresponds to a sample of 30 people composed of:

- 40% (12) are VET's experts
- 30% (9) are Learners
- 23% (7) are industrial's experts
- 7% (2) are from Governments

In the following scheme, these people evaluated the impact of each digital trend on jobs, and the number of skills involved:

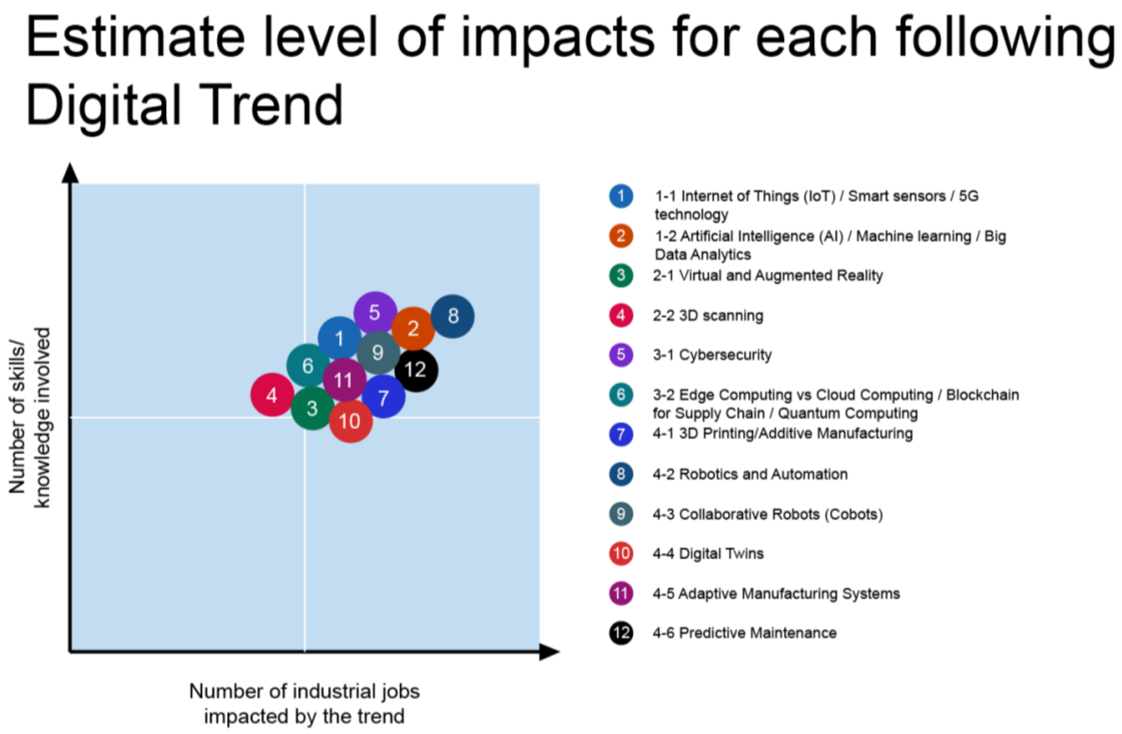

Figure 10 : Estimated level of impacts for each following Digital Trend

In the following scheme, they evaluated the impact of each green transition trend on jobs, and the number of skills involved:

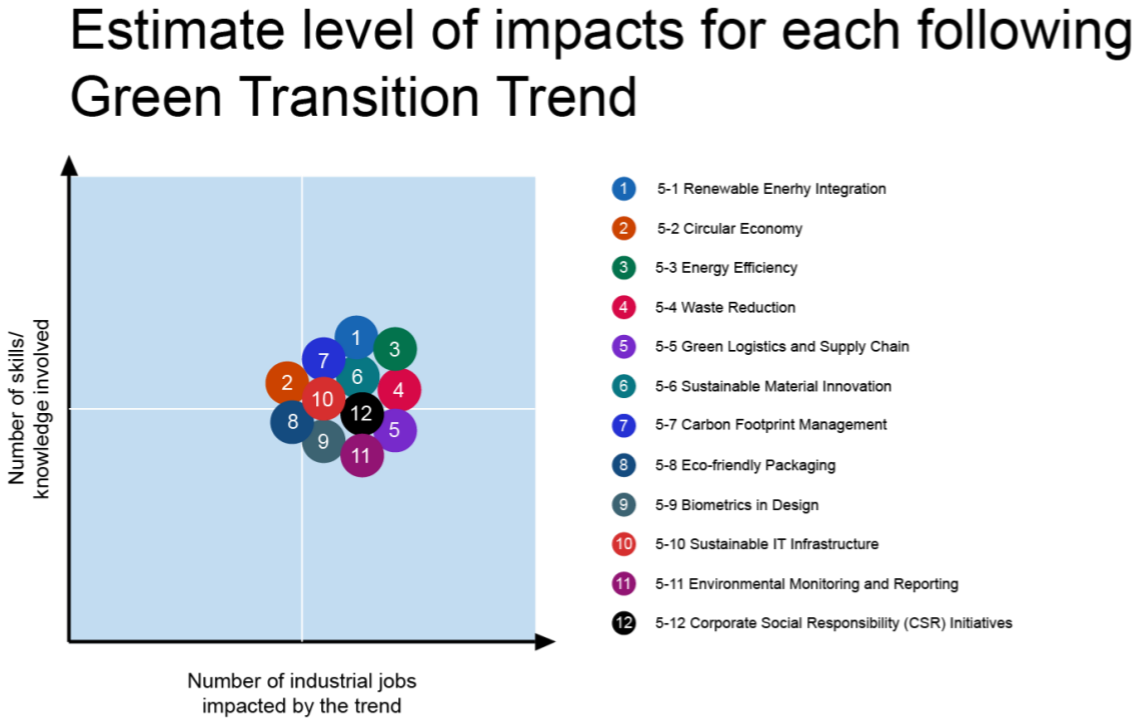

Figure 11 : Estimated level of impacts for each following Green Transition Trend

In the following scheme, these people evaluated which digital and green transition trend are impacting Product Quality Controller occupation:

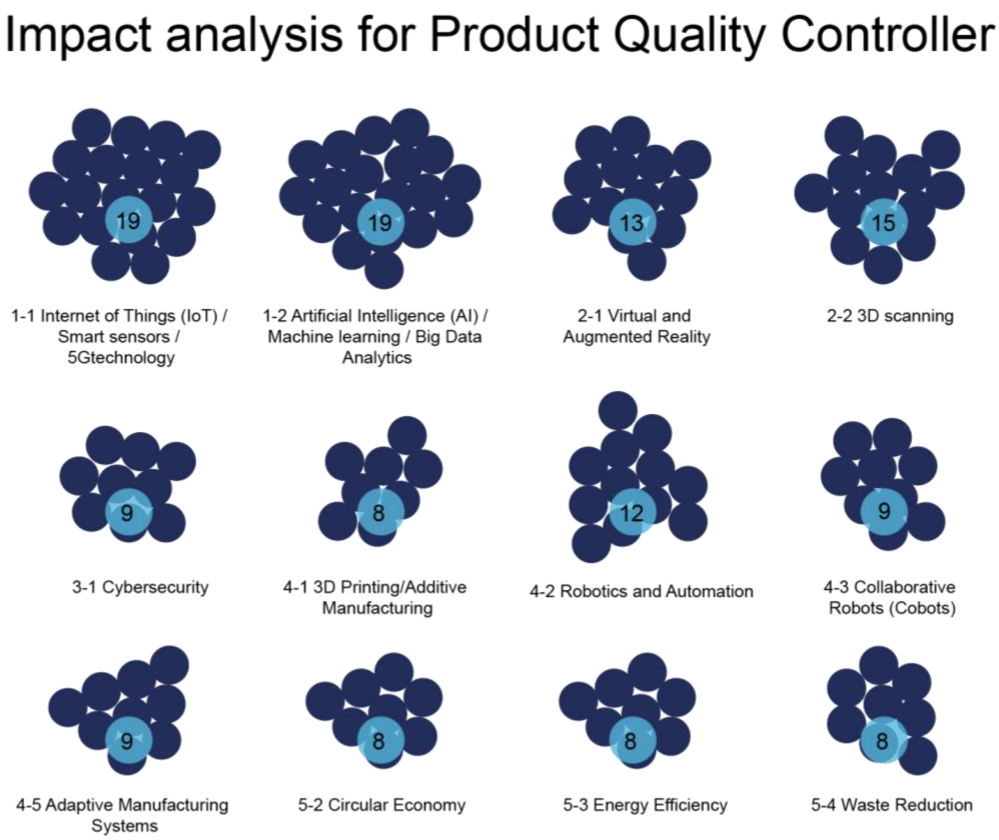

Figure 12 : Impact analysis for Product Quality Controller

Discrepancies can be easily seen between this survey and the deep factual impact analysis performed and presented in this report which can be sum-up as following:

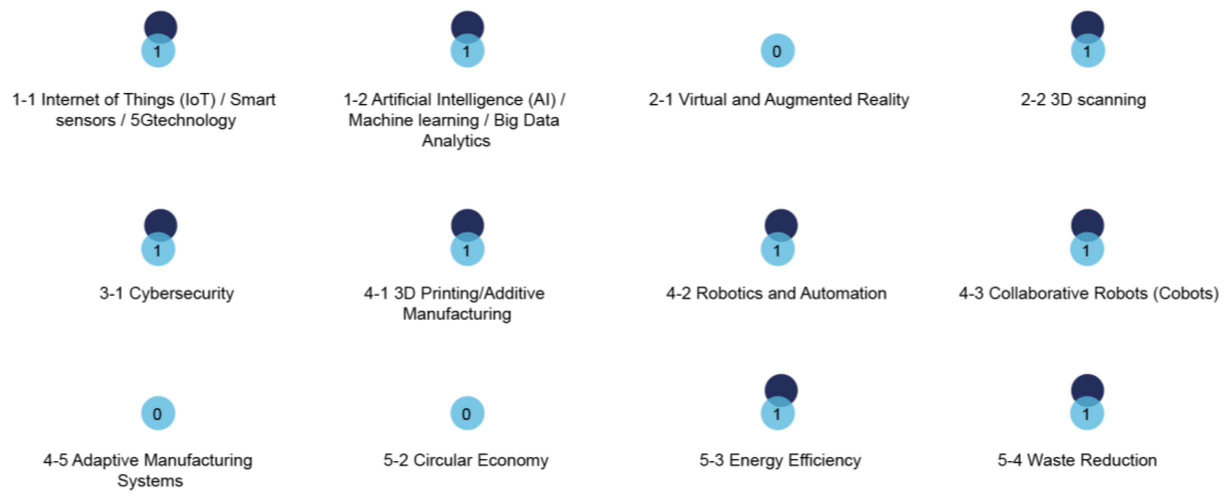

Figure 13 : Sum-up of the impact analysis

5.10. CONCLUSION AND OUTLOOKS

This sub-report, marking the second year, is inherently an intermediate update, reflecting two years of work and collaboration among all partners and experts. The French team, for instance, convened three times to review work and analyse results.

The expert review indicated that the number of experts in each country or region is insufficient to provide a unified and comprehensive assessment of the findings. Instead, they offered individual expert opinions as documented in the sub-reports. A notable point of discussion among some experts is the perceived impact of Artificial Intelligence (AI) on design. While some experts currently see no significant effects or consider it a low priority, AI is already influencing the creation and control of 3D models. A thorough understanding of AI tools is essential for bringing industrial designers up to speed.

Further, more in-depth studies are necessary to analyse the green and digital impacts on Advanced Manufacturing jobs. This research will provide trainers and teachers with valuable data to revise current courses, develop new micro-credentials, and facilitate comparisons of results across different countries and regions. The aim is to enhance the quality of deliverables in the coming years.

The ultimate goal is to gather sufficient data on a substantial number of jobs affected by green and digital trends. This will enable the provision of clear, valuable data for trainers and teachers to effectively update European and National Advanced Manufacturing curricula.

5.11. SOURCES

3D Printing Technician

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Industrial perspectives of 3D scanning: Features, roles and it's analytical applications. Sensors International, 2, 100114. https://doi.org/10.1016/j.sintl.2021.100114

Kim, C. (2021). Inspection & Quality Control Applications. https://www.capture3d.com/applications/inspection-quality-control

Molitch-Hou, M. (2022). 3d printing opportunities for small businesses. 3DPrint.Com | The Voice of 3D Printing / Additive Manufacturing. https://3dprint.com/293013/3d-printing-opportunities-for-small-businesses/

Yao, A. W. L. (2004). Applications of 3D scanning and reverse engineering techniques for quality control of quick response products. The International Journal of Advanced Manufacturing Technology, 26(11–12), 1284–1288. https://doi.org/10.1007/s00170-004-2116-5

Industrial Designer

PHI DESIGN. (2023). PHI DESIGN Agency - PHI Design. Phi Design. https://www.phi-design.com/en/lagence-phi-design/

World Economic Forum. (2020). The future of jobs report 2020. https://www.weforum.org/publications/the-future-of-jobs-report-2020/

Industrial Robot Controller

Dataiku. (2024). Dataiku Everyday AI, Extraordinary people. https://content.dataiku.com/manufacturing-efficiency/driving-efficiency-ai-manufacturing?fbclid=IwAR1JTVZbMBDGEsPKUByaHyADhN6vg3MHQJaNQ_Pu1AF3L-AN2xnBen3Vxzg

Predictive Maintenance Technician

Ulring, E. (2023, May 2). How predictive maintenance improves efficiencies across five industries - IBM Blog. https://www.ibm.com/blog/predictive-maintenance-efficiencies-client-case-studies/

Product Quality Controller

Hartmann, A. (2023). Manufacturers find opportunity in AI. NAM. https://nam.org/manufacturers-find-opportunity-in-ai-23271/

Sensor Engineering Technician

D. Wang, P. Guo, & L. Li. (n.d.). “Sensor-Based Energy Efficiency Monitoring and Optimization in Industrial Processes: A review.” Energy Conversion and Management.

Pech, M., Vrchota, J., & Bednář, J. (2021). Predictive maintenance and Intelligent Sensors in Smart Factory: review. Sensors, 21(4), 1470. https://doi.org/10.3390/s21041470

Srivastava, M., Rathee, S., Patel, V., Kumar, A., & Koppad, P. G. (2022). A review of various materials for additive manufacturing: Recent trends and processing issues. Journal of Materials Research and Technology, 21, 2612–2641. https://doi.org/10.1016/j.jmrt.2022.10.015

Y. Sun, Z. Li, & J. Liu. (n.d.). Sensor Integration for Intelligent Systems: A Review. IEEE Sensors Journal.

Y. Wu, D. He, & S. Zhao. (n.d.). “Cybersecurity for Sensor Networks: A review.” IEEE Wireless Communications.

Trends

Aegilmez, S. (2021). Forcam Force Edge Manual. (F. gmbh, Producer) Retrieved from https://forcam.com/app/uploads/2021/11/Manual-FORCAM-FORCE-EDGE.pdf

Argolini, R., Bonalumi, F., Deichmann, J., & Pellegrinelli, S. (2023). Digital twins: The key to smart product development. McKinsey & Company. https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/digital-twins-the-key-to-smart-product-development

Barbier, L. (2020). Industry 4.0 adoption for US aerospace and defense industry (S. Grinsted, Ed.) [Bachelor’s Thesis, Aalto University]. https://aaltodoc.aalto.fi/bitstream/handle/123456789/44095/bachelor_Barbier_Louis_2020.pdf?sequence=1&isAllowed=y

Belinski, R., Peixe, A., Frederico, G., & Garza-Reyes, J. (2020). Organizational learning and industry 4.0: findings from a systematic literature review and research agenda.. Benchmarking 27(8), 2435–2457. doi:https:// doi. org/ 10. 1108/BIJ- 04- 2020- 0158

Bergs, T., Stauder, L., Beckers, A., Grünebaum, T., & Barth, S. (2021). Adaptive design of manufacturing process sequences in case of short-term disruptions in the production process. Manufacturing Letters, 27, 92–95. https://doi.org/10.1016/j.mfglet.2021.01.004

Bisen, A. S., & Payal, H. (2022). Collaborative robots for industrial tasks: A review. Materials Today: Proceedings, 52, 500–504. https://doi.org/10.1016/j.matpr.2021.09.263

Carvalho, A., Mahony, N. O., Krpálková, L., Campbell, S., Walsh, J. T., & Doody, P. (2019). Edge computing applied to industrial machines. Procedia Manufacturing, 38, 178–185. https://doi.org/10.1016/j.promfg.2020.01.024

Cerliani, M. (2022). Quality Control with Machine Learning - Towards Data Science. Medium. https://towardsdatascience.com/quality-control-with-machine-learning-d7aab7382c1e Collaborative robots: quality inspections. (n.d.). Automate. https://www.automate.org/robotics/cobots/collaborative-robots-quality-inspections

Engelhart. (2023). The reality of the clean energy transition. https://www.linkedin.com/pulse/reality-clean-energy-transition-engelhart-commodities-trading-part

Gordon, J. (2023). Cybersecurity in the manufacturing industry - Industrial cyber. Industrial Cyber. https://industrialcyber.co/expert/cybersecurity-in-the-manufacturing-industry/

Haarman, De Klerk, Decaigny, Mulders, Vassiliadis, Sijtsema, & Gallo. (2018). Predictive Maintenance 4.0 - Beyond the hype: PDM 4.0 Deliver results. https://www.pwc.de/de/industrielle-produktion/pwc-predictive-maintenance-4-0.pdf

Hartmann, D., & Van Der Auweraer, H. (2020). Digital Twins. ResearchGate. https://www.researchgate.net/publication/338853051_Digital_Twins

Huelsman, T., Powers, E., Peasley, S., & Robinson, R. (2016). Cyber risk in advanced manufacturing. Deloitte. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manu-cyber-risk-in-advanced-manufacturing.pdf

Kim, H., Lin, Y., & Tseng, T. (2018). A review on quality control in additive manufacturing. Rapid Prototyping Journal, 24(3), 645–669. https://doi.org/10.1108/rpj-03-2017-0048

Kopacek, P. (2019). Trends in production automation. IFAC-PapersOnLine, 52(25), 509–512. https://doi.org/10.1016/j.ifacol.2019.12.595

Loorpuu, A. (2020). Adoption of AI based predictive maintenance technologies in the manufacturing industry [MA thesis, TU Delft]. https://repository.tudelft.nl/islandora/object/uuid:1db63388-3c42-4003-af7b-fe09085e25c3/datastream/OBJ/download

Melina.Bluhm. (2024). How to ensure quality in 3D printing. Replique. https://replique.io/2022/05/10/how-to-ensure-quality-in-3d-printing/

Povlsen, K. (2023). A new generation of robots can help small manufacturers. Harvard Business Review. https://hbr.org/2023/11/a-new-generation-of-robots-can-help-small-manufacturers

Raj, P., & Surianarayanan, C. (2020). Digital twin: The industry use cases. In Advances in Computers (pp. 285–320). https://doi.org/10.1016/bs.adcom.2019.09.006

Ratava, J., Penttilä, S., Lund, H., Lohtander, M., Kah, P., Ollikainen, M., & Varis, J. (2019). Quality assurance and process control in virtual reality. Procedia Manufacturing, 38, 497–504. https://doi.org/10.1016/j.promfg.2020.01.063

Sallee, B. (2021). How AR can (Actually) shape the future of Manufacturing. Forbes. https://www.forbes.com/sites/forbestechcouncil/2021/03/04/how-ar-can-actually-shape-the-future-of-manufacturing/

Segovia, D. F., González-Mendoza, M., Mendoza, E., & González, E. (2015). Augmented reality as a tool for production and quality monitoring. Procedia Computer Science, 75, 291–300. https://doi.org/10.1016/j.procs.2015.12.250

Spinger Nature Group (n.d.) Taking responsibility https://group.springernature.com/gp/group/taking-responsibility

Tzermia, C. (2021). Applications of Machine Learning and Object Recognition In Virtual Worlds [MA thesis, Hellenic Mediterranean University]. https://apothesis.lib.hmu.gr/bitstream/handle/20.500.12688/10260/TzermiaChrysoula2021.pdf?sequence=1&isAllowed=y

Zio, E. (2024). Data-driven prognostics and health management (PHM) for predictive maintenance of industrial components and systems. In Elsevier eBooks (pp. 113–137). https://doi.org/10.1016/b978-0-323-91152-8.00014-4

5.12. REFERENCES

Aerospace Industries Association. (2024). *Aerospace Industries Association*. https://www.aia-aerospace.org/

Bill M. (n.d.). IFR International Federation of Robotics. President's Report by Marina Bill. https://ifr.org/ifr-press-releases/news/presidents-report-1-2024

Bureau of Labor Statistics, U.S. Department of Labor. (2023). Electrical and electronics engineering technicians. Occupational Outlook Handbook. https://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineering-technicians.htm

International Labour Organization. (n.d.). Skills and lifelong learning. https://www.ilo.org/skills/lang--en/index.htm

Prior, M. (2023). What were the trends on the 3d printing job market in 2022? 3Dnatives. https://www.3dnatives.com/en/trends-on-the-3d-printing-job-market-in-2022-020320234/

U.S. Bureau of Labor Statistics. (n.d.). https://www.bls.gov/

World Economic Forum (2023). The Future of Jobs Report 2020. https://www.weforum.org/publications/the-future-of-jobs-report-2020/

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - G Germany sub-report

Co-funded by the European Union

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6. GERMANY: JOB'S IMPACT ANALYSIS

This section deals with the analysis of the selected job. As mentioned in the methodology it was analysed the changes faced by companies and identifying the **levers of those changes** affecting the specific jobs; then it was described the **changes in skills and knowledges** detected in the analysis.

6.1. LIST OF SELECTED JOBS

Here is the short list selected by Germany (comes from “job selection list GE V10 Germany V09; 31.05.2024”):

Table 26 : List of selected jobs: 3D printing technician and CNC machine operator

ESCO CODE	ESCO OCCUPATION	1 - INDUSTRY SECTORS	2 - DIGITAL AND GREEN TRANSITIONS NEW TRENDS IMPACTING	3 - EMPLOYABILITY	4.RELEVANCE FOR THE SMART SPECIALISATION STRATEGY – AT REGIONAL/COUNTRY?	5 - EDUCATION LEVEL.
3118.1	3D printing technician	**Automotive,** **Aerospace,** **Electric and electronic Industries,** **Machine tools (Mechanical Engineering),** **Maritime**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D scanning, 4-1 3D Printing/Additive Manufacturing, 4-2 Robotics and Automation, 4-4 Digital Twins, 4-5 Adaptive Manufacturing Systems, 4-6 Predictive Maintenance, 5-4 Waste Reduction, 5-2 Circular Economy, 5-3 Energy Efficiency, 5-6 Sustainable Material Innovation, 5-11 Environmental Monitoring and Reporting	**Employability in 2024:** **The rapid adoption of additive manufacturing in aerospace, automotive, healthcare, and consumer goods is driving demand for skilled operators. Additive manufacturing's benefits, like reduced lead times and design flexibility, boost job opportunities across sectors. High demand exists for operators skilled in managing Advanced Manufacturing equipment, preparing digital models, post-processing, and quality control.** **Employability in 5 Years (2029):** **Technological advancements require operators to update their skills to enhance speed, accuracy, and material diversity. More integrated roles in hybrid manufacturing settings create additional jobs, blending traditional and additive manufacturing skills. Specialisation in specific types of additive manufacturing, such as metal or polymer printing, offers new career paths.** **Employability in 10 Years (2034):** **Seasoned operators find opportunities in leadership, training, or entrepreneurial roles within the industry. Full integration with Industry 4.0 necessitates a deep understanding of digital technologies and data analytics. Staying competitive will require continuous learning and adaptability to modern technologies and market demands.** **Conclusion:** **Promising employability prospects exist for Additive Manufacturing Operators, with rapid growth expected in this sector.**	The region of Baden-Württemberg considers Advanced Manufacturing as one of the priorities in its S3. https://ec.europa.eu/regional_policy/assets/s3-observatory/regions/de1.html	EQF Level 4 (trained skilled worker or equivalent): Operators undertake corresponding tasks, potentially with supervisory roles, troubleshooting, and process optimisation.
7223.4	Computer Numerical Control machine operator	**Machine tools (Mechanical Engineering), Automotive, Aerospace, Maritime, Electric and electronic Industries**	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-4 Digital Twins, 4-5 Adaptive Manufacturing Systems, 1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 5-3 Energy Efficiency, 5-4 Waste Reduction	**Current Factors (2024):** **CNC machining is crucial in industries like aerospace, automotive, electronics, and medical devices, ensuring steady demand for skilled operators. Technological advancements in automation, precision, and efficiency require highly skilled operators. Integration of robotics and CAM software boosts efficiency, increasing the need for proficient operators. A skill shortage has created a competitive job market with many opportunities for qualified individuals.** **Employability in 5 Years (2029):** **Increased automation and robotics integration sustain high demand for adaptable CNC operators. Advanced digital skills, including proficiency in CAD/CAM software and CNC programming, are essential. Specialisation in areas like additive manufacturing, multi-axis, or high-speed machining could offer new career paths based on industry needs.**	The region of Baden-Württemberg considers Advanced Manufacturing as one of the priorities in its S3. https://ec.europa.eu/regional_policy/assets/s3-observatory/regions/de1.html	EQF Level 5 (technician or equivalent): CNC-Technicians at this level have advanced CNC skills, capable of programming complex operations, proficient in multi-axis machining, adaptive control, and integrated CAD/CAM systems optimizing tool paths, and conducting

				Employability in 10 Years (2034): **CNC machining remains vital to manufacturing, ensuring continued demand for skilled operators. Engaging with emerging technologies such as nanotechnology, advanced materials, and digital twins are crucial, necessitating ongoing learning. Global economic and industry trends will influence employability, emphasizing flexibility and adaptability in skills and practices.** **Conclusion:** **CNC operators who continuously update their skills and adapt to innovative technologies and industry trends can expect to remain highly employable, supporting the hypothesis provided.**		comprehensive troubleshooting. They also manage less experienced operators and contribute to process improvements.

6.2. 3D PRINTING TECHNICIAN

6.2.1. JOB DESCRIPTION AND SCOPE

Job Description

3D Printing Technician (ESCO 3118.1) ESCO description: *"3D printing technicians assist in the designing and programming of products, ranging from prosthetic products to 3D miniatures. They may also provide 3D printing maintenance, check 3D renders for customers and run 3D printing tests. 3D printing technicians can also repair, maintain, and clean 3D printers"* (ESCO, n.d.).

LCAMP description proposal: 3D printing technicians, also known as additive manufacturing technicians or specialists, are responsible for operating and maintaining 3D printing equipment and processes to create three-dimensional objects from digital models.

Here after the **ESCO table for reviewing an existing Occupation** filled to propose a change on the description:

Table 27 : ESCO template for reviewing an existing Occupation.

OCCUPATION URI	OCCUPATION TITLE	COMMENTS ON THE PREFERRED TERM	NEW DESCRIPTION OF AN EXISTING OCCUPATION	ALTERNATIVE LABELS TO BE REMOVED/ MODIFIED/ ADD	ESSENTIAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE	OPTIONAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE
3118.1 **http://data.europa.eu/esco/occupation/4cf7be91-fed9-47a7-9ca9-e74c7eb6becb**	3D printing technician	Description ESCO should now contain "operating 3D printers"	3D printing technician is now part of serial production processes, not only focused on design phase and prototype production	N/A	N/A	N/A

Business Area

The job profile of a 3D Printing Technician spans across various sectors, including engineering, manufacturing, medical, aerospace, automotive, consumer goods, electronics, tooling, jigs and fixtures, custom machine parts, and even emerging areas such as concrete printing. This summary explores the responsibilities and impact of 3D Printing Technicians in these industries, compare traditional manufacturing processes with additive manufacturing methods, analyse the benefits for B2B and B2C sectors, discuss technical developments, the Green Factory transformation, and the implications for German SMEs.

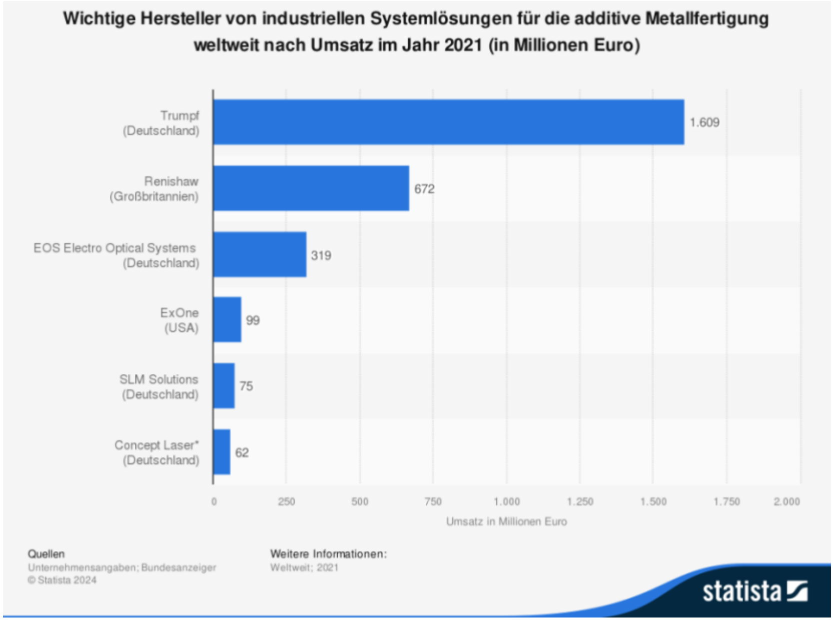

Figure 14 : [Digital Trends: Additive Manufacturing]. In Statista Digital Trends Report (p. 33).

The chart provides valuable insights into the current state and future projections of additive manufacturing technologies.

- **Adoption rates:** Shows the increasing adoption rates of additive manufacturing in various industries.
- **Market growth:** The chart illustrates the projected market growth and investment trends within the industry worldwide.

This ensures that the essential information is accessible to English-speaking readers while providing proper attribution to the original German source.

Engineering and Manufacturing

In engineering and manufacturing, 3D Printing Technicians contribute to rapid prototyping, tooling, and final part production. They work with engineers to optimise designs for additive manufacturing, select appropriate materials and operate 3D printers. Quality control, process optimisation and troubleshooting are essential aspects of their role to ensure efficient production. According to the OECD (2018), "*3D printing is transforming traditional manufacturing processes by enabling decentralised production, thus enhancing the entire value chain from design to delivery*." (Rural regions of the future: Seizing technological change).

Medical

3D printing technicians play a critical role in the medical field, producing patient-specific implants, surgical guides, and anatomical models. They work closely with healthcare professionals to translate medical imaging data into 3D printed objects for surgical planning and training. Regulatory compliance and quality control are paramount in medical applications. As highlighted by Conner et al. (2014), "*The medical sector is significantly benefiting from 3D printing technologies, which allow for the creation of customized medical devices tailored to individual patient needs*" (Rural regions of the future: Seizing technological change).

Aerospace and Automotive

In the aerospace and automotive industries, 3D printing technicians contribute to lightweighting, part consolidation and rapid prototyping. They use additive manufacturing to produce complex geometries, reducing material waste and assembly time. Applications include engine components, air ducts, brackets, and interiors, where additive manufacturing offers design freedom and performance benefits. Beyer (2014) notes, "*Boeing has integrated 3D printing into their manufacturing process, producing over 20,000 parts, thus illustrating the significant impact of additive manufacturing on reducing production time and costs*"

Consumer Goods and Electronics

3D printing technicians in the consumer goods and electronics sector produce customised articles, wearables, and electronic housings. They use additive manufacturing for rapid iteration, low-volume production, and product personalisation. From smartphone cases to home appliances, additive manufacturing enables efficient production of intricate designs with minimal tooling requirements. As mentioned in "*Introduction to Digital Economics," "Additive manufacturing allows for high customization and rapid production cycles, making it ideal for consumer goods and electronics sectors.*" (Ebin, 2021).

