D5.3

Initial impact assessment & policy recommendations

D5.3 Initial impact assessment & policy recommendations

Work Package:	WP5 - Large-Scale Validation of Rapid Repurposed Manufacturing Processes
Lead partner:	Politecnico di Milano (POLIMI)
Author(s):	Federica Acerbi – Mahdi Mohammadian (POLIMI)
Due date:	31/05/2022
Deliverable Type:	Report
Version number:	1.0
Status:	Final

Project Number:	101016175	**Project Acronym:**	Eur3ka
Project Title:	*EUropean Vital Medical Supplies and Equipment Resilient and Reliable Repurposing Manufacturing as a Service NetworK for Fast PAndemic Reaction*		
Start date:	December 1st, 2020		
Duration:	24 months		
Call identifier:	H2020-SC1-PHE-CORONAVIRUS-2020-2-NMBP		
Topic:	SC1-PHE-CORONAVIRUS-2020-2A Repurposing of manufacturing for vital medical supplies and equipment.		
Instrument:	IA		

Dissemination Level	
PU: Public	✓
PP: Restricted to other programme participants (including the Commission)	
RE: Restricted to a group specified by the consortium (including the Commission)	
CO: Confidential, only for members of the consortium (including the Commission)	

Revision History

Revision	Date	Who	Description
V0.1	19 / 04 / 2022	POLIMI	Table of Contents
V0.2	03/05/2022	POLIMI	Section 3
V0.3	14/05/2022	POLIMI	Sections 4 and Section 5
V0.4	15/06/2022	UNP	Comments from peer review
V0.5	17/05/2022	POLIMI	Sections 1,2,6,7,8, and 9
V0.6	18/05/2022	SQS	Comments from peer review
V0.7	20/06/2022	POLIMI	Review comments modification
V1.0	24/06/2022	ENG	Final version for submission

Quality Control

Role	Date	Who	Approved/Comment
Internal review	15/06/2022	Pedro Maló (Unparallel)	Approved
Internal review	18/06/2022	Begoña Laibarra (SQS)	Approved

Disclaimer

This document has been produced in the context of the Eur3ka Project. The Eur3ka project is part of the European Community's Horizon 2020 Program for research and development and is as such funded by the European Commission. All information in this document is provided 'as is' and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and liability. For the avoidance of all doubts, the European Commission has no liability with respect to this document, which is merely representing the authors' view.

Executive Summary

The introduction of Industry 4.0, Data Management, digital platforms, and the use of modern technology to the production and manufacturing process as well as the occurrence of unexpected events and crises creates the need to optimally and proportionately review the performance of companies by measuring key performance indicators in various dimensions such as Operational/Technical, Economic, Environmental, and others, as well as need for new skills within a company's workforce, which have historically not been appropriate. Aspects like lifelong learning and new paradigms in education are becoming more and more relevant to enhance companies' resilience. This deliverable **(D5.3), [Due to Month:18]** "Initial impact assessment & policy recommendations" is related to WP5, presents the following aspects:

Research background and related reports: Recent studies have been conducted in the field of Performance, and skills have been reviewed and introduction of 6Ps methodology - People dimension, which is the model, that examines six different aspects of experiments (Product-Process-Platform-People-Partnership Performance), that generally adopted by the University of Politecnico di Milano is done. This methodology has been implemented and analysed in previous European projects such as BOOST4.0, MIDIH, and CAPRI. The goal of this model is to assess manufacturing companies' current level of AI and digital maturity (AS-IS), quantify the desired level of AI and digital maturity that these companies want to achieve (TO-BE), and design a specific action plan to allow the transition needed to fill the gaps identified. The main focus of this deliverable is on Performance and People dimensions.

Performance Dimension: regarding the performance dimension of the 6P methodology, it appeared extremely relevant to include it in the assessment proposed in this deliverable, with the goal to ensure to keep under control a wider set of performances not only limited to the financial aspects to ensure the proper assessment and monitoring of resilience. Indeed, an analysis of the literature has been performed highlighting several elements fundamental to consider a manufacturing company resilient. Thus, even though the economic and financial aspects are still relevant in this context, it was decided to extend the company's view towards other performances to be monitored to make the model more useful for the context in which it is used.

People Dimension: As a first step of methodology, nine jobs and related skills have been introduced. Six out of nine are related to "data science management" which are new jobs that are introduced in line with the growth of technology in the field of data science management, and three out of nine are related to "Professions due to the COVID-19", that many companies currently most probably have these roles but need to improve and develop skills in line with technology and arising new crises such as Covid-19. In addition to the skills assigned to each job profile, which are mostly technical skills, a review of soft skills has been conducted at managers, professionals, and worker levels.

Analysing approach "Three main surveys": One survey for performance dimension was conducted to investigate the resilience of companies by looking the current maturity (the AS-IS maturity) of 6 relevant sub-sections (i.e., economical, operational and technical,

environmental, social, product-service system, and supply chain). And Two surveys (Voting, Needed and Possessed) for people dimension were conducted in relation to the introduced jobs and skills in order to prioritize skills dedicated to each job profiles and analyse the current situation of the experiments and identify the gaps in them. Then, as the next step of the methodology, in accordance with the Performance situation, skills and jobs introduced, relevant activities have been defined.

Keywords: 6Ps migration model, Performance dimension, People dimension, Surveys, Gap analysis

Table of Contents

List of figures

List of Tables

Definitions and acronyms

AAS	Asset Administration Shell
AI	Artificial Intelligence
AM	Additive Manufacturing
AMN	Additive Manufacturing Network
AOs	Application Ontologies
API	Application Programming Interface
BCF	Business Continuity Framework
BFO	Basic Formal Ontology
BPM	Breaths Per Minute
CA	Consortium Agreement
CAD	Computer Aided Design
CCE	Clinical Care Equipment
CNC	Computer Numerical Control
CPPS	Cyber Physical Production Systems
CSV	Comma Separated Values
DDOs	Domain Dependent Ontologies
DIH	Digital Innovation Hub
DMP	Data Management Plan
GD&T	Geometries and Dimensional and geometric Tolerances
GMP	Good Manufacturing Practices
DE	Digital Enabler
DFA	Digital Factory Alliance
DIROs	Domain Independent Reference Ontologies
DoA	Description of Action
DSROs	Domain Specific Reference Ontologies
EC	European Commission
EDI	Electronic Data Interchange
EU	European Union
Euratex	European textile and clothing industry
FF	Full Face
FO	Foundation Ontology
FTP	File Transfer Protocol
GA	Grant Agreement
I4.0	Industry 4.0
IDS	International Data Spaces
IDSA	International Data Space Association
IIC	Industrial Internet Consortium
IOF	Industry Ontology Foundry
IPP	Intermediate Product Properties
IRR	Internal Rate of Return
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
LCA	Lifecycle Assessment
LCC	Life Cycle Costing
MAL	Manufacturing Autonomy Level

MaaS	Manufacturing as a Service
MES	Manufacturing Execution System
MILP	Mixed-Integer Linear Programming
MRT	Manufacturing Repurposing Transformations
NPV	Net Present Value
OEM	Original Equipment Manufacturer
PBT	Pay Back Time
PC	Personal Computer
PDF	Portable Document Format
PLM	Product Lifecycle Management
PoC	Proof of Concept
PP	Polypropylene
PPE	Personal Protection Equipment
PPS	Production Planning and Scheduling
P&R	Plug & Respond
QIF	Quality Information Framework
RA	Reference Architecture
REST	Representational State Transfer
RFQ	Request For Quote
ROI	Return on Investment
SCMP	Supply Chain Management Platforms
SCSN	Smart Connected Supplier Network
SFW	Smart Factory Web
SFWC	Smart Factory Web Connector
S-LCC	Social Life Cycle Costing
SMMA	Smart Matching/Mediation App
SROI	Social Return of Investments (SROI)
TBL	Triple Bottom Line
TC	Technical Coordinator
W3C	World Wide Web Consortium
WEF	World Economic Forum
WHO	World Health Organization
WMF	World Manufacturing Forum
WP	Work Package
XSDL	XML Schema Definition Language
ZDM	Zero Defect Manufacturing

1 Introduction

1.1 Scope and Purpose

For over one year and half, the Eur3ka project has been actively working towards the specification, implementation, and validation of a novel manufacturing response framework, which demonstrates the critical importance of paying attention to the evolving technological trends, novel performance, and new skills in the manufacturing environment. Unexpected events and crises, on the other hand, are another factor that affects executive, financial, management, and production issues, and having a predetermined plan and special skills in company employees helps them overcome these crises. Industry 4.0 is focused on enterprise digital transformation, and the main challenges are related to the introduction of digital tools into industrial practices, such as artificial intelligence, virtual reality tolls, big data and analytics, and others. The development of these new digital tools had a significant impact on the two primary dimensions of manufacturing activities, performance, and people, and could represent the driver towards the creation of more resilient companies. The performance dimension is related to the monitoring of indicators such as Overall equipment effectiveness, Yield, cost, throughput, and others that can be used to measure the efficiency of factory production activities, whereas the people dimension is related to the creation of new jobs and skills that include people at all levels "management, professional, and worker." Managers, professionals, and blue-collar workers will require new lifelong learning programs to help them keep up with the pace of change. Rapid advancements in manufacturing technology and Information and Communication Technologies (ICT) have placed a high demand on manufacturing education for a continuous update of knowledge content and delivery methods. Understanding the technical essence and business potential of new knowledge/technology is critical for its successful adaptation and integration into industrial working practice. Additionally, to these traditional performance and skills, those highly related with resilience have been studied. This deliverable proposes the deployment of two different assessment tools focused respectively on performances, and skills. On one side, it is studied how the resilience-related performances are defined, monitored, and interpreted looking at the KPIs that manufacturing companies might keep under control in terms of Operational/Technical, Economic, Environmental, Social, Product-Service Lifecycle, and Supply Chain dimensions. Furthermore, this deliverable aims to identify emerging, new skills and job requirements aligned with Data Science Management, as well as new skills about Professions due to the COVID-19 to improve employees' abilities at three different organizational levels (Manager, Professional, and Worker levels).