Tooling, Jigs, and Custom Machine Parts

In tooling, jigs and custom machine parts, 3D printers create specialised tools, fittings and components to optimise production processes. Additive manufacturing offers benefits such as design complexity, lead time reduction and cost effectiveness compared to traditional machining methods. According to the OECD (2018), "*The ability to produce custom tools and fixtures quickly and at a lower cost gives manufacturers a competitive edge in optimizing production workflows.*" (Rural regions of the future: Seizing technological change).

Concrete Printing

Emerging areas such as concrete printing also fall within the remit of 3D printing technicians. They are contributing to the development and deployment of large-scale 3D printers capable of constructing buildings, infrastructure and architectural elements using concrete-based materials. This innovative approach offers potential benefits in terms of construction speed, cost effectiveness and design flexibility. As noted by Conner et al. (2014), "*Concrete 3D printing has the potential to revolutionize the construction industry by enabling faster, more cost-effective building methods while allowing for complex architectural designs.*"

Wood Printing

The process of 3D printing with wood allows for the fabrication of objects from two principal materials: filaments or powders. The technology offers the advantage of producing objects with a natural look and feel, while also enabling the creation of complex shapes. The technology has applications in the fields of art, crafts, and education.

These examples demonstrate the broad applicability of additive manufacturing across different business sectors, with ongoing research aimed at advancing the technology and its integration into green factory practices. As noted by Chinga-Carrasco (2020), "*Biocomposite filaments, including those derived from wood, offer the potential for sustainable 3D printing applications due to their natural aesthetics and versatility in design.*"

Traditional Manufacturing vs. Additive Manufacturing Processes

While traditional manufacturing processes such as injection moulding, CNC machining and casting are well established, additive manufacturing offers unique benefits such as design freedom, reduced material waste and on-demand production capabilities. As Balubaid and Alsaadi (2023) explain, "*Additive manufacturing (AM) has been widely adopted in various industries to enhance new product development with minimal time constraints, offering significant advantages in terms of design flexibility and reduced waste*". Additive manufacturing processes such as Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS) enable the production of complex geometries and customised parts without the need for expensive tooling.

Benefits for the B2B and B2C Sectors

Additive manufacturing brings several benefits to both the B2B and B2C sectors. For businesses, it offers faster time-to-market, lower production costs and improved product customisation, leading to increased competitiveness and profitability. According to Perifanis and Kitsios (2023), "*The integration of advanced manufacturing technologies such as additive manufacturing enhances business agility, reduces lead times, and allows for greater product customization, which are critical factors for maintaining competitiveness in today's fast-paced market*". Consumers gains from access to personalised products, on-demand manufacturing and sustainable solutions tailored to their preferences.

Technical Developments and Future Expectations

Recent advances in additive manufacturing include the development of high-performance materials, multi-material printing and improved process automation. Innovations such as bioprinting, 4D printing and in-situ monitoring systems hold promise for applications in healthcare, construction, and aerospace. Future developments may focus on improving the printing speed, scalability, and sustainability of additive manufacturing processes. As noted by Tuvayanond and Prasittisopin (2023), "*The integration of advanced technologies such as bioprinting and 4D printing is set to revolutionize sectors like healthcare and construction, offering unprecedented capabilities in design and functionality.*"

They are also contributing to emerging areas such as concrete and wood printing, where additive manufacturing techniques are providing innovative solutions for the construction and furniture industries. According to a report by The Business Research Company (2023), "*The use of 3D printing in construction, including concrete printing, is expected to grow significantly, driven by the need for efficient, sustainable building practices*".

Green Factory Transformation

Additive manufacturing contributes to the green factory transformation by reducing material waste, energy consumption and carbon emissions compared to classic production methods. According to Gopal, Lemu, and Gutema (2023), "*Using additive manufacturing over traditional subtractive technologies may result in considerable material and energy resource savings, especially if the component is appropriately designed for manufacture.*" Material recycling, the use of bio-based resins, and localised production further enhance the sustainability of additive manufacturing processes, in line with the growing emphasis on environmental responsibility in manufacturing.

Impact on German SMEs

German SMEs are increasingly adopting additive manufacturing technologies to remain competitive in global markets. According to the German Engineering Federation (VDMA), the number of companies using additive manufacturing in Germany is steadily increasing. SMEs are using additive manufacturing to streamline production, offer customised solutions and differentiate themselves from the competition. As highlighted by Yaqub and Alsabban (2023), "*Industry 4.0 technologies, including additive manufacturing, are key drivers of digital transformation, enhancing competitiveness and operational efficiency for contemporary organizations*." In the future, it can be expected to see further integration of additive manufacturing into the workflows of German SMEs, fuelling innovation and economic growth. According to Zhang et al. (2021), "*The continuous evolution of smart manufacturing paradigms, driven by advanced information technologies and digital twins, will enable SMEs to innovate and scale their operations more effectively*".

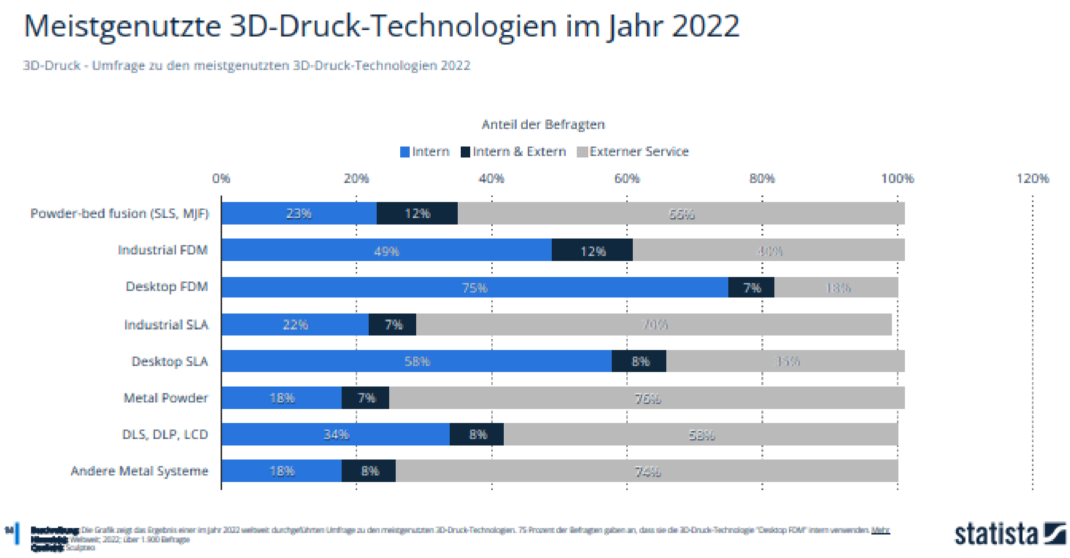

Figure 15 : Most used 3D printing technologies in 2022]. In Statista Digital Trends: Additive Fertigung (p. 14).

This graphic, sourced from the "Statista Digital Trends: Additive Fertigung" report, is presented in German. It offers valuable insights into the prevalent 3D printing technologies based on a worldwide survey conducted in 2022 with over 1,900 respondents.

The graphic highlights several key points:

- **Desktop FDM:** 75% of respondents reported using desktop FDM technology internally.
- **Powder-bed Fusion:** Includes technologies such as SLS and MJF, widely used across various sectors.
- **Industrial FDM and SLA:** Both are significant, with notable usage both internally and externally.

This ensures that the essential information is accessible to English-speaking readers while providing proper attribution to the original German source.

Key Figures

- **Global Additive Manufacturing Employment Trend:** The employment trend in global additive manufacturing has shown significant growth over the past decade. According to industry reports, the market growth in the additive manufacturing sector has been around 20% in recent years. This indicates a strong upward trend in employment opportunities within the additive manufacturing industry, driven by increased adoption in various sectors such as aerospace, automotive, healthcare and consumer goods.
- **Global Development of Additive Manufacturing Patents:** The development of additive manufacturing patents has increased globally, reflecting continued innovation and investment in 3D printing technologies. According to the European Patent Office, the annual growth rate of patent applications related to additive manufacturing has been overwhelming over the past decade. This suggests a robust expansion of intellectual property protection and technological advancement in the field of additive manufacturing.
- **Evolution of 3D Printing Technologies:** 3D printing technologies have evolved significantly over the past decade, with advances in speed, accuracy, material diversity and scalability. The annual growth rate of technological advances in 3D printing has been stunning based on industry analysis. This includes improvements in additive manufacturing processes such as selective laser sintering (SLS), fused deposition modelling (FDM), stereolithography (SLA) and binder jetting, as well as the development of new materials and software tools to improve functionality and efficiency.

While these figures provide a general indication of trends, specific percentages may vary depending on the source and timeframe of the data analysed see Figure 16 below.

6.2.2. CONTEXT AND LIMITATIONS

Context and Evolution

Over the past two decades, the additive manufacturing (AM) industry in Germany has experienced significant growth and evolution. Initially, additive manufacturing was primarily used for rapid prototyping and low-volume production. However, advances in technology and materials have expanded its applications to include end-use parts, tooling and even components for critical industries such as aerospace and automotive. According to The Business Research Company, "*The growth observed in the additive manufacturing market can be attributed to the increasing demand for prototyping, the necessity for customization, and handling complex geometries, especially in the aerospace and automotive industries.*" (Additive Manufacturing Global Market Report, 2024). While large industrial companies have been quick to adopt additive manufacturing, small and medium-sized enterprises (SMEs) have faced with unique dares combined with chances in utilizing this technology. As highlighted by IMARC Group (2023), "*Despite the rapid adoption of additive manufacturing technologies by large industrial firms, SMEs encounter both challenges and opportunities that require addressing specific technological, financial, and skill-related barriers to fully leverage AM's potential*".

- **Rapid prototyping**: Additive manufacturing has gained traction in Germany for rapid prototyping, allowing companies to quickly iterate designs and validate concepts.
- **Positive development:** Rapid prototyping has become more accessible and affordable, leading to increased adoption across industries.
- **Production of end-use parts:** Advances in materials and process reliability have enabled additive manufacturing to produce end-use parts in industries such as aerospace, automotive and medical.
- **Positive development:** The use of additive manufacturing for end-use parts has resulted in reduced lead times, cost savings, and design flexibility.
- **Tool and jig making:** Additive manufacturing is increasingly used to produce customized tools, jigs, and fixtures, offering benefits in terms of design complexity and lead time reduction.
- **Positive development:** The adoption of additive manufacturing for tooling has enabled manufacturers to optimise production processes and reduce downtime.

6.2.3. FACTORS SHOWING POSITIVE DEVELOPMENT, STAGNATION, OR NEGATIVE TRENDS FOR SMES

Positive Development Factors for SMEs

- **Accessibility:** Low-cost 3D printers and accessible materials have made additive manufacturing more feasible for SMEs.
- **Customisation:** Additive manufacturing allows SMEs to offer highly customized products without the need for expensive tooling.
- **Innovation:** SMEs often have the agility to adopt new technologies and innovate in their respective industries.

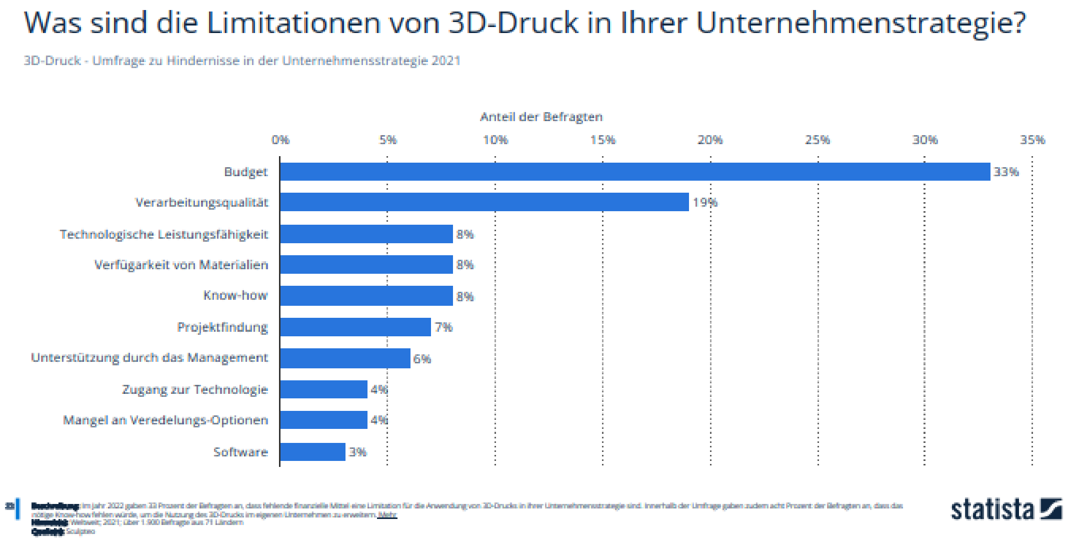

Figure 16: S [What are the limitations of 3D printing in your business strategy?]. In Statista Digital Trends: Additive Fertigung (p. 22).

In this study, a graphical interpretation detailing the limitations of 3D printing in business strategies is provided in Figure 16. The graphic provides valuable insights into the challenges faced by companies in adopting 3D printing technologies based on a worldwide survey conducted in 2022 with over 1,900 respondents from 71 countries.

The graphic highlights several key points:

- **Budget Constraints:** 33% of respondents indicated that financial limitations are a major barrier.
- **Lack of Know-how:** 8% reported a lack of necessary expertise to expand 3D printing usage.
- **Technological Capabilities and Material Availability:** Other significant barriers include processing quality, technological performance, and material availability.

Stagnation or Negative Trend factors for SMEs

- **Lack of resources:** SMEs may lack the financial resources and expertise required to invest in and fully exploit additive manufacturing technologies.
- **Scalability issues:** Scaling up additive manufacturing processes for mass production can be challenging for SMEs due to limited resources and infrastructure.
- **Skills gap:** SMEs may struggle to find skilled personnel with expertise in additive designing, additive manufacturing, hindering adoption and implementation.

6.2.4. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 28 : Tasks and skills impacted related to Printing technician occupation.

	Occu-pation Title	**3D Printing Technician**						
TASK	**IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION**	**IMPACT DESCRIPTION**	**RELATED NEEDED SKILLS/KNOW-LEDGE IMPACTED**	**EXPECTED TENDENCY FOR SKILL EVOLUTION**	**SKILL TYPE**	**MATURITY LEVEL TO REACH**	**SKILL ESCO URL**	**SKILL DESCRIPTION**
Material Handling	**5-6 Sustainable Material Innovation**	Integrate 3D Printing Technology ability, constraints in Material Handling	**Material Science**	+	**Knowledge**	L2	http://data.europa.eu/esco/skill/142f3f7f-f15f-412e-a5fe-f75755b5dbe0	Field of science and engineering that researches new materials based on their structure, properties, synthesis, and performance for a variety of purposes, including increasing fire resistance of construction materials.
			Data Analysis		**Skill**	L3	http://data.europa.eu/esco/skill/2b92a5b2-6758-4ee3-9fb4-b6387a55cc8f	Collect data and statistics to test and evaluate to generate assertions and pattern predictions, with the aim of discovering useful information in a decision-making process.
Operate, Control & Monitor	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Integrate 3D Printing Technology ability, constraints in Machinery Operation	**IOT Integration**		**Knowledge**	L2	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).

	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Integrate 3D Printing Technology ability, constraints in Quality	**Real Time Data Analytics**			L3	http://data.europa.eu/esco/skill/97bd1c21-66b2-4b7e-ad0f-e3cda590e378	The science of analysing and making decisions based on raw data collected from various sources. Includes knowledge of techniques using algorithms that derive insights or trends from that data to support decision-making processes.
		Integrate 3D Printing Technology ability, constraints in CAD/CAM	**AI Applications**				http://data.europa.eu/esco/skill/7a757fa5-9a6f-43ab-9e66-f8f4dba1ffcb	Use computer-aided manufacturing (CAM) programmes to control machinery and machine tools in the creation, modification, analysis, or optimisation as part of the manufacturing processes of workpieces.
	4-6 Predictive Maintenance	Integrate 3D Printing Technology ability, constraints in safety standards	**Dynamic Risk Management**		Skill	L2	http://data.europa.eu/esco/skill/96550830-539b-4746-96aa-92aa4959945d	Identify risks and apply a risk management process, e.g. hazard analysis and critical control points (HACCP).
Problem Solving		Integrate 3D Printing Technology ability, constraints in Basic Troubleshooting	**Predictive Maintenance**		Knowledge	L3	http://data.europa.eu/esco/skill/334e3e49-fb02-4051-809a-f06adfdc1c40	Identify operating problems, decide what to do about it and report accordingly.
			Advanced Creative Problem Solving		Skill		http://data.europa.eu/esco/skill/adc6dc11-3376-467b-96c5-9b0a21edc869	Find solutions to practical, operational or conceptual problems in a wide range of contexts.
Machine & Process Safety	3-1 Cyber-security	Integrate 3D Printing Technology ability, constraints in safety standards	**Cybersecurity Basics**		Knowledge		http://data.europa.eu/esco/skill/a4346013-a967-4a58-a533-6b32ad1364c5	The principles, ethical issues, regulations and protocols of data protection.

General Advanced Manufacturing	**4-1 3D Printing/Additive Manufacturing**	Integrate 3D Printing Technology ability, constraints in Advanced Manufacturing Processes	**Digital Literacy**		**Skill**		http://data.europa.eu/esco/skill/c8fa4313-80b0-4f37-8b1b-1739707bc362	Instruct students in the theory and practice of (basic) digital and computer competency, such as typing efficiently, working with basic online technologies, and checking email. This also includes coaching students in the proper use of computer hardware equipment and software programmes.
Work with multidisciplinary teams		Integrate 3D Printing Technology ability, constraints in Teamwork and Customer Interaction	**Enhance Collaboration**			L2	http://data.europa.eu/esco/skill/e4da156d-a6c4-4b29-935b-eff9c9553cf1	Working confidently within a group with each doing their part in the service of the whole. Understanding and respecting the roles and competencies of other team members.

6.2.5. IMPACT ON SKILLS

The previous analysis described impacts on skills. Here after new skills changes on skills/knowledges already identified in ESCO database and new skills/knowledges.

Table 29: Impact on Skills - 3D Printing Technician

EXISTING SKILL/ KNOWLEDGE URI	NEW RELEVANT SKILL/KNOWLEDGE NAME ADDED	ESSEN-TIAL SKILL	NEW RELEVANT SKILL/KNOWLEDGE DESCRIPTION	EXISTING SKILL/KNOWLEDGE NAME TO BE UNLINKED	ASSOCIATED OCCUPATIONS TO BE ADDED /REMOVED
http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	IOT Integration	Skill	Keep up with latest I4.0 applications	No	Production Engineers Process Engineers R&D Engineers SCM
http://data.europa.eu/esco/skill/8d4271ca-c9fd-40b3-875f-15f78332a49e	Real Time Data Analytics	Know-ledge	Keep up with Real Time Quality Control	No	Production Management Quality Management Process Engineers
http://data.europa.eu/esco/skill/cb1b0777-0388-4b01-a0cf-7c6bbfbbd61d	AI Applications	Skill	Keep up with the latest I4.0 applications	No	Production Engineers Process Engineers R&D Engineers SCM
http://data.europa.eu/esco/skill/d55e3866-3ec1-4bbb-b946-2c16696d0dcb	Material Science	Skill	Keep up with material specifications	Add to ESCO Database: “material specification”	Process Engineer R&D Engineer

http://data.europa.eu/esco/skill/2b92a5b2-6758-4ee3-9fb4-b6387a55cc8f	Data Analysis	Skill	Collect data and statistics to test and evaluate to generate assertions and pattern predictions, with the aim of discovering useful information in a decision-making process.	No	Process Engineer Quality Engineer
http://data.europa.eu/esco/skill/13d301d0-98cb-414f-a8f9-a3f059228133	Advanced Creative Problem Solving	Skill	Ability to develop innovative solutions to complex engineering challenges. This ability includes the critical thinking to identify and apply novel approaches to machine programming, process optimisation and production planning, increasing efficiency, quality, and performance in the advanced manufacturing environment.	Add to ESCO Database: “Ability to develop innovative solutions to complex engineering challenges”	Production Management Process Engineers R&D

6.3. CNC MACHINE OPERATOR

6.3.1. JOB DESCRIPTION AND SCOPE

Job Description

CNC Machine Operator (ESCO 7223.4) ESCO description: *"Computer numerical control machine operator's set-up, maintain and control a computer numerical control machine to execute the product orders. They are responsible for programming the machines, ensuring the required parameters and measurements are met while maintaining quality and safety standards"* (ESCO, n.d.).

Here after the **ESCO table for reviewing an existing Occupation** filled to propose a change on the description:

Table 30 : CNC machine operator occupation definition

OCCUPATION URI	OCCUPATION TITLE	COMMENTS ON THE PREFERRED TERM	NEW DESCRIPTION OF AN EXISTING OCCUPATION	ALTERNATIVE LABELS TO BE REMOVED/ MODIFIED	ESSENTIAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE	OPTIONAL SKILLS AND KNOWLEDGE CONCEPTS TO ADD/REMOVE
7223.4 **http://data.europa.eu/esco/occupation/5c082067-ea18-4ccb-8c43-e70b18ad8120**	computer numerical control machine operator	Smart Factory content expansion	CNC operator should include I4.0 contents	N/A	Advanced Machining Enhance Collaboration Advanced Creative Problem Solving Advanced Creative Trouble Shooting Adapt To Changing Situations Predictive Maintenance Advanced Coding Robotics And Automation Data Analysis	Cybersecurity Basics

Business Area

CNC (Computer Numerical Control) operators are an integral part of many industries, operating sophisticated machinery to produce precise parts and components. Their job profiles cover a wide range of sectors, including engineering and manufacturing, medical, aerospace, automotive, consumer goods and electronics, tooling and jigs, and bespoke machine parts. In addition, this summary provides an insight into traditional manufacturing processes as well as newer techniques such as 3D measurement and additive manufacturing. The benefits for both the B2B and B2C sectors are identified together with current technical developments, the Green Factory transformation, and its impact on German SMEs.

- **Engineering and manufacturing**: In the manufacturing process, the role of the CNC operator is significant, as they are responsible for interpreting intricate technical drawings and ensuring that the fabricated parts comply with the exacting specifications set out. Their expertise ensures that all components produced meet the required standards for precision and quality. According to the U.S. Bureau of Labor Statistics (2023), "*CNC operators play a critical role in the manufacturing process by interpreting complex technical drawings and ensuring that the produced parts meet stringent specifications*".
- **Medical**: In the medical field, CNC operators are responsible for the precise manufacturing of implants, prosthetics, and medical instruments. They use biocompatible materials and strictly adhere to rigorous quality standards to ensure the safety and efficacy of these medical products. As noted by Legg (2024), "*The high precision and accuracy of CNC machining allow for the creation of custom implants and surgical instruments that meet stringent medical standards, ensuring the safety and effectiveness of these critical medical products*".
- **Aerospace:** CNC machinists in aerospace manufacturing produce critical components for aircraft and spacecraft that meet stringent requirements for strength, durability, and reliability. They work with advanced materials and complex geometries to meet aerospace standards. As noted by the U.S. Bureau of Labor Statistics (2023), "*CNC machinists play a pivotal role in aerospace manufacturing by producing components with high precision and tight tolerances, essential for ensuring the safety and reliability of aircraft and spacecraft*".
- **Automotive**: In the automotive industry, CNC operators are responsible for the precision manufacturing of crucial components, including powertrains, parts for electrical and combustion engines, and numerous other components. Their work ensures that the produced vehicles adhere to stringent standards of safety, performance, and efficiency. By maintaining tight tolerances during the machining process, they contribute significantly to the overall quality and reliability of automotive products. As stated by Mastercam (2023), "*CNC machining is essential in the automotive industry for manufacturing complex parts such as engine components and transmission systems, ensuring high precision and adherence to stringent safety and performance requirements*".
- **Consumer goods and electronics**: CNC machinists produce intricate parts for consumer electronics, appliances, and gadgets. By meticulously assembling components, they enhance both the functionality and the visual attractiveness of consumer products. According to Grand View Research (2023), "*The demand for CNC machines in the consumer electronics sector is driven by the need for precision in manufacturing intricate components, which are essential for the functionality and aesthetic appeal of modern electronic devices*".
- **Tooling and jigs**: CNC machinists produce tools, moulds and fixtures used in various manufacturing processes. By manufacturing high quality tools intended for mass production, they significantly enhance profitability. As noted by Yusof and Latif (2019), "*CNC machining is essential for creating precise tooling and fixtures, which significantly enhances manufacturing efficiency and productivity by ensuring accurate and repeatable processes*".
- **Custom Machine Parts**: CNC machinists address the custom machining demands of diverse industries by fabricating specialised components tailored to distinct customer specifications. Leveraging their proficiency in CNC programming and machining methodologies, they provide highly customized and precise solutions. As noted by Prakash (2022), "*The ability of CNC machinists to produce customised, precision parts are vital across multiple sectors, including automotive, aerospace, and consumer electronics, ensuring that specific customer requirements are met with high accuracy*".

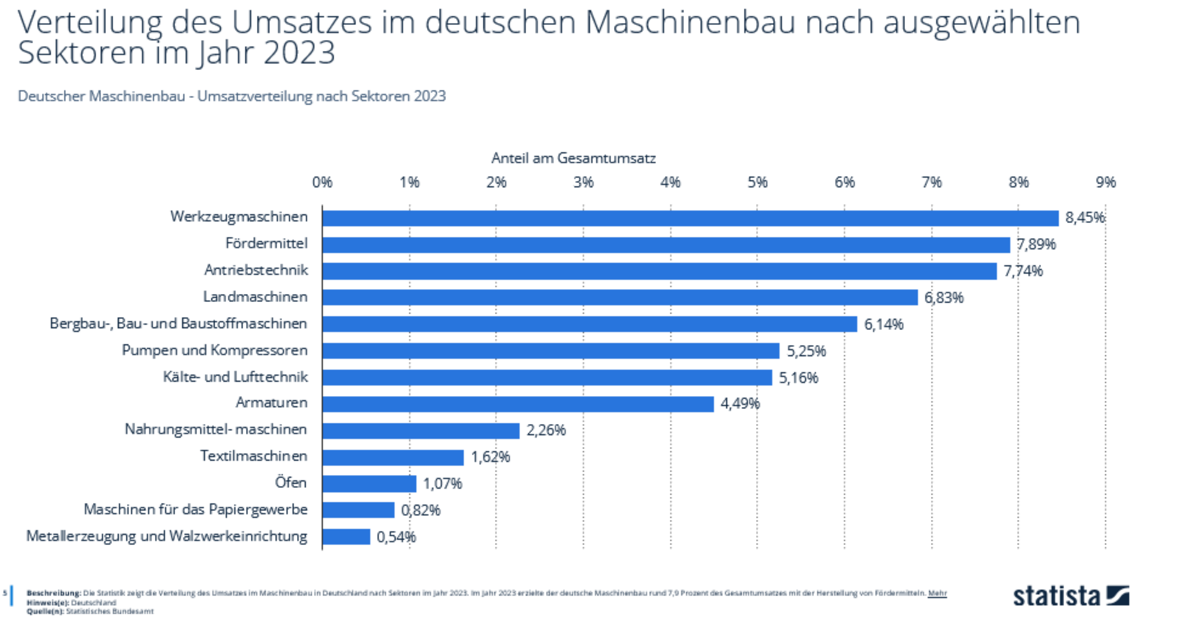

Figure 17: [Distribution of revenue in German mechanical engineering by selected sectors in 2023]. In Statista Industrien & Märkte: Werkzeugmaschinen in Deutschland (p. 5).

The graphic provides valuable insights into the revenue contributions of different sectors within the German mechanical engineering industry.

The graphic highlights several key points:

- **Tool Machinery:** Constitutes 8.45% of the total revenue in the mechanical engineering sector.
- **Conveying Machinery:** Accounts for 7.89% of the total revenue.
- **Drive Technology:** Represents 7.74% of the total revenue.

This ensures that the essential information is accessible to English-speaking readers while providing proper attribution to the original German source.

Traditional Manufacturing Processes

- **CNC milling machine:** Used for cutting and shaping solid materials, CNC milling machines enable the production of complex shapes with high precision.
- **CNC Lathe:** CNC lathes rotate workpieces while cutting tools remove material, facilitating the production of cylindrical parts with precise dimensions.
- **CNC wire EDM:** Using electrically charged wire, CNC wire cutting machines accurately shape conductive materials, ideal for intricate designs.
- **CNC Eroding:** Using electrical discharges, CNC eroding machines remove material from workpieces, suitable for producing complex shapes and hardened materials.
- **CNC 3D Measurement:** Advanced metrology techniques such as 3D measuring systems are used to inspect and verify the dimensional accuracy of machined components.

Benefits for the B2B and B2C sectors

- **B2B Sector**: CNC machining offers B2B customers cost-effective solutions to produce customised parts, reducing lead times and improving supply chain efficiency. As noted by Attar et al. (2022), "*The integration of CNC machining into B2B operations has streamlined production processes, allowing for greater customization and efficiency in supply chains, which are critical for maintaining competitiveness*".
- **B2C Sector:** Consumers derive considerable benefit from the use of CNC machining. This process enables the production of products that are not only meticulously engineered with high precision, but also exhibit enhanced functionality and fancy appeal. According to Perifanis and Kitsios (2023), "*CNC machining enables the production of consumer goods with high precision and quality, enhancing the functionality and aesthetic appeal of products, thus meeting the growing demand for high-standard consumer items*”.

Technical and Innovative Developments

- **Automation and robotics:** The integration of advanced automation with CNC machining has the potential to significantly enhance productivity, as it allows for the minimisation of cycle times and the reduction of labour expenses. Furthermore, this integration has the capacity to enhance the overall efficiency of manufacturing processes. As noted by Monzón et al. (2024), "*Combining advanced automation with CNC machining enhances productivity by reducing cycle times and labour costs, while improving the overall efficiency of manufacturing processes”.*
- **Advanced materials:** The application of CNC machining in the processing of advanced materials, such as composites and high-performance alloys, significantly expands the potential for innovation and development within the aerospace, automotive, and other high-technology sectors. This technological advancement facilitates the creation of intricate and high-precision components, thereby enhancing the capabilities and performance of products in these industries. Monzón et al. (2024) further highlight that "*the use of CNC machining to process advanced materials, including composites and high-performance alloys, opens up new possibilities in aerospace, automotive, and other high-tech industries*".
- **Digitalisation:** Industry 4.0 technologies enable simulations, real-time monitoring, predictive maintenance, and data-driven decision-making in CNC machining processes, optimising efficiency, and quality. According to a study by Yu et al. (2024), "*The integration of digital twin frameworks and AI algorithms in CNC systems significantly enhances the accuracy and efficiency of machining processes by enabling real-time monitoring and predictive maintenance*".
- **Hybrid manufacturing:** Integrating additive manufacturing with traditional CNC machining processes offers hybrid manufacturing solutions that combine the benefits of both techniques for complex geometries and rapid prototyping. The OpenHybrid project demonstrated that "*hybrid machines equipped with both subtractive and additive manufacturing technologies provide unmatched flexibility and efficiency in producing complex parts, reducing the overall production time and costs*" (3DPrint.com, 2021).

- **Sustainable practices:** CNC operators contribute to sustainability efforts by optimising machining parameters, reducing material waste and implementing environmentally friendly manufacturing processes. As noted by the Energy Efficiency Directive (2023), "*Optimizing energy usage and adopting advanced manufacturing techniques are crucial for improving sustainability in industrial operations, which significantly contributes to reducing waste and conserving resources*".
- **Energy Efficiency:** The integration of energy-efficient technologies alongside renewable energy sources within computer numerical control (CNC) machining processes is essential for reducing energy usage and decreasing the environmental impact of manufacturing operations. By adopting such practices, manufacturers can significantly reduce their carbon emissions and enhance the sustainability of their production activities. According to Félix and Mena (2023), "*Incorporating energy-efficient technologies and renewable energy in CNC machining processes is vital for minimizing energy consumption and lowering the carbon footprint of manufacturing activities*".