1.2 Linking to and difference from Deliverables D3.1 and D3.2

The present deliverable titled "Initial impact assessment & policy recommendations" can be considered as a continuation of the D3.1 and D3.2 in the workforce training, and performance/Financial Impact Assessment sections. However, with respect to the D3.1 and D3.2 reports, D5.3 has the following differences:

- **In the performance section**: Following the financial review performed in D3.1 and updated with its extension in D3.2, this Deliverable conducts a review of the resilience maturity of manufacturing companies in six dimensions, and for this purpose, a survey of project partners was conducted. The results of the survey are discussed looking at all the six dimensions: operational/technical, economic, environmental, social, product-service lifecycle, and supply chain.
- **On the people, dimension**: the introduction of jobs in the field of data science management and Professions due to the COVID-19 was done in the D3.1 by investigating WMF[1][2] and WEF[3] annual reports and Osservatorio Industria 4.0[4] of Politecnico di Milano. These jobs and their skills were updated in D3.2, and two main surveys "voting survey" and "Possessed and Needed survey" were designed and implemented to understand the current level (AS-IS) of project partners in relation to these roles. In this Deliverable, we go a step further and analyze the responses received from project partners in relation to the introduced jobs and skills in order to identify gaps and propose a suitable solution to bridge these gaps.

1.3 Structure of the Document

The document is structured as follows:

In chapter 2, "Research Background and related reports" is presented. State the art material, as well as recent reports WEF, are used in order to give an overview of the need for new change due to technology trends and raising crises in manufacturing.

In chapter 3, a brief explanation of the 6P Migration Model and especially Performance and People dimension is provided.

Chapter 4 and 5 review the surveys implemented in the performance and people dimensions, respectively, and present the results of the analysis of these surveys as well as appropriate activities to fill the existing gaps.

Chapter 6 deals with ethical issues, which attempts to explain the relationship between this deliverable and especially the surveys conducted with ethical issues which are mainly explained in D7.1.

Finally, in chapter 7 and 8 respectively the next steps of the methodology and the results obtained in this deliverable are discussed.

In Annex section, there are also questionnaires related to ethical issues that have been completed by the POLIMI team to express the compatibility of the issues of the performance and skills with the ethical issues and policies of the Eur3Kap project.

---

[1] World Manufacturing Forum's ten skills for the future of manufacturing World Manufacturing Forum - https://worldmanufacturing.org/

[2] https://worldmanufacturing.org/wp-content/uploads/WorldManufacturingForum2020_Report.pdf

[3] World Economic Forum, 2020, The Future of Jobs Report, October 2020.

[4] Osservatorio Industria 4.0 - Politecnico di Milano

2 Research Background and related reports

2.1 Background on Performance / Financial Impact Assessment

The global market has been recently highly affected by great events (e.g., COVID-19 pandemic) creating several issues for the entire society, and touching the manufacturing world too. For this reason, it has been set a number of countermeasures to react and be ready in the next future.

More in detail, looking at this project, among the different goals the willingness is also to understand how to keep under control the resilience of manufacturing companies and to do that, it has been initially thought to ensure the monitoring of financial performances of a company once it has undertaken and conducted certain investments to face these challenging events.

Although it was evident the need for companies to monitor their financial prosperity in this context, it was immediately evident that the number of issues to be kept under control that characterize the resilience of a company are many more such as the production or operational resilience, the product or material resilience, the social of people resilience, and the supply chain resilience (Romero et al. 2021). For this reason, it was considered necessary to extend this limited view on the financial part towards other elements, thus integrating the 6Ps methodology already developed and validated in a previous EU project (additional information is reported in Chapter 3) with the results from previous studies on resilience in manufacturing. The modification and update of the framework have been reported in an extensive manner also in D3.2.

This updated version of the assessment framework enabled to provide manufacturing companies with an extended view on the key aspects to be monitored to be resilient. Therefore, as widely described in Chapter 4 of this deliverable, the model facilitates companies in understanding where they are currently positioned and where the areas of improvements are. These results emerged especially from the survey conducted with participants of the project.

2.2 Background on workforce training

Global labour markets are undergoing major transformations, with changes to business needs and unexpected crises, workforce profiles picking up an even more incredible pace in recent years. The human-centred paradigm shift will only be successful if work processes are reshaped, and new training approaches are introduced to support the continuous development of skills taking into account personal capabilities, skills and situational preferences of individual operators[5]. The Future of Jobs Report 2020[2] from World Economic Forum (WEF) maps the jobs and skills of the future. For 2020 the report suggests that "while technology- resilience driven job creation is still expected to outpace job destruction over the next five years, the economic contraction is reducing the rate of growth in the jobs of tomorrow". WEF reports estimate the needs in terms of reskilling needed according to the

---

[5] Ace factories, White paper on Human-centred factories from theory to industrial practice. Lessons learned and recommendations, 2019.

expected needs of the labour market. In Figure 1 below the infographics of the WEF report is presented that mentions that 73% of the employees will require a considerable amount of training (i.e., more than one month).
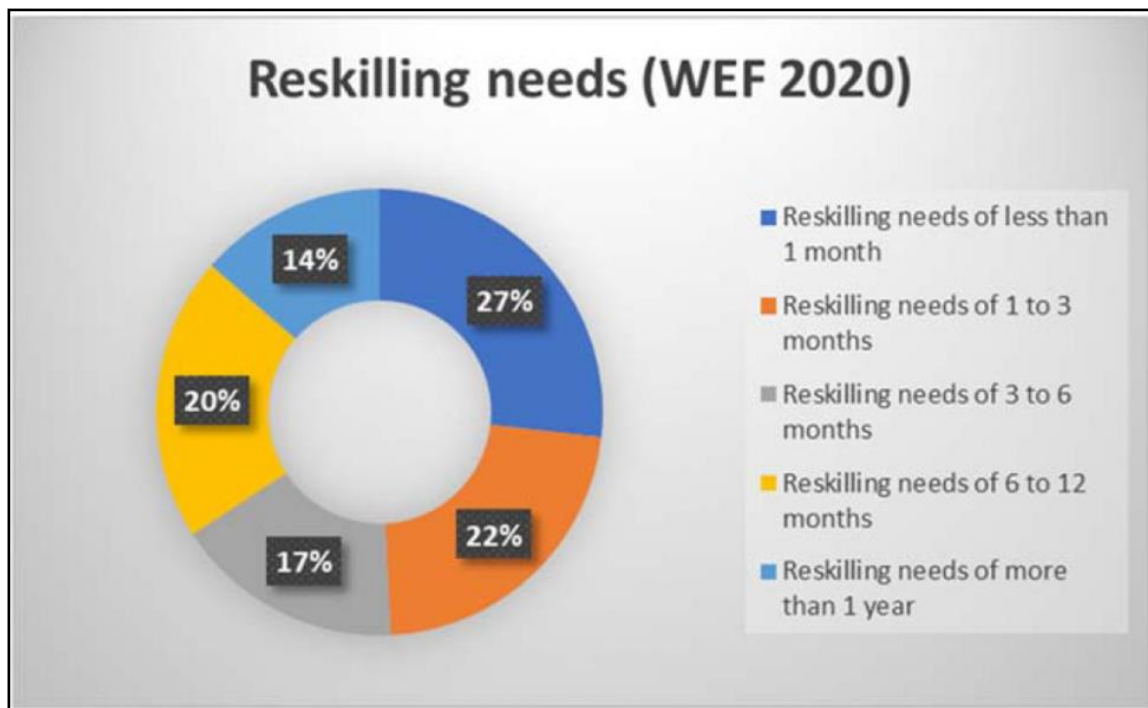
Figure 1 Reskilling needs in Advanced Manufacturing according to WEF 2020 report[6]

As also mentioned in D3.2, based on the content of Eur3Ka project, we identified new roles and professions in the field of data science management and resilience. In the following sections, we will introduce the process of analysing these profiles in the project partners and review their As-Is and desired situations.

---

[6] World Economic Forum, 2020, The Future of Jobs Report, October 2020.

3 Performance and People pathways – 6Ps Methodology

3.1 6Ps Methodology Overview

Politecnico di Milano university, within the H2020's MIDIH Project, has developed a structured methodology aimed at supporting manufacturing companies in defining it current level of digital maturity, identifying the desired level of digital maturity to reach in a given time horizon and consequently structuring a digital transformation roadmap to achieve the goals set (Spaltini et al. 2022).

This methodology, called 6Ps Migration Model, is organised according to 6 dimensions (the Ps), 3 belonging to the technical area (Product, Process, Platform) and 3 belonging the socio-business area (People, Partnership, Performance). All together are meant to identifying the most suitable strategy to ensure the successful digital improvement mentioned above as well as identifying the right tools and services propaedeutic to concretely reach the results.

This chapter has the aim of presenting in detail the 6Ps MM's Performance and People dimensions (Figure 2).

Figure 2 6Ps Digital Transformation Tool

3.1.1 Performance Dimension

6Ps' **Performance dimension** aims at investigating the role that Industry 4.0 technologies have in the definition, monitoring, and interpretation of KPIs of the manufacturing enterprises. As anticipated before, this part of the 6Ps model has been updated and used to cover the Financial Performance analysis (see also for additional details D3.2).

The dimension is divided into 6 areas, namely: Operational/Technical, Economic, Environmental, Social, Product-Service Lifecycle and Supply Chain.