Impact on German SMEs

- **Competitive Advantage:** German SMEs using advanced CNC technologies gain a competitive edge through improved productivity, quality, and innovation. According to Altintas et al. (2022), "*The adoption of advanced manufacturing technologies enables SMEs to enhance their competitive position by improving operational efficiency and product quality*" (Management International Review, 62(3), 456-478).
- **Skills Development:** Training programmes and education initiatives ensure a skilled workforce capable of driving technological innovation and growth in the manufacturing sector. As highlighted by Proksch et al. (2021), "*Continuous skill development and education initiatives are vital for SMEs to maintain technological competitiveness and foster innovation*".
- **Collaborative Networks:** Collaborative networks play a pivotal role in bolstering the innovation capabilities of small and medium-sized enterprises (SMEs). Through these networks, SMEs gain access to a wealth of new knowledge and cutting-edge technologies, which are instrumental in enhancing their competitiveness on a global scale. This interconnected approach facilitates the exchange of expertise and resources, thereby driving technological advancement and market leadership. Neumeyer et al. (2021) note that "*Collaborative networks significantly contribute to the innovation capacity of SMEs, allowing them to access new knowledge and technologies that enhance their global competitiveness*".

6.3.2. CONTEXT AND LIMITATIONS

Over the past two decades, CNC (Computer Numerical Control) manufacturing has played a significant role in the industrial landscape of Germany. This summary provides an overview of the development of CNC use in German industry, identifying factors that show growth, stagnation, or negative trends. It also examines the constraints and challenges facing CNC manufacturing, including employee turnover, training, and recruitment.

- **Technological advances:** Germany has been at the forefront of technological innovation, leading to the widespread adoption of CNC machines in manufacturing processes. The implementation of sophisticated CNC technologies has notably enhanced efficiency, accuracy, and adaptability within industrial contexts. According to the German Trade & Invest report (2024), "*Germany's leadership in industrial technology and continuous innovation have positioned it as a global hub for CNC manufacturing, enhancing productivity and precision in various sectors.*"
- **Industry 4.0 integration:** The concept of Industry 4.0, which emphasises the digitalisation and automation of manufacturing processes, has driven the development of CNC manufacturing in Germany. This integration has enabled seamless communication between CNC machines, production systems, and enterprise networks, facilitating data-driven decision-making and optimising production efficiency. "*Industry 4.0 has revolutionized German manufacturing by integrating digital and physical systems, leading to smarter and more efficient production processes*" (SAP News, 2024).
- **Diversification of applications:** The use of CNC technology has broadened significantly, extending its applications beyond the traditional automotive and engineering sectors. It is now used in fields as diverse as aerospace, medical device manufacturing and consumer electronics. This expansion into diverse industries has not only created new opportunities for CNC manufacturers and service providers but has also been a catalyst for innovation and economic progress. "*The expansion of CNC technology into new industries has opened up significant opportunities for growth and innovation, particularly in high-precision sectors like aerospace and medical devices*" (SpringerLink, 2024).
- **Focus on precision engineering**: German manufacturers prioritise precision engineering in their CNC manufacturing processes. By using advanced machining techniques and high-quality materials, they are able to produce components with tight tolerances and superior surface finishes. This focus on precision and quality has established Germany's reputation for manufacturing excellence. This focus on quality has reinforced Germany's global reputation for manufacturing excellence. "*The emphasis on precision and quality in CNC manufacturing has solidified Germany's reputation as a leader in high-quality industrial production.*" (SpringerLink, 2024).

Factors for Positive Development

- Investment in research and development: Germany's commitment to research and innovation has catalysed significant advances in CNC technology. This focus has facilitated the development of state-of-the-art machining and improved process optimisation methods. According to Cunningham et al. (2023), "Germany's robust investment in R&D fosters technological innovation in CNC manufacturing, enhancing the country's competitive edge through the development of advanced machining solutions".
- Skilled workforce: Germany boasts a highly skilled workforce of technicians, engineers, and machinists skilled in CNC programming, operation, and maintenance. This skilled labour pool has contributed to the successful implementation and utilisation of CNC machines across all industries. As highlighted by Monzón et al. (2024), "A highly skilled workforce is crucial for the successful adoption and operation of advanced CNC technologies, driving efficiency and innovation in manufacturing processes".
- Industry Collaboration: Government agencies, industry associations and academic institutions have worked together to advance CNC manufacturing through knowledge sharing, technology transfer and skills development, creating an environment that supports innovation and growth. Neumeyer et al. (2021) state that "Collaborative networks significantly enhance the innovation capacity of SMEs by facilitating knowledge exchange and technology transfer, which are essential for maintaining competitive advantage in global markets".

Factors Indicating Stagnation or Negative Trends

- **Skills shortage:** Germany's shortage of CNC operators and technicians persists despite its skilled workforce. This issue is compounded by an ageing workforce and a decreasing interest in technical careers among younger generations, making it increasingly difficult to fill CNC-related positions. According to Salco Global (2023), "*The CNC industry is currently grappling with a significant skills gap, partly due to an ageing workforce and a declining interest in technical trades among younger people, making it challenging to find qualified CNC operators and technicians.*"
- **Decline in apprenticeships:** The number of apprenticeships in CNC machining and related disciplines has declined in recent years. This decline can be attributed to changing perceptions of vocational education, an increased emphasis on academic routes and a lack of awareness of the opportunities available in CNC manufacturing. As noted by Monzón et al. (2024), "*The shift in educational preferences towards academic degrees over vocational training has led to a noticeable decline in apprenticeships in the CNC sector, which poses a risk to maintaining a skilled workforce.*"
- **Global competition:** Germany faces significant competition from emerging economies in Asia and Eastern Europe, which benefit from lower labour and production costs. This competitive landscape has created challenges for Germany, particularly in maintaining market share and profitability within certain CNC manufacturing sectors. Reduced operating costs in these regions provide a competitive advantage, forcing German CNC manufacturers to continually innovate and improve efficiency to remain viable in the global marketplace. This economic dynamic has necessitated strategic adjustments and an increased focus on improving productivity to counter the cost advantages of their international competitors. According to the Emerald Insight report (2022), "*Intense global competition, especially from countries with lower labour costs, continues to pressure German CNC manufacturers to maintain their market position and profitability*."

- **Investment costs:** The initial investment required to purchase and implement CNC machines can be significant, creating a barrier to entry for small and medium-sized enterprises (SMEs) and start-ups. In addition, ongoing maintenance and training costs add to the overall cost of CNC manufacturing. KnowCNC (2024) emphasizes, "*High upfront costs and continuous expenses for maintenance and training are significant barriers for SMEs looking to adopt advanced CNC technologies.*"
- **Complexity of programming:** CNC programming requires specialised knowledge and skills, making it difficult for companies to find qualified programmers. The complexity of programming languages and the need for ongoing innovation and optimisation add to the complexity of CNC operations. Salco Global (2023) states, "*The intricacies of CNC programming and the necessity for constant updates pose significant challenges for businesses in recruiting and retaining skilled programmers*."
- **Quality control:** Ensuring rigorous quality control in CNC manufacturing is crucial, as even small errors can have a significant impact, leading to expensive defects and the need for rework or scrap. This highlights the importance of implementing comprehensive quality assurance protocols to maintain high standards and efficiency. KnowCNC (2024) notes, "*Maintaining stringent quality control is paramount in CNC manufacturing, as minor errors can result in costly defects and rework, underscoring the need for comprehensive quality assurance protocols.*"

Figure 18: [Apprentices: Newly concluded apprenticeship contracts in the most popular training professions in Germany in 2022]. In Statista Arbeit & Beruf: Beliebteste Ausbildungsberufe in Deutschland 2022 (p. 4).

In this study, an essential graphic detailing the newly concluded apprenticeship contracts in the most popular vocational training professions in Germany for the year 2022. The graphic offers valuable insights into the distribution and popularity of various vocational training programs among apprentices in Germany.

The graphic highlights several key points:

- **Most Popular Professions:** Lists the top 20 vocational training professions by the number of new apprenticeship contracts.
- **Quantitative Data:** Provides the exact number of apprenticeship contracts for each profession, showing trends and preferences among apprentices.

This ensures that the essential information is accessible to English-speaking readers while providing proper attribution to the original German source.

While CNC manufacturing in Germany has experienced significant growth and technological advancement over the past two decades, challenges such as skills shortages, declining apprenticeship numbers - *this is also confirmed by the number of apprenticeship contracts concluded, which indicates that the CNC operator profession does not appear in the top 20 in Germany* - and global competition are limiting its further development. Addressing these challenges through targeted initiatives, investment in education and training, and fostering industry collaboration is essential to maintaining the momentum of CNC manufacturing in Germany.

Despite the availability of advanced simulation tools like “CNC Lehrgang / SINUTRAIN”, “VERICUT” or “NCSIMUL”, there may still be room for improvement in the training of skilled workers, particularly in the integration of theory and practice. The constant evolution of technology and the demands of industry mean that training institutions must constantly update their curricula and integrate the latest simulation technologies to effectively prepare students for the challenges of the labour market. To fully address potential gaps, there is a need for continued collaboration between industry, software providers and educational institutions to ensure that training content remains current and that learners acquire the skills they need for successful careers.

6.3.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills

Table 31 : Tasks and skills impacted related to CNC Machine operator occupation

TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACT DESCRIPTION	RELATED NEEDED SKILLS/KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH	SKILL ESCO URL	SKILL DESCRIPTION
Operate, Control & Monitor	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	Integrate CNC Manufacturing ability, constraints in CAD/CAM	**Advanced Machining**	+	**Knowledge**	L3	**http://data.europa.eu/esco/skill/7a757fa5-9a6f-43ab-9e66-f8f4dba1ffcb**	Use computer-aided manufacturing (CAM) programmes to control machinery and machine tools in the creation, modification, analysis, or optimisation as part of the manufacturing processes of workpieces.
		Integrate CNC Manufacturing ability, constraints in Basic CNC Programming	**Advanced Coding**				**N.N.**	"Advanced Coding" in the context of CNC machining usually refers to advanced CNC programming techniques and methods that go far beyond basic G-code commands. It involves the use of complex and highly automated strategies to machine workpieces to maximise the efficiency, precision and quality of the parts produced.
		Integrate CNC Manufacturing ability, constraints in Measurement	**Data Analysis**			L2	**http://data.europa.eu/esco/skill/ad59afe4-6f8a-4bc4-acfd-0f228277508a**	Specific software system (SAS) used for advanced analytics, business intelligence, data management, and predictive analytics.

	4-2 Robotics and Automation	Integrate CNC Manufacturing ability, constraints in Operating Standard Machines	**Advanced Machining**			L3	**http://data.europa.eu/esco/skill/4f0e579d-ca7b-427c-ace6-9e2de3eb19c7**	Improve production rates, efficiencies, yields, costs, and changeovers of products and processes using relevant advanced, innovative, and cutting-edge technology.
		Integrate CNC Manufacturing ability, constraints in Automation	**Robotics And Automation**			L2	**http://data.europa.eu/esco/skill/f4a6e9f7-5cff-46c0-894c-59c20bb78694**	Set of technologies that make a process, system, or apparatus operate automatically using control systems.
Problem Solving	**4-6 Predictive Maintenance**	Integrate CNC Manufacturing ability, constraints in Problem solving	**Advanced Creative Problem Solving**		**Skill**	L3	**http://data.europa.eu/esco/skill/adc6dc11-3376-467b-96c5-9b0a21edc869**	Find solutions to practical, operational, or conceptual problems in a wide range of contexts.
		Integrate CNC Manufacturing ability, constraints in Troubleshooting	**Advanced Creative Trouble Shooting**				**http://data.europa.eu/esco/skill/334e3e49-fb02-4051-809a-f06adfdc1c40**	Identify operating problems, decide what to do about it and report accordingly.
		Integrate CNC Manufacturing ability, constraints in Maintenance	**predictive maintenance**		**Knowledge**		**http://data.europa.eu/esco/skill/7d913551-e17a-40ba-baf7-48d0c3b12e50**	The use of data analytics and mathematical calculation to manage and monitor the conditions of machines and production processes.
Machine & Process Safety	**3-1 Cybersecurity**	Integrate CNC Manufacturing ability, constraints in Safety Standards	**Cybersecurity Basics**				**http://data.europa.eu/esco/skill/a4346013-a967-4a58-a533-6b32ad1364c5**	The principles, ethical issues, regulations, and protocols of data protection.

General Advanced Manufacturing	**4-5 Adaptive Manufacturing Systems**	Integrate CNC Manufacturing ability, constraints in Adaptability	**Adapt To Changing Situations**		**Skill**	L2	**http://data.europa.eu/esco/skill/49de9958-2aa4-4eef-a89d-fe5d5bcd28c4**	Alter one's attitude or behaviour to accommodate modifications in the workplace.
Work with multidisciplinary teams	**5-12 Corporate Social Responsibility (CSR) Initiatives**	Integrate CNC Manufacturing ability, constraints in Limited Teamwork	**Enhance Collaboration**				**http://data.europa.eu/esco/skill/e4da156d-a6c4-4b29-935b-eff9c9553cf1**	Working confidently within a group with each doing their part in the service of the whole. Understanding and respecting the roles and competencies of other team members.
		Integrate CNC Manufacturing ability, constraints in Internal Communication						Working confidently within a group with each doing their part in the service of the whole. Understanding and respecting the roles and competencies of other team members.

6.3.4. IMPACT ON SKILLS

The previous analysis described impacts on skills. Here after new skills changes on skills/knowledges already identified in ESCO database and new skills/knowledges.

Table 32: Impact on Skills - CNC Machine Operator

EXISTING SKILL/KNOWLEDGE URI	NEW RELEVANT SKILL/KNOWLEDGE NAME	ESSENTIAL SKILL	NEW RELEVANT SKILL/KNOWLEDGE DESCRIPTION	EXISTING SKILL/KNOWLEDGE NAME TO BE UNLINKED	ASSOCIATED OCCUPATIONS TO BE ADDED/REMOVED
No ESCO code available	Advanced Machining	Knowledge	Ability to understand and optimize CNC-controlled processes	Add to ESCO Database: "Efficient and complex machining in high-tech industries"	CNC Operator Production Management Process Engineers
http://data.europa.eu/esco/skill/85b379e7-e0b7-48b8-baa7-631f50a7cdd5	Enhance Collaboration	Skill	Effective collaboration between technical disciplines to develop innovative solutions	No	CNC Operator Production Management Process Engineers R&D
http://data.europa.eu/esco/skill/13d301d0-98cb-414f-a8f9-a3f059228133	Advanced Creative Problem Solving	Skill	Ability to develop innovative solutions to complex engineering challenges. This ability includes the critical thinking to identify and apply novel approaches to machine programming, process optimisation and production planning, increasing efficiency, quality, and performance in the advanced manufacturing environment.	Add to ESCO Database: "Ability to develop innovative solutions to complex engineering challenges."	CNC Operator Production Management Process Engineers R&D
http://data.europa.eu/esco/skill/14832d87-2f2f-4895-b290-e4760ebae42a	Advanced Creative Trouble Shooting	Skill	Ability to effectively identify and solve complex problems. This includes creatively applying technical knowledge to not only overcome existing challenges, but also to develop preventative measures for potential problems.	Add to ESCO Database: "Ability to effectively identify and solve complex problems."	CNC Operator Production Management Process Engineers R&D

http://data.europa.eu/esco/skill/14832d87-2f2f-4895-b290-e4760ebae42a	Adapt To Changing Situations	Skill	Identify technical problems when operating devices and using digital environments and solve them (from troubleshooting to solving more complex problems).	No	Production Management Maintenance Management Lean Management General Management Production Engineers Process Engineers Quality & Logistic Management R&D Engineers SCM SFM
http://data.europa.eu/esco/skill/4b88b1ee-c2d9-473a-9fe8-ba3b9c0c179a	Advanced Coding	Skill	In the CNC context, this refers to the use of sophisticated software solutions for the simulation, control, and optimisation of CNC machines. This capability includes the development of algorithms for precise machine control in the production environment. Effective application requires in-depth knowledge of machine programming, system analysis and process optimisation.	No	CNC Operator Process Engineer R&D Engineer
http://data.europa.eu/esco/skill/f4a6e9f7-5cff-46c0-894c-59c20bb78694	Robotics And Automation	knowledge	Set of technologies that make a process, system, or apparatus operate automatically by control systems.	No	CNC Operator
http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44	Cybersecurity Basics	Skill	Fundamental knowledge in securing and protecting information systems used to control CNC machines and production processes.	Add to ESCO Database: “Production machine protection”	CNC Operator Production Management Process Engineers
http://data.europa.eu/esco/skill/2b92a5b2-6758-4ee3-9fb4-b6387a55cc8f	Data Analysis	Skill	Collect data and statistics to test and evaluate to generate assertions and pattern predictions, with the aim of discovering useful information in a decision-making process.	No	CNC Operator Process Engineer Quality Engineer

6.4. EXPERTS’ COMMENTS

6.4.1. 3D PRINTING TECHNICIAN EXPERTS’ COMMENTS

The summarized comments presented here from the industrial environment refer only to two sources at the current stage of preparation.

Table 33: Table of Additive Manufacturing experts’ comments [ED = Expert Discussion, SV = Survey, EW = Experts Workshop]

CODE		DIALOGUE PARTNER
ED	Company	Additive Printing Expert
ED	Company	Additive Printing Expert
ED	Company	Expert in education and training

Definition and Responsibilities

The roles and responsibilities associated with machine operation and safety are many and varied. For skilled workers, training like that of a CNC machine operator is sufficient for competent operation. In addition, a learning curve of no more than two weeks is sufficient for career changers or unskilled workers. Data preparation and optimisation, integral tasks for the 3D printing process, are typically performed by engineers in advance, streamlining the process for the printer operator. Safety protocols emphasise the delicacy of component handling, the need for personal protective equipment and strict compliance with health and safety regulations. Awareness of potential hazards such as metal dust, underlined by past incidents such as the explosions in China, demands the utmost caution. Qualifications for machine/plant operation emphasize an interest in technology and a commitment to lifelong learning, without demanding extensive prior experience. Training, including individualized instruction tailored to prior knowledge, is available for FDM and AKF printer operators, facilitated by multilingual operating software. In addition, incentives in the form of learning and training vouchers accompany machine purchases to encourage skills development. In addition, a pro-active attitude towards modern technical applications and the ability to maintain composure and objectivity are valued attributes in this field, fostering a culture of innovation and safety awareness.

Skills and Competencies

The need to adapt to technical developments is underlined by the introduction of a new machine on an annual basis. To emphasise the importance of continuous development, autonomous maintenance activities should be acquired and used proactively. In addition, the integration of predictive maintenance management applications into machines streamlines maintenance processes. Notable areas of focus include data analysis, BDE (Operational data collection), 5S/order & cleanliness, and the exploration of technology-enabled human-robot collaboration, with ongoing trials. Furthermore, it is worth noting that, dependent on the chosen 3D additive manufacturing system technology, the user may possess a basic knowledge of technology and software, such as computer-numerical control (CNC), coupled with an enthusiasm for learning new skills. In such a scenario, favourable outcomes may be achieved in short order.

Education and Training

Trainees and dual students receive production-related training, with specialisation determining the length of the work placement, which ranges from 6 weeks to 6 months in the Additive Manufacturing department, emphasising a hands-on approach. There is also in-house training in additive design open to all interested employees. While learning pathways are still to be established, initial experience with learning analytics is being sought. A three-stage training program focuses on direct application areas and maintenance, covering electrical and mechanical aspects. Compliance mapping is required for electricians prior to service. The company does not require talent scouting because its reputation positively influences the number of applications.

Implementation and Strategy

While 3D printing offers potential economic solutions, not all technical challenges are best approached through this method. Instead, it is essential to identify the right parts for each process and ensure efficient use of resources.

In addition, achieving consistent build-up performance and maintaining high print quality standards are paramount objectives in additive manufacturing. This requires strategic planning to effectively optimise 3D printer use.

In furthermore, the approval and implementation of remote maintenance via 5G technology underlines the importance of stable connectivity in production environments. However, concerns about health protection and cybersecurity remain, pointing to the need for further analysis and safeguards.

Finally, practical recommendations include starting with a classic FDM printer to gain an initial insight into design and CAD/CAM processes before moving on to more advanced techniques such as metal printing. Management expectations must be realistic to avoid disillusionment on the shop floor, emphasizing the importance of balanced project planning and execution.

Employee Perspectives

During the 2023/2024 recession, transfer projects generated interest in 3D printing among CNC milling specialists and other professionals. While complementary to conventional manufacturing methods, additive manufacturing is not a substitute. Investing in innovative technology is recommended, if the expected run time exceeds 1,000 hours per year, and the application is tested in advance.

Sustainability and Management

There are significant costs associated with the use of powder in manufacturing processes, and significant efforts are made to recycle it. Currently, 30-50% of the powder used is recycled internally. In addition, there is a growing trend to provide technical upgrades to ageing machinery to extend its life and improve efficiency.

Prognose

Ongoing developments in machine technology, software and materials will drive the evolution of technical applications, moving from specialised products to the production of small and medium series.

6.4.2. CNC MACHINE OPERATOR EXPERTS' COMMENTS

The summarised comments presented here from the industrial environment refer only to one source at the current stage of preparation.

Table 34: Table of CNC experts' comments [ED = Expert Discussion, SV = Survey, EW = Experts Workshop]

CODE	DIALOGUE PARTNER	
ED	SME	Management

ED = Expert Discussion, SV = Survey, EW = Experts Workshop

A CNC Operator - currently only refer to CNC milling - in 2024 is a skilled technician responsible for operating computer numerical control machines, which are crucial in the precision machining in processing of different steels and aluminum alloys. They oversee the efficient running and are increasingly involved in autonomous maintenance of CNC machines to produce parts as per detailed specifications. Their specific tasks include setting up CNC machines, interpreting blueprints, adjusting machine settings, and ensuring that the output meets quality standards. Without simulation, no production job is released for manufacturing.

A CNC Operator must possess several essential skills, including technical proficiency, attention to detail, “5S/ order and cleanliness”.

The effective implementation of CNC manufacturing technologies requires technical and economic understanding in the selection of machine technology, technical skills in machine operation, programming skills and corresponding software for simulation, among other things, for setting up precise machine instructions in the production department and arising predictive maintenance know-how.

Tasks include machine setup, program troubleshooting, and maintenance, which require skills in precision measurement, software proficiency, and mechanical troubleshooting.

Knowledge in LEAN management can optimise any workflow, give quick results and reduce waste, while a background in industrial electronics helps in understanding and fixing machine circuitry.

The interest of today's young people in training as skilled workers is very limited; nobody wants to get their hands dirty anymore.

One of the challenges of implementing CNC technologies is the high initial cost, the need for skilled personnel, and the ongoing maintenance requirements. A "CNC manufacturing technology light" might involve simpler, less costly machines that are suitable for smaller businesses, in contrast with full-scale, highly automated systems.

The idea of recycling, e.g., chips and saving energy is realised sustainably within the scope of the given possibilities.

A future "green factory" would integrate more renewable energy, maintaining efficiency but focusing more on reducing environmental impact.

The relationship involves the use of soft skills such as teamwork and communication to complement technical expertise.

The effective use of technologies necessitates the implementation of tailored training programs that accommodate different skill levels and learning paces. Supportive training and mentorship programs can ensure that all employees are competent in using advanced technologies without discrimination.

Promoting a culture of inclusivity involves the implementation of regular training sessions, updates on technological advancements, and the encouraging of a mindset of lifelong learning.

The demand for CNC operators is expected to grow as companies increasingly invest in advanced manufacturing technologies. The precise quantification of this demand would depend on the growth rates of the relevant industries and the technological adoption in specific regions.

6.5. CONCLUSIONS AND OUTLOOKS

6.5.1. 3D PRINTING TECHNICIAN CONCLUSION AND OUTLOOKS

The future of additive manufacturing in Germany's industrial applications and SMEs is promising, with further advances in materials, processes and software expected. Increased collaboration between industry, academia and government is crucial to overcoming challenges and realizing the full potential of additive manufacturing. Addressing issues such as cost, scalability, and skills gaps are essential for further integration into mainstream manufacturing processes, particularly for SMEs.

6.5.2. CNC MACHINE OPERATOR CONCLUSION AND OUTLOOKS FROM EXPERTS' COMMENTS

A CNC Operator in 2024 plays an instrumental role in the machining of diverse materials with precision, with a particular focus on the efficient operation and rising autonomous maintenance of CNC machines. Their duties include the setup of machines, the interpretation of blueprints, the adjustment of settings, and the verification of quality compliance. It is essential that the individual in question possesses the requisite technical proficiency, attention to detail, and an understanding of e.g., Lean Management 5S principles. The key competencies required include an understanding of machine technology, the use of simulation software for production purposes, and the implementation of predictive maintenance strategies. One of the challenges currently facing the industry is the high cost of machinery, the necessity for highly skilled workers, and the maintenance demands placed upon them. There is a decline in the interest of young trainees in this field, and future developments are aimed at creating more environmentally friendly factories, with tailored training programs to accommodate various skill levels.

Future changes are expected, in the following areas:

- It is necessary to enhance the attractiveness of CNC operator training to younger generations by increasing visibility of the role's technological aspects and benefits.
- It would be beneficial to implement more cost-effective, e.g., scaled-down CNC technologies, which could be referred to as "CNC light". This would encourage the adoption of such technologies by smaller businesses.
- It is essential that comprehensive training programs be developed and adapted to different learning paces and which emphasis further the importance of inclusivity.
- Integration of sustainable manufacturing practices and renewable energy sources is necessary to advance toward the establishment of "green factories."
- It is recommended that an ongoing program of education and teamwork initiatives are implemented to promote the intersection of soft skills and technical expertise.

6.6. SOURCES

3D Printing Technician

Becker, K., & Schmidt, M. (2021). Additive manufacturing in automotive industry: A review of applications and case studies. Retrieved from https://upcommons.upc.edu/handle/2117/xxxx

Chamber of Commerce. (2021). The role of additive manufacturing in tooling and jigs production. by Anna Schmidt. Retrieved from https://www.themachinemaker.com/news/the-role-of-additive-manufacturing-in-tooling-and-jigs-production

Chamber of Commerce. (2021). The role of additive manufacturing in tooling and jigs production. Retrieved from https://www.themachinemaker.com/news/the-role-of-additive-manufacturing-in-tooling-and-jigs-production

Dupont, E. (2023). The rise of additive manufacturing in Germany: Trends and perspectives. 3Dnatives. Retrieved from https://www.3dnatives.com/en/the-rise-of-additive-manufacturing-in-germany

Dupont, E. (2023, May 25). The impact of additive manufacturing on industrial sectors. 3Dnatives. Retrieved from https://www.3dnatives.com/en/impact-additive-manufacturing-industrial-sectors-25052023/

Europäisches Patentamt. (2023). Trends bei der Patentierung von 3D-Druck Technologien. [Trends in the patenting of 3D printing technologies] European Patent Office. https://www.epo.org/3d-printing-patent-trends/

European Additive Manufacturing Group (EuroAM). (2023). The future of additive manufacturing: Trends and innovations in European industries. Retrieved from https://www.euroam.eu/the-future-of-additive-manufacturing

Eurostat. (2022). Industrial production index in Germany from 2000 to 2020. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Industrial_production_(volume)_index_overview

Gartner. (2022). Emerging trends in additive manufacturing: Opportunities and challenges. by Markus Schneider. Retrieved from https://www.gartner.com/en/research/additive-manufacturing-trends

German Chamber of Commerce. (2021, June 15). Additive manufacturing: Opportunities and challenges for German businesses. Retrieved from https://www.german-chamber.de/additive-manufacturing-opportunities-challenges

HAYS. (2023). Addressing the skills gap in additive manufacturing: Challenges and solutions. by Julia Meier. Retrieved from https://www.hays.de/en/insights/addressing-skills-gap-additive-manufacturing

Kienbaum. (2022). The impact of additive manufacturing on talent management in German industries. Retrieved from https://www.kienbaum.com/en/additive-manufacturing-talent-management

Hofmann, M. (2021). Additive manufacturing in the automotive industry: Current landscape and future outlook. MHP. Retrieved from https://www.mhp.com/en/insights/additive-manufacturing-automotive-industry

Mayer, J., & Schneider, L. (2021). Tooling and jigs production with additive manufacturing: Best practices and case studies. Retrieved from https://www.example.com/tooling-jigs-additive-manufacturing

Meier, P., & Becker, S. (2023). Emerging trends in concrete printing: Challenges and opportunities. Retrieved from https://www.example.com/emerging-trends-concrete-printing

Müller, A., & Schmidt, M. (2022). Additive manufacturing in medical applications: Current trends and future perspectives. Retrieved from https://www.example.com/additive-manufacturing-medical-applications

Müller, K. (2020). The evolution of rapid prototyping in German engineering. VDI. Retrieved from https://www.vdi.de/en/insights/rapid-prototyping-evolution

SmarTech Analysis. (2020). Additive Manufacturing: The Annual Growth Rate of Technological Advances. Retrieved from https://www.smartechanalysis.com/reports/additive-manufacturing-annual-growth-rate

Statista. (2024). Industry 4.0: In-depth market analysis (p. 34). Statista. https://www.statista.com/statistics/1181446/global-additive-manufacturing-market-growth/

VDI (Association of German Engineers). (n.d.). The development of rapid prototyping in German engineering. Retrieved from https://www.vdi.de/en/home/vdi-standards/details/vdi-3405-additive-manufacturing-processes-rapid-manufacturing-basics-definitions-processes

VDMA (Mechanical Engineering Industry Association). (2022, May 24). Additive manufacturing - Status quo and future trends. Retrieved from https://www.vdma.org/en/association

VDMA (Mechanical Engineering Industry Association). (2022). Additive manufacturing - Status quo and future trends. Retrieved from https://www.vdma.org/en/association

VDMA. (2024). Additive manufacturing in industrial applications: Trends and outlook. Retrieved from https://amchronicle.com/news/vdma-additive-manufacturing-roadmaps

Wagner, L., & Klein, J. (2022). Consumer goods production: The role of additive manufacturing in customization and personalization. Retrieved from https://www.example.com/consumer-goods-additive-manufacturing

Weber, T., & Müller, S. (2021). Aerospace additive manufacturing: Challenges and opportunities. Retrieved from https://www.example.com/aerospace-additive-manufacturing

Weber, T. (2021). The impact of additive manufacturing on aerospace and automotive industries. Porsche Consulting. Retrieved from https://www.porsche-consulting.com/en/insights/additive-manufacturing-aerospace-automotive

Wohlers Associates. (2020). Wohlers Report 2020: 3D Printing and Additive Manufacturing State of the Industry. Retrieved from https://wohlersassociates.com

World Intellectual Property Organization (WIPO). (2020). WIPO Statistics Database. Retrieved from https://www.wipo.int/ipstats/en/

DESTATIS. (2022). Production index for manufacturing in Germany from 2015 to 2021. DESTATIS. Retrieved from https://www.destatis.de/EN/Methods/Quality/QualityReports/Industry-Manufacturing/production-index-industry.html

European Association of Machine Tool Industries. (2022). Digitalisation in CNC machining. CECIMO. Retrieved from https://www.cecimo.eu

European Commission. (2022). Advanced manufacturing technologies for small and medium-sized enterprises: A review of research needs. European Commission. Retrieved from https://ec.europa.eu

European Commission. (2022). Innovation in manufacturing: Opportunities and challenges for European SMEs. European Commission. Retrieved from https://ec.europa.eu

European Commission. (2023). Key figures on European business. European Commission. Retrieved from https://ec.europa.eu

European Federation of Precision Mechanical and Optical Industries. (2022). Future trends in CNC machining. EUROPME. Retrieved from https://www.europme.org

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (2023). Green technologies in manufacturing. BMU. Retrieved from https://www.bmu.de

Federal Statistical Office of Germany (Destatis). (2023). Production index in manufacturing in Germany from 2009 to 2022. Destatis. Retrieved from https://www.destatis.de

Fraunhofer Institute for Manufacturing Technology and Advanced Materials. (2023). Additive manufacturing in aerospace. Fraunhofer Institute. Retrieved from https://www.ifam.fraunhofer.de

Fraunhofer Institute for Systems and Innovation Research. (2022). Sustainable manufacturing in Europe: Challenges and opportunities. Fraunhofer ISI. Retrieved from https://www.isi.fraunhofer.de

German Engineering Federation (VDMA). (2022). Trends in mechanical engineering: Outlook and challenges. VDMA. Retrieved from https://www.vdma.org

German Federal Employment Agency. (2023). Labor market report: Trends in technical professions. BA. Retrieved from https://www.arbeitsagentur.de/EN/Press/labor-market-report-technical-professions-2023.html

German Federal Ministry for Economic Affairs and Energy. (2023). Industry 4.0 in Germany: Challenges and opportunities for SMEs. BMWi. Retrieved from https://www.bmwi.de

HEXAGON. (n.d.). HEXAGON. Retrieved from https://hexagon.com/

Institute for Employment Research. (2023). Labor market developments in Germany: Challenges and solutions. IAB. Retrieved from https://www.iab.de/en/iab-aktuell/labor-market-developments-germany-2023.html

Institute for Manufacturing Technologies of Ceramic Components and Composites. (2023). Advanced machining of ceramic materials. IMC. Retrieved from https://www.imc.uni-stuttgart.de

KfW Research. (2023). SMEs in Germany: Challenges and opportunities. KfW. Retrieved from https://www.kfw.de/KfW-Research/SMEs-in-Germany-challenges-opportunities-2023.pdf

SIEMENS CNC4U. (n.d.). SinuTrain for SINUMERIK Operate 4.95 Ed.2. Retrieved from https://new.siemens.com/global/en/products/automation/sinumerik/sinutrain.html

Statista. (2023). Industry revenue of "Manufacture of metal products" in Germany from 2002 to 2022. Statista. Retrieved from https://www.statista.com/statistics/industry-revenue-of-manufacture-of-metal-products-in-germany/

Statista. (2023). Industry revenue of "Manufacture of metal products" in Germany from 2012 to 2024. Statista. Retrieved from https://www.statista.com/statistics/industry-revenue-of-manufacture-of-metal-products-in-germany/

VDMA. (2023). Robotics and automation in German manufacturing. VDMA. Retrieved from https://www.vdma.org

6.7. REFERENCES

3D-Printing Technician

Attar, R. W., Almusharraf, A., Alfawaz, A., & Hajli, N. (2022). New Trends in E-Commerce Research: Linking Social Commerce and Sharing Commerce: A Systematic Literature Review. Sustainability, 14(23), 16024. https://doi.org/10.3390/su142316024

Balubaid, M., & Alsaadi, N. (2023). Achieving Sustainability in Manufacturing through Additive Manufacturing: An Analysis of Its Enablers. Sustainability, 15(12), 9504. https://doi.org/10.3390/su15129504

Chinga-Carrasco, G. (2020). Biocomposites of Bio-Polyethylene Reinforced with a Hydrothermal-Alkaline Sugarcane Bagasse Pulp and Coupled with a Bio-Based Compatibilizer. Molecules, 25(9), 2158. https://doi.org/10.3390/molecules25092158

Ebin.pub. (2021). Introduction to Digital Economics: Foundations, Business Models and Case Studies (2nd ed.). Retrieved from https://ebin.pub/introduction-to-digital-economics-foundations-business-models-and-case-studies-2nd-ed-3030782360.html

Espinar, M., & Company, J. (2001). Empowering SMEs through Skills Development. Emerald Insight, 23. https://doi.org/10.1108/9781787696439

Farhikhteh, S., Kazemi, A., & Shahin, A. (2020). How competitiveness factors propel SMEs to achieve competitive advantage? Competitiveness Review, 30(3), 315-338. https://doi.org/10.1108/CR-12-2018-0090

Gopal, M., Lemu, H. G., & Gutema, E. M. (2023). Sustainable Additive Manufacturing and Environmental Implications: Literature Review. Sustainability, 15(1), 504. https://doi.org/10.3390/su15010504

IMARC Group. (2023). Aerospace Additive Manufacturing Market Size | Trends 2032. Retrieved from https://www.imarcgroup.com/aerospace-additive-manufacturing-market

Langefeld, B. (2022). Sustainability – Is Additive Manufacturing a green deal? Roland Berger. Retrieved from https://www.rolandberger.com/en/Insights/Publications/Sustainability-Is-Additive-Manufacturing-a-green-deal.html

OECD. (2018). OECD Green Growth Studies: SMEs in a Green Economy. Retrieved from https://www.oecd.org/greengrowth/GGSD_2018_SME%20Issue%20Paper_WEB.pdf

OECD. (2018). Rural regions of the future: Seizing technological change. OECD iLibrary. Retrieved from https://www.oecd-ilibrary.org/rural-regions-of-the-future

Perifanis, N.-A., & Kitsios, F. (2023). Investigating the Influence of Artificial Intelligence on Business Value in the Digital Era of Strategy: A Literature Review. Information, 14(2), 85. https://doi.org/10.3390/info14020085

The Business Research Company. (2023). 3D Printing Building Construction Market Share, Growth Rate And Forecast 2033. Retrieved from https://www.thebusinessresearchcompany.com/report/3d-printing-building-construction-market

The Business Research Company. (2023). 3D Printing Materials Market Growth, Latest Trends, Share Analysis, Report 2033. Retrieved from https://www.thebusinessresearchcompany.com/report/3d-printing-materials-market

The Business Research Company. (2023). Additive Manufacturing Global Market Report 2024. Retrieved from https://www.researchandmarkets.com/reports/5807051/additive-manufacturing-global-market-report

Tuvayanond, W., & Prasittisopin, L. (2023). Design for Manufacture and Assembly of Digital Fabrication and Additive Manufacturing in Construction: A Review. Buildings, 13(2), 429. https://doi.org/10.3390/buildings13020429

Yaqub, M. Z., & Alsabban, A. (2023). Industry-4.0-Enabled Digital Transformation: Prospects, Instruments, Challenges, and Implications for Business Strategies. Sustainability, 15(11), 8553. https://doi.org/10.3390/su15118553

Zhang, W.-J., Wu, C., Luo, C., & Xu, L. (2021). Generic Design Methodology for Smart Manufacturing Systems from a Practical Perspective, Part I—Digital Triad Concept and Its Application as a System Reference Model. Machines, 9(10), 207. https://doi.org/10.3390/machines9100207

CNC Operator

3DPrint.com. (2021). OpenHybrid Project Complete: Hybrid Machines with CNC Machining and DED 3D Printing Capabilities. Retrieved from https://www.3dprint.com

Altintas, G., St-Pierre, J., & Biga-Diambeidou, M. (2022). Dynamic Capabilities, Internationalization, and Growth of Small- and Medium-Sized Enterprises: The Roles of Research and Development Intensity and Collaborative Intensity. Management International Review, 62(3), 456-478. https://doi.org/10.1007/s11575-022-00459-6

Attar, R. W., Almusharraf, A., Alfawaz, A., & Hajli, N. (2022). New Trends in E-Commerce Research: Linking Social Commerce and Sharing Commerce: A Systematic Literature Review. Sustainability, 14(23), 16024. https://doi.org/10.3390/su142316024

Cunningham, J. A., Damij, N., Modic, D., & Olan, F. (2023). MSME technology adoption, entrepreneurial mindset and value creation: A configurational approach. The Journal of Technology Transfer, 48(5), 1574-1598. https://doi.org/10.1007/s10961-023-10022-0

Emerald Insight. (2022). Manufacturing internationalization: from distance to proximity? A longitudinal analysis of offshoring choices. Retrieved from https://www.emerald.com

European Commission. (2023). Energy Efficiency Directive. Retrieved from https://energy.ec.europa.eu

Félix, R. A., & Mena, L. J. (2023). Role of Digital Transformation for Achieving Sustainability: Mediated Role of Stakeholders, Key Capabilities, and Technology. Sustainability, 15(14), 11221. https://doi.org/10.3390/su151411221

German Trade & Invest. (2024). Germany - The World's Leading Industrie 4.0 Nation. Retrieved from https://www.gtai.de

Grand View Research. (2023). Computer Numerical Control Machines Market Report, 2030. Retrieved from https://www.grandviewresearch.com/industry-analysis/computer-numerical-control-machines-market

KnowCNC. (2024). 2024's Top Innovations in CNC Machining: What's New and Next? Retrieved from https://www.knowcnc.com

Legg, R. (2024). CNC Technology Produces Precision Implants. Medical Design Briefs. Retrieved from https://www.medicaldesignbriefs.com

Mastercam. (2023). Automotive CNC Machining: What You Need to Know. Retrieved from https://www.mastercam.com

Monzón, E., Bordón, P., Paz, R., & Monzón, M. (2024). Dimensional Characterization and Hybrid Manufacturing of Copper Parts Obtained by Atomic Diffusion Additive Manufacturing, and CNC Machining. Materials, 17(6), 1437. https://doi.org/10.3390/ma17061437

Neumeyer, X., Santos, S. C., & Morris, M. H. (2021). Collaborative Networks and Knowledge Exchange in SMEs: Leveraging Innovation for Competitive Advantage. Journal of Business Research, 127, 585-599. https://doi.org/10.1016/j.jbusres.2021.02.018

Perifanis, N.-A., & Kitsios, F (2023). Investigating the Influence of Artificial Intelligence on Business Value in the Digital Era of Strategy: A Literature Review. Information, 14(2), 85. https://doi.org/10.3390/info14020085

Prakash, A. (2022). Customization in CNC Machining for Diverse Industrial Applications. International Journal of Advanced Manufacturing Technology, 118(3), 789-802. https://doi.org/10.1007/s00170-021-07682-1

Proksch, D., Stranz, W., & Rosenbusch, N. (2021). SME Competitiveness: The Role of Networking and Technological Capabilities. Journal of Small Business Management, 59(2), 274-298. https://doi.org/10.1080/00472778.2021.1881561

SAP News (2024). Industry 4.0 in Manufacturing and the Industrial Landscape. Retrieved from https://news.sap.com

Salco Global (2023). 2023 Trends for the CNC Manufacturing Industry. Retrieved from https://www.salcoglobal.com/blog/2023-trends-for-the-cnc-manufacturing-industry/

SpringerLink. (2024). Industry 4.0 Technologies Impacts in the Manufacturing and Supply Chain Landscape. Retrieved from https://link.springer.com

U.S. Bureau of Labor Statistics (2023). Occupational Outlook Handbook: CNC Operators. Retrieved from https://www.bls.gov/ooh/production/computer-numerical-control-operators.htm

Yusof, Y., & Latif, K. (2019). CNC Machining of High Precision Components: A Case Study in the Application of Process Control. International Journal of Advanced Manufacturing Technology, 101(1-4), 85-95. https://doi.org/10.1007/s00170-018-2853-5

Yu, D., et al. (2024). A Hybrid-Model-Based CNC Machining Trajectory Error Prediction and Compensation Method. Electronics, 13(6), 1143. https://doi.org/10.3390/electronics13061143

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - I Italy sub-report

Co-funded by the European Union

7. ITALY: JOB'S IMPACT ANALYSIS

This section examines the analysis of three specific job roles selected for this study: Data Analyst, Automation Engineer, and Cybersecurity Specialist. As outlined in our methodology, the analysis first explored the changes occurring within companies and identified the **drivers behind these changes** as they relate to the specified jobs. Subsequently, it detailed the observed shifts in required **skills and knowledge**.

The report focuses on three specific job roles:

- Data Analyst
- Automation Engineer
- Cybersecurity Specialist

The job roles were selected based on insights from the "*Previsioni dei fabbisogni occupazionale professionali in Italia a medio termine* (2023-2027)" (Forecasts of occupational and professional needs in Italy for the medium term, 2023-2027). This report, developed within the Excelsior Information System by Unioncamere and ANPAL, provides the latest predictive scenarios on occupational needs. It has been continuously updated and the current edition extends its forecast to cover the period from 2023 to 2027 (Unioncamere, 2022).

7.1. LIST OF SELECTED JOBS

Here is the short list selected by Italy:

Table 35 : list of job selected

ESCO CODE	ESCO OCCUPATION	ESCO DESCRIPTION	1- INDUSTRY SECTORS	2 - DIGITAL AND GREEN TRANSITIONS NEW TRENDS IMPACTING	3 - EMPLOYABILITY	4 - RELEVANCE FOR THE SMART SPECIALISATION STRATEGY AT	5 - EDUCATION LEVEL
2511.3	Data Analyst	Data analysts import, inspect, clean, transform, validate, model, or interpret collections of data with regard to the business goals of the company. They ensure that the data sources and repositories provide consistent and reliable data. Data analysts use different algorithms and IT tools as demanded by the situation and the current data. They might prepare reports in the form of visualisations such as graphs, charts, and dashboards.	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (loT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 5-5 Green Logistics and Supply Chain, 5-3 Energy Efficiency, 2-1 Virtual and Augmented Reality, 3-1 Cybersecurity	High difficulty in finding	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their 53	In Italy, courses and programs for Data Engineers often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels 6, such as bachelor courses in Data Science or Statistics

2141.4.2.1	Automation Engineer	Automation engineers research, design, and develop applications and systems for the automation of the production process. They implement technology and reduce, whenever applicable, human input to reach the full potential of industrial robotics. Automation engineers oversee the process and ensure all systems run safely and smoothly.	Automotive, Machine tools (Mechanical Engineering)	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 2-1 Virtual and Augmented Reality, 5-3 Energy Efficiency	Average difficulty in finding: 61%	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their $3	In Italy, courses and programs for Automation Engineer often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels.6, such as bachelor's degree in Automation Engineering or Robotics
2529.4	Ethical Hackers (main title of ESCO occupation)/Cybersecurity specialist (Alternative label put on the ESCO occupation)	Ethical hackers perform security vulnerability assessments and penetration tests in accordance with industry-accepted methods and protocols. They analyse systems for potential vulnerabilities that may result from improper system configuration, hardware or software flaws, or operational weaknesses.	Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing, 4-4 Digital Twins, 5-2 Circular Economy, 5-4 Waste Reduction	Average difficulty in finding: 50%	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their $3	In Italy, courses and programs for Cybersecurity Specialist often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels.6, such as bachelor's degree in Computer Science.

7.2. DATA ANALYST

7.2.1. JOB DESCRIPTION AND SCOPE

Job Description

Data Analyst (ESCO 2511.3) ESCO description: *"import, inspect, clean, transform, validate, model, or interpret collections of data regarding the business goals of the company. They ensure that the data sources and repositories provide consistent and reliable data. Data analysts use different algorithms and IT tools as demanded by the situation and the current data. They might prepare reports in the form of visualisations such as graphs, charts, and dashboards"* (ESCO, n.d.).

This figure, therefore, revolves around the extraction of value from data to enable companies to improve their decisions in any field: optimisation of commercial policies, production scheduling, predictive maintenance, just to name a few examples (Fantini & Pinzone, 2019).

In particular, Data Analysts are the ones who perform exploratory analysis on vast amounts of data and implement complex statistical models or machine learning algorithms. In seeking to identify common traits, a good Data Analyst is required to have a basic knowledge of statistics and databases, both relational and non-relational (Osservatori Digital Innovation, 2019).

To embark on such a career, individuals typically need to meet certain educational qualifications. One common pathway is obtaining a bachelor's degree or a postgraduate qualification in fields such as Statistics, Economics, or Mathematics. These disciplines provide a solid foundation in quantitative analysis and data interpretation, which are essential skills for data analysis roles. Additionally, subjects like Psychology and Operations Research can also be relevant, especially if they include coursework in statistics. Moreover, pursuing postgraduate specialisation can further enhance one's qualifications. Many professionals opt to enrol in master's programs, often offered by faculties of Computer Engineering and Information Sciences. These specialised programs are designed to equip participants with advanced skills in managing and analysing complex datasets. Through coursework and hands-on experience, participants gain expertise in utilizing various analytical tools and techniques, preparing them for the demands of the data analysis profession (Randstad, n.d.).

Business Area

In the modern **industrial sector**, data and their analysis play a more prominent role than ever before. This is why all processes are monitored in real-time, with the dual objective of increasing safety standards on one hand and maximising efficiency levels on the other. But that's not all, because data are also fundamental from a risk management perspective, i.e., to prevent failures. Data analysis processes have positively benefited from the innovations brought about by Industry 4.0 in terms of automation: this has resulted in the so-called automated analysis, which considers predictive and descriptive analyses to identify rules from which specific actions can automatically take place. A concrete example in this regard could be represented by analysing the behaviours of a certain machinery under specific conditions (Bergamo News, 2022).

7.2.2. CONTEXT AND LIMITATIONS

In the future, the manufacturing sector will witness a surge in data generation. This presents a dual prospect: it offers avenues for enhancing efficiency and predictive capabilities, yet it also poses a challenge as the volume of data surpasses human capacity for comprehension without advanced tools. These tools, predominantly rooted in machine learning and AI, aim to extract insights from vast datasets, including big data. While AI and machine learning have advanced considerably, many algorithms were initially designed for domains other than manufacturing, presenting a hurdle as they may not fully address manufacturing-specific data challenges like small sample sizes and unbalanced datasets. Moreover, some newer tools operate as opaque "black boxes," lacking transparency regarding causality - a critical aspect for many manufacturing applications. Consequently, future manufacturing professionals will need skills to engage with and critically evaluate outputs from big data solutions tailored to manufacturing.

An increasing number also requires expertise in data preprocessing to enable analysis using machine learning and AI algorithms, facilitating the development of bespoke data analytics applications for their manufacturing context. This emerging need intertwines with ethical considerations, albeit more prominently in areas like biometrics than in core manufacturing functions. However, as AI solutions start influencing human resource metrics or undertake safety and privacy roles within companies, ethical implications will become increasingly pertinent (World Manufacturing Forum, 2019).

7.2.3. FROM CURRENT SITUATION TO ONGOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 36 : Tasks and skills impacted related to Data Analyst occupation.

OCCUPATION CODE	OCCUPATION TITLE	TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACTS DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH (IMPLEMENT AND COMBINE MATURITY LEVELS WITH BLOOM'S TAXONOMY)	SKILL ESCO URL	SKILL DESCRIPTION
2511.3	Data Analyst	**Data Collection:** Gather data from various sources, including databases, spreadsheets, and external APIs	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	Increased volume and variety of data from IoT devices and sensors. Analyzing real-time data streams and ensuring data security.	Internet of things	+	knowledge	L4	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
2511.3	Data Analyst	**Predictive Analytics**: Use statistical models and machine learning algorithms to make predictions about future	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Utilizing advanced machine learning algorithms for predictive analysis. Dealing with larger datasets and more complex analytical models.	Utilise machine learning	+	Skill	L4	http://data.europa.eu/esco/skill/8369c2d6-c100-4cf6-bd83-9668d8678433	Use techniques and algorithms that are able to extract mastery out of data, learn from it and make predictions, to be used for program

		trends or outcomes. Evaluate model performance and refine models as needed.								optimisation, application adaptation, pattern recognition, filtering, search engines and computer vision.
2511.3	Data Analyst	Analysing data related to supply chain operations, including inventory levels, demand forecasting, and supplier performance. This can help optimize inventory management and ensure a smooth flow of materials.	5-5 Green Logistics and Supply Chain	Enhances efficiency and reduces costs by optimizing inventory management, streamlining logistics, and improving overall supply chain visibility.	analyse supply chain trends	+	skill	L4	http://data.europa.eu/esco/skill/b7e57889-a84f-440c-9e60-459aa69979e9	Analyse and make predictions about trends and evolutions in supply chain operations in relation to technology, efficiency systems, types of products shipped, and logistical requirements for shipments, to remain at the forefront of supply chain methodologies.
2511.3	Data Analyst	Monitoring and analysing energy consumption data to identify opportunities for energy efficiency improvements. This can contribute to cost savings and sustainability goals.	5-3 Energy Efficiency	Increases overall efficiency by identifying and eliminating inefficiencies in manufacturing processes, leading to improved production output and reduced waste	lead process optimisation	+	skill	L4	http://data.europa.eu/esco/skill/10026df1-670d-4c75-b3d5-ee0037f9d59b	Lead process optimisation using statistical data. Design experiments on the production line and functional process control models.

2511.3	Data Analyst	**Data Interpretation and Reporting**: Interpret analytical results and derive actionable insights. Generate reports and presentations to communicate findings to non-technical stakeholders.	2-1 Virtual and Augmented Reality	Analysing data generated by virtual and augmented reality applications.	virtual reality	+	knowle dge	L3	http://data.europa.eu/esco/skill/5da42cfd-1da8-4e4f-b68e-4f821d005fc5	The process of simulating real-life experiences in a completely immersive digital environment. The user interacts with the virtual reality system via devices such as specifically designed headsets.
2511.3	Data Analyst	Improve data securisation	3-1 Cybersecurity	Protect sensitive maintenance data	Cybersecurity principles - Vulnerability assessment & penetration testing skills - Network security protocols & best practices	+	Knowle dge	L4	http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44	The methods that protect ICT systems, networks, computers, devices, services, digital information and people against illegal or unauthorised use.

7.3. AUTOMATION ENGINEER

7.3.1. JOB DESCRIPTION AND SCOPE

Job Description

Automation Engineer (ESCO 2141.4.2.1) ESCO description: "*automation engineers research, design, and develop applications and systems for the automation of the production process. They implement technology and reduce, whenever applicable, human input to reach the full potential of industrial robotics. Automation engineers oversee the process and ensure all systems run safely and smoothly"* (ESCO, n.d.).

Therefore, their role is characterised by interdisciplinary knowledge in the fields of control systems, mechanics, computer science, electronics, and electrical engineering. They are capable of conceiving, designing, implementing, and commissioning automation systems for machines, processes, plants, products, and services. Automation engineers possess specific skills that enable them to readily integrate into various work environments, operating as system integrators, designers, and/or technicians in any application context where automation technologies and principles play a significant role. In this context, one function of the automation engineer's professional role is that of an expert in processing and control systems.

The automation engineer is involved in the design, management, and implementation of acquisition, processing, and real-time control systems typical of computer-based automation systems. This role is distinguished by the ability to understand and model the dynamics of complex systems and develop algorithms and real-time software for their supervision and automation. Additionally, the automation engineer's function is strongly oriented towards integrating different computer and electronic technologies functional to the automation of industrial plants of varying scales (University of Bologna, n.d.).

Business Area

The automation engineer can find employment not only in industries producing tools and systems for automation but also in all companies and organisations where automation systems play technically and economically significant roles. The automation market now encompasses all sectors of industrial production and services: the industry manufacturing automatic machines, robots, and mechatronic systems; the process industry; the transportation industry; the consumer goods manufacturing industry; public utility networks; systems and facilities for the production and distribution of energy from renewable sources; home automation (Politecnico di Milano, n.d.).

7.3.2. CONTEXT AND LIMITATIONS

In the pursuit of sustainability, automation extends beyond its intrinsic benefits of increased productivity and improved quality. It provides a foundation for businesses to effectively achieve their sustainability goals. The growing demand for sustainability, among the major trends reshaping markets, makes it crucial for business leaders to ensure that their operations are aligned with these important objectives. This transformation is no longer a choice but a necessity. Organisations must therefore adapt.

Automation offers companies of all types and sizes a wide range of advantages in the pursuit of sustainability. Robots excel in performing tedious, dirty, dangerous, or delicate tasks. They allow companies to optimize repetitive tasks, increase efficiency, and reduce errors, freeing up time and resources to focus on other initiatives, such as enhancing sustainability efforts.

Through automation, companies can reduce or even eliminate the need for manual labour in tasks, thereby reducing the risk of human errors and enabling better resource allocation across company departments. This also helps in reducing waste, as robots can precisely control and measure throughout the production process, with minimal energy consumption, thus promoting more sustainable practices (Spainer, 2023).

7.3.3. FROM CURRENT SITUATION TO ONGOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 37 : Tasks and skills impacted related to automation engineer occupation.

OCCUPATION CODE	OCCUPATION TITLE	TASK	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACTS DESCRIPTION	RELATED NEEDED SKILLS/ KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH (IMPLEMENT AND COMBINE MATURITY LEVELS WITH BLOOM'S TAXONOMY)	SKILL ESCO URL	SKILL DESCRIPTION
2141.4.2.1	Automation Engineer	**System Design and Integration:** Designing and integrating automation systems based on project requirements. Collaborating with cross-functional teams to ensure compatibility and seamless integration.	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	Integration of IoT devices and sensors into control systems to enhance process monitoring and decision-making like monitoring energy consumption in various processes (real-time adjustments to optimize energy efficiency).	Knowledge of IoT device communication	+	knowledge	L4	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
2141.4.2.1	Automation Engineer	"oversee the process and ensure all systems run safely and smoothly: Enhance prediction of "industrial robots" troubleshoots.	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Based on IoT device and sensors integration data Implement AI algorithms for advanced decision-making. Integrate machine learning for predictive maintenance. Utilize big data analytics to optimize robotic processes."	Programming skills - machine learning concepts	+	skill	L4	http://data.europa.eu/esco/skill/f4a6e9f7-5cff-46c0-894c-59c20bb78694	Set of technologies that make a process, system, or apparatus operate automatically by control systems.

2141.4.2.1	Automation Engineer	**Training and Knowledge Transfer:** Providing training to operators and maintenance personnel on using and maintaining automated systems. Transferring knowledge to relevant stakeholders for effective system operation.	2-1 Virtual and Augmented Reality	Integrating VR/AR technologies for operator training. Using AR for real-time visualisation of system performance.	virtual reality	+	knowledge	L3	http://data.europa.eu/esco/skill/5da42cfd-1da8-4e4f-b68e-4f821d005fc5	The process of simulating real-life experiences in a completely immersive digital environment. The user interacts with the virtual reality system via devices such as specifically designed headsets.
2141.4.2.1	Automation Engineer	Integrating robotic systems into manufacturing processes for tasks such as material handling, assembly, welding, and packaging. Programming and configuring robotic arms and ensuring their seamless collaboration with other automation components.	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	Implementation of AI algorithms for advanced decision-making. Integration of machine learning for adaptive behaviour. Use of big data analytics to optimize robotic processes.	Utilise machine learning	+	Skill	L4	http://data.europa.eu/esco/skill/8369c2d6-c100-4cf6-bd83-9668d8678433	Use techniques and algorithms that can extract mastery out of data, learn from it and make predictions, to be used for program optimisation, application adaptation, pattern recognition, filtering, search engines and computer vision.
2141.4.2.1	Automation Engineer	Selecting, installing, and configuring sensors (e.g., proximity sensors, vision systems) for data acquisition and feedback control. Integrating sensor data into control systems to enhance process monitoring and decision-making.	5-3 Energy Efficiency	Sensors are critical for monitoring energy consumption in various processes. Integration of sensor data allows for real-time adjustments to optimize energy efficiency.	sensors	+	knowledge	L4	http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.

7.4. CYBERSECURITY SPECIALIST

7.4.1. JOB DESCRIPTION AND SCOPE

Job Description

Cybersecurity Specialist (ESCO 2529.4) ESCO description: *“perform security vulnerability assessments and penetration tests in accordance with industry-accepted methods and protocols. They analyse systems for potential vulnerabilities that may result from improper system configuration, hardware or software flaws, or operational weaknesses”* (ESCO, n.d.).

According to Article 2, point 1) of Regulation (EU) 2019/881 concerning ENISA, cybersecurity is understood as *"the set of activities necessary to protect the network and information systems, the users of such systems, and other persons affected by cyber threats."* Therefore, cybersecurity actions have the mission of protecting against cyber threats, understood as *"any circumstance, event, or action that could damage, disrupt, or otherwise have a negative impact on the network and information systems, their users, and other persons."*

Business Area

Given the significant technological advancements and widespread adoption of information systems across all economic sectors, the role of a cyber-security expert is increasingly indispensable. Their expertise is sought after not only by companies, both public and private, but also by associations, organisations, and governmental entities. As reliance on digital infrastructure grows, so too does the need for professionals who can safeguard these systems from cyber threats.

Cyber security experts play a pivotal role in protecting sensitive data, ensuring the integrity of digital operations, and bolstering resilience against cyber-attacks. Their work encompasses a broad range of responsibilities, including risk assessment, threat detection and mitigation, incident response, and compliance with regulatory standards. In essence, the demand for cyber security experts reflects the critical importance of securing digital assets and maintaining trust in the digital age (Randstad, n.d.).

7.4.1. CONTEXT AND LIMITATIONS

Cybersecurity refers to a series of actions designed to defend electronic systems, networks, servers, and devices from hacker attacks (Kasa, 2020). Essentially, it consists of a series of actions and measures intended for information security. Hackers are those who threaten information, systems, and networks, so it's necessary to take precautions, making cybersecurity fundamental (Cyber Security 360, n.d.). Neglecting it exposes one to a series of risks because threats multiply at an alarming rate, almost doubling year after year. When thinking about the industrial sector, it's important to implement the right procedures to safeguard information and all the most sensitive data. Cyberattacks orchestrated by one or more hackers with the aim of economic gain could cause disruptions in a company's production continuity.

It is also useful to define the figure of the cybercriminal, also known as a hacker: they are individuals driven by criminal intent to carry out cyberattacks via the internet. The network, therefore, becomes the access point for these criminals whose goal is to gain profit or as mentioned, disrupt the operations of a company, organisation, or other entity. Often, political motivations underlie all this, driving hackers to action. Cyberattacks are devised to endanger cybersecurity, which is why they are very dangerous and must be prevented absolutely. When prevention is not possible, they must be minimised as quickly as possible to try to limit the damage (Alteredu, n.d.). For this reason, it is important to implement proper procedures to protect information and all sensitive data.

7.4.2. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 38 : Tasks and skills impacted related to cybersecurity specialist occupation.

OCCUPATION CODE	OCCUPATION TITLE	TASK	IMPACT IN DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	IMPACTS DESCRIPTION	RELATED NEEDED SKILLS/KNOWLEDGE IMPACTED	EXPECTED TENDENCY FOR SKILL EVOLUTION	SKILL TYPE	MATURITY LEVEL TO REACH (IMPLEMENT AND COMBINE MATURITY LEVELS WITH BLOOM'S TAXONOMY)	SKILL ESCO URL	SKILL DESCRIPTION
2529.4	Cybersecurity Specialist	Identifying and assessing vulnerabilities in the manufacturing network and systems, followed by developing and implementing risk mitigation strategies.	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	Increased complexity due to a larger attack surface with the proliferation of IoT devices. Need for securing communication protocols and data transmitted by smart sensors.	Internet of things	+	knowledge	L4	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
2529.4	Cybersecurity Specialist	Creating and implementing security policies tailored to the manufacturing environment, covering aspects like access controls, data protection, and incident reporting.	3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing	Securing edge computing environments and decentralized processing. Addressing cybersecurity implications of cloud computing and securing data in the cloud. Ensuring the security of blockchain technology in supply chain applications. Preparing for potential cybersecurity challenges posed by quantum computing.	establish an ICT security prevention plan	+	skill	L4	http://data.europa.eu/esco/skill/114c9698-c999-4369-8498-81bf641fe871	Define a set of measures and responsibilities to ensure the confidentiality, integrity and availability of information. Implement policies to prevent data breaches, detect and respond to unauthorised access to systems and resources, including up-to-date security applications and employee education.