Table 1 Performance dimension table

OPERATIONAL/ TECHNICAL	Performance is often not measured or understood	Descriptive Measurement and analysis are largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
ECONOMIC	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
ENVIRONMENTAL	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
SOCIAL	Performance is often not measured or understood	Descriptive Measurement is largely retrospective	Diagnostic Measurement is clear. Attempt to understand the causes of events and behaviours	Predictive Measurement is prospective. Statistical models and forecasts techniques to understand the future	Prescriptive future-oriented. Optimization and simulation to find the best course of action
P-S LIFECYCLE	No product life cycle assessment	A few aspects are included	Life Cycle Costing (LCC)	Life Cycle Costing + Environmental LCA	Life Cycle Costing + Environmental LCA + Social LCA
SUPPLY CHAIN	Performance is often not measured or understood	Only the most important physical performance of suppliers (e.g., punctuality, quality, operational flexibility)	Physical and Economical performance (purchase price, non-quality costs, delivery delays, lack of flexibility, etc.).	Physical, economical, sustainability performance for almost all the suppliers.	Physical, economical, sustainability and integration with other external sources (e.g., social media, weather)

1. **Operational and Technical KPIs**: the aim is to assess the approach in monitoring the performances of machines and production activities such as OEE, or accuracies

of plans and procedures such as MAPE belong to this category. The monitoring of this kind of operations is particularly relevant for 2 different reasons. Firstly, they are extremely useful and often essential for the creation of input information for the calculation of other kind of KPIs (e.g., Economic or Environmental ones) as well as for supporting relevant decision-making processes that may significantly affect KPIs of different typologies (e.g., Increase in production capacity through the introduction of new machineries would affect the ROI of the firm). Secondly, Operational and Technical KPIs are those whose measuring and monitoring can directly benefit the most from the implementation of Industry 4.0 Technologies. For the evaluation of the digital maturity level, great importance has been given to 1) the modalities through which the data in input are collected (they are largely analysed in the previous pillars) and 2) the approaches adopted to use the KPIs once measured. In particular, level 1 is assigned to those firms that do not track all performances at least in a structured way. Level 2 to those firms that although they monitor some KPIs, are not able to exploit them to make significant analysis. In level 3, the KPIs monitored are used to understand the root causes behind potential alarms detected. Level 4 is referred to those realities in which the measurement of KPIs is exploited to avoid the predict the occurrence of problems and thus allow the firm to take countermeasures in advance. Finally, level 5 is for those firms that are not only able to forecast issues detectable through KPIs but are also equipped with a system able to dynamically optimize the processes in order to postpone or even avoid the occurrence of problems generating the deterioration of the KPIs themselves.

2. **Economic KPIs**: the aim is to analyse the approach adopted by manufacturing companies for the monitoring of those KPIs focused on economic and financial results (e.g., ROI). The scoring methodology adopted for this dimension is the same used for the assessment of the Digital Maturity Level of the Operational and Technical area.

3. **Environmental and Social KPIs:** the aim is to measure the approach adopted by manufacturing firms in monitoring social and environmental KPIs. All the dimensions of the Triple Bottom Line (TBL) are assessed in this dimension. In fact, more and more frequently customers and other external stakeholders (e.g., distributors, governments, NGOs, institutional investors etc) are particularly sensitive to the issue of Environmental and Social responsibility. Hence, manufacturing firms are in some cases transforming their processes to respond to these changes. By not taking into consideration all the TBLs for the evaluation of the firms some results and considerations may in fact be biased as they cannot be justified looking only at the economic side. For this reason, 6Ps Methodology has introduced 2 areas dedicated to the assessment of approaches adopted by manufacturing companies for the monitoring and management of respectively the Environmental and Social performances. Exactly like the Economic area, the scoring method is mainly based on the capability of the firm to exploit the KPIs measured to optimize their processes.

4. **Product-Service Lifecycle KPIs**: the aim is to measure to which extent and what areas of the PSS delivered are taken into consideration for the analysis of its lifecycle. While in the previous areas the objective of the assessment was focused

on the performances of company's processes, in this field the attention is shifted toward the PSS that the company delivers to its customers. In particular, the area aims at quantifying how, to which extent and according to which criteria the Product (either physical good or service) is assessed by the firm once offered to the market. Hence, the quantification of the Digital Maturity Level of the manufacturing firm is mainly driven by an analysis of which parameters characterizing for the monitoring of the Product-Service Lifecycle are taken into consideration. In this sense, Level 1 is assigned to those realities in which no lifecycle assessment is performed at all, Level 2 for those in which only some KPIs are designed specifically and monitored. From level 3 to level 5 the scoring depends on the dimensions of the abovementioned TBL that are systematically considered for the LCA, namely: Level 3 considers only Economic LCA, Level 4 considers Economic and Environmental LCA and Level 5 considers all the 3 dimensions of the TBL (Economic, Environmental and Social).

5. **Supply Chain KPIs:** the aim is to assess the modalities through which manufacturing firms are able to measure the overall performances of their entire Supply Chain. Similar to the other areas described, the level is strongly dependent on the typologies of information and events taken into account and monitored. In particular, Level 1 is assigned whenever the company is not able or does not monitor any performance related to the external environment in which they operate, Level 2 is assigned if only what has been already defined as Operational and Technical performances are considered, Level 3 if also Economic Performances are assessed systematically. Finally, Level 4 and 5 are dedicated to those firms who, in addition to the dimension already mentioned, are actively involved in the monitoring of Sustainable performances (level 4) and are also capable to successfully collect and integrate external data to achieve a better understanding of the whole status of the Supply Chain.

The first step of 6Ps methodology in this dimension is asking for the main survey where partners can specify their AS-IS and desire situation related to the aforementioned aspects. The first iteration of survey implementation among project partners has already been completed. The summary result of this step is reported in Chapter 4.

3.1.2 People Dimension

The 2020 WMF Report and the 2020 WEF (Mentioned in Chapter 2) suggest that the digitalization process and upgrading skills based on new crises in the world and new technologies do not refer to technologies and processes but must encompass also a proportionate empowering of skills at every level (from shop floor to top management) and eventually the creation of roles aligned to the digital advancement that industry is facing. In light of this, metrics aimed at measuring which skills are needed and how much developed must be at every level of an organization seems to be a fundamental element to transform the suggestions articulated into practice.

The main scope of this chapter is to consider People dimension of 6Ps model affected by digitalization within the industrial environments. In this regard, the objective is to design and develop a structured methodology (6Ps) able to assess the current level of digital and

resilience maturity of manufacturing companies (AS-IS), quantify the desired level of digital and resilience maturity that these latter aim at achieving (TO-BE), and design a specific action plan to allow the transition needed to fill the gaps identified. The main focus will be on the People dimension since a thorough analysis of current jobs and professions involved in this project context will be conducted in order to identify possible skills gaps digital and resilience adoption. In addition, this process will dedicate some of the efforts to organizing workshops and surveys to collect the needed feedback from the partners in the development stage of the project to ensure providing simple and easy-to-use tools. A structured approach – Survey-based (Industry 4.0) will be followed and skills needed/possessed analysed and discussed as well as identification of the most suitable training programs to bridge such gaps. The first step of this methodology is primarily concerned with identifying new roles, professions, and relevant skills based on the project's content. in addition, related to these new roles and skills, two main questionnaires were asked of project partners and the first iteration of surveys implementation among project partners have already been completed. (The Summary result of this step is reported in Chapter 5).

According to the analyses performed in the content of the project, two main groups were identified under the titles of "**Data Science Management roles**" and "**Professions due to the COVID-19**". The first group, **"**Data Science Management roles" includes jobs and skills that do not yet exist in the industrial environment but will be needed in the coming years due to technological trends. Of course, it's worth noting that some businesses may have already recognized the value of some of the skills associated with these jobs and have begun to implement them. The second group "Professions due to the COVID-19" is related to jobs that already exist in some form in companies, but due to the happening of unexpected crises such as COVID-19, they need to update their skills. These jobs were examined at three levels "Managers, Professionals, and Workers Level" which will be introduced in D3.2 and also Section 5 of this deliverable.

4 Performance (financial) Survey

The "performance" survey covered the financial part of the assessment tool extending the limited view of economic performance to other relevant performances to be kept under control as anticipated in the "Background" chapter of this deliverable. Therefore, additionally to the economic performance, the following performances reflecting those of the 6Ps were investigated across five levels of maturity: technological, organizational, environmental, social, product-service system, and supply chain. Looking at financial performance only would have been limiting for companies in the undertaking of an improvement path since the view over the implications of certain decisions would have been constrained and the resilience wouldn't be properly assessed. This addition was not only observed in the scientific and grey literature, but it was also explicitly asked by practitioners. The survey conducted, hence, took into account this modification and enabled to perform the analysis throughout all the questions related to every single performance.

4.1 Introduction to survey structure - goal - audience

This sub-chapter aims to clarify the key elements characterising the performance-related survey thus, the goal of the survey, the audience addressed in this survey, and the structure of the survey itself.

4.1.1 Goal

The goal of this survey is to start investigating the resilience of companies by looking the current maturity (the AS-IS maturity) of 6 relevant dimensions (i.e., economical, operational and technical, environmental, social, product-service system, and supply chain) for the resilience. Indeed, the main objective of this survey is to describe each company's current resilience level (AS-IS) and compare it with the desired future level (TO-BE) identified by the company itself. The gaps between the AS-IS and TO-BE maturity levels will be used to define together the best resilience strategy and action plan for the development of a tailored migration roadmap towards greater levels of resilience.

4.1.2 Audience

The target audience is formed by companies, especially manufacturing companies (internal project partners), which dealt with the rising of exogenous changes and issues (e.g., COVID-19) which can be considered the causes affecting the entire organization and, especially their core business activities, asking them for greater levels of resilience. Indeed, the representatives of different companies were asked to participate to the survey (i.e., one person for each company) to answer in the name of the company itself. In this way, the company can understand the current state and imagine the potential improvements towards a TO-BE scenario to be more resilient in the future. The anonymity was ensured to avoid sharing confidential information.

4.1.3 Structure

The survey is based on 7 questions (one for each dimension except for the economic performance which has two corresponding questions). For each question, it was asked to

specify the company current level (AS-IS) and the expected and desired level (TO-BE) to be achieved at the completion of the Eur3Ka project. The questions will be focused on different performances to ensure to keep under control several aspects characterising resilience which are: operational and technical, economic, environmental, social, product/service lifecycle, and supply chain.

OPERATIONAL / TECHNICAL: What approach does your company adopt for measuring operational performances (e.g., OEE) to monitor the flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Operational performance is often not measured or understood

- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective

- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours

- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI, statistical models, and forecasts techniques to understand the future KPIs

- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ECONOMIC - Q1: What approach does your company adopt for monitoring economic performances on the already established investments (e.g., ROI)?