2529.4	Cybersecurity Specialist	Identifying and assessing potential security risks and vulnerabilities within an organisation's systems, networks, and applications	4-4 Digital Twins	Digital twins create an extended attack surface as they mirror physical systems. Cybersecurity specialists must secure both the physical and virtual components to prevent compromise.	establish an ICT security prevention plan	+	skill	L4	http://data.europa.eu/esco/skill/114c9698-c999-4369-8498-81bf641fe871	Define a set of measures and responsibilities to ensure the confidentiality, integrity and availability of information. Implement policies to prevent data breaches, detect and respond to unauthorised access to systems and resources, including up-to-date security applications and employee education.
2529.4	Cybersecurity Specialist	Assessing and analysing security risks and threats, evaluating their potential impact, and developing risk mitigation strategies.	5-2 Circular Economy	cybersecurity experts may be involved in securing the data and systems related to recycling processes, product lifecycle management, and reverse logistics to ensure the integrity and confidentiality of sensitive information.	Skills in risk management and compliance	+	knowledge		http://data.europa.eu/esco/skill/6eff134b-e34f-4d6e-a6e8-5e47cf2228d0	The process of identifying, assessing, and prioritising of all types of risks and where they could come from, such as natural causes, legal changes, or uncertainty in any given context, and the methods for dealing with risks effectively.
2529.4	Cybersecurity Specialist	Creating and implementing security policies tailored to the manufacturing environment, covering aspects like access controls, data protection, and incident reporting.	5-4 Waste Reduction	cybersecurity professionals would need to safeguard the data collected from IoT devices, sensors, and waste management software to prevent data breaches or tampering that could compromise waste reduction efforts or violate privacy regulations.	Understanding of waste management processes	+	knowledge	L3	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).

7.5. EXPERTS' COMMENTS

The five Italian experts, representing Research Centres, Business Organisations, and Industry, were engaged to evaluate three specific job profiles: Data Analyst, Automation Engineer, and Cybersecurity Specialist.

- **Data Analyst:** The experts largely concurred with the identified trends and skill impacts for Data Analysts. However, they highlighted the evolving importance of this role due to the increase in data generated by Industry 4.0 initiatives and the need to monitor business process variables. They emphasised that Data Analysts must ensure data reliability and security, analyse significant content, and possess extensive knowledge of IoT technologies, which are fundamental in data collection for Industry 4.0. They also noted the expanding scope of the Data Analyst's role beyond individual companies to encompass the entire supply chain, underscoring the need for efficiency analysis extending to subcontractors.
- **Automation Engineer:** The feedback on the Automation Engineer profile also supported the pre-identified trends, with additional insights emphasising the need for integration between IoT devices / smart sensors and automation systems. Experts pointed out that Automation Engineers must understand IoT communication technologies and protocols to design systems that meet operational expectations and align with technical requirements.
- **Cybersecurity Specialist:** This profile garnered the most interest and detailed feedback. Experts validated the identified trends and skills, adding that securing IoT devices demands a comprehensive approach involving data encryption, strong authentication, network segmentation, and proactive monitoring. Cybersecurity Specialists need robust knowledge of IoT-related issues, including device isolation, anomaly detection, and security update mechanisms. They should also be adept at managing the complexities of new data-sharing technologies and the associated cyber risks within manufacturing environments.

The experts positively evaluated the overall analysis of these job profiles at the Italian level, noting the crucial role these professionals play in digital transformation. They emphasised the necessity for all three profiles to continuously adapt and acquire new skills to meet the demands of evolving data collection, analysis, and sharing processes. Moreover, the responsibilities of Data Analysts, Automation Engineers, and Cybersecurity Specialists extend beyond individual companies, integrating into broader supply and value chain mechanisms. This interconnected approach underscores the need for comprehensive skills in handling digital transformation challenges effectively.

7.6. CONCLUSIONS

In conclusion, the experts have affirmed the importance of equipping Data Analysts, Automation Engineers, and Cybersecurity Specialists with the necessary skills to navigate the ongoing challenges of Digital Transformation. The tasks performed by these professional figures are crucial not only within their respective companies but also across broader supply and value chains, highlighting their integral role in the modern industrial landscape.

Their roles extend beyond traditional boundaries, emphasising the need for a comprehensive understanding of new Technologies, trends and skills that are needed to ensure efficiency, reliability, and security in increasingly interconnected business environments.

7.7. REFERENCES

Alteredu. *Cybersecurity: Definizione, Significato e Perché Serve* (Cybersecurity: Definition, Meaning, and Why It Matters). Retrieved from https://www.alteredu.it/cybersecurity-definizione-e-significato/

Bergamo News. (n.d.). *L'importanza dell'analisi dei dati nell'industria 4.0* (The Importance of Data Analysis in Industry 4.0). Retrieved from https://www.bergamonews.it/dal-territorio/limportanza-dellanalisi-dei-dati-nellindustria-4-0/

Cyber Security 360. *Nuove minacce alla sicurezza informatica tra malware e attacchi hacker* (New Threats to Cybersecurity Between Malware and Hacker Attacks). Retrieved from https://www.cybersecurity360.it/nuove-minacce/

ESCO. (n.d.). Occupation: Automation Engineer. Retrieved from http://data.europa.eu/esco/occupation/bb609566-3ab6-44dd-8f48-cf0b15b96827

ESCO. (n.d.). Occupation: Cyber Security Expert. Retrieved from http://data.europa.eu/esco/occupation/76ef0a87-6afe-4560-b5d0-9a086abe45c5

ESCO. (n.d.). Occupation: Software Developer. Retrieved from http://data.europa.eu/esco/occupation/d3edb8f8-3a06-47a0-8fb9-9b212c006aa2

Fantini, P. M., & Pinzone, M. (2019). "S*viluppo di nuove competenze"* (Development of New Skills). Retrieved from https://re.public.polimi.it/bitstream/11311/1118135/2/007_Fantini_Pinzone.pdf

Kasa, N. (2020, September 15). *Che cos'è un server? La spiegazione semplice* (What is a Server? The Simple Explanation). Retrieved from https://www.kasadellacomunicazione.it/server/

Osservatori Digital Innovation. (2019). "*Data Analyst: Cosa fa, stipendio*" (Data Analyst: what does he do, salary). Retrieved from https://blog.osservatori.net/it_it/data-analyst-cosa-fa-stipendio

Politecnico di Milano. (n.d.). Ingegneria dell'automazione (Automation Engineering). Retrieved from https://www.polimi.it/futuri-studenti/corsi-di-laurea/ingegneria-dellautomazione

Randstad. *I lavori più richiesti: Cyber Security Expert* (Most Requested Jobs: Cyber Security Expert). Retrieved from https://www.randstad.it/candidato/lavori-piu-richiesti/cyber-security-expert/#:~:text=Per%20il%20grande%20sviluppo%20tecnologico,organizzazioni%20e%20dalla%20Pubblica%20Amministrazione

Randstad. (n.d.). "*I lavori più richiesti: Data Analyst*" (Most Requested Jobs: Data Analyst). Retrieved from https://www.randstad.it/candidato/lavori-piu-richiesti/data-analyst/

Spainer V. (2023). "*Come promuovere la sostenibilità grazie all'automazione"* (How to Promote Sustainability Through Automation), The Innovation Post. Retrieved from https://www.innovationpost.it/tecnologie/robotica/come-promuovere-la-sostenibilita-grazie-allautomazione-la-guida-di-epson/

Unioncamere. (2022). "*Previsioni dei fabbisogni occupazionali e professionali in Italia a medio termine*" (Forecasts of Occupational and Professional Needs in Italy in the Medium Term, 2023-2027). Retrieved from https://excelsior.unioncamere.net/pubblicazioni/2023/previsioni-dei-fabbisogni-occupazionali-e-professionali-italia-medio-termine

University of Bologna. (n.d.). Prospettive: Ingegneria dell'automazione (Perspectives: Automation Engineering). Retrieved from https://corsi.unibo.it/laurea/IngegneriaAutomazione/prospettive

World Manufacturing Forum (2019), "*Skills for the Future of Manufacturing*", retrieved from https://worldmanufacturing.org/wp-content/uploads/2019-WMF-Report-Presentation.pdf

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - T Turkey sub-report

Co-funded by
the European Union

8. TURKEY: JOB'S IMPACT ANALYSIS

This section deals with the analysis of the selected 5 jobs. As mentioned in the methodology it was analysed the changes faced by companies and identifying the **levers of those changes** affecting the specific jobs; then it was described the **changes in skills and knowledges** detected in the analysis.

8.1. LIST OF SELECTED JOBS

Here is the short list selected by Turkey:

Table 39 : List of selected jobs

ESCO CODE	ESCO OCCUPATION	1 - INDUSTRY SECTORS	2 - DIGITAL AND GREEN TRANSITIONS NEW TRENDS IMPACTING	3 - EMPLOYABILITY	4.RELEVANCE FOR THE SMART SPECIALISATION STRATEGY – AT REGIONAL/COUNTRY?	5 - EDUCATION LEVEL.
7223.4	Computer Numerical Control Machine Operator	**Machine tools (Mechanical Engineering), Automotive, Aerospace**	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-6 Sustainable Material Innovation"	**April 2024 - Türkiye: CNC Operator: 64 job offers (İŞKUR) 373 job offers (kariyer.net) Sources: İŞKUR - Bilgisayarlı Makine (CNC Operatörü) https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx https://www.kariyer.net/is-ilanlari/cnc+operatoru?pst=4150&pkw=cnc%20operat%C3%B6r%C3%BC**	Aligns with the S3 priorities of "Automotive plastics" and "Power units" https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	EQF Level 4
7543.9	Product Quality Controller	**Automotive, Aerospace, Electric and electronic Industries, Machine tools (Mechanical Engineering)**	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 2-2 3D scanning, 3-1 Cybersecurity, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 5-3 Energy Efficiency, 5-4 Waste Reduction"	**April 2024 - Türkiye: Quality Controller: 222 job offers (İŞKUR) 514 job offers (kariyer.net) Sources: İŞKUR - Kalite Kontrolcü https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx https://www.kariyer.net/is-ilanlari/kalite+kontrol+elemani?pst=960&pkw=kalite%20kontrol%20eleman%C4%B1**	Aligns with most of the S3 priorities given for TR42 region. https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	EQF Level 6

2529.8	ICT Security Manager	**Transport, Electric and electronic Industries, Aerospace, Automotive**	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 5-10 Sustainable IT Infrastructure, 5-12 Corporate Social Responsibility (CSR) Initiatives"	**April 2024 - Türkiye: ICT Security Specialist: 28 job offers (kariyer.net) https://www.kariyer.net/is-ilanlari/it+guvenlik+uzmani?pst=4558&pkw=%C4%B1t%20g%C3%BCvenlik%20uzman%C4%B1**	Although not directly addressed under S3, it is relevant to all businesses, especially ones affected more by the digital transition trends.	EQF Level 5
1213.8	Sustainability Manager	**Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime**	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 5-1 Renewable Energy Integration, 5-3 Energy Efficiency, 5-4 Waste Reduction, 5-5 Green Logistics and Supply Chain, 5-6 Sustainable Material Innovation, 5-7 Carbon Footprint Management, 5-11 Environmental Monitoring and Reporting, 5-12 Corporate Social Responsibility (CSR) Initiatives"	**April 2024 - Türkiye: Sustainability Manager: 2 job offers (kariyer.net)** **https://www.kariyer.net/is-ilanlari?pst=12185&pkw=s%C3%BCrd%C3%BCr%C3%BClebilirlik%20m%C3%BCd%C3%BCr%C3%BC**	Although not directly addressed under S3, it is relevant to all businesses, especially ones affected more by the green transition trends.	EQF Level 6
3139.1	Automated Assembly Line Operator	**Automotive, Aerospace, Electric and electronic Industries**	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-6 Predictive Maintenance, 5-6 Sustainable Material Innovation"	**This occupation is not directly listed in career sites, instead they are listed under assembly line operators for different types of sectors.**	Aligns with the S3 priority of "Automotive plastics" https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	**EQF Level 3**

8.2. SUSTAINABILITY MANAGER

8.2.1. JOB DESCRIPTION AND SCOPE

Job Description

Sustainability Manager (ESCO 1213.8) ESCO description: *"Sustainability managers are responsible for ensuring the sustainability of business processes. They helped in the design and implementation of plans and measures to ensure that the manufacturing processes and products comply with given environmental regulations and social responsibility standards and they monitor and report on the implementation of sustainability strategies within the company supply chain and business process. They analyse issues linked to manufacturing processes, use of materials, waste reduction, energy efficiency and products traceability to improve environmental and social impacts and integrate sustainability aspects into the company culture"* (ESCO, n.d.).

Business Area

Sustainability has become an important aspect on all kinds of business operations as the digital and green transition are gaining traction. Businesses are adapting their operations for long term success by following these trends. The Sustainability Manager is a key advocate for driving sustainability initiatives that have a profound impact on shaping a greener, more resilient future. They are instrumental in leading efforts to integrate sustainability into the core business practices of various industries, some of them are listed below (Coursera, 2024):

- **Renewable Energy:** Lead sustainability efforts in the renewable energy sector by promoting the development and adoption of clean energy technologies, such as solar, wind, and hydroelectric power.
- **Waste Management and Recycling:** Innovate sustainable solutions in waste management and recycling industries by implementing circular economy principles, reducing landfill waste, and promoting resource recovery and reuse.
- **Green Technology Manufacturing:** The green technology sector encompasses industries involved in renewable energy, energy-efficient technologies, and sustainable infrastructure. Sustainability Managers in green technology manufacturing lead efforts to reduce carbon emissions, promote renewable energy adoption, and develop eco-friendly products and solutions, driving sustainability in advanced manufacturing.
- **Advanced Materials Production:** Advanced materials are essential for innovation in various industries, including aerospace, automotive, and electronics. Sustainability Managers in advanced materials production focus on sustainable sourcing, recycling, and manufacturing processes to minimise environmental impact and enhance material efficiency, contributing to sustainable development in advanced manufacturing.
- **Smart Manufacturing and IoT:** Smart manufacturing technologies, including IoT (Internet of Things) and data analytics, are revolutionising production processes and supply chain management. Sustainability Managers in smart manufacturing industries prioritize energy efficiency, waste reduction, and resource optimisation, leveraging IoT and data-driven insights to enhance sustainability across manufacturing operations.
- **Industrial Automation and Robotics:** Industrial automation and robotics play a crucial role in enhancing efficiency and productivity in manufacturing. Sustainability Managers

in automation and robotics industries promote energy-efficient automation solutions, optimise resource use, and ensure responsible disposal of electronic waste, driving sustainability in advanced manufacturing processes.

The Sustainability Manager is responsible for leading and implementing sustainability initiatives across various industries, driving forward environmental conservation, social equity, and economic viability. They develop and execute tailored sustainability strategies, collaborate with stakeholders to foster collaborative efforts, and ensure compliance with environmental regulations and standards. By championing resource optimisation, risk management, and education, they play a pivotal role in shaping a greener, more resilient future for organisations and communities alike. The demand for sustainability managers in the near future is likely to increase (Coursera, 2024).

8.2.2. CONTEXT AND LIMITATIONS

Insights from global sustainability trends and regional initiatives can provide valuable context for understanding the evolving role of sustainability managers in driving organisational change. The global sustainability landscape is undergoing transformative shifts, with increasing emphasis on climate action, social responsibility, and sustainable development goals. Organisations across various industries are recognising the imperative to integrate sustainability into their core business strategies, reflecting growing societal expectations and regulatory pressures, (see webpage of the Türkiye's Directorate of Climate Change (iklim.gov.tr., n.d.).

In Turkey, sustainability has become a key focus area, with businesses and government initiatives alike prioritizing green initiatives, circular economy principles, and carbon-neutral objectives. National policies and programs, such as the National Climate Change Strategy (iklim.gov.tr., n.d.) and the 11th Development Plan (iklim.gov.tr., n.d.) are driving significant investments in renewable energy, green infrastructure, and eco-friendly technologies, creating new opportunities and challenges for sustainability professionals.

While specific data on the demand for sustainability managers in Turkey may vary, the broader trends in the region suggest a growing need for skilled professionals capable of leading sustainability initiatives, fostering stakeholder collaboration, and navigating complex regulatory landscapes. The increasing convergence of environmental, social, and governance (ESG) factors in business decision-making highlights the pivotal role of sustainability managers in driving organisational resilience, innovation, and long-term value creation.

Given the escalating global focus on sustainability and the strategic importance of sustainable practices across industries, professionals with expertise in sustainability management are likely to encounter expanding opportunities in Turkey and beyond. The integration of sustainability into business operations, risk management, and stakeholder engagement underscores the importance of skilled leadership in advancing sustainable business practices and achieving meaningful impact.

8.2.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 40 : Tasks and skills impacted related to sustainability manager occupation.

TASK	IMPACTİNG DİGİTAL TECHNOLOGY AND/OR GREEN TRANSİTİON	IMPACT DESCRİPTİON	RELATED NEEDED SKİLLS/ KNOWLEDGE	EXPECTED TENDENCY FOR SKİLL EVOLUTİON	SKİLL TYPE	MATURİTY LEVEL TO REACH	SKİLL ESCO URL	SKİLL DESCRİPTİON
Conducting sustainability audits and reporting	**5-11 Environmental Monitoring and Reporting**	Performing sustainability audits to assess environmental impact and compliance, and reporting findings to stakeholders.	**Lead the sustainability reporting process**	+	**Skill**	L4	http://data.europa.eu/esco/skill/bbcc7e1b-3d4d-4422-9fac-efd636eb9de4	Oversee the process of reporting on the sustainability performance of the organisation, according to established guidelines and standards.
		Performing sustainability audits to assess environmental impact and compliance, and reporting findings to stakeholders. With the new trends in environmental monitoring and reporting, related reports and audits have to be updated and enhanced.	**Global standards for sustainability reporting**		**Knowledge**		http://data.europa.eu/esco/skill/4300b453-9bcf-474c-9ee3-92ec2229720c	The global, standardised reporting framework that enable organisations to quantify and communicate about their environmental, social and governance impact.
Development of corporate sustainability strategies	**5-12 Corporate Social Responsibility (CSR) Initiatives**	Creating comprehensive sustainability strategies that align with corporate goals and reduce environmental footprint.	**Corporate social responsibility**				http://data.europa.eu/esco/skill/66db424f-2abe-420d-8e5b-186607266b61	The handling or managing of business processes in a responsible and ethical manner considering the economic responsibility towards shareholders as equally important as the responsibility towards environmental and social stakeholders.

Implementation of sustainable manufacturing and procurement strategies	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	The incorporation of IoT, smart sensors, and 5G technology into sustainable manufacturing and procurement strategies yields tangible results for Sustainability Managers. By harnessing real-time data insights from interconnected devices, they can optimize resource use, minimise waste, and enhance supply chain transparency. This enables them to achieve cost savings, reduce environmental impact, and ensure ethical sourcing practices, ultimately fostering a more sustainable and resilient manufacturing ecosystem.	**Energy efficiency**		**Knowledge**	**L4**	http://data.europa.eu/esco/skill/83fc0b2b-6cd2-46af-b1ff-d3fc83604c26	Field of information concerning the reduction of the use of energy. It encompasses calculating the consumption of energy, providing certificates and support measures, saving energy by reducing the demand, encouraging efficient use of fossil fuels, and promoting the use of renewable energy.
			Implement sustainable procurement	**+**	**Skill**	**L3**	http://data.europa.eu/esco/skill/6962058d-9808-4820-a6bc-d7cabce60cde	Incorporate strategic public policy goals into procurement procedures, such as green public procurement (GPP) and socially responsible public procurement (SRPP). Contribute to reducing the environmental impact of procurement, to achieving social goals and to improving value for money for the organisation and for society at large.
			Mitigate waste of resources				http://data.europa.eu/esco/skill/d2c81ad1-2439-43cf-9c63-204187b8f771	Evaluate and identify opportunities to use resources more efficiently with continuously striving to reduce waste of utilities.
	5-7 Carbon Footprint Management	Monitoring, handling and improving operations in a more efficient way, ultimately with the aim of reducing carbon footprint and environmental impacts.	**Manage environmental impact**				http://data.europa.eu/esco/skill/d3a8ef9c-8572-438c-91dc-010537070be3	Implement measures to minimise the biological, chemical and physical impacts of mining activity on the environment.

Implementation of sustainable manufacturing practices	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	The implementation of sustainable manufacturing practices by Sustainability Managers is bolstered by leveraging AI, machine learning, and big data analytics. These technologies enable precise identification of resource inefficiencies and predictive model	**Energy efficiency**		**Knowledge**	**L4**	http://data.europa.eu/esco/skill/83fc0b2b-6cd2-46af-b1ff-d3fc83604c26	Field of information concerning the reduction of the use of energy. It encompasses calculating the consumption of energy, providing certificates and support measures, saving energy by reducing the demand, encouraging efficient use of fossil fuels, and promoting the use of renewable energy.
			Mitigate waste of resources		**Skill**	**L3**	http://data.europa.eu/esco/skill/d2c81ad1-2439-43cf-9c63-204187b8f771	Evaluate and identify opportunities to use resources more efficiently with continuously striving to reduce waste of utilities.
Implementation of sustainable manufacturing practices	**5-4 Waste Reduction**	Implementing sustainable manufacturing processes is a task affected by several aspects of digital and green transition trends. Waste reduction is an important practice for a more sustainable process; therefore, measures to reduce waste across all kinds of processes will be a task under the implementation of sustainable manufacturing practices.	**Mitigate waste of resources**		**Skill**	**L3**	http://data.europa.eu/esco/skill/d2c81ad1-2439-43cf-9c63-204187b8f771	Evaluate and identify opportunities to use resources more efficiently with continuously striving to reduce waste of utilities.
Implementation of sustainable materials in manufacturing	**5-6 Sustainable Material Innovation**	Adoption of sustainable and eco-friendly materials in manufacturing processes have a direct impact for more sustainable operations.	**Use environmentally friendly materials**	**+**			http://data.europa.eu/esco/skill/9438b0dc-062a-4893-b176-959706e4ae1e	Work with ecofriendly materials such as water-based finishing materials systems or formaldehyde free adhesives.

			Use sustainable materials and components				http://data.europa.eu/esco/skill/73576419-31c2-4e45-8e30-ab1afec3db4e	Identify, select environmentally friendly materials and components. Decide on the substitution of certain materials by the one that are environmentally friendly, maintaining the same level of functionality and other characteristics of the product.
Implementation of sustainable procurement practices	**5-5 Green Logistics and Supply Chain**	Implementing sustainable manufacturing processes is a task affected by several aspects of digital and green transition trends. Green logistics and supply chain is an eco-friendlier way against conventional logistics, and it's applied under the implementation of sustainable manufacturing practices.	**Implement sustainable procurement**				http://data.europa.eu/esco/skill/6962058d-9808-4820-a6bc-d7cabce60cde	Incorporate strategic public policy goals into procurement procedures, such as green public procurement (GPP) and socially responsible public procurement (SRPP). Contribute to reducing the environmental impact of procurement, to achieving social goals and to improving value for money for the organisation and for society at large.
Integration of more energy efficient operations	**5-3 Energy Efficiency**	Facilitating energy efficient operations into the organisation's strategies to reduce carbon footprint and environmental effects. Tendency towards more energy efficient operations affect this task not only in terms of importance but also new opportunities and applications of energy efficient systems are sought after.	**Energy efficiency**		**Knowledge**	**L4**	http://data.europa.eu/esco/skill/83fc0b2b-6cd2-46af-b1ff-d3fc83604c26	Field of information concerning the reduction of the use of energy. It encompasses calculating the consumption of energy, providing certificates and support measures, saving energy by reducing the demand, encouraging efficient use of fossil fuels, and promoting the use of renewable energy.
Integration of renewable energy sources	**5-1 Renewable Energy Integration**	Facilitating the integration of renewable energy sources into the organisation's energy mix to reduce carbon footprint.	**Renewable energy technologies**		**Knowledge**	**L4**	http://data.europa.eu/esco/skill/f8413360-6114-40de-a276-c59b764b9913	The different types of energy sources which cannot be depleted, such as wind, solar, water, biomass, and biofuel energy. The different technologies used to implement these types of energy to an increasing degree, such as wind turbines, hydroelectric dams, photovoltaics, and concentrated solar power.

Promoting a culture of sustainability within the organisation	**5-12 Corporate Social Responsibility (CSR) Initiatives**	Encouraging a culture of sustainability through employee engagement initiatives and sustainability education programs.	**Advise on corporate social responsibility**	**+**	**Skill**	**L3**	http://data.europa.eu/esco/skill/b2f05068-c409-43ec-ba58-b5dfe991ca5e	Inform others about the social responsibility of companies and organisations in society and advise about matters to prolong their sustainability.
			Implement corporate governance				http://data.europa.eu/esco/skill/f2c63b7a-ed6c-4890-9f8c-7685d172624c	Apply a set of principles and mechanisms by which an organisation is managed and directed, set procedures of information, control flow and decision making, distribute rights and responsibilities among departments and individuals, set corporate objectives and monitor and evaluate actions and results.

8.3. ICT SECURITY MANAGER

8.3.1. JOB DESCRIPTION AND SCOPE

Job Description

ICT Security Manager (ESCO 3512) ESCO description: *"ICT security managers propose and implement necessary security updates. They advise, support, inform and provide training and security awareness and take direct action on all or part of a network or system"* (*ICT security manager*.,n.d.).

Business Area

The ICT security manager plays a critical role in safeguarding the organisation's information assets and ensuring the integrity, confidentiality, and availability of data across all digital platforms. They are responsible for developing, implementing, and overseeing comprehensive cybersecurity strategies and practices to protect against internal and external threats, including cyberattacks, data breaches, and unauthorized access. Some of the sectors related to an ICT security managers (Apud Agency, n.d.) are:

- **Automotive Manufacturing:** The automotive industry relies heavily on advanced manufacturing processes. ICT Security Managers play a crucial role in safeguarding digital systems and production networks in automotive plants, ensuring the integrity and confidentiality of proprietary designs, production data, and supply chain information.
- **Electronics Manufacturing:** The electronics manufacturing sector is experiencing rapid growth, driven by demand for consumer electronics, telecommunications equipment, and semiconductor components. ICT Security Managers are essential in protecting intellectual property, sensitive customer data, and manufacturing processes in electronics factories, where cybersecurity risks can have far-reaching implications for product quality and market competitiveness.
- **Defence and Aerospace:** The defence and aerospace industries are increasingly reliant on advanced manufacturing technologies, including additive manufacturing, robotics, and digital twin simulations. ICT Security Managers play a critical role in safeguarding classified information, critical infrastructure, and sensitive data across the defence and aerospace supply chain, ensuring compliance with stringent cybersecurity standards and protecting national security interests.
- **Machinery and Equipment Manufacturing:** The machinery and equipment manufacturing sector encompasses a wide range of industries, including industrial machinery, agricultural equipment, and construction machinery. ICT Security Managers are instrumental in securing digital manufacturing systems, industrial IoT devices, and smart factory networks, mitigating cybersecurity risks and ensuring uninterrupted operations in manufacturing facilities.
- **Energy and Utilities:** The energy and utilities sector is undergoing digital transformation, with a growing emphasis on renewable energy, smart grids, and energy efficiency initiatives. ICT Security Managers play a vital role in protecting critical infrastructure, power generation facilities, and utility networks from cyber threats, ensuring the reliability and resilience of energy supply systems.

The role of an ICT Security Manager (Apud Agency, n.d.) is pivotal in establishing a robust cybersecurity posture, fostering resilience against evolving cyber threats, and ensuring the organisation's compliance with cybersecurity regulations and standards. As the digital landscape continues to evolve and cyber threats become increasingly sophisticated, the demand for skilled professionals in ICT security is expected to grow, making this role indispensable across various industries.

8.3.2. CONTEXT AND LIMITATIONS

Insights from the global and regional ICT security landscapes can provide valuable context for understanding the demand and challenges faced by ICT Security Managers in Türkiye. The global cybersecurity landscape is rapidly evolving, with increasing cyber threats, sophisticated attacks, and stringent regulatory requirements shaping the cybersecurity priorities of organisations worldwide.

In Türkiye, the digital transformation and rapid adoption of technology across various sectors have amplified the importance of cybersecurity. With the government's Digital Transformation Office initiatives (*Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi.*, n.d.-c) and the National Cybersecurity Strategy (*Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi.*, 2020) aiming to strengthen Türkiye's cyber resilience, there is a growing emphasis on enhancing cybersecurity measures, fostering collaboration between public and private sectors, and raising cybersecurity awareness among businesses and the general public.

Despite the growing recognition of cybersecurity's importance, Türkiye faces several challenges, including a shortage of skilled cybersecurity professionals, limited awareness of cybersecurity risks among SMEs, and the evolving nature of cyber threats targeting critical sectors such as finance, healthcare, and government institutions. The lack of comprehensive cybersecurity frameworks tailored to the Türkiye market and the need for greater investment in cybersecurity infrastructure and technologies further underscore the complexities and limitations in the current cybersecurity landscape.

While specific data on the demand for ICT Security Managers in Türkiye may vary, the broader trends suggest a growing need for skilled professionals capable of navigating the complex cybersecurity landscape, implementing robust cybersecurity strategies, and addressing the unique challenges and regulatory requirements specific to Türkiye. The increasing convergence of technology, data, and connectivity highlights the pivotal role of ICT Security Managers in safeguarding organisations' digital assets, ensuring compliance with cybersecurity regulations, and fostering a culture of cybersecurity awareness and resilience.

Given the escalating cyber threats and the strategic importance of cybersecurity in Türkiye's digital transformation journey, professionals with expertise in ICT security management are likely to encounter expanding opportunities and challenges. The integration of cybersecurity into business operations, risk management, and regulatory compliance underscores the critical role of skilled leadership in advancing cybersecurity practices and protecting organisations against evolving cyber threats in the Türkiye context.

8.3.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 41 : Tasks and skills impacted related to ICT security manager occupation.

TASK	IMPACTİNG DİGİTAL TECHNOLOGY AND/OR GREEN TRANSİTİON	IMPACT DESCRİPTİON	RELATED NEEDED SKİLLS/ KNOWLEDGE	EXPECTED TENDENCY FOR SKİLL EVOLUTİON	SKİLL TYPE	MATURİTY LEVEL TO REACH	SKİLL ESCO URL	SKİLL DESCRİPTİON
Development of incident response plans	**5-10 Sustainable IT Infrastructure**	Creating and implementing incident response plans to quickly address and mitigate cybersecurity breaches.	**Cyber-attack countermeasures**	+	**Knowledge**	L4	http://data.europa.eu/esco/skill/5898d99a-62a4-4e10-a2e3-0d815ce44248	The strategies, techniques and tools that can be used to detect and avert malicious attacks against organisations' information systems, infrastructures or networks. Examples are secure hash algorithm (SHA) and message digest algorithm (MD5) for securing network communications, intrusion prevention systems (IPS), public-key infrastructure (PKI) for encryption and digital signatures in applications.
Ensuring cybersecurity in digital manufacturing environments	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology 3-1 Cybersecurity**	IoT and new forms of communication between devices and platforms require new safety measures to be taken and protocols created by the ICT security personnel. Moreover, smart sensors and 5G technology are other advancements where the flow of information changes, requiring new safety measures and procedures. Implementation of advanced cybersecurity measures to protect digital manufacturing data and systems.	**Internet of Things**	+	**Knowledge**	L4	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
			Sensors				http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.