- INITIAL: Operational performance is often not measured or understood

- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective

- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours

- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI and statistical models and forecasts techniques to understand the future KPIs

- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ECONOMIC - Q2: What approach does your company adopt to compare the economic performances of different investment opportunities (e.g. NPV, PBT, IRR) required to ensure flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Operational performance is often not measured or understood

- MANAGED: Descriptive Performance - Measurement and analysis of business KPIs are largely retrospective

- DEFINED: Diagnostic Performance - Measurement of KPIs is clear. Attempt to understand the causes that affect events and behaviours

- INTEGRATED: Predictive Performance - Measurement of KPIs is prospective. AI and statistical models and forecasts techniques to understand the future KPIs

- EXPLOITED: Prescriptive Performance – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and operational KPIs measurement

ENVIRONMENTAL: What approach does your company adopt for measuring environmental performances (e.g. CO2 emissions, water consumption per product, LCA) about investments performed to ensure sustainable flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Environmental performance is often not measured or understood

- MANAGED: Descriptive – Measurement of environmental KPIs is largely retrospective

- DEFINED: Diagnostic - Measurement of environmental KPIs is clear. Attempt to understand the causes of events and behaviours

- INTEGRATED: Predictive - Measurement of environmental KPIs is prospective. AI and statistical models and forecasts techniques to understand the future

- EXPLOITED: Prescriptive – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and environmental KPIs measurement

SOCIAL: What approach does your company adopt for measuring social performances (e.g. social return on investments S-ROI, Social lifecycle assessment S-LCA) about investments performed to ensure flexibility and resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Social performance is often not measured or understood

- MANAGED: Descriptive - Measurement of social KPIs is largely retrospective

- DEFINED: Diagnostic - Measurement of social KPIs is clear. Attempt to understand the causes of events and behaviours

- INTEGRATED: Predictive - Measurement of social KPIs is prospective. AI and statistical models and forecasts techniques to understand the future

- EXPLOITED: Prescriptive – future-oriented. A decision-making support system boosting optimization and simulation to find the best course of action and social KPIs measurement

PRODUCT-SERVICE LIFECYCLE: Which dimensions of analysis are taken into account in the assessment of the lifecycle of the products/services offered to the customers in a disruptive situation (like a Covid Pandemic)?

- INITIAL: No product life cycle assessment

- MANAGED: A few life-cycle aspects are included in some KPIs but occasionally

- DEFINED: Life Cycle Costing (LCC) towards recycling, de- re-manufacturing KPIs

- INTEGRATED: Life Cycle Costing + Environmental LCA towards Circular Economy

- EXPLOITED: Life Cycle Costing + Environmental LCA + Social LCA towards Sustainability and Green Deal

SUPPLY CHAIN: Which dimensions of analysis are taken into account for the overall evaluation of your company's supply chain resilience in a disruptive situation (like a Covid Pandemic)?

- INITIAL: Performance is often not measured or understood

- MANAGED: Only the most important physical performance of suppliers (e.g., punctuality, quality, operational flexibility)

- DEFINED: Physical and Economical performance (purchase price, non-quality costs, delivery delays, lack of flexibility, etc.).

- INTEGRATED: Physical, economical, sustainable performance for almost all the suppliers. In addition, the recovery time of the entire supply chain is monitored to evaluate resilience.

- EXPLOITED: Physical, economic, sustainability, and integration with other external sources (e.g., social media, weather). In addition, both disruption severity and recovery time of the entire supply chain are monitored to evaluate resilience.

4.2 Result of the first iteration

This sub-chapter aims to clarify and interpret the results observed from the performance survey. Indeed, in each sub-section of this sub-chapter is going to be reported an analysis of the different performances. An anticipation of the results can be reported here, hence, in accordance with what was studied in the extant literature and what emerged from the preliminary interactions with practitioners, none of the performances was considered not applicable, highlighting the key role covered by all of these performances in the resilience of all the manufacturing companies.

4.2.1 Operational and Technical

Starting with the first performance (see Figure 3), the operational and technical one, there is a predominant part of companies considering themselves at the "initial" level (around 50%), and only respectively around 25% and 25% in the "managed" and "defined" levels. This means that companies are aware about the still limited operational and technical performances and more in detail, they are aware about the fact that they are not monitoring these types of performances so implicitly they do not have under control these issues and if something happens, they do not have an immediate visibility on it. Nevertheless, they expressed their desired TO-BE scenario willing at least to reach the "defined" or "integrated" levels. This means that the understood the need to start having a complete view on this performance and to keep it under control with specific KPIs.
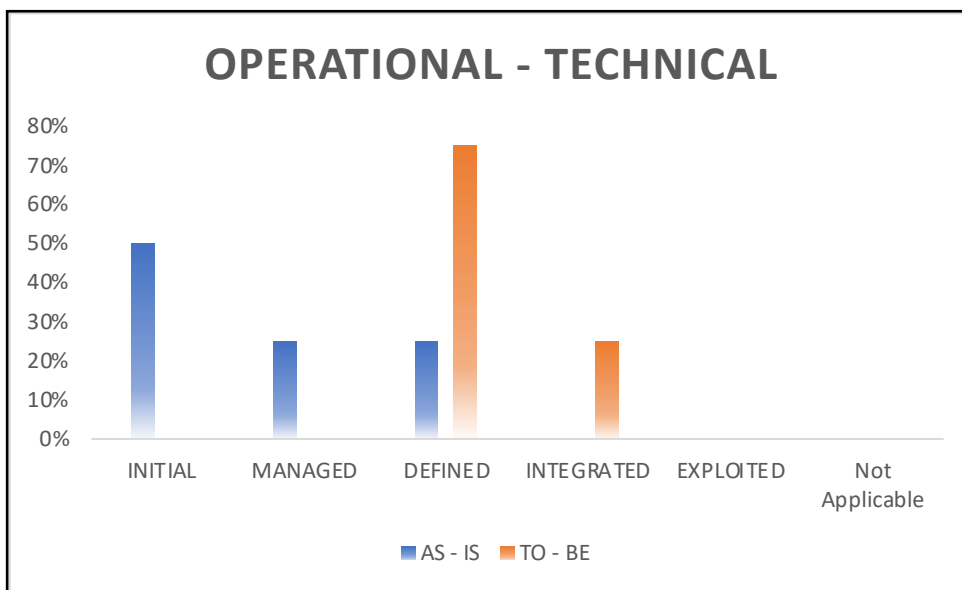
Figure 3 Operational aspect – Technical

4.2.2 Economic

Regarding the economic-related questions (see Figure 4 and Figure 5), the first one aimed to address the monitoring of the financial and economic performances on investments previously undertaken, while the second one is focused on the indicators used to compare different optional investments.

Starting from the results coming from the initial question on past investments (Figure 4), it is visible a quite good position of all the companies being at minimum at level "defined". Indeed, around 75% is at the "defined" level, and the remaining 25% considered its company at an "integrated" level. Therefore, the return on investments previously done is monitored and predictive performance measurements of KPIs are sometimes established. Regarding the TO-BE scenario, it is visible how much all the companies are oriented towards a big improvement, expecting to reach in the 50% of the cases an "exploited value" according to which the company deals with prescriptive performance measurements.
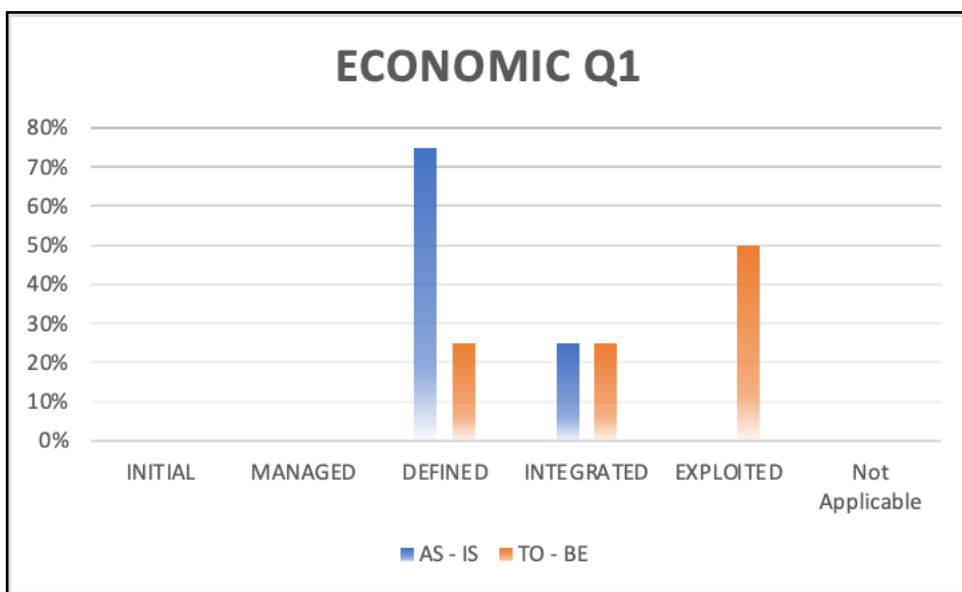
Figure 4 Economic aspect – Question 1

Looking at the second question about the comparison among investments to be done (see Figure 5), the situation is a little bit different and less homogeneous. Indeed, especially in the AS-IS scenario, the distribution of the answers covers the first four levels respectively with the 25% of the answer in each level. Nevertheless, there is still a predominant part of companies (50%) willing to reach an exploited level in the future. Considering the big gap, at least for some of the companies, between the AS-IS and the TO-BE scenarios, it is needed a structured improvement path to avoid introducing unnecessary KPIs where the maturity is still too low to grasp the benefits.