			Cyber security				http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44	The methods that protect ICT systems, networks, computers, devices, services, digital information and people against illegal or unauthorised use.
		Implementation of advanced cybersecurity measures to protect digital manufacturing data and systems. To ensure cybersecurity, cyber attack counter-measures should be improved by collecting and processing related data.	**Maintain database security**	+	**Skill**	L4	http://data.europa.eu/esco/skill/ec85cc63-4e24-4631-bf92-8789db2605c0	Master a wide variety of information security controls to pursue maximal database protection.
		Implementation of advanced cybersecurity measures to protect digital manufacturing data and systems. To ensure cybersecurity, defence mechanisms should be improved by collecting and processing related data.	**Manage system security**		**Skill**		http://data.europa.eu/esco/skill/2a3a96a3-709e-4d60-81f6-d247d6933f13	Analyse the critical assets of a company and identify weaknesses and vulnerabilities that lead to intrusion or attack. Apply security detection techniques. Understand cyber-attack techniques and implement effective countermeasures.
Integration of AI and machine learning in threat detection	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	Implementation of advanced cybersecurity measures to protect digital manufacturing data and systems. To ensure cybersecurity, cyber-attack countermeasures should be improved by collecting and processing related data. Implementation of advanced cybersecurity measures to protect digital manufacturing data and systems. To ensure cybersecurity, defence mechanisms should be improved by collecting and processing related data.	**Cyber-attack counter-measures**		**Knowledge**	L4	http://data.europa.eu/esco/skill/5898d99a-62a4-4e10-a2e3-0d815ce44248	The strategies, techniques and tools that can be used to detect and avert malicious attacks against organisations' information systems, infrastructures or networks. Examples are secure hash algorithm (SHA) and message digest algorithm (MD5) for securing network communications, intrusion prevention systems (IPS), public-key infrastructure (PKI) for encryption and digital signatures in applications.
			Collect cyber defence data	+	**Skill**	L4	http://data.europa.eu/esco/skill/fcbb3a90-cdde-49ff-9ecc-8e2c0a6dfca2	Collect data for cyber defence using various data collection tools. Data may be gathered from a number of internal or external sources such as online trade records, DNS request logs, email servers' logs, digital communications packet capturing, deep web resources, etc.

Integration of AI and machine learning in threat detection	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	Utilizing AI and machine learning technologies to enhance threat detection and predictive cybersecurity measures.	**Principles of artificial intelligence**		**Knowledge**	L3	http://data.europa.eu/esco/skill/e465a154-93f7-4973-9ce1-31659fe16dd2	The artificial intelligence theories, applied principles, architectures and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies and cognition theories.
			Utilise machine learning		**Skill**	L3	http://data.europa.eu/esco/skill/8369c2d6-c100-4cf6-bd83-9668d8678433	Use techniques and algorithms that can extract mastery out of data, learn from it and make predictions, to be used for program optimisation, application adaptation, pattern recognition, filtering, search engines and computer vision.
Training and awareness programs for employees	**5-12 Corporate Social Responsibility (CSR) Initiatives**	Conducting training and awareness programs to educate employees about cybersecurity threats and best practices.	**Educate on data confidentiality**	+	**Skill**	L3	http://data.europa.eu/esco/skill/6aef2baa-5fa7-4c16-bd28-3e070ec4e4df	Share information with and instruct users in the risks involved with data, especially risks to the confidentiality, integrity, or availability of data. Educate them on how to ensure data protection.
			Train employees				http://data.europa.eu/esco/skill/e54ff029-1ce9-447d-a5b2-eb7283a23ee	Lead and guide employees through a process in which they are taught the necessary skills for the perspective job. Organise activities aimed at introducing the work and systems or improving the performance of individuals and groups in organisational settings.

8.4. CNC MACHINE OPERATOR

8.4.1. JOB DESCRIPTION AND SCOPE

Job Description

CNC Machine Operator (ESCO 7223.4) ESCO Job description: Computer numerical control machine operator’s (*Computer numerical control machine operator.,* n.d.) set-up, maintain and control a computer numerical control machine in order to execute the product orders. They are responsible for programming the machines, ensuring the required parameters and measurements are met while maintaining the quality and safety standards. (*ESCO*, n.d.)

Business Area

CNC operators typically work in the manufacturing industry, managing the production of parts using computerized numerical control (CNC) machines. Areas of work and job duties may include:

- **CNC Machine Machining:** Machining and producing parts on various CNC machines, such as CNC milling, CNC turning, and CNC laser cutting.
- **Programming and Tuning:** Writing the programs necessary to operate CNC machines or making adjustments by loading existing programs.
- **Machine Control:** Monitoring the operation of CNC machines, identifying and responding to possible errors during operation.
- **Part Quality Control:** Measuring the machined parts, checking whether they comply with quality standards and taking corrective actions when necessary.
- **Material and Tool Selection:** Selection of the material to be processed and the tools to be used, determining the most appropriate techniques for the process.
- **Following Work Orders and Instructions:** Working in accordance with customer orders or production instructions.
- **Machine Maintenance:** Performing regular maintenance of CNC machines and troubleshooting minor malfunctions.
- **Following Safety Standards:** Working in accordance with occupational health and safety standards, ensuring machine and personnel safety.

CNC operators can generally work in factories, manufacturing workshops, the automotive industry, the aerospace industry and metalworking facilities. With the advancing technology, the working areas of CNC operators are also expanding and diversifying.

8.4.2. CONTEXT AND LIMITATIONS

The working context and limitations of CNC operators often vary according to the size of the business, the industry and the characteristics of the equipment used. Here are some examples that can be considered in this context:

- **Technological Limitations:** The CNC machines used have specific machining capabilities and may not be able to perform some operations. For example, a particular CNC milling machine may not be able to process very complex geometries or may not have the capacity to process a particular material.
- **Machine Capacity:** Every CNC machine has a certain machining capacity. This includes limitations in terms of material sizes that can be machined, maximum speeds and other machining parameters. Operators must plan and optimize jobs with these capacities in mind.
- **Programming Skills:** CNC operators must have a certain level of knowledge and ability to program the CNC machines they use. Programming complex parts can depend on the operators' programming skills, and these limitations can affect work processes.
- **Machine Maintenance and Breakdown:** CNC machines require regular maintenance and may experience breakdowns. When this happens, work processes can be disrupted or halted. Operators must intervene quickly and effectively in maintenance and breakdown situations and plan to ensure business continuity.
- **Production Standards and Quality Control:** CNC operators must adhere to certain production standards and quality control procedures. This may include certain limitations on tolerances, surface quality and other characteristics of workpieces.
- **Safety and Health Standards:** CNC operators must comply with occupational health and safety standards. This includes factors such as machine safety, use of personal protective equipment and workplace organisation. Operators must conduct their work safely by working in accordance with these standards.

These limitations are important factors that CNC operators must consider when planning and managing their work processes.

8.4.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 42 : Tasks and skills impacted related to CNC machine operator occupation.

TASK	IMPACTİNG DİGİTAL TECHNOLOGY AND/OR GREEN TRANSİTİON	IMPACT DESCRİPTİON	RELATED NEEDED SKİLLS/ KNOWLEDGE	EXPECTED TENDENCY FOR SKİLL EVOLUTİON	SKİLL TYPE	MATURİTY LEVEL TO REACH	SKİLL ESCO URL	SKİLL DESCRİPTİON
Advanced programming and operation of CNC machines	**1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics**	With the changes coming from AI and machine learning, operations of CNC machinery become more time, energy and material efficient. To implement the advancements in AI and ML to CNC operations, the operators must understand these concepts and interpret current data, eventually coming up with solutions.	**Analyse big data**	+	**Skill**	L3	http://data.europa.eu/esco/skill/47a49cd6-097d-457a-9f7b-c290c14930d5	Collect and evaluate numerical data in large quantities, especially for the purpose of identifying patterns between the data.
			Principles of artificial intelligence		**Knowledge**		http://data.europa.eu/esco/skill/e465a154-93f7-4973-9ce1-31659fe16dd2	The artificial intelligence theories, applied principles, architectures and systems, such as intelligent agents, multi-agent systems, expert systems, rule-based systems, neural networks, ontologies and cognition theories.
			Utilise machine learning		**Skill**		http://data.europa.eu/esco/skill/8369c2d6-c100-4cf6-bd83-9668d8678433	Use techniques and algorithms that can extract mastery out of data, learn from it and make predictions, to be used for program optimisation, application adaptation, pattern recognition, filtering, search engines and computer vision.

Implement Sustainability Practices	**4-3 Collaborative Robots (Cobots)**	The incorporation of collaborative robots (cobots) into CNC machine operations streamlines repetitive tasks, such as material handling and part loading, previously performed by CNC operators. This shift allows operators to allocate their time and expertise towards fine-tuning programming parameters, optimizing toolpaths, and troubleshooting complex machining operations.	**Human-robot collaboration**		**Knowledge**	L4	http://data.europa.eu/esco/skill/0f5374e3-0b9b-4b16-af7a-49654ce0bb15	Human-Robot Collaboration is the study of collaborative processes in which human and robot agents work together to achieve shared goals. Human-Robot Collaboration (HRC) is an interdisciplinary research area comprising classical robotics, human-computer interaction, artificial intelligence, design, cognitive sciences and psychology. It is related to the definition of the plans and the rules for communication to perform a task and achieve a goal in a joint action with a robot.
Implement Sustainability Practices Troubleshoot and maintain CNC machines	**5-3 Energy Efficiency 1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	By increasing predictive maintenance capabilities, possible malfunctions are prevented, and efficient energy use is ensured. Also, the energy efficiency trend causes the current machinery and operations methods and the operators most likely must adapt to this trend in terms of both physical changes as well as operational behaviour. Increased data collection from connected CNC- Real-time monitoring of CNC and health is possible via the implementation of IoT and smart sensors to current CNC lines. This impact changes the way how data is collected and interpreted and enhance the production and maintenance processes.	**Energy efficiency**			L4	http://data.europa.eu/esco/skill/83fc0b2b-6cd2-46af-b1ff-d3fc83604c26	Field of information concerning the reduction of the use of energy. It encompasses calculating the consumption of energy, providing certificates and support measures, saving energy by reducing the demand, encouraging efficient use of fossil fuels, and promoting the use of renewable energy.
			Internet of Things			L3	http://data.europa.eu/esco/skill/f049d050-12da-4e40-813a-2b5eb6df6b51	The general principles, categories, requirements, limitations and vulnerabilities of smart connected devices (most of them with intended internet connectivity).
	4-6 Predictive Maintenance	Use predictive analytics for timely maintenance and reducing downtime. Predictive maintenance trend affect the conventional maintenance timeline and procedure.	**Sensors**			L3	http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.

Use of sustainable materials and practices	**4-6 Predictive Maintenance**	Use predictive analytics for timely maintenance and reducing downtime. Predictive maintenance trend affect the conventional maintenance timeline and procedure.	**Predictive maintenance**		**Knowledge**	L4	http://data.europa.eu/esco/skill/7d913551-e17a-40ba-baf7-48d0c3b12e50	The use of data analytics and mathematical calculation to manage and monitor the conditions of machines and production processes.
Use of sustainable materials and practices	**5-6 Sustainable Material Innovation**	With the innovations in sustainable material technology, the materials used in CNC operations will be more environment friendly materials with different physical, thermal properties or other important properties such as brittleness or ductility, which needs to be studied before using materials in manufacturing. The operator must follow the recent developments and trends in sustainable materials to adapt CNC operations to these kinds of new materials accordingly.	**Use sustainable materials and components**		**Skill**	L3	http://data.europa.eu/esco/skill/73576419-31c2-4e45-8e30-ab1afec3db4e	Identify, select environmentally friendly materials and components. Decide on the substitution of certain materials by the one that are environmentally friendly, maintaining the same level of functionality and other characteristics of the product.
Use of advanced design and simulation software	**4-2 Robotics and Automation**	Adoption of advanced software for design and simulation in CNC machining to improve efficiency and product quality more likely raise the needed proficiency level of operators in using and programming CAM software.	**Use CAM software**			L4	http://data.europa.eu/esco/skill/7a757fa5-9a6f-43ab-9e66-f8f4dba1ffcb	Use computer-aided manufacturing (CAM) programmes to control machinery and machine tools in the creation, modification, analysis, or optimisation as part of the manufacturing processes of workpieces.

8.5. PRODUCT QUALITY CONTROLLER

8.5.1. JOB DESCRIPTION AND SCOPE

Job Description

Product Quality Controllers (ESCO 1213.8) ESCO Job description: "*check the quality of manufactured products. They work in manufacturing facilities where they perform basic inspection and evaluation of products before, during or after the production process. They track production problems and send inferior or malfunctioning items back for repair*" (*Product Quality Controller*, n.d.).

Business Area

The role of a Product Quality Controller is critical across various industries where maintaining high standards of product quality is essential. These professionals are responsible for inspecting and testing products to ensure they meet established quality standards, regulatory compliance, and customer satisfaction. Here are some of the key industries within scope that employ Product Quality Controllers:

- **Manufacturing:** This is one of the largest sectors employing Product Quality Controllers. They work in different manufacturing industries, including automotive, electronics, consumer goods, textiles, and machinery, ensuring products are manufactured to specifications and quality standards.
- **Aerospace and Defence:** Given the critical nature of products in the aerospace and defence industry, Product Quality Controllers ensure that components, systems, and final products meet strict quality and safety standards.
- **Construction Materials:** In the construction industry, Product Quality Controllers ensure that materials like cement, steel, and glass meet required quality standards and specifications for safety and durability.
- **Technology and Electronics:** Product Quality Controllers in the technology sector work with electronic devices, software, and hardware products to ensure they meet quality standards, functionality, and user experience requirements.

Across these industries, Product Quality Controllers use a variety of tests and inspection methods to ensure products meet quality standards, including visual inspections, performance tests, durability tests, and regulatory compliance checks. Their work is essential for protecting consumers, maintaining brand reputation, and ensuring the long-term success of products in the market.

8.5.2. CONTEXT AND LIMITATIONS

The general trends and importance of quality control and assurance roles across various industries provide useful insights. Quality controllers ensure products meet specifications and quality standards, a critical function in manufacturing and production processes. Their roles encompass monitoring manufacturing processes, ensuring compliance with standards, maintaining quality documentation, evaluating and maintaining quality management systems, and more.

The skillset for quality control roles has evolved, with an increased emphasis on technical skills, problem-solving, and familiarity with industry standards like ISO regulations. Demonstrating precision, consistency, analytical skills, and a practical approach to problem-solving is essential. These trends suggest a growing need for skilled professionals in quality control and assurance, reflecting the broader demand for roles that support operational excellence and product integrity.

Related skills and roles of “Product Quality Controller” in industries sectors indicate the importance of quality control functions. These sectors are significant employers of quality control expertise to maintain product standards and compliance. Thus, individuals with experience in quality control and a deep understanding of industry-specific regulations are likely to find opportunities in France's diverse industrial landscape.

8.5.3. FROM THE CURRENT SITUATION TO AN ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 43 : Tasks and skills impacted related to product quality controller occupation.

TASK	IMPACTİNG DİGİTAL TECHNOLOGY AND/OR GREEN TRANSİTİON	IMPACT DESCRİPTİON	RELATED NEEDED SKİLLS/KNOWLEDGE	EXPECTED TENDENCY FOR SKİLL EVOLUTİON	SKİLL TYPE	MATURİTY LEVEL TO REACH	SKİLL ESCO URL	SKİLL DESCRİPTİON
Analyze product performance data from sensors	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	Integrate sensors into production tools for real-time performance monitoring, improving process control through quality defect detection	**Sensors**	+	**Knowledge**	L3	http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.
Application of Lean Six Sigma methodologies	**5-4 Waste Reduction**	Applying Lean Six Sigma methodologies to improve efficiency and reduce waste in quality control processes. This task will have to be reasssed through the improvements coming from changes in energy optimisation field.	**Continuous improvement philosophies**				http://data.europa.eu/esco/skill/0550431f-9c8b-4204-9c45-59bc5feacf06	Underlying ideas of quality management systems. Implementation process of lean manufacturing, Kanban, Kaizen, Total Quality Management (TQM) and other continuous improvement systems.
			Total quality control				http://data.europa.eu/esco/skill/8af372fa-7b85-4bab-ab20-3f2eb980c400	The quality control philosophy that expects each part to be of top quality, without any tolerance for subpar materials or methods. The mindset of striving to deliver top quality work without compromises.

	5-3 Energy Efficiency		**Continuous improvement philosophies**				http://data.europa.eu/esco/skill/0550431f-9c8b-4204-9c45-59bc5feacf06	Underlying ideas of quality management systems. Implementation process of lean manufacturing, Kanban, Kaizen, Total Quality Management (TQM) and other continuous improvement systems.
			Total quality control				http://data.europa.eu/esco/skill/8af372fa-7b85-4bab-ab20-3f2eb980c400	The quality control philosophy that expects each part to be of top quality, without any tolerance for subpar materials or methods. The mindset of striving to deliver top quality work without compromises.
Inspect products for visual and dimensional defects	**2-2 3D Scanning**	Thanks to the advancements in 3D scanning technology, the visual inspections for quality control processes of a product are enriched by using 3D scanning for automated, high-precision inspection and defect detection, including complex geometries, for detailed and accurate quality inspections. Visual inspection task of the controller becomes more digitalized through 3D scanning practices.	**Apply 3D imaging techniques**		**Skill**	L4	http://data.europa.eu/esco/skill/1859883d-c047-4fe1-8e74-7bb4385d6ad2	Implement a variety of techniques such as digital sculpting, curve modelling and 3D scanning to create, edit, preserve and use 3D images, such as point clouds, 3D vector graphic and 3D surface shapes.
Maintain accurate and complete quality control records	**3-1 Cybersecurity**	Implementation of robust cybersecurity measures to protect sensitive quality control data, including production information and intellectual property.	**Cybersecurity principles**		**Knowledge**	L3	http://data.europa.eu/esco/skill/8088750d-8388-4170-a76f-48354c469c44	The methods that protect ICT systems, networks, computers, devices, services, digital information and people against illegal or unauthorised use.

Perform destructive and non-destructive testing	**4-2 Robotics and Automation**	Automation of repetitive, hazardous or high-volume testing procedures using robots increases efficiency and consistency have an impact on the job of a quality controller thanks to the advancements in robotics and automation fields.	**Human-robot collaboration**			L4	http://data.europa.eu/esco/skill/0f5374e3-0b9b-4b16-af7a-49654ce0bb15	Human-Robot Collaboration is the study of collaborative processes in which human and robot agents work together to achieve shared goals. Human-Robot Collaboration (HRC) is an interdisciplinary research area comprising classical robotics, human-computer interaction, artificial intelligence, design, cognitive sciences and psychology. It is related to the definition of the plans and the rules for communication to perform a task and achieve a goal in a joint action with a robot.
			Robotics			L3	http://data.europa.eu/esco/skill/e87ec79a-c9ff-46f5-84fa-7a0f394cdf40	The branch of engineering that involves the design, operation, manufacture, and application of robots. Robotics is part of mechanical engineering, electrical engineering, and computer science and overlaps with mechatronics and automation engineering.
	4-3 Collaborative Robots (Cobots)		**Human-robot collaboration**			L4	http://data.europa.eu/esco/skill/0f5374e3-0b9b-4b16-af7a-49654ce0bb15	Human-Robot Collaboration is the study of collaborative processes in which human and robot agents work together to achieve shared goals. Human-Robot Collaboration (HRC) is an interdisciplinary research area comprising classical robotics, human-computer interaction, artificial intelligence, design, cognitive sciences and psychology. It is related to the definition of the plans and the rules for communication to perform a task and achieve a goal in a joint action with a robot.

8.6. AUTOMATED ASSEMBLY LINE OPERATOR

8.6.1. JOB DESCRIPTION AND SCOPE

Job Description

Automated Assembly Line Operators (ESCO 3139.1) ESCO description: *"operate, maintain and clean production machines. They are responsible for the assembly of a whole product or a part of a product. Automated assembly line operators perform all tasks in a production process via a rotation system"* (*Automated Assembly Line Operator*, n.d.).

Business Area

The job scope of an automated assembly line operator includes working with a variety of machines and tools to assemble products. They are responsible for the proper functioning of machinery and equipment and for products to meet quality standards.

Automated assembly line operators are the people responsible for the operation of automated assembly lines in production facilities. Job areas may include:

- **Operating in Manufacturing Plants:** Automated assembly line operators operate and manage assembly lines in manufacturing plants. This includes assembling products, placing components and overseeing the flow of production processes.
- **Line Maintenance and Troubleshooting:** Operators perform regular maintenance to ensure the assembly line is running properly. They also identify and fix any malfunctions encountered during production.
- **Quality Control:** Automated assembly line operators control the quality of the products. This involves conducting quality control tests at each stage of the assembly process and may be related to detecting defective products.
- **Productivity and Process Improvement:** Operators continuously review processes to improve the efficiency of the assembly line. They identify potential improvements and help optimize production processes.
- **Equipment and Technology Upgrades:** Automated assembly line operators can be involved in introducing new equipment and technologies and updating existing systems. This can include the adoption of more efficient and innovative production methods.
- **Training and Experience Development:** Operators can provide training to assembly line personnel and participate in training programs to continuously improve their own knowledge and skills.

Automated assembly line operators play an important role in manufacturing plants and ensure that the production process runs efficiently. They need to have strong technical skills, a careful work style and troubleshooting abilities.

8.6.2. CONTEXT AND LIMITATIONS

Automated assembly line operators may face specific contexts and limitations as they are responsible for the operation of automated assembly lines in production facilities:

- **Technological Limitations:** Automated assembly lines are supported by a specific set of technology and equipment. Therefore, the operators' workspace may be within the limits of the available technology and equipment. Innovative technologies may need to be adopted or existing systems may need to be updated.
- **Product Variety and Flexibility:** Automated assembly lines are often optimized for a specific product or product line. In this case, the operators' workspace may be limited to the assembly and production of specific products. Lines may need to be reconfigured or adjusted to produce different products.
- **Safety and Health Regulations:** Automated assembly line operators must comply with safety and occupational health regulations when working in production facilities. This may include issues such as the use of safety equipment, handling of hazardous materials and machine safety.
- **Productivity and Production Targets:** Operators are often responsible for achieving specific production targets. This means that a certain amount of product needs to be produced at a certain time. To achieve these targets, it is important that operators work efficiently and that production processes are optimized.
- **Quality Control and Defective Products:** Operators on automated assembly lines are responsible for controlling the quality of products and detecting defective products. It is important to pay attention to quality control processes to minimize the number of defective products and ensure compliance with quality standards.
- **Equipment Maintenance and Breakdowns:** Operators are responsible for performing regular maintenance to ensure the proper functioning of the automated assembly line. They may also need to intervene quickly to detect and remedy malfunctions that occur during production.

8.6.3. FROM CURRENT SITUATION TO ON-GOING SITUATION

Here after the description of the main tasks impacted by **Digital Technology** and/or **Green transition**, modifications and evolutions of the related needed skills.

Table 44 : Tasks and skills impacted related to automated assembly line operator occupation.

TASK	IMPACTİNG DİGİTAL TECHNOLOGY AND/OR GREEN TRANSİTİON	IMPACT DESCRİPTİON	RELATED NEEDED SKİLLS/ KNOWLEDGE	EXPECTED TENDENCY FOR SKİLL EVOLUTİON	SKİLL TYPE	MATURİTY LEVEL TO REACH	SKİLL ESCO URL	SKİLL DESCRİPTİON
Automation in assembly processes	**1-1 Internet of Things (IoT) / Smart Sensors / 5G technology**	In assembly automation, the integration of IoT, 5G, and smart sensors empowers operators with sensor expertise to optimize assembly processes. By leveraging real-time data from smart sensors, operators can monitor equipment performance, detect anomalies, and fine-tune assembly parameters, ensuring efficient and error-free production. This seamless integration enhances productivity, reduces downtime, and drives continuous improvement in assembly operations.	**Sensors**	+	**Knowledge**	L3	http://data.europa.eu/esco/skill/70a7b3b3-31ef-4b29-a30f-bb7299dff39b	Sensors are transducers that can detect or sense characteristics in their environment. They detect changes in the apparatus or environment and provide a corresponding optical or electrical signal. Sensors are commonly divided in six classes: mechanical, electronic, thermal, magnetic, electrochemical, and optical sensors.
Automation in assembly processes	**4-2 Robotics and Automation**	Increased use of robotics and automation in assembly processes for efficiency and precision is a trend expected through digital transition. Operators have to adapt to advances in the assembly line technology by mastering the new implementations of more advanced robots and more automation than before.	**Operate automated process control**	+	**Skill**	L3	http://data.europa.eu/esco/skill/0a0532c2-ee60-4410-8e07-70e4d69370ec	Operate process control or automation system (PAS) used to control a production process automatically.
		Transitioning to sustainable, bio-based, or recycled materials to reduce environmental impact and meet sustainability goals is an expected trend to impact this task. Operators have to learn more about eco-friendly materials and implement them in the processes as much as possible. .	**Knowledge of robotics**		**Knowledge**		http://data.europa.eu/esco/skill/e87ec79a-c9ff-46f5-84fa-7a0f394cdf40	The branch of engineering that involves the design, operation, manufacture, and application of robots. Robotics is part of mechanical engineering, electrical engineering, and computer science and overlaps with mechatronics and automation engineering.

Automation in assembly processes	**4-3 Collaborative Robots (Cobots)**	For automated assembly line operators, the integration of cobots and automation into the assembly process represents a transformative shift in operations. By working alongside cobots, operators oversee and optimize automated assembly tasks, ensuring seamless collaboration between humans and machines	**Human-robot collaboration**	+	**Knowl edge**	L4	http://data.europa.eu/esco/skill/0f5374e3-0b9b-4b16-af7a-49654ce0bb15	Human-Robot Collaboration is the study of collaborative processes in which human and robot agents work together to achieve shared goals. Human-Robot Collaboration (HRC) is an interdisciplinary research area comprising classical robotics, human-computer interaction, artificial intelligence, design, cognitive sciences and psychology. It is related to the definition of the plans and the rules for communication to perform a task and achieve a goal in a joint action with a robot.
	4-6 Predictive Maintenance	Automated assembly line operator's adept at maintaining and cleaning production machines leverage predictive maintenance techniques for optimal performance. By utilizing predictive analytics, they proactively address potential equipment failures, minimizing downtime and maximizing productivity in manufacturing operations.	**Maintain machinery**		**Skill**	L3	http://data.europa.eu/esco/skill/61d9ad65-6a78-4c72-9824-aeca20d9a102	Maintain machinery and equipment to ensure that it is clean and in safe, working order. Perform routine maintenance on equipment and adjust or repair when necessary, using hand and power tools. Replace defective parts components or systems.
Implementation of eco-friendly materials	**5-6 Sustainable Material Innovation**	Transitioning to sustainable, bio-based, or recycled materials to reduce environmental impact and meet sustainability goals is an expected trend to impact this task. Operators have to learn more about eco-friendly materials and implement them in the processes as much as possible.	**Types of plastic**		**Knowl edge**	L3	http://data.europa.eu/esco/skill/9c66b182-96ec-43b3-8821-2aeb7df66f12	Types of plastic materials and their chemical composition, physical properties, possible issues and usage cases.
Implementation of eco-friendly materials	**5-6 Sustainable Material Innovation**	Transitioning to sustainable, bio-based, or recycled materials to reduce environmental impact and meet sustainability goals is an expected trend to impact this task. Operators have to learn more about eco-friendly materials and implement them in the processes as much as possible.	**Use sustainable materials and components**	+	**Skill**	L3	http://data.europa.eu/esco/skill/73576419-31c2-4e45-8e30-ab1afec3db4e	Identify, select environmentally friendly materials and components. Decide on the substitution of certain materials by the one that are environmentally friendly, maintaining the same level of functionality and other characteristics of the product.

8.7. EXPERTS' COMMENTS

The findings presented in Turkish sub-report were validated by the experts from various backgrounds and sectors but are all related to advanced manufacturing, digital and green transition. Feedback provided by the experts were collected through a survey tool in May 2024.

Participants

- **Candan Umut OZDEN**, MARKA, Monitoring and Evaluation Unit Specialist
- **Kadir OZKAN**, ZEISS, Application Specialist
- **Zeynep DERELI**, Teknoloji ve İnsan Kolejleri, Founder
- **Talha BEKTAS**, ISTMTAL, School Principal
- **Deniz AYGAN,** IMES CoVE, General Manager.

The main consideration when reaching out to experts was to approach people with different experiences and careers, to evaluate the opinions on the multi-faceted vocational analysis from whole advanced manufacturing ecosystem more accurately. With this concern, findings in this report were evaluated by a wide array of experts, including private sector specialists, VET center and high school executives and CoVE’s.

The study for evaluation had to be carried out in a simplified manner in terms of a survey tool for two reasons; to standardise the input and outputs and have a comparable and meaningful feedback and to offer the experts a smooth validation experience where they could pick the occupations they want to evaluate and skip ones they are not an expert of.

Statements regarding **CNC machine operator** were widely accepted by the experts and in line with their responses. There was only a slight disagreement, or to be precise not a strong agreement, in the statement that claims improving the skill of using sustainable material and components is required for a CNC operator to face the impact of adapting to sustainable materials in manufacturing by also following recent trends.

There was a gap between findings presented for **sustainability manager** occupation and the expert comments. Experts were slightly against the statement that corporate social responsibility knowledge must be improved in order to create comprehensive sustainable strategies, yet they approved that knowledge was needed to accomplish this task. Moreover, sustainable managers needs to improve their mitigating waste of resources skill to implement sustainable manufacturing processes but the trend impact for the same task was only mildly agreed upon.

ICT security managers’ impact analysis was also mostly agreed on by the experts with a few statements that they slightly or partially agreed. Collecting cyber defence data, implementing cyber-attack counter measures, implementation of cybersecurity measures to protect data and systems, principles of AI were the skills and knowledges that are needed to be improved to cover respective tasks, all strongly agreed upon. Managing system security, maintaining database security and knowledge of IoT, smart sensors and 5G technology were the skills and knowledges experts barely agreed that are affected and needed to be improved after digital and green transition trends.

Findings related to **product quality controller** were also mostly aligned with the evaluation with a few statements that the experts only mildly agreed with. Performing destructive and non-destructive testing, robotics knowledge and continuous improvement philosophies were all skill and knowledge that are forecasted to be impacted by new trends, both by experts and the report's authors. Experts were also supporting the statements regarding human-robot collaboration, 3D scanning and application of Six Sigma principles, but they were not in complete agreement.

Automated assembly line operator was the last occupation within the scope of this report. There was not any conflict between statements in the report and reviewers' responses.

Overall, expert review process was carried in a simple, yet effective manner and the results were mostly in line with experts' comments, responses and insights about the expected outcomes of digital and green transition trends on occupations, skills and tasks related to advanced manufacturing.

8.8. CONCLUSION AND OUTLOOKS

The green and digital transitions are fundamentally transforming the job landscape within advanced manufacturing, particularly within Türkiye's strategic industrial sectors. These transitions are not only driving technological advancements but are also fostering the need for a workforce adept in new digital and sustainable practices, aligning with Türkiye's Smart Specialisation Strategy.

In the realm of manufacturing, the integration of collaborative robots (cobots), predictive maintenance, IoT, 5G, and smart sensors is revolutionizing production processes. These technologies are enhancing operational efficiency, minimizing downtime, and optimizing resource use, all while ensuring high product quality. The ability to leverage real-time data and advanced analytics is critical, enabling industries to anticipate and address issues proactively, thus maintaining a competitive edge in the global market.

Sustainability is another cornerstone of this transformation. The implementation of sustainable manufacturing and procurement strategies is crucial for reducing environmental impact and promoting resource efficiency. By embracing AI, machine learning, and big data analytics, industries can develop more eco-friendly practices, reducing waste and ensuring that operations align with global sustainability standards. This is particularly relevant for Türkiye, where environmental considerations are increasingly influencing industrial policies and practices.

The convergence of digital and green technologies also underscores the importance of cybersecurity. As industries become more interconnected and reliant on digital systems, protecting these systems from cyber threats is paramount. Robust ICT security measures are essential to safeguard sensitive information and ensure the continuity of operations, which is vital for maintaining trust and stability in the industrial sector.

In conclusion, the green and digital transitions are driving a profound evolution in the manufacturing landscape, with significant implications for the workforce. Professionals who can navigate and harness these technological advancements are essential for fostering sustainable growth and innovation. Türkiye's emphasis on smart specialisation and alignment with these global trends positions it well to capitalize on these shifts, ensuring its industries remain competitive and resilient. As the country continues to integrate these advanced technologies, it, not only, enhances its manufacturing capabilities but also contribute to a more sustainable and secure industrial future.

8.9. SOURCES

CNC Operatörü İş İlanları. (n.d.). Kariyer.net. https://www.kariyer.net/is-ilanlari/cnc+operatoru?pst=4150&pkw=cnc%20operat%C3%B6r%C3%BC

İş İlanları—Aradığın Güncel İş Fırsatları Kariyer.net'te. (n.d.). Kariyer.net. https://www.kariyer.net/is-ilanlari?pst=12185&pkw=s%C3%BCrd%C3%BCr%C3%BClebilirlik%20m%C3%BCd%C3%BCr%C3%BC

IT Güvenlik Uzmanı İş İlanları. (n.d.). Kariyer.net. https://www.kariyer.net/is-ilanlari/it+guvenlik+uzmani?pst=4558&pkw=%C4%B1t%20g%C3%BCvenlik%20uzman%C4%B1

Kalite Kontrol Elemanı İş İlanları. (n.d.). Kariyer.net. https://www.kariyer.net/is-ilanlari/kalite+kontrol+elemani?pst=960&pkw=kalite%20kontrol%20eleman%C4%B1

8.10. REFERENCES

American Public University System. (n.d.). Cybersecurity trends. Retrieved from https://www.apu.apus.edu/area-of-study/information-technology/resources/cybersecurity-trends/

Apud Agency. (n.d.). Cybersecurity trends: Looking over the horizon to the future. Retrieved from https://www.apu.apus.edu/area-of-study/information-technology/resources/cybersecurity-trends/

Automated assembly line operator. (n.d.). Retrieved from https://esco.ec.europa.eu/en/classification/occupation

Computer numerical control machine operator. (n.d.). Retrieved from https://esco.ec.europa.eu/en/classification/occupation

Coursera. (2024, March 18). What does a sustainability manager do? Retrieved from https://www.coursera.org/articles/sustainability-manager

ESCO. (n.d.). Retrieved from https://esco.ec.europa.eu/en/classification/occupation?uri=http%3A%2F%2Fdata.europa.eu%2Fesco%2Foccupation%2F2cf2b905-3308-4b5d-8e8d-633fc7a3f3ce

GreenBiz. (n.d.). The sustainability job market is booming. What does that mean for hiring? Retrieved from https://www.greenbiz.com/article/sustainability-job-market-booming-what-does-mean-hiring

ICT security manager. (n.d.). Retrieved from https://esco.ec.europa.eu/en/classification/occupation

İklim.gov.tr. (n.d.). The 2024-2030 climate change mitigation and adaptation strategy and action plans are published. Retrieved from https://iklim.gov.tr/en/the-2024-2030-climate-change-mitigation-and-adaptation-strategy-and-action-plans-are-published-news-4245

Product quality controller. (n.d.). Retrieved from https://esco.ec.europa.eu/en/classification/occupation

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi. (n.d.-a). Proje açıklaması. Retrieved from https://cbddo.gov.tr/projeler/siber-platform/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi. (n.d.-b). Proje açıklaması. Retrieved from https://cbddo.gov.tr/projeler/siber-myo/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi. (n.d.-c). Siber güvenlik. Retrieved from https://cbddo.gov.tr/siber-guvenlik/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi. (2020). Ulusal siber güvenlik stratejisi ve eylem planı (2020-2023). Retrieved from https://cbddo.gov.tr/siber-guvenlik-stratejisi/

Türkiye İş Kurumu. (n.d.). Açık iş ilanları. Retrieved from https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 – S Synthesis of all D3.2 - M24 sub-reports.

Co-funded by
the European Union

9. SYNTHESIS OF ALL JOB'S IMPACT ANALYSIS

This section deals with the analysis of the selected 28 jobs. As mentioned in the methodology (chapter 3), it was started analysing the changes faced by companies and identifying the **levers of those changes** affecting the specific jobs; then, it was described the **changes in skills and knowledges** detected in the analysis.

9.1. LIST OF SELECTED JOBS

Going through the 5 main criteria that WP3 decided to evaluate, here after the short list of jobs analysed by the 4 countries France, Turkey, Italy and Germany for which detailed data analysis are available:

Table 45 : synthesis of all jobs selected.

COUNTRY	ESCO CODE	ESCO OCCUPATION	1 - INDUSTRY SECTORS	2 - DIGITAL AND GREEN TRANSITIONS NEW TRENDS IMPACTING	3 - EMPLOYABILITY	4.RELEVANCE FOR THE SMART SPECIALISATION STRATEGY – AT REGIONAL/COUNTRY?	5 - EDUCATION LEVEL.
FR	2152.1.13	Predictive Maintenance Expert	Machine tools (Mechanical Engineering), Automotive, Aerospace, Transport, Electric and electronic Industries, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D scanning, 3-1 Cybersecurity, 5-2 Circular Economy		13 regions among the 21 FR regions consider this generic job among the priorities: FRC2; FRD1; FRD2; FRE1; FRE2; FRF1; FRF3; FRG0; FRH0; FRJ2; FRK1; FRK2; FRL0	EQF 6
	2163.1	Industrial Designer	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-1 Virtual and Augmented Reality, 2-2 3D scanning, 3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-6 Predictive Maintenance, 5-2 Circular Economy, 5-4 Waste Reduction, 5-6 Sustainable Material Innovation	November 2023 - France: 17852 job offers - Product designer: 712 offers (4%) https://www.glassdoor.fr/Emploi/france-product-designer-emplois-SRCH_IL.0,6_IN86_KO7,23.htm	18 regions among the 21 FR regions consider this generic job among the priorities: FR10; FRC2; FRD1; FRD2; FRE1; FRE2; FRF1; FRF2; FRF3; FRG0; FRH0; FRI2; FRI3; FRJ1; FRJ2; FRK1; FRK2; FRL0	EQF 6

	3114.1 .10	Sensor Engineering Technician	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-10 Sustainable IT Infrastructure, 5-11 Environmental Monitoring and Reporting		18 regions among the 21 FR regions consider this generic job among the priorities:	EQF5
	3118.1	3D Printing Technician	Maritime, Electric and electronic Industries, Aerospace, Automotive, Transport	3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-4 Digital Twins, 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-4 Waste Reduction, 5-6 Sustainable Material Innovation	In 2022, more than 900 job offers for 3D printing roles were published across the French, English, Spanish, Italian, and German sites of 3Dnatives. This number represents more than double the offers published in the previous year.	10 regions among the 21 FR regions consider this generic job among the priorities: FRC2; FRE1; FRF1; FRF2; FRF3; FRG0; FRH0; FRI2; FRJ2; FRK1	EQF 5
	3139.2	Industrial Robot Controller	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-1 Virtual and Augmented Reality, 3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-4 Digital Twins, 4-6 Predictive Maintenance, 5-12 Corporate Social Responsibility (CSR) Initiatives	November 2023 - France: Robotics technician: 3090 job offers https://candidat.pole-emploi.fr/offres/recherche?motsCles=technicien+robotique&offresPartenaires=true&range=0-19&rayon=10&tri=0	10 regions among the 21 FR regions consider this generic job among the priorities: FR10; FRC2; FRD1; FRF3; FRG0; FRH0; FRJ2; FRK1; FRK2; FRL0	EQF6
	7543.9	Product Quality Controller	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D scanning, 3-1 Cybersecurity, 4-1 3D Printing/Additive Manufacturing, 4-2 Robotics and Automation	November 2023 - France: QA engineer: 1639 job offers https://candidat.pole-emploi.fr/offres/recherche?motsCles=ing%C3%A9nieur+testeur&offresPartenaires=true&range=0-19&rayon=10&tri=0	12 regions among the 21 FR regions consider this generic job among the priorities: FRC2; FRD1; FRD2; FRE1; FRF2; FRF3; FRG0; FRH0; FRJ2; FRK1; FRK2; FRL0	EQF 6

TR	7223.4	Computer Numerical Control Machine Operator	Machine tools (Mechanical Engineering), Automotive, Aerospace	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-6 Predictive Maintenance, 5-3 Energy Efficiency, 5-6 Sustainable Material Innovation"	April 2024 - Türkiye: CNC Operator: 64 job offers (İŞKUR) 373 job offers (kariyer.net) Sources: İŞKUR - Bilgisayarlı Makine (CNC Operatörü) https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx https://www.kariyer.net/is-ilanlari/cnc+operatoru?pst=4150&pkw=cnc%20operat%C3%B6r%C3%BC	Aligns with the S3 priorities of "Automotive plastics" and "Power units" https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	EQF Level 4
	7543.9	Product Quality Controller	Automotive, Aerospace, Electric and electronic Industries, Machine tools (Mechanical Engineering)	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 2-2 3D scanning, 3-1 Cybersecurity, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 5-3 Energy Efficiency, 5-4 Waste Reduction"	April 2024 - Türkiye: Quality Controller: 222 job offers (İŞKUR) 514 job offers (kariyer.net) Sources: İŞKUR - Kalite Kontrolcü https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx https://www.kariyer.net/is-ilanlari/kalite+kontrol+elemani?pst=960&pkw=kalite%20kontrol%20eleman%C4%B1	Aligns with most of the S3 priorities given for TR42 region. https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	EQF Level 6
	2529.8	Ict Security Manager	Transport, Electric and electronic Industries, Aerospace, Automotive	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 5-10 Sustainable IT Infrastructure, 5-12 Corporate Social Responsibility (CSR) Initiatives"	April 2024 - Türkiye: ICT Security Specialist: 28 job offers (kariyer.net) https://www.kariyer.net/is-ilanlari/it+guvenlik+uzmani?pst=4558&pkw=%C4%B1t%20g%C3%BCvenlik%20uzman%C4%B1	Although not directly addressed under S3, it is relevant to all businesses, especially ones affected more by the digital transition trends.	EQF Level 5

	1213.8	Sustainability Manager	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 5-1 Renewable Energy Integration, 5-3 Energy Efficiency, 5-4 Waste Reduction, 5-5 Green Logistics and Supply Chain, 5-6 Sustainable Material Innovation, 5-7 Carbon Footprint Management, 5-11 Environmental Monitoring and Reporting, 5-12 Corporate Social Responsibility (CSR) Initiatives"	April 2024 - Türkiye: Sustainability Manager: 2 job offers (kariyer.net) https://www.kariyer.net/is-ilanlari?pst=12185&pkw=s%C3%BCrd%C3%BCr%C3%BClebilirlik%20m%C3%BCd%C3%BCr%C3%BC	Although not directly addressed under S3, it is relevant to all businesses, especially ones affected more by the green transition trends.	EQF Level 6
	3139.1	Automated Assembly Line Operator	Automotive, Aerospace, Electric and electronic Industries	"1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-6 Predictive Maintenance, 5-6 Sustainable Material Innovation"	This occupation is not directly listed in career sites, instead they are listed under assembly line operators for different types of sectors.	Aligns with the S3 priority of "Automotive plastics" https://s3platform.jrc.ec.europa.eu/region-page-test/-/regions/TR42	EQF Level 3
IT	2511.3	Data Analyst	Machine tools (Mechanical Engineering), Automotive, Aerospace, Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 5-5 Green Logistics and Supply Chain, 5-3 Energy Efficiency, 2-1 Virtual and Augmented Reality, 3-1 Cybersecurity	High difficulty in finding	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their S3	In Italy, courses and programs for Data Engineers often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels.6, such as bachelor courses in Data Science or Statistics.

	2141.4.2.1	Automation Engineer	Automotive, Machine tools (Mechanical Engineering)	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 2-1 Virtual and Augmented Reality, 5-3 Energy Efficiency	Average difficulty in finding: 61%	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their S3	In Italy, courses and programs for Automation Engineer often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels.6, such as bachelor's degree in Automation Engineering or Robotics.
	2529.4	Ethical Hackers (Main Title Of ESCO Occupation)/Cybersecurity Specialist (Alternative Label Put On The ESCO Occupation)	Electric and electronic Industries, Transport, Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing, 4-4 Digital Twins, 5-2 Circular Economy, 5-4 Waste Reduction	Average difficulty in finding: 50 %	Lombardy Region and Piedmont Region consider Advanced Manufacturing as one of the priorities in their S3	In Italy, courses and programs for Cybersecurity Specialist often fall within EQF (European Qualifications Framework) levels 6 to 8, which correspond to undergraduate and postgraduate levels.6, such as bachelor's degree in computer science.

GERMANY	3118.1	3D Printing Technician	Automotive, Aerospace, Electric and electronic Industries, Machine tools (Mechanical Engineering), Maritime	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 2-2 3D scanning, 4-1 3D Printing/Additive Manufacturing, 4-2 Robotics and Automation, 4-4 Digital Twins, 4-5 Adaptive Manufacturing Systems, 4-6 Predictive Maintenance, 5-4 Waste Reduction, 5-2 Circular Economy, 5-3 Energy Efficiency, 5-6 Sustainable Material Innovation, 5-11 Environmental Monitoring and Reporting	Employability in 2024: The rapid adoption of additive manufacturing in aerospace, automotive, healthcare, and consumer goods is driving demand for skilled operators. Additive manufacturing's benefits, like reduced lead times and design flexibility, boost job opportunities across sectors. High demand exists for operators skilled in managing **Advanced Manufacturing** equipment, preparing digital models, post-processing, and quality control. Employability in 5 Years (2029): Technological advancements require operators to update their skills to enhance speed, accuracy, and material diversity. More integrated roles in hybrid manufacturing settings create additional jobs, blending traditional and additive manufacturing skills. Specialisation in specific types of additive manufacturing, such as metal or polymer printing, offer new career paths. Employability in 10 Years (2034): Seasoned operators find opportunities in leadership, training, or entrepreneurial roles within the industry. Full integration with Industry 4.0 necessitates a deep understanding of digital technologies and data analytics. Staying competitive require continuous learning and adaptability to new technologies and market demands. Conclusion: Promising employability prospects exist for Additive Manufacturing Operators, with strong growth expected in this sector.	The Region of Baden-Württemberg considers Advanced Manufacturing as one of the priorities in its S3. https://ec.europa.eu/regional_policy/assets/s3-observatory/regions/de1.html	EQF Level 4 (trained skilled worker or equivalent): Operators undertake corresponding tasks, potentially with supervisory roles, troubleshooting, and process optimisation.

	7223.4	Computer Numerical Control Machine Operator	Machine tools (Mechanical Engineering), Automotive, Aerospace, Maritime, Electric and electronic Industries	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics, 3-1 Cybersecurity, 4-2 Robotics and Automation, 4-3 Collaborative Robots (Cobots), 4-4 Digital Twins, 4-5 Adaptive Manufacturing Systems, 1-1 Internet of Things (IoT) / Smart Sensors / 5G technology, 5-3 Energy Efficiency, 5-4 Waste Reduction	Current Factors (2024): CNC machining is crucial in industries like aerospace, automotive, electronics, and medical devices, ensuring steady demand for skilled operators. Technological advancements in automation, precision, and efficiency require highly skilled operators. Integration of robotics and CAM software boosts efficiency, increasing the need for proficient operators. A skill shortage has created a competitive job market with ample opportunities for qualified individuals. Employability in 5 Years (2029): Increased automation and robotics integration sustain high demand for adaptable CNC operators. Advanced digital skills, including proficiency in CAD/CAM software and CNC programming, are essential. Specialisation in areas like additive manufacturing, multi-axis, or high-speed machining could offer new career paths based on industry needs. Employability in 10 Years (2034): CNC machining remains vital to manufacturing, ensuring continued demand for skilled operators. Engaging with emerging technologies such as nanotechnology, advanced materials, and digital twins are crucial, necessitating ongoing learning. Global economic and industry trends influence employability, emphasizing flexibility and adaptability in skills and practices. Conclusion: CNC operators who continuously update their skills and adapt to new technologies and industry trends can expect to remain highly employable, supporting the hypothesis provided.	Th Region of Baden-Württemberg considers Advanced Manufacturing as one of the priorities in its S3. https://ec.europa.eu/regional_policy/assets/s3-observatory/regions/de1.html	EQF Level 5 (technician or equivalent): CNC-Technicians at this level have advanced CNC skills, capable of programming complex operations, proficient in multi-axis machining, adaptive control, and integrated CAD/CAM systems optimizing tool paths, and conducting comprehensive troubleshooting. They also manage less experienced operators and contribute to process improvements.

9.2. RESULTS AND STATISTICS

Here after the synthesis of the 16 jobs analysed per country:

Table 46 : Synthesis of the jobs analysed per country.

OCCUPATION REF	OCCUPATION TITLE	FR	GE	IT	TR
2152.1.13	Predictive maintenance expert	`8			
2163.1	industrial designer	9			
3114.1.10	sensor engineering technician	8			
3118.1	3D printing Technician	7	11		
3139.2	Industrial robot controller	16			
7543.9	product quality controller	11			10
7223.4	Computer Numerical Control machine operator		12		10
2511.3	Data Analyst			6	
2141.4.2.1	Automation Engineer			5	
2529.4	Ethical Hackers			5	
1213.8	Sustainability Manager				17
2529.8	ICT Security Manager				12
2152.1	Electronics Engineer				11
3139.1	Automated Assembly Line Operator				7

9.2.1. JOBS IMPACTED BY TRENDS

Below, it is presented a table which summarises jobs considered as impacted by each trend (list of trends detailed in chapter 3.1.1 Fields, Areas of observation). Details of the analysis are available in the corresponding sub-reports.

Table 47 : Jobs impacted by trends.

IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	OCCUPATION REF.	OCCUPATION TITLE	FR	GE	IT	TR
1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	**2152.1.13**	Predictive maintenance expert	2			
	3114.1.10	sensor engineering technician	3			
	3118.1	3D printing Technician		1		
	3139.2	Industrial robot controller	2			
	7543.9	product quality controller	2			1

	7223.4	Computer Numerical Control machine operator				2
	2511.3	Data Analyst			1	
	2141.4.2.1	Automation Engineer			1	
	2529.4	Ethical Hackers			1	
	1213.8	Sustainability Manager				3
	2529.8	ICT Security Manager				2
	3139.1	Automated Assembly Line Operator				1
1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	**2152.1.13**	Predictive maintenance expert	1			
	2163.1	industrial designer	2			
	3114.1.10	sensor engineering technician	2			
	3118.1	3D printing Technician		2		
	3139.2	Industrial robot controller	3			
	7543.9	product quality controller	4			
	7223.4	Computer Numerical Control machine operator		3		3
	2511.3	Data Analyst			1	
	2141.4.2.1	Automation Engineer			2	
	1213.8	Sustainability Manager				2
	2529.8	ICT Security Manager				2
2-1 Virtual and Augmented Reality	**2152.1.13**	Predictive maintenance expert	2			
	2163.1	industrial designer	1			
	3139.2	Industrial robot controller	3			
	2511.3	Data Analyst			1	
	2141.4.2.1	Automation Engineer			1	
2-2 3D scanning	**2152.1.13**	Predictive maintenance expert	1			
	2163.1	industrial designer	2			
	7543.9	product quality controller	1			1
3-1 Cybersecurity	**2152.1.13**	Predictive maintenance expert	1			
	3114.1.10	sensor engineering technician	1			

	3118.1	3D printing Technician	1	1		
	3139.2	Industrial robot controller	1			
	7543.9	product quality controller	1			1
	7223.4	Computer Numerical Control machine operator		1		
	2511.3	Data Analyst			1	
	2529.8	ICT Security Manager				5
3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing	**2529.4**	Ethical Hackers			1	
4-1 3D Printing/Additive Manufacturing	**2163.1**	industrial designer	2			
	3118.1	3D printing Technician	2	2		
	3139.2	Industrial robot controller	1			
	7543.9	product quality controller	2			
4-2 Robotics and Automation	**7543.9**	product quality controller	1			2
	7223.4	Computer Numerical Control machine operator		2		1
	3139.1	Automated Assembly Line Operator				2
4-3 Collaborative Robots (Cobots)	**7543.9**	product quality controller				1
	7223.4	Computer Numerical Control machine operator				1
	3139.1	Automated Assembly Line Operator				1
4-4 Digital Twins	**3118.1**	3D printing Technician	1			
	3139.2	Industrial robot controller	1			
	2529.4	Ethical Hackers			1	
4-5 Adaptive Manufacturing Systems	**7223.4**	Computer Numerical Control machine operator		1		
4-6 Predictive Maintenance	**3114.1.10**	sensor engineering technician	1			
	3118.1	3D printing Technician	1	3		
	3139.2	Industrial robot controller	1			
	7223.4	Computer Numerical Control machine operator		3		1
	3139.1	Automated Assembly Line Operator				1

5-1 Renewable Energy Integration	**1213.8**	Sustainability Manager				1
5-10 Sustainable IT Infrastructure	**2529.8**	ICT Security Manager				1
5-11 Environmental Monitoring and Reporting	**1213.8**	Sustainability Manager				2
5-12 Corporate Social Responsibility (CSR) Initiatives	**3139.2**	Industrial robot controller	1			
	7223.4	Computer Numerical Control machine operator		2		
	1213.8	Sustainability Manager				3
	2529.8	ICT Security Manager				2
5-2 Circular Economy	**2152.1.13**	Predictive maintenance expert	1			
	2163.1	industrial designer	1			
	2529.4	Ethical Hackers			1	
5-3 Energy Efficiency	**3118.1**	3D printing Technician	1			
	7543.9	product quality controller				2
	7223.4	Computer Numerical Control machine operator				1
	2511.3	Data Analyst			1	
	2141.4.2.1	Automation Engineer			1	
	1213.8	Sustainability Manager				1
5-4 Waste Reduction	**7543.9**	product quality controller				2
	2529.4	Ethical Hackers			1	
	1213.8	Sustainability Manager				1
5-5 Green Logistics and Supply Chain	**2511.3**	Data Analyst			1	
	1213.8	Sustainability Manager				1
5-6 Sustainable Material Innovation	**2163.1**	industrial designer	1			
	3118.1	3D printing Technician	1	2		
	7223.4	Computer Numerical Control machine operator				1
	1213.8	Sustainability Manager				2
	3139.1	Automated Assembly Line Operator				2
5-7 Carbon Footprint Management	**1213.8**	Sustainability Manager				1
5-X All Green Transition Trends / Sustainable Manufacturing	**3114.1.10**	sensor engineering technician	1			
	3139.2	Industrial robot controller	3			

9.2.2. TRENDS IMPACTING JOBS

Below, it is presented a table which lists trends which are considered as impacting jobs (list of trends detailed in chapter 3.1.1 Fields, Areas of observation). Details of the analysis are available in the corresponding sub-reports.

When several countries analysed the same occupation, it is easy to identify when the results are not always the same. This is the case for instance for 3D printing technician analysed by France and Germany.

Table 48 : Trends impacting jobs

OCCUPATION REF	OCCUPATION TITLE	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	FR	GE	IT	TR
2152.1.13	**Predictive maintenance expert**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	2			
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	1			
		2-1 Virtual and Augmented Reality	2			
		2-2 3D scanning	1			
		3-1 Cybersecurity	1			
		5-2 Circular Economy	1			
2163.1	**industrial designer**	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	2			
		2-1 Virtual and Augmented Reality	1			
		2-2 3D scanning	2			
		4-1 3D Printing/Additive Manufacturing	2			
		5-2 Circular Economy	1			
		5-6 Sustainable Material Innovation	1			
3114.1.10	**sensor engineering technician**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	3			
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	2			
		3-1 Cybersecurity	1			
		4-6 Predictive Maintenance	1			
		5-X All Green Transition Trends / Sustainable Manufacturing	1			
3118.1	**3D printing Technician**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology		1		
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics		2		

		3-1 Cybersecurity	1	1		
		4-1 3D Printing/Additive Manufacturing	2	2		
		4-4 Digital Twins	1			
		4-6 Predictive Maintenance	1	3		
		5-3 Energy Efficiency	1			
		5-6 Sustainable Material Innovation	1	2		
3139.2	**Industrial robot controller**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	2			
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	3			
		2-1 Virtual and Augmented Reality	3			
		3-1 Cybersecurity	1			
		4-1 3D Printing/Additive Manufacturing	1			
		4-4 Digital Twins	1			
		4-6 Predictive Maintenance	1			
		5-12 Corporate Social Responsibility (CSR) Initiatives	1			
		5-X All Green Transition Trends / Sustainable Manufacturing	3			
7543.9	**product quality controller**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology	2			1
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics	4			
		2-2 3D scanning	1			1
		3-1 Cybersecurity	1			1
		4-1 3D Printing/Additive Manufacturing	2			
		4-2 Robotics and Automation	1			2
		4-3 Collaborative Robots (Cobots)				1
		5-3 Energy Efficiency				2
		5-4 Waste Reduction				2
7223.4	**Computer Numerical Control machine operator**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				2
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics		3		3

		3-1 Cybersecurity		1		
		4-2 Robotics and Automation		2		1
		4-3 Collaborative Robots (Cobots)				1
		4-5 Adaptive Manufacturing Systems		1		
		4-6 Predictive Maintenance		3		1
		5-12 Corporate Social Responsibility (CSR) Initiatives		2		
		5-3 Energy Efficiency				1
		5-6 Sustainable Material Innovation				1
2511.3	**Data Analyst**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1	
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics			1	
		2-1 Virtual and Augmented Reality			1	
		3-1 Cybersecurity			1	
		5-3 Energy Efficiency			1	
		5-5 Green Logistics and Supply Chain			1	
2141.4.2.1	**Automation Engineer**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1	
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics			2	
		2-1 Virtual and Augmented Reality			1	
		5-3 Energy Efficiency			1	
2529.4	**Ethical Hackers**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1	
		3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing			1	
		4-4 Digital Twins			1	
		5-2 Circular Economy			1	
		5-4 Waste Reduction			1	
1213.8	**Sustainability Manager**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				3
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics				2

		5-1 Renewable Energy Integration				1
		5-11 Environmental Monitoring and Reporting				2
		5-12 Corporate Social Responsibility (CSR) Initiatives				3
		5-3 Energy Efficiency				1
		5-4 Waste Reduction				1
		5-5 Green Logistics and Supply Chain				1
		5-6 Sustainable Material Innovation				2
		5-7 Carbon Footprint Management				1
2529.8	**ICT Security Manager**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				2
		1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics				2
		3-1 Cybersecurity				5
		5-10 Sustainable IT Infrastructure				1
		5-12 Corporate Social Responsibility (CSR) Initiatives				2
2152.1	**Electronics Engineer**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				4
		4-1 3D Printing/Additive Manufacturing				3
		5-1 Renewable Energy Integration				3
		5-3 Energy Efficiency				1
3139.1	**Automated Assembly Line Operator**	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				1
		4-2 Robotics and Automation				2
		4-3 Collaborative Robots (Cobots)				1
		4-6 Predictive Maintenance				1
		5-6 Sustainable Material Innovation				2

9.2.3. JOBS – TRENDS IMPACT – SKILLS NEEDED

From trends impacts, it is identified related needed skills to support the changes. To simplify the analysis, all needed skills identified in 7 groups are grouped Here after, are the needed type of skills, allowing to support trends impacts, per occupation and trend. To sum up, 165 skills are identified which are involved by these trends' impacts.

Table 49 : Needed type of skills

OCCUPATION TITLE	IMPACTING DIGITAL TECHNOLOGY AND/OR GREEN TRANSITION	INTER-DISCIPLINARY COOPERATION AND PROJECT MANAGEMENT	PRODUCTION AND MANU-FACTURING TECHNOLOGIES	DIGITALISATION AND IT SECURITY	TECHNOLOGICAL CORE COMPETENCES	DATA ANALYSIS AND ARTIFICIAL INTELLIGENCE	SUSTAINABILITY AND ENVIRONMENTAL MANAGEMENT	VIRTUAL AND AUGMENTED REALITY
Predictive Maintenance Expert	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					1		
	2-1 Virtual and Augmented Reality	1						1
	2-2 3D scanning		1					
	3-1 Cybersecurity			1				
	5-2 Circular Economy						1	
Industrial Designers	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	2-1 Virtual and Augmented Reality							1
	2-2 3D scanning		2					
	4-1 3D Printing/Additive Manufacturing	1	1					
	5-2 Circular Economy						1	

	5-6 Sustainable Material Innovation						1	
Sensor Engineering Technicians	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2	1			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	3-1 Cybersecurity			1				
	4-6 Predictive Maintenance					1		
	5-X All Green Transition Trends / Sustainable Manufacturing						1	
3D printing Technician	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	3-1 Cybersecurity			2				
	4-1 3D Printing/Additive Manufacturing	2	1	1				
	4-4 Digital Twins			1				
	4-6 Predictive Maintenance	1				3		
	5-3 Energy Efficiency						1	
	5-6 Sustainable Material Innovation				1	1	1	
Industrial Robot Controller	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					3		
	2-1 Virtual and Augmented Reality							3
	3-1 Cybersecurity			1				
	4-1 3D Printing/Additive Manufacturing		1					
	4-4 Digital Twins		1					
	4-6 Predictive Maintenance					1		
	5-12 Corporate Social Responsibility (CSR) Initiatives						1	

	5-X All Green Transition Trends / Sustainable Manufacturing	1					2	
Product Quality Controller	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				3			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					4		
	2-2 3D scanning		1					1
	3-1 Cybersecurity			2				
	4-1 3D Printing/Additive Manufacturing		2					
	4-2 Robotics and Automation		3					
	4-3 Collaborative Robots (Cobots)		1					
	5-3 Energy Efficiency	1				1		
	5-4 Waste Reduction	1				1		
Computer Numerical Control Machine Operator	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1	1			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					5		
	3-1 Cybersecurity			1				
	4-2 Robotics and Automation		2			1		
	4-3 Collaborative Robots (Cobots)		1					
	4-5 Adaptive Manufacturing Systems	1						
	4-6 Predictive Maintenance					4		
	5-12 Corporate Social Responsibility (CSR) Initiatives	2						
	5-3 Energy Efficiency						1	
	5-6 Sustainable Material Innovation						1	
Data Analyst	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					1		
	2-1 Virtual and Augmented Reality							1
	3-1 Cybersecurity			1				
	5-3 Energy Efficiency	1						

	5-5 Green Logistics and Supply Chain	1						
Automation Engineer	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1				
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	2-1 Virtual and Augmented Reality							1
	5-3 Energy Efficiency				1			
Ethical Hackers	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1				
	3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing			1				
	4-4 Digital Twins			1				
	5-2 Circular Economy	1						
	5-4 Waste Reduction						1	
Sustainability Manager	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology						3	
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics						2	
	5-1 Renewable Energy Integration						1	
	5-11 Environmental Monitoring and Reporting						2	
	5-12 Corporate Social Responsibility (CSR) Initiatives	3						
	5-3 Energy Efficiency						1	
	5-4 Waste Reduction						1	
	5-5 Green Logistics and Supply Chain						1	
	5-6 Sustainable Material Innovation						2	
	5-7 Carbon Footprint Management						1	
ICT Security Manager	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			1	1			
	1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics					2		
	3-1 Cybersecurity			5				
	5-10 Sustainable IT Infrastructure			1				
	5-12 Corporate Social Responsibility (CSR) Initiatives	1		1				

Electronics Engineer	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology			2	2			
	4-1 3D Printing/Additive Manufacturing		1	1	1			
	5-1 Renewable Energy Integration				1		2	
	5-3 Energy Efficiency						1	
Automated Assembly Line Operator	1-1 Internet of Things (IoT) / Smart Sensors / 5G technology				1			
	4-2 Robotics and Automation		2					
	4-3 Collaborative Robots (Cobots)		1					
	4-6 Predictive Maintenance					1		
	5-6 Sustainable Material Innovation						2	

9.2.4. JOBS / SKILLS IMPACTS BY DIGITAL TRENDS

All these results can be visualised and classified, allowing to identify the "level" of digital trends' impacts related to number of jobs impacted (horizontal axis) and related number of skills involved (vertical axis) as shown in figure 20.