Figure 5 Economic aspect – Question 2

4.2.3 Environmental

Looking at the environmental point of view (see Figure 6), the situation is quite heterogeneous but most of the companies are still at an "initial" level (the 50%), and in the 25% of the c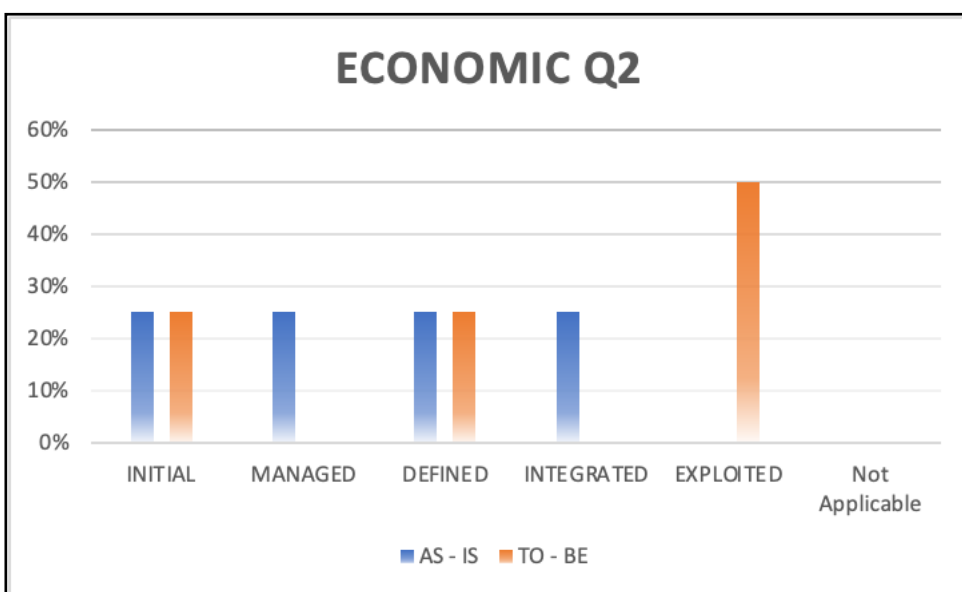ases this initial condition seems to be proper also for the future without really understanding the key role of this performance in the current context. Despite this result, the 50% of the respondents stated that they are willing to reach, in the TO-BE scenario, at least a "defined" level, meaning that there is the intention to identify the key KPIs to be kept under control to investigate the causes of some events creating issues especially from an environmental point of view. To report an example, the production of PPEs (Personal Protection Equipment) was done to encounter a specific need of that moment without keeping into account the disposal of those devices affecting our plant.
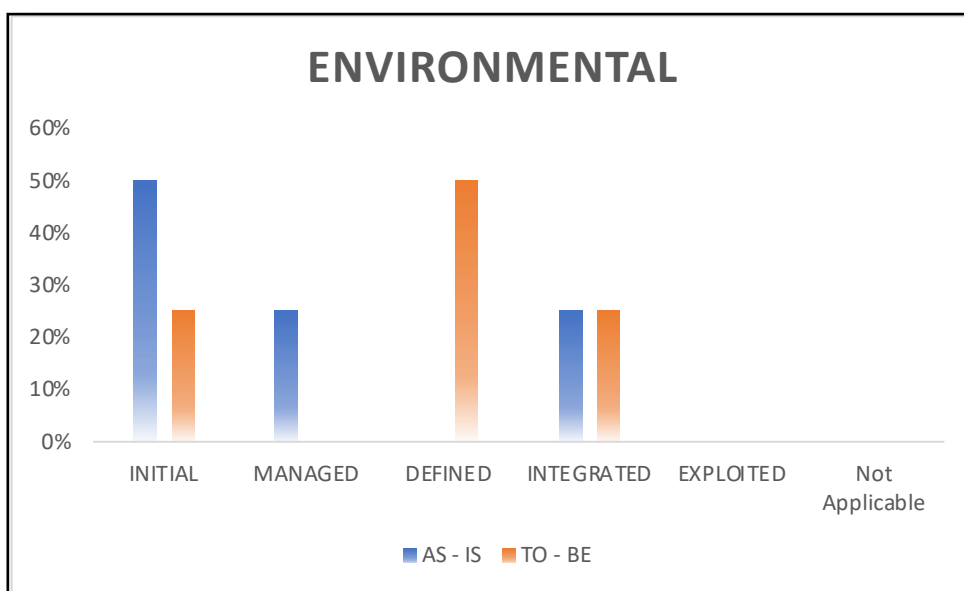
Figure 6 Environmental aspect

4.2.4 Social

Moving to the social performance (see Figure 7), thus the one highly focused on people and the creation of a human-centric environment, this is still at an "Initial" level for the majorly of the companies, the 75%, by having only the 25% of companies at a "defined" level. This means that until now very few companies are using structured plans and KPIs to monitor this type of performance. Anyway, in the TO-BE scenario, it has been stated by most of them that an improvement is expected, thus only the 25% will remain at the "initial" level, while the 50% aim to reach at least a "managed" level and the remaining 25% aims to reach an "integrated" level. This means that in most of the cases an improvement in this sense is expected and at least the intention is to set the KPIs to start monitoring it and in the best cases, the goal is to start performing measurements with the future oriented expectation to anticipate potential issues.
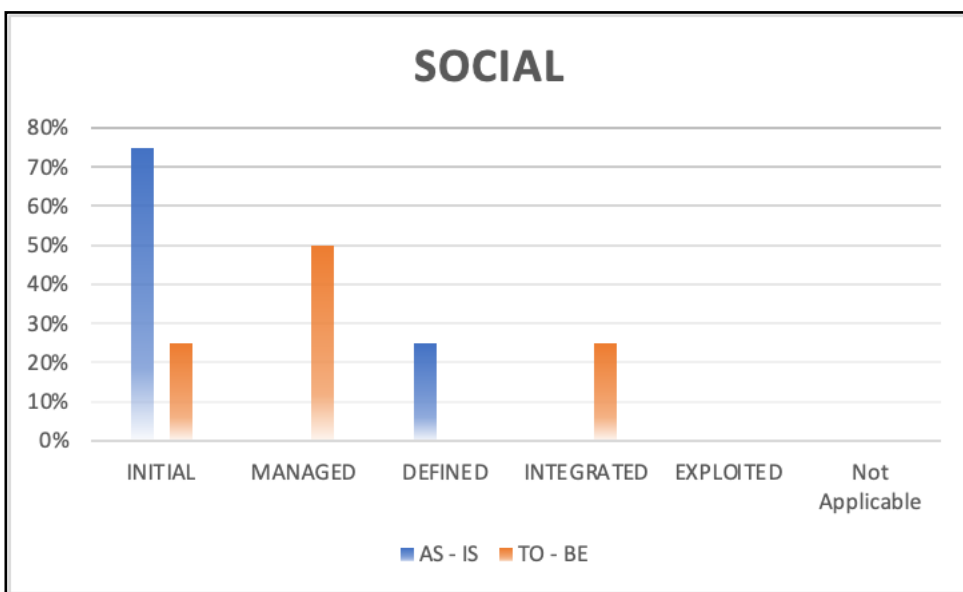
Figure 7 Social aspect

4.2.5 Product – service life cycle

The product-service lifecycle performances (see Figure 8), in terms of monitoring, are currently quite limited but at least managed to have a distribution of 25% of participants to the survey at an "initial" level while the rest at a "managed" one. This underlines the fact that most of the companies are aware of the need to keep information about both products and service life cycle under control and to start defining the KPIs to be monitored with at least a diagnostic purpose to empower the company resilience. This is also aligned with their expectations in the TO-BE scenario which are all at an improved level. Indeed, the 25% aims to reach a "managed" level, the 50% a "defined" level and the remaining 25% an "integrated" level. These results highlight the willingness to act with a purpose oriented to the future, by reaching a preventive attitude in some of the cases overcoming the limited diagnostic one.

Figure 8 Product – Service – Lifecycle aspect

4.2.6 Supply chain

The last performance, the most common one to be kept under control when we are dealing with resilience, is the supply chain (see Figure 9). With respect to the other performances, hence, the results from participants seem to be at a higher level since is common knowledge that exogenous events affecti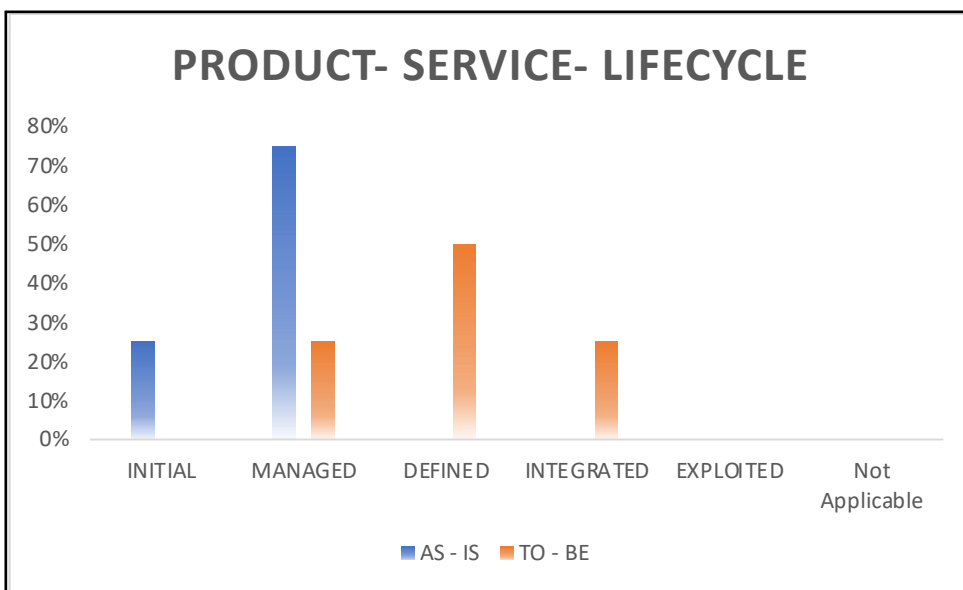ng the actors along the supply chain might be detrimental for the activities of the other companies within the same supply chain. Indeed, none of the companies answered to be at an initial level, but at least at the managed level. Additionally, according to the percentage of the answers reflecting each level (i.e., AS-IS: 50% at managed, 25% at defined and 25% at integrated; TO-BE: 50% at defined, 25% at integrated, and 25% at exploited), it seems that all the companies are willing to improve towards at least the next level in the future by starting to orient their analyses of potential future events.
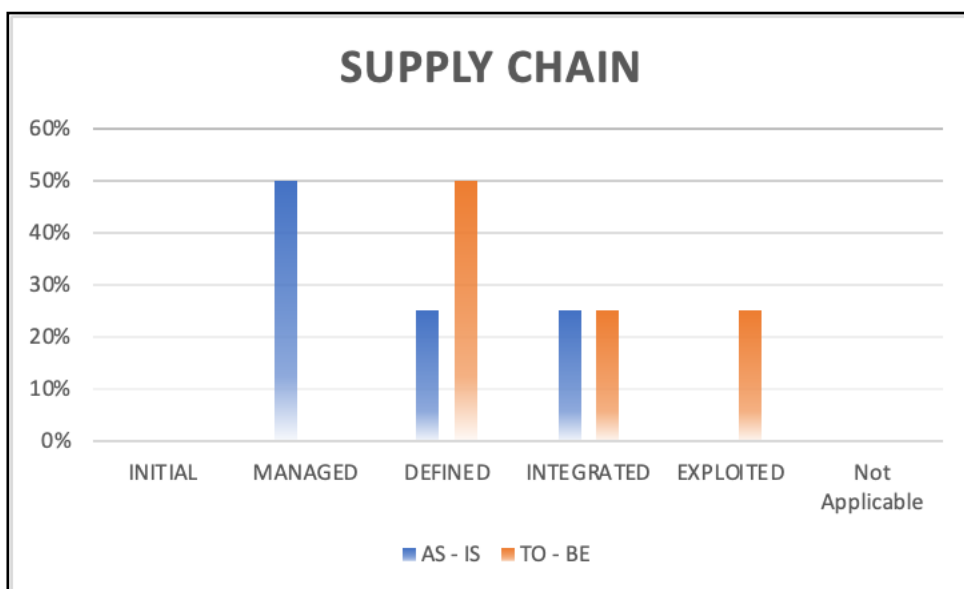
Figure 9 Supply chain aspect

4.3 Gap identification and Suggested actions

Based on the results observed in the survey, it is evident the shared view, common to all the participants in the survey, to necessitate an improvement based on their current state. Indeed, in all the performances, it has been seen an ideal TO-BE scenario improved with respect to the current one which in most of the cases embeds the idea to keep under control specific KPIs to be oriented toward the future without being limited to a diagnostic purpose only, but also to predictive and prescriptive ones. This future orientation is the key element fostering companies' resilience performances and facilitates them in facing rapidly, or even better anticipating, problems and challenges.

It is worth highlighting that the expected improvements cannot be something separated and parallel with respect to the strategy of the company but they must be fully integrated with the vision, mission, and strategy of the company itself. Therefore, structured improvement paths need to be designed and put in practice. More in detail, it is not valuable for a company to keep under control all the performances in an unstructured and not coherent manner

especially if it would be at an initial level for most of them. Instead, the improvement process should be supported by a structured and objective roadmap aligned with their strategic goals enabling to improve in a coherent manner.

Additionally, according to the context, a certain company might require keeping a specific performance under control since highly relevant for its resilience and thus, efforts in that direction should be conducted.

5 Workforce training surveys

5.1 Introduction to survey structure - goal - audience

This sub-chapter aims to clarify the key elements characterising the skills-related surveys: the goal of these surveys, the audience addressed in these surveys, and the structure of the surveys.

5.1.1 Goal

- **Voting survey**

This survey has the main objective of Introducing new skills, roles, and professions about DATA, Resilience, and Emerged roles or skills during COVID-19 and voting to relevant Skills.
The survey is divided into 2 blocks, New profiles related to Data (Data science management Pentagon), Profiles related to resilience, and the working environment during the COVID-19 pandemic. By analysing the answers of project partners, we can get opinions and prioritize the available skills.

- **Possessed and Needed survey**

This survey has the main objective of analysing the Possessed and Needed (AS-IS) situation of Partners about new skills, roles, and professions. In this survey, partners should specify whether they need these skills in their company or are currently using them. By analysing received answers, AS-IS situation and gaps related to identified roles can be determined.

5.1.2 Audience

The target audience is companies, especially manufacturing companies (internal project partners), which dealt with the rising exogenous changes and issues (e.g. COVID-19) which can be considered the causes affecting the entire organization and, especially their core business activities, asking them for greater levels of resilience. Indeed, for **voting** survey all individual internal to the project team can participate, while for **possessed and needed** survey representatives of different companies were asked to participate in the survey (i.e., one person for each company) to answer in the name of the company itself. In this way, the company can understand the current state and imagine the potential improvements toward a TO-BE scenario to be more resilient in the future. The anonymity was ensured to avoid sharing confidential information.

5.1.3 Structure

- **Voting survey**

This survey which is for prioritizing skills related to each profile consists of 3 main parts, and participants are asked to vote on each of the assigned skills. The first part is related to jobs and skills about "data science management" and their relevant skills:

1. **Data Science Manager:** Data Science Managers propose, plan, and manage functional and technical evolutions of the data science operations within the relevant domain.

   - Develop and execute the data strategy according to business objectives
   - Knowledge about business processes
   - Communication with domain experts
   - Manage the data science team and resources
   - Knowledge about performance indicators
   - Knowledge about domain specific processes

2. **Data Scientist:** Data scientists find, interpret and merge data sources, manage large amounts of data, ensure consistency of datasets, and create visualizations to aid in understanding data**.**

   - Identify and interpret relevant data sources
   - Ability to use a programming language (R, Python)
   - Mathematical and statistical models Knowledge
   - Use of machine learning, Bayes classifier, Deep Learning techniques and OR methods
   - Knowledge about domain-specific processes
   - Communicate with domain experts
   - Use of optimization algorithms

3. **Data Science Architect:** Data Science Architects design and maintain the architecture of data science applications and facilities.
   - Ability to select software platforms for big data (Hadoop, Data Lake)
   - Knowledge about big data architectural standards
   - Ability to select hardware platforms for big data (performances, costs, etc.)
   - Ability to integrate data universe

4. **Data Engineer:** Data Engineers build, manage, and maintain data pipelines.

   - Knowledge about data storage and query languages
   - Ability to use cloud computing
   - Develop data models and workflows
   - Ability to maintain security, quality, integrity, safety, and availability of data
   - Ability to integrate new data technologies into existing systems

5. **Visual Data Designer:** Visual Data Designers create custom visualizations from complex data sets in a compelling way.

   - Develop vector graphics, scientific illustrations, and icons (maps, charts, diagrams)
   - Ability to understand complex information
   - Develop insightful and engaging data analytics view
   - Visualize the huge and complex volume of data
   - Create infographics (maps, charts, diagrams)
   - Develop interface and interaction to increase user experience
   - user experience analysis, design, and evaluation.

6. **Remote Workers:** Remote worker is worker of a company but works outside of a traditional plant environment.
   - Use applications to increase sensory, remote, and cognitive abilities
   - Interpret quantitative data, graphs (KPIs) and 3D digital models
   - Understand and use additive manufacturing technologies and mathematical models
   - Perform scenario analysis to evaluate and prepare for possible interventions

The second part is related to roles about "Professions due to the COVID-19":

1. **Resilience Manager:** Resilience Managers understand, interpret & discover new insights about their team's resilience and impact of emerging tech. even during times of change and high pressure.

   - Understand the impact of emerging technologies on business (e.g., distributed systems, …)
   - Rapidly adapt technological innovations to business and Supply Networks
   - Redesign the production process end-to-end, improving it with the introduction of new technologies 4.0.
   - Foresee elements of flexibility, when necessary, in redesigning production processes.
   - Engage and dialogue with stakeholders, trade unions first and foremost, to better manage change related to the introduction of new technologies.
   - Collaborate with other players (including those from outside the company) and integrate them into the value chains.
   - Anticipate business requirements and end-user needs

2. **Repurposing supervisor:** Repurposing supervisor transforms products or their components to suit a second purpose after their first has expired

- Identify opportunities for new/alterative applications of existing components, products, machines, etc.
- Knowledge and ability to use and Re-use (new) materials.
- Ability to innovate and engineer the product in 3D printing perspective and to use 3D printers
- Ability to design around new materials/processes or used material/processes (e.g., light polymerization, …)
- Knowledge about Reduce, Reuse and Recycle Wastes
- Ability to define the business model around the product-service

3. **Operator 4.0:** works in a field of technology who is proficient in the relevant skill and technique, with a relatively practical understanding of the theoretical principles.

- interact with smart warehouses equipped with automated picking systems and autonomous vehicles
- Ability to use discrete event simulation
- Analytical skills to Interpret data from operations
- Use sensors/actuators/ ports/ antennas/HMI standards
- Ability to use 3D printers

And third part is related to soft skills for three different levels of organizations (management, professional, and worker levels):

- Emotional Judgment,
- Teamwork,
- Communication,
- Professional ethics,
- Problem solving,
- Critical thinking,
- Innovation,
- Ethical / Legal mindset,
- speak second language,
- Time management Judgment,
- Interpersonal skills,
- Critical problem solving,
- Digital literacy problem solving,
- Self-management,

- Global perspective,

- Digital skills,

- Possessed and Needed survey

In this survey, all the jobs mentioned above appear one by one to the voters and they are asked to review these jobs' definitions and skills, and determine their desire to have these jobs with yes and no. In case of yes, if they need or possess these jobs, they are asked to specify the level of need or possess from the basic to expert level (by using numbering method: 1- basic, 2- lower intermediate, 3- Intermediate, 4- upper intermediate, and 5- expert) and state what is their plan to cover the existing gaps in the future and what are their expectations.

5.2 Result of the first iteration

5.2.1 Voting survey

In order to examine the perspectives of project partners on the jobs and skills mentioned in the section 5.1.3 and D3.2, surveys were set up to ask the partners' opinions on the skills assigned to each job in the first place, and the skills were prioritized based on the answers received. This survey, which is named "Voting survey", was published in online mode[7], and in the following sections, the results of its first iteration are depicted.

Data Science Manager

Based on the responses received for "Data Science Manager" – Figure 10; Skills can be divided into three categories; The most important skills are "Develop and execute the data strategies – 28.95%", and "Manage the data science team and resources - 21.05%".

Then "Communication with domain experts – 18.42%" and "Knowledge about domain-specific processes- 13.16%"in the second place.

Finally, "Knowledge about business processes – 10.53%" and "Knowledge about performance indicators – 7.89%" are less important than others.