It is identified for instance the two main trends considered as the most impacting in regards of these two axes:

- **The ability to gather information from the shop floor:** 1-1 Internet of things, smart sensors, 5G technology
- **The ability to analyse these data:** 1-2 Artificial Intelligence (AI) / Machine learning, Big Data Analytics.

1. 1-1 Internet of Things (IoT) / Smart sensors / 5G technology
2. 1-2 Artificial Intelligence (AI) / Machine learning / Big Data Analytics
3. 2-1 Virtual and Augmented Reality
4. 2-2 3D scanning
5. 3-1 Cybersecurity
6. 3-2 Edge Computing vs Cloud Computing / Blockchain for Supply Chain / Quantum Computing
7. 4-1 3D Printing/Additive Manufacturing
8. 4-2 Robotics and Automation
9. 4-3 Collaborative Robots (Cobots)
10. 4-4 Digital Twins
11. 4-5 Adaptive Manufacturing Systems
12. 4-6 Predictive Maintenance

Figure 19 : Trends

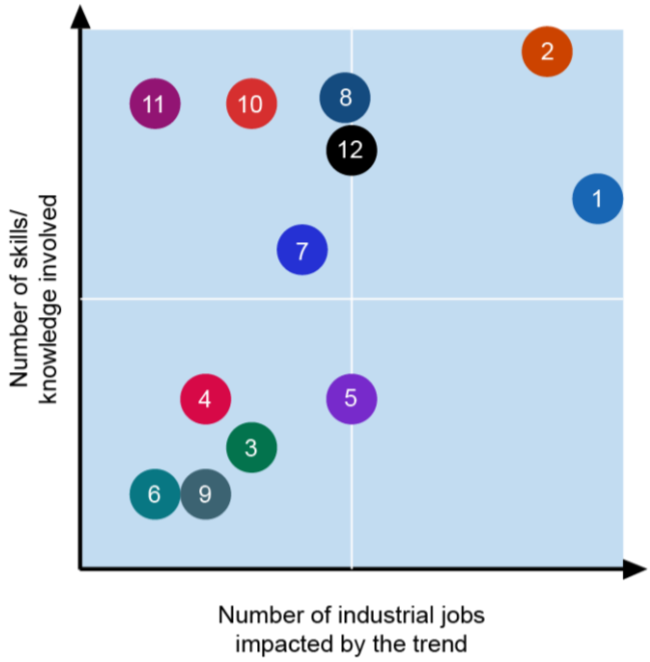

Figure 20 : Level of Digital trends' impacts related to jobs impacted

9.2.5. JOBS/SKILLS IMPACTS BY GREEN TRANSITION TRENDS

The presentation and classification can be carried out in the same manner, facilitating the identification of the "level" of impact from Green transition trends, as depicted in Figure 22.

This summarised analysis of impacts suggests that Green transition trends are not significantly affecting the 16 selected jobs.

Figure 21 : Green transition trends

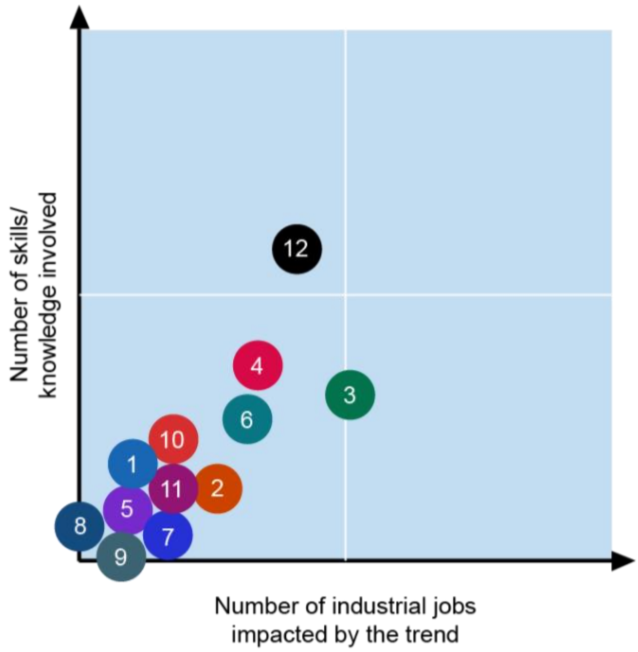

Figure 22 : Level of Green transition trends' impacts

The question which raises, thanks to this presentation is: did impacts well identified on jobs regarding green transition trends?

Indeed, in accordance with [World Economic Forum](https://www.weforum.org/agenda/2024/01/green-transition-skilled-workforce-manpowergroup/) (https://www.weforum.org/agenda/2024/01/green-transition-skilled-workforce-manpowergroup/) (Prising, 2022), the green transition is anticipated to create up to 30 million new jobs by 2030, yet 75% of employers struggle to find skilled talent, and 94% lack the skills needed to meet their ESG (Environmental, Social, and Governance criteria) goals, emphasizing the necessity for substantial upskilling and reskilling efforts. This transition is particularly impactful within highly technical industries like renewable energy and automotive, where specific green skills are in short supply and urgently needed to meet the growing demand.

If we do consider the following figure, the impact of the green transition will be more focused on the greening of existing jobs versus entirely new jobs.

The presentation raises a critical question: Are the impacts on jobs from green transition trends accurately identified? According to the World Economic Forum (https://www.weforum.org/agenda/2024/01/green-transition-skilled-workforce-manpowergroup/) (Prising, 2022), the green transition is expected to generate up to 30 million new jobs by 2030.

However, 75% of employers report difficulties in finding skilled talent, and 94% of them are lacking the necessary skills to meet their Environmental, Social, and Governance (ESG) objectives. This underscores a significant need for comprehensive upskilling and reskilling, particularly in highly technical industries such as renewable energy and automotive, where there is a critical shortage of specific green skills required to meet increasing demands. Considering the subsequent figure, the influence of the green transition appears to be more about enhancing the green capabilities of existing jobs rather than creating entirely new positions.

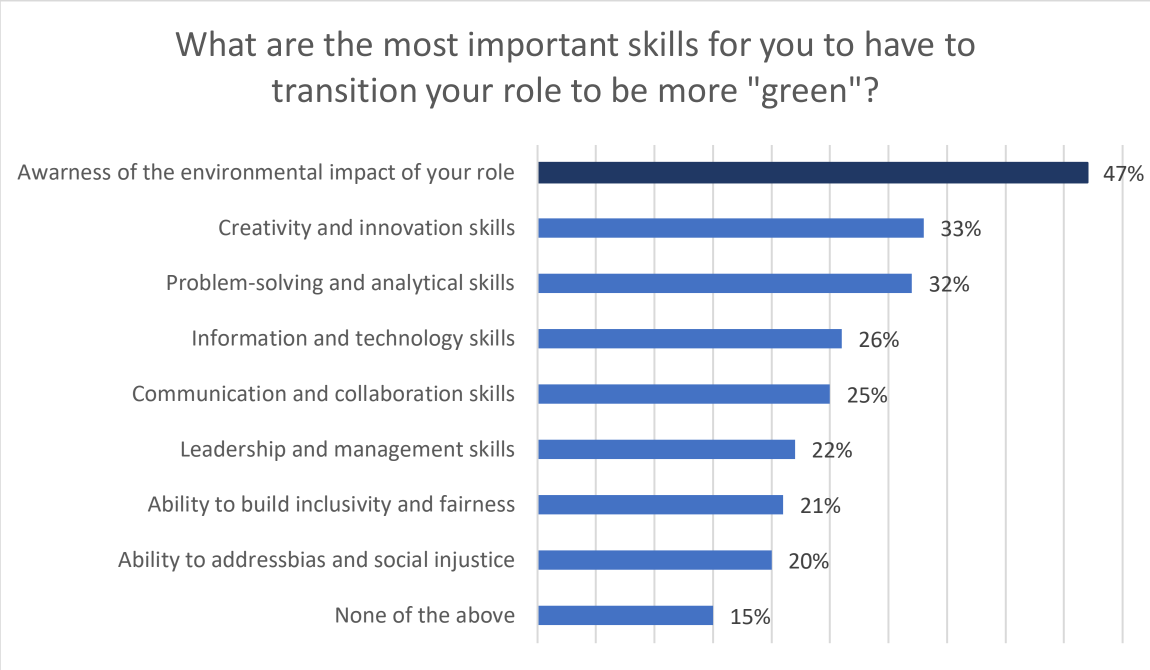

Figure 23: the most important skills to have to transition roles to be more "green"

These statements are confirmed in this this publication (https://economy-finance.ec.europa.eu/system/files/2022-12/dp176_en_green%20transition%20labour.pdf) from Europe (Vandeplas, 2022).

Learner Centric Advanced Manufacturing Platform

D3.2 - M24 - Analysis of the Impacts and Evolution of jobs in Advanced Manufacturing

D3.2 - M24 - C - Consolidated report

Co-funded by
the European Union

10. CONCLUSION AND OUTLOOKS

This comprehensive study has analysed the progression and transformation of advanced manufacturing employment across several regions and countries, focusing on the impact of digital and green transitions. Data from multiple national and regional reports and interviews with numerous companies have revealed key trends, drivers of change, and the technological and sustainability advancements shaping the future workforce.

Basque Country

The digital transformation aims primarily at enhancing company performance, with significant impacts on job roles, especially in data analytics, maintenance, and automation. The evolution of job roles is influenced by company size, digital maturity, and organisational culture, among other factors. Technological advancements such as Internet of Things (IoT) and automation are crucial, along with the integration of multifunctional machines and data-driven management practices. Sustainability efforts, including carbon footprint automation and energy efficiency improvements, are more prevalent in larger companies. The need for highly specialized profiles and in-house training programs is emphasized, with vocational education and training (VET) programs playing a critical role.

Turkey

The green and digital transitions are revolutionizing manufacturing through the integration of collaborative robots, IoT, 5G, and smart sensors, enhancing efficiency and promoting sustainability. Embracing Artificial Intelligence (AI), machine learning, and big data analytics helps develop eco-friendly practices. Cybersecurity is crucial as industries become more interconnected. Turkey's focus on smart specialisation and alignment with global trends positions it well to capitalize on these shifts, ensuring competitiveness and resilience

France

The result of the study highlights the necessity for deeper analysis of green and digital impacts on advanced manufacturing jobs. Links raised between job's activities impacts and related needed skills are crucial to anticipate curricula adaptations. For instance, the impact of AI and new production technologies like 3D Printing on industrial design is noted, with a need for mastery of AI tools and 3D printing capabilities and constraints among designers. The goal is to gather comprehensive and usable data to fill the future LCAMP Platform allowing educational curricula adaptations and create new micro-credentials for trainers and teachers, ensuring they can adapt to these evolving trends.

Germany

The future of additive manufacturing in Germany is promising, with advances in materials, processes, and software expected. Collaboration between industry, academia, and government is crucial. The role of CNC operators is evolving, requiring technical proficiency and an understanding of lean management principles. Sustainable manufacturing practices and renewable energy integration are essential for green factories. Comprehensive training programs and the promotion of soft and technical skills intersection are recommended.

Italy

The evaluation of job profiles such as Data Analyst, Automation Engineer, and Cybersecurity Specialist reveals the growing importance of data collection and analysis, IoT integration, and robust cybersecurity measures. The need for extensive knowledge in IoT, data encryption, and proactive monitoring is emphasized. Experts highlight the importance of these roles beyond individual companies, integrating them into broader supply and value chains.

All these individual conclusions can be gathered and summed-up as follows:

Digital Transformation

Across various regions, digital transformation is significantly reshaping the advanced manufacturing sector. Technologies such as IoT, AI, augmented reality, and automation are central to this shift, enhancing company performance and introducing new competencies, particularly in data analytics, maintenance, and automation. Companies are integrating multifunctional machines and adopting data-driven management practices to stay competitive. The integration of these technologies is revolutionizing production processes involving Cybersecurity management which becomes increasingly crucial as industries become more interconnected, as mentioned in the Turkey report.

Sustainability

Sustainability is a critical component of this transformation, with efforts to reduce environmental impact and promote resource efficiency. Large companies, are automating carbon footprint calculations and improving energy efficiency while sustainable manufacturing and procurement strategies are being implemented, supported by AI and big data analytics to develop eco-friendly practices. The focus on sustainability aligns with global standards and is increasingly influencing industrial policies and practices.

Competencies and Training

The evolving job landscape demands highly specialized profiles tailored to specific manufacturing processes. This specialisation is often developed through in-house training and experience, building on foundational knowledge from vocational education and training (VET) programs. Especially mentioned in the Basque Country report, VET programs are crucial for roles in mechanical manufacturing, mechatronics, and industrial automation. Training programs are widespread, with dual training and internships being highly valued for providing hands-on experience and attracting talent. Similar needs for specialized skills are identified in Italy, where the role of Data Analysts, Automation Engineers, and Cybersecurity Specialists is expanding.

Impact on Job Roles

The digital and green transitions are transforming job roles across the advanced manufacturing sector. While new jobs in data analytics are emerging, existing roles in maintenance, automation, and other areas are evolving to incorporate new technologies. Among the examples mentioned, in France the impact of AI and new production technologies like 3D Printing on industrial design is becoming more prominent, necessitating mastery of AI tools and 3D printing capabilities and constraints. In Germany, the role of CNC operators is changing, requiring technical proficiency and an understanding of lean management principles.

Challenges and Future Directions

Several challenges persist, including attracting talent and addressing the aging workforce. Companies face difficulties in hiring skilled personnel, with younger workers often seeking more technologically advanced environments. The gender gap remains a significant issue, with women underrepresented in technical roles.

Addressing these challenges requires enhancing the attractiveness of technical training programs and promoting inclusivity. Future directions include the development of cost-effective technologies, comprehensive training programs, and the integration of sustainable manufacturing practices.

What this study reveals are that Digital and Green transformations are fundamentally altering the job landscape in advanced manufacturing. These changes necessitate a workforce adept in new technologies and sustainable practices, supported by continuous training and education. Aligning with global trends and leveraging advanced technologies will enable European regions and countries to enhance their manufacturing capabilities, ensuring competitiveness and resilience. The study paves the way for refining educational programs and supporting the workforce’s adaptation to these profound changes.

The study has established a robust methodology and framework for analysing the impact of digital and green trends on jobs, allowing for accurate identification of regional discrepancies and guiding the analysis roadmap. The framework has proven useful, comprehensive and usable data to fill the future LCAMP Platform. It will provide valuable insights for trainers and teachers to modify curricula and create new micro-credentials.

The primary objective being to gather sufficient data to propose clear and valuable data for European and National Advanced Manufacturing curricula, this year of work sets the stage for further analysis and data collection, supporting the workforce’s adaptation to these significant shifts.

11. REFERENCES

ACICAE. (2024, 03 01). The Basque Automotive Sector. Retrieved 2024, from Acicae.es: https://www.acicae.es/en/the-basque-automotive-sector/#:~:text=The%20automotive%20sector%20is%20feeling,changes%20in%20its%20business%20model

Aerospace Industries Association. (2024). Aerospace Industries Association. https://www.aia-aerospace.org/

AFM. (2022). El futuro del trabajo en fabricación avanzada. Nuevos retos, roles y competencias. Donostia. Retrieved from https://www.afm.es/es/descargas

Alteredu. Cybersecurity: Definizione, Significato e Perché Serve (Cybersecurity: Definition, Meaning, and Why It Matters). Retrieved from https://www.alteredu.it/cybersecurity-definizione-e-significato/

Anneleen Vandeplas, Istvan Vanyolos, Mauro Vigani and Lukas Vogel: European Commission, Directorate-General for Economic and Financial Affairs. The Possible Implications of the Green Transition for the EU Labour Market, 2022

Automated assembly line operator. (n.d.). Retrieved 18 June 2024, from https://esco.ec.europa.eu/en/classification/occupation

Bergamo News. (n.d.). L'importanza dell'analisi dei dati nell'industria 4.0 (The Importance of Data Analysis in Industry 4.0). Retrieved from https://www.bergamonews.it/dal-territorio/limportanza-dellanalisi-dei-dati-nellindustria-4-0/

Bill M. (n.d.). IFR International Federation of Robotics. President's Report by Marina Bill. https://ifr.org/ifr-press-releases/news/presidents-report-1-2024

Bureau of Labor Statistics, U.S. Department of Labor. (2023). Electrical and electronics engineering technicians. Occupational Outlook Handbook. https://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineering-technicians.htm

Capgemini Invent; European Digital SME Alliance; Executive Agency for Small and Medium-sized Enterprises (European Commission). (2020). Skills for SMEs – Cybersecurity, Internet of things and big data for small and medium-sized enterprises. Publications Office,. doi: https://data.europa.eu/doi/10.2826/708138

Catena-X Automotive Network e.V. (n.d.). Open data ecosystem for the automotive industry designed to create data chains that will enhance your value chain. Retrieved 03 03, 2024, from Catena-X: https://catena-x.net/en/

Cecimo. (2023). Transformation of Manufacturing: Embracing Digital and Green Skills. Retrieved 02 02, 2024, from https://www.cecimo.eu/wp-content/uploads/2023/07/Final-Skills-Paper-1.pdf

Cecimo. (2024). From survey to strategy. Understanding Skills Trends in Advanced Manufacturing. Retrieved 03 22, 2024, from https://www.cecimo.eu/publications/from-survey-to-strategy-understanding-skills-trends-in-advanced-manufacturing/

CNC Operatörü İş İlanları. (n.d.). Retrieved 18 June 2024, from https://www.kariyer.net/is-ilanlari/cnc+operatoru?pst=4150&pkw=cnc%20operat%C3%B6r%C3%BC

Computer numerical control machine operator. (n.d.). Retrieved 18 June 2024, from https://esco.ec.europa.eu/en/classification/occupation

Confebask. (2022). Necesidades de empleo y cualificaciones de las empresas vascas 2022. Retrieved from https://www.confebask.eus/sites/default/files/2022-05/Necesidades%20Empleo%20y%20Cualificaciones%202022_0.pdf

Cyber Security 360. Nuove minacce alla sicurezza informatica tra malware e attacchi hacker (New Threats to Cybersecurity Between Malware and Hacker Attacks). Retrieved from https://www.cybersecurity360.it/nuove-minacce/

Cybersecurity Trends: Looking Over the Horizon to the Future. (n.d.). Retrieved 18 June 2024, from https://www.apu.apus.edu/area-of-study/information-technology/resources/cybersecurity-trends/

Danton-a. (2023, July). *Observatory report N1-2* (D3.2). Retrieved from

Danton-b. (2023, April). *Observatory methodology: Final version* (D3.1). Retrieved from https://lcamp.eu/wp-content/uploads/sites/53/2023/04/D3-1-Observatory-Methodolgy-Final-version.pdfDervojeda, K. K. (2019). Skills for industry curriculum guidelines 4.0 – Future-proof education and training for manufacturing in Europe,. European Commission, Executive Agency for Small and Medium-sized Enterprises,. European Commission Publications Office. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/75478035-56b9-11ea-aece-01aa75ed71a1/language-en

Eleventh Development Plan 2019-2023. (n.d.).

European Commission. (n.d.). Automation Engineer. Retrieved 27 June 2024 from http://data.europa.eu/esco/occupation/bb609566-3ab6-44dd-8f48-cf0b15b96827

European Commission. (n.d.). *Data Analyst*. Retrieved 27 June 2024 from http://data.europa.eu/esco/occupation/d3edb8f8-3a06-47a0-8fb9-9b212c006aa2

European Commission. (n.d.). *Ethical Hacker*. Retrieved 27 June 2024 from http://data.europa.eu/esco/occupation/76ef0a87-6afe-4560-b5d0-9a086abe45c5

European Commission. (n.d.). *Smart specialisation platform*. Retrieved from https://s3platform.jrc.ec.europa.eu/

ESCO. (n.d.). Retrieved 18 June 2024, from https://esco.ec.europa.eu/en/classification/occupation?uri=http%3A%2F%2Fdata.europa.eu%2Fesco%2Foccupation%2F2cf2b905-3308-4b5d-8e8d-633fc7a3f3ce

European Commission. (n.d.). Digital Skills and Jobs Platform. Retrieved from https://digital-skills-jobs.europa.eu/en/about/digital-skills-and-jobs-platform

EUSTAT. (2023, 12 1). EUSTAT.eus. Retrieved 01 12, 2024, from Euskal Estatitiska Erakundea-Instituto Vasco de Estadística: https://en.eustat.eus/elementos/ele0020000/ti_indicadores-de-la-industria-40-en-los-establecimientos-industriales-de-la-ca-de-euskadi-segun-estrato-de-empleo--sobre-establecimientos-2022-/tbl0020003_i.html

Fantini, P. M., & Pinzone, M. (n.d.). "Sviluppo di nuove competenze" (Development of New Skills). Retrieved from https://re.public.polimi.it/bitstream/11311/1118135/2/007_Fantini_Pinzone.pdf

Homs, O. (2023). Detección de necesidades de formación de perfiles del sector de fabricación automatizada. Report for the Spanish Network of Centres of VET Excellence on Automated Manufacturing, Ministerio de Educación, Formación Profesional y Deportes., Madrid, Spain.

Osservatori Digital Innovation. (n.d.). Data analyst: Cosa fa, stipendio. Retrieved from https://blog.osservatori.net/it_it/data-analyst-cosa-fa-stipendio

ICT security manager. (n.d.). Retrieved 18 June 2024, from https://esco.ec.europa.eu/en/classification/occupation

iklim.gov.tr. (n.d.). The 2024-2030 Climate Change Mitigation and Adaptation Strategy and Action Plans are published. Retrieved 18 June 2024, from https://iklim.gov.tr/en/the-2024-2030-climate-change-mitigation-and-adaptation-strategy-and-action-plans-are-published-news-4245

Innobasque. (2019). Tecnologías y competencias profesionales 4.0-Análisis de la demanda empresarial. Retrieved from https://www.innobasque.eus/publicaciones/tecnologias-y-competencias-profesionales-4-0-analisis-de-la-demanda-empresarial/

International Labour Organization. (n.d.). Skills and lifelong learning. https://www.ilo.org/skills/lang--en/index.htm

İş İlanları—Aradığın Güncel İş Fırsatları Kariyer.net'te. (n.d.). Retrieved 18 June 2024, from https://www.kariyer.net/is-ilanlari?pst=12185&pkw=s%C3%BCrd%C3%BCr%C3%BClebilirlik%20m%C3%BCd%C3%BCr%C3%BC

IT Güvenlik Uzmanı İş İlanları. (n.d.). Retrieved 18 June 2024, from https://www.kariyer.net/is-ilanlari/it+guvenlik+uzmani?pst=4558&pkw=%C4%B1t%20g%C3%BCvenlik%20uzman%C4%B1

JOIND. (2024, 03 01). Plataforma de empleo para la industria. Retrieved from https://joind.es/

Kalite Kontrol Elemanı İş İlanları. (n.d.). Retrieved 18 June 2024, from https://www.kariyer.net/is-ilanlari/kalite+kontrol+elemani?pst=960&pkw=kalite%20kontrol%20eleman%C4%B1

Kasa, N. (2020, September 15). Che cos'è un server ? La spiegazione semplice (What is a Server? The Simple Explanation). Retrieved from https://www.kasadellacomunicazione.it/server/

MIGUEL ALTUNA LHII. (2024, 03 01). www.maltuna.eus. Retrieved from https://www.maltuna.eus/en/services/students-and-ex-student/job-listing/

OECD. (2023). Skills Outlook 2023: Skills for a Resilient Green and Digital Transition,. Paris: ECD Publishing. doi: https://doi.org/10.1787/27452f29-en

Oeij., P., Rhijn, G. v., Wietse van Dijt, F. K., Dickinson, P., Chris Warhust, Johnsen, H. C., . . . Rhomberg, W. (2023). Conceptual framework of Industry 5.0 to study workforce skills (BRIDGES 5.0 deliverable D1.1. Leiden: BRIDGES 5.0. Retrieved from https://bridges5-0.eu/wp-content/uploads/2023/12/BRI_WP1_-D1-1-Framework-report-Industry-5.0-and-skills_2023.pdf

Orkestra. (2024). Basque Country Competitiveness report 2023. doi: https://doi.org/10.18543/YJLS9838

Pedersen, B., Probst, L., Wenger, J., & Cracan, R. (2019). Skills for industry – Skills for smart industrial specialisation and digital transformation. European Commission, Executive Agency for Small and Medium-sized Enterprises. European Commission, Executive Agency for Small and Medium-sized Enterprises, Publications Office. Retrieved from https://data.europa.eu/doi/10.2826/69861

Politecnico di Milano. (n.d.). Ingegneria dell'automazione (Automation Engineering). Retrieved from https://www.polimi.it/futuri-studenti/corsi-di-laurea/ingegneria-dellautomazione

Prior, M. (2023). What were the trends on the 3d printing job market in 2022? 3Dnatives. https://www.3dnatives.com/en/trends-on-the-3d-printing-job-market-in-2022-020320234/

Product quality controller. (n.d.). Retrieved 18 June 2024, from https://esco.ec.europa.eu/en/classification/occupation

Randstad. (n.d.). "I lavori più richiesti: Data Analyst" (Most Requested Jobs: Data Analyst). Retrieved from https://www.randstad.it/candidato/lavori-piu-richiesti/data-analyst/

Randstad. I lavori più richiesti: Cyber Security Expert (Most Requested Jobs: Cyber Security Expert). Retrieved from https://www.randstad.it/candidato/lavori-piu-richiesti/cyber-security-expert/#:~:text=Per%20il%20grande%20sviluppo%20tecnologico,organizzazioni%20e%20dalla%20Pubblica%20Amministrazione.

Spainer V. (2023, August 16). “Come promuovere la sostenibilità grazie all'automazione” (How to Promote Sustainability Through Automation), The Innovation Post. Retrieved from https://www.innovationpost.it/tecnologie/robotica/come-promuovere-la-sostenibilita-grazie-allautomazione-la-guida-di-epson/

The Future of Jobs Report 2020. (2023). World Economic Forum. https://www.weforum.org/publications/the-future-of-jobs-report-2020/

The sustainability job market is booming. What does that mean for hiring? | GreenBiz. (n.d.). Retrieved 18 June 2024, from https://www.greenbiz.com/article/sustainability-job-market-booming-what-does-mean-hiring

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi—Proje Açıklaması. (n.d.-a). Retrieved 18 June 2024, from https://cbddo.gov.tr/projeler/siber-platform/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi—Proje Açıklaması. (n.d.-b). Retrieved 18 June 2024, from https://cbddo.gov.tr/projeler/siber-myo/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi—Siber Güvenlik. (n.d.). Retrieved 18 June 2024, from https://cbddo.gov.tr/siber-guvenlik/

Türkiye Cumhuriyeti Cumhurbaşkanlığı Dijital Dönüşüm Ofisi—Ulusal Siber Güvenlik Stratejisi ve Eylem Planı (2020-2023). (n.d.). Retrieved 18 June 2024, from https://cbddo.gov.tr/siber-guvenlik-stratejisi/

Türkiye İş Kurumu—Açık İş İlanları. (n.d.). Retrieved 18 June 2024, from https://esube.iskur.gov.tr/Istihdam/AcikIsIlanAra.aspx

U.S. Bureau of Labor Statistics. (n.d.). https://www.bls.gov/

Unioncamere. (n.d.). “Previsioni dei fabbisogni occupazionali e professionali in Italia a medio termine” (Forecasts of Occupational and Professional Needs in Italy in the Medium Term, 2023-2027). Retrieved from https://excelsior.unioncamere.net/pubblicazioni/2023/previsioni-dei-fabbisogni-occupazionali-e-professionali-italia-medio-termine

University of Bologna. (n.d.). Prospettive: Ingegneria dell'automazione (Perspectives: Automation Engineering). Retrieved from https://corsi.unibo.it/laurea/IngegneriaAutomazione/prospettive

What Does a Sustainability Manager Do? (2024, March 18). Coursera. https://www.coursera.org/articles/sustainability-manager

World Economic Forum, Jonas Prising, Chairman and Chief Executive Officer, ManpowerGroup, The green transition requires an upskilled workforce. Here's why, Jan 13, 2024

World Manufacturing Forum Report, “Skills for the Future of Manufacturing”, 2019 retrieved from https://worldmanufacturing.org/wp-content/uploads/2019-WMF-Report-Presentation.pdf

12. INDEX OF ILLUSTRATIONS

13. INDEX OF TABLES

14. ANNEX

14.1. GATHERING OF SKILLS PER TYPE OF SKILLS

Here after the gathering skills/type:

Table 50: Gathering of skills per type of skills

RELATED NEEDED SKILLS/KNOWLEDGE IMPACTED - HARMONIZED	RELATED NEEDED SKILLS/KNOWLEDGE IMPACTED
If Skill available in ESCO data base: ESCO Skill name. **If not indicate skill name**	If Skill available in ESCO data base: ESCO Skill name. If not indicate skill name
Inter-disciplinary Cooperation And Project Management	collaborate with all staakeholder teams
	collaborate with designer
	Collaborate with Machines Operators
Production And Manu-facturing Technologies	3D printing technologies, materials, and processes
	Be aware about 3D printing abilities to propose efficient and flexible solutions in day-to-day Robots usage
	Knowledge of 3D printing technologies, materials, and processes
	Proficiency in 3D scanning technology and software
	Proficiency in reverse engineering tool
	Understand 3D printing capabilities for creating custom testing tools, knowledge of relevant testing procedures, and data analysis skills
	Understand new tools of 3D scanning technology, data analysis, and defect identification in industrial settings
	Understand of 3D printing principles, design for additive manufacturing (DfAM) guidelines, and customized product quality standards
	Understand robotic systems, industrial testing procedures, and quality control standards
	Use of digital twins for optimisation
Digitalisation and IT Security	Cybersecurity
	Cybersecurity principles - Vulnerability assessment and penetration testing skills - Network security protocols and best practices
	Internet of things

	Knowledge of IoT device communication
	Knowledge of sensors technology
	Skills in cybersecurity
	Understanding of 5G communication protocols, and data analysis
	Understanding of cybersecurity principles and best practices for protecting sensor data from Cyber threats
Technological Core Competences	Understand sensor data, data analysis techniques, and quality control principles in industrial contexts
	Understanding of sensor calibration principles, communication protocols, and data analysis
Data Analysis And Artificial Intelligence	AI proficiency for 3D modeling
	machine learning concepts
	predictive maintenance
	Programming skills - AI concepts
	Programming skills - machine learning concepts
	Technical skills - analyse big data
	Understand AI principles, data analysis techniques, and non-destructive testing methods
	Understand AI principles, image analysis techniques, and surface quality standards
	Understand AI principles, image/video analysis techniques, and quality control standards
	Understand predictive maintenance principles, data analysis, and their application in industrial automation
	Understanding of AI principles
Sustainability and Environmental Management	advise on sustainability solutions
	CSR initiative participation, Ethical operation understanding
	knowledge of Green Transition Trends / Sustainable manufacturing principles
	Knowledge of sustainable manufacturing principles, energy efficiency techniques, and their impact on industrial robot processes
	Knowledge of sustainable materials, design principles, and their application in product design
	Knowledge of sustainable materials, environmental impact assessment
	Lifecycle assessment, circular economy strategies
	Understanding of circular design principles
Virtual And Augmented Reality	AR development training design

	Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety
	Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety. Augmented Reality
	Growing adoption of VR and AR technologies, for robot simulation, training, and design, enhancing collaboration and improving safety. Virtual Reality

LCAMP

Learner Centric Advanced Manufacturing Platform

Co-funded by
the European Union

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.