---

[7] https://polimi.eu.qualtrics.com/jfe/form/SV_eajGqrsgnsIGufY
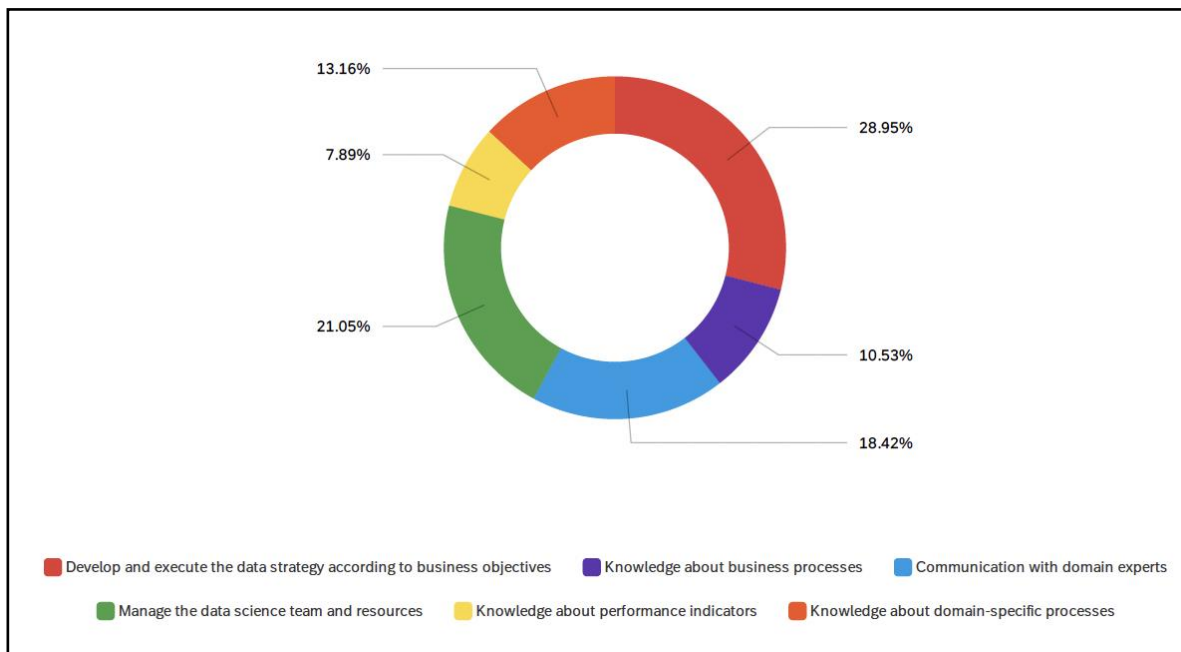
Figure 10 Data Science Manager - result of Voting survey - 1st Iteration

Data Scientist

Skills related to this job title – Figure 11, in terms of importance can be divided into high priority " Use of machine learning, Bays classifier, Deep learning and OR methods – 20 %", "Identify and Interpret relevant data sources – 17.78%", and "Ability to use a programming language – 15.56 %", medium priority "Communicate with domain expert – 13.33%", "Use of optimization algorithm – 13.33%", and "Mathematical and statistical models knowledge – 13.33%", as well as low priority "Knowledge about domain-specific process – 6.67%".
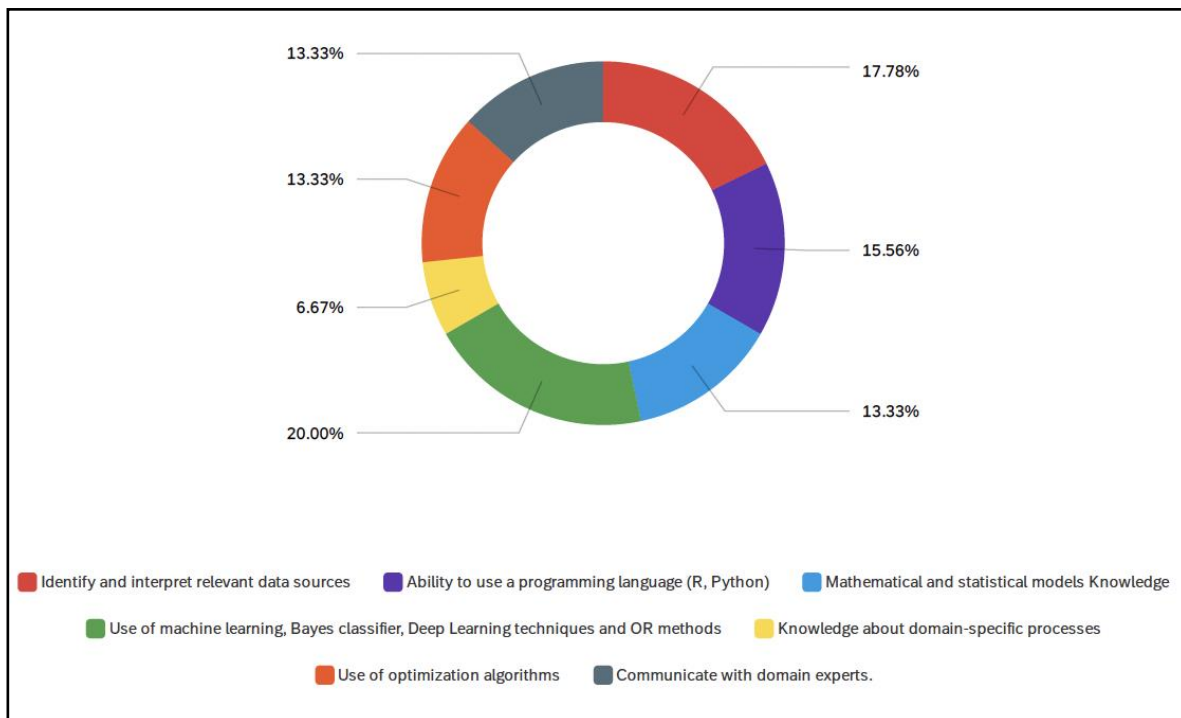
Data Science Architect

In this job profile – Figure 12, all the identified skills are nearly equal in importance, but it should be noted that according to the project partners' point of view "Ability to select software platforms for big data (Hadoop, Data Lake, …) – 35.48%" is more significant than the other skills.
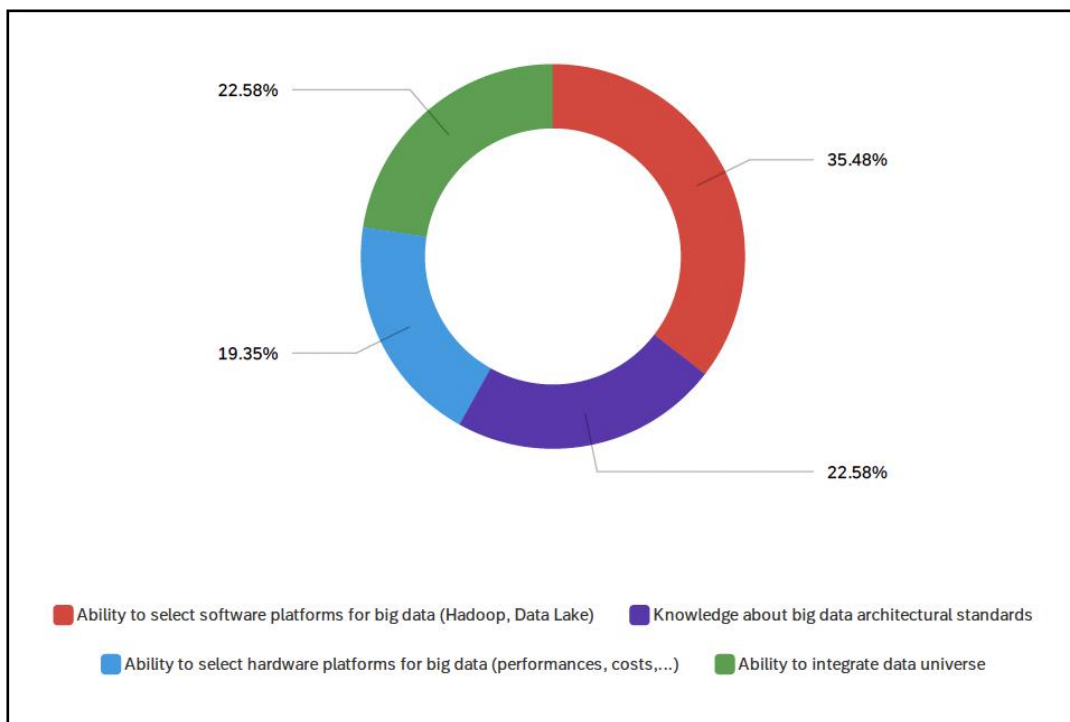
Figure 12 Data Science Architect - result of Voting survey - 1st Iteration

Data Engineer

In this role – Figure 13, three main skills are "knowledge about data storage and query languages – 25.71%", "Ability to maintain security, quality, integrity, safety and availability of data – 22.86%", and "Ability to integrate new data technologies into existing systems – 22.86%", which are related to information about new technologies and how to use them in existing systems and organizations. On the opposite side, based on project partners' point of view skills related to cloud computing have a lower priority in this job profile.
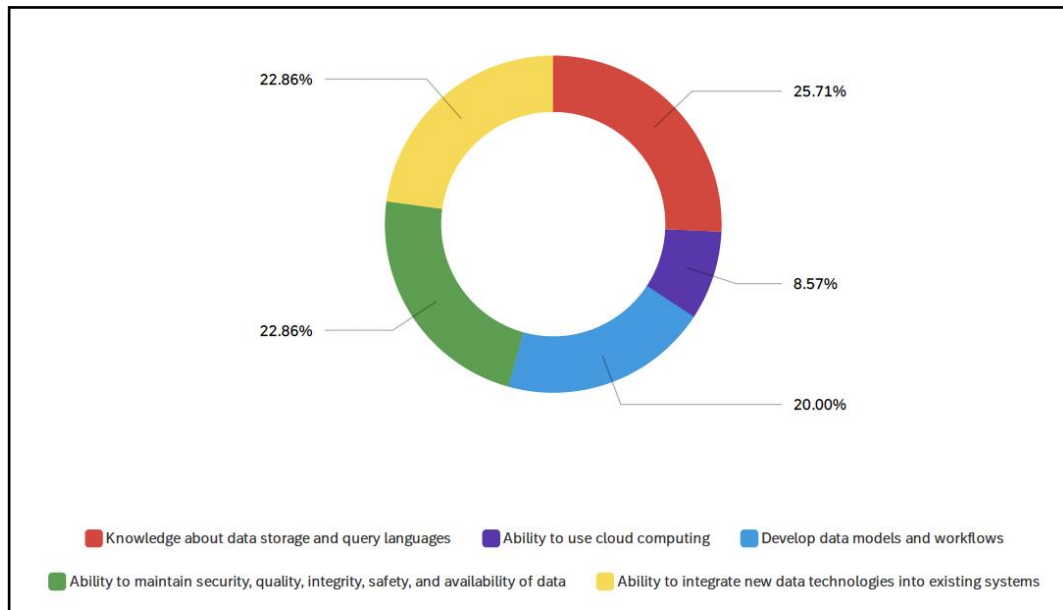
Figure 13 Data Engineer - result of Voting survey - 1st Iteration

Visual Data Designer

As can be seen in the Figure 14, the most important skills of this job are "Create infographics (maps, charts, diagrams) – 22.86%", and "Develop interface and interaction to increase user experience – 17.14%" which are related to better display data and create better communication with users.
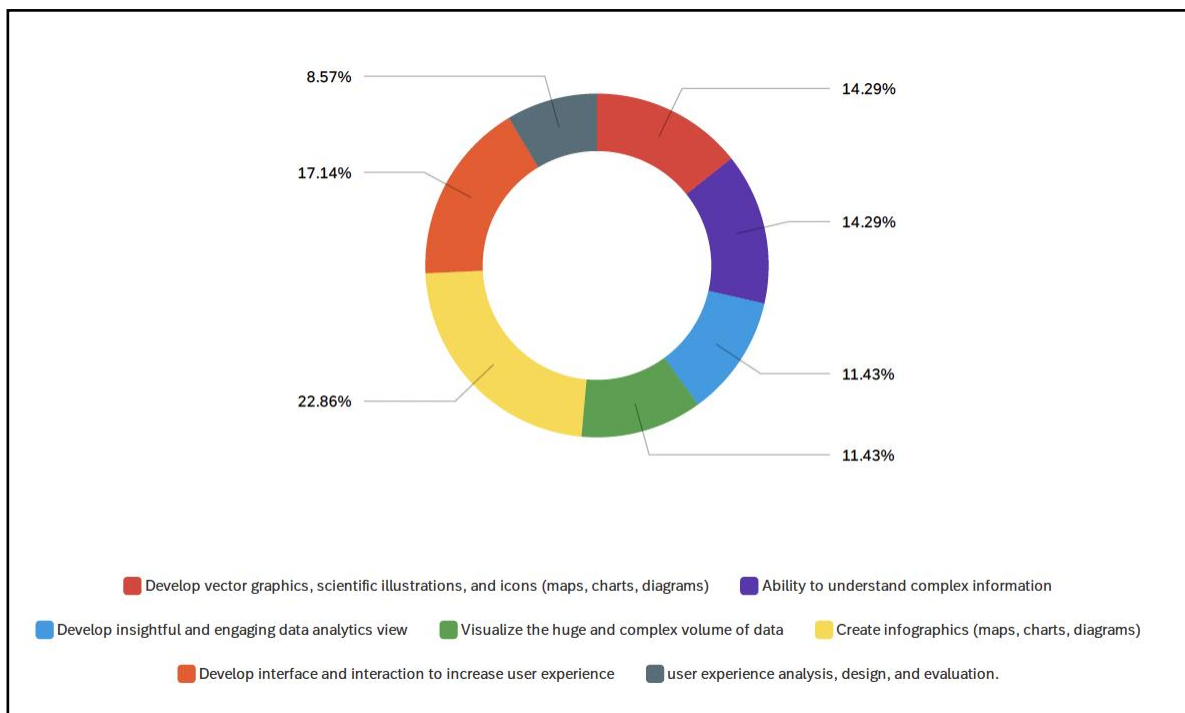
Figure 14 Visual Data Designer- result of Voting survey - 1st Iteration

Remote Workers

Since people in this role work from outside the company environment, skills such as "Interpret quantitative data, graphs (KPIs), and 3D digital models – 33.33%", "Perform scenario analysis to evaluate and prepare for possible interventions – 27.78", and "Use applications to increase sensory, physical, and cognitive abilities – 27.78%" are crucial and according to the responses received from project partners "Understand and use additive manufacturing / AI technologies and mathematical models" is a skill with less importance compared to others (Figure 15).
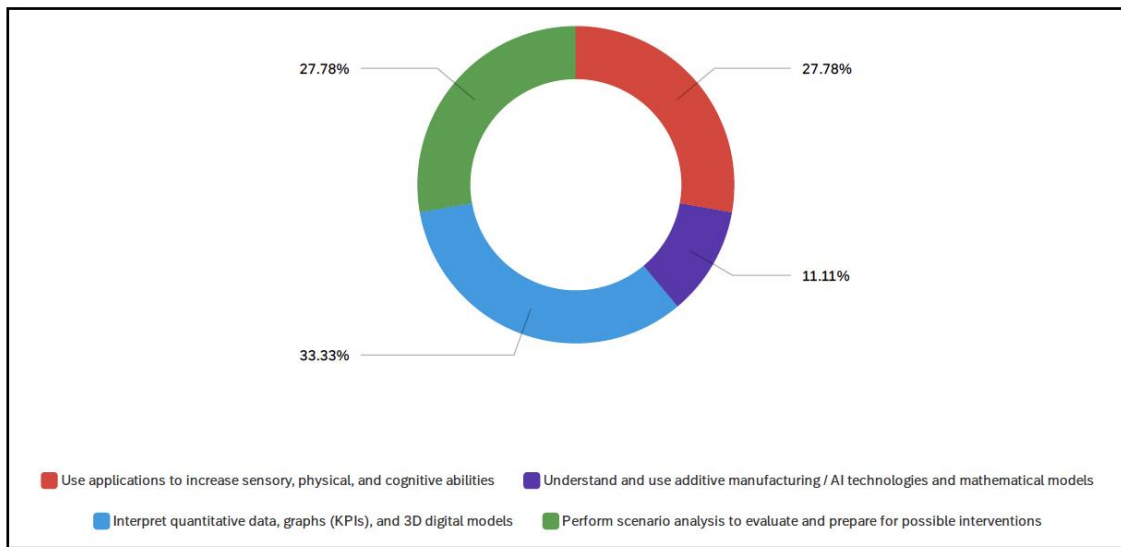
Figure 15 Remote Worker - result of Voting survey - 1st Iteration

Resilience Manager

This job, which has been analyzed at the management level, needs to improve some skills due to the growing trend of technology and rising new crises. The most important of which (Figure 16) are related to "Foresee elements of flexibility, when necessary, in redesigning production process – 22.22%", and "engage and dialogue with stakeholders and trade unions to better manage change related to the introduction of new technologies – 19.44%".
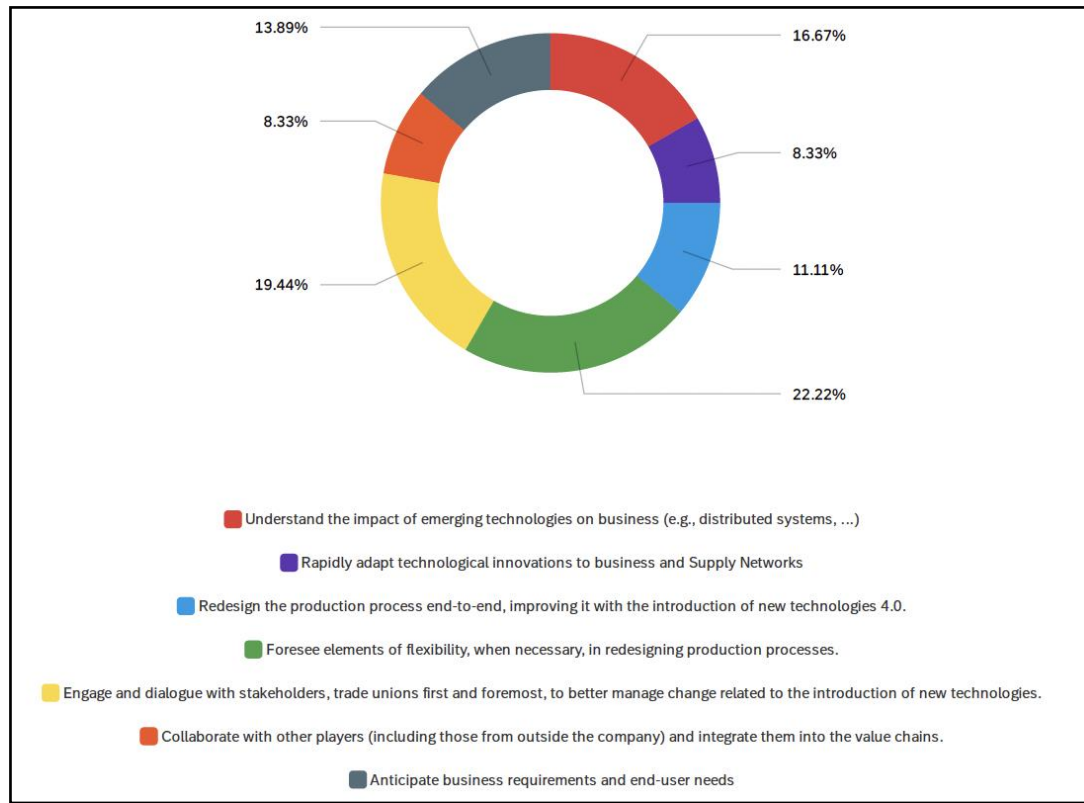
Figure 16 Resilience Manager - result of Voting survey - 1st Iteration

Repurposing supervisor

This job profile (Figure **17**) has been analyzed in professional level. Its skills need to be improved in line with trend of new technologies. Therefore, the most important skills which have been considered by project partners are "Identify opportunities for new/alternative applications of existing components, products, machines, etc. – 21.88%", and "Ability to define the business model around the product-service – 21.88%".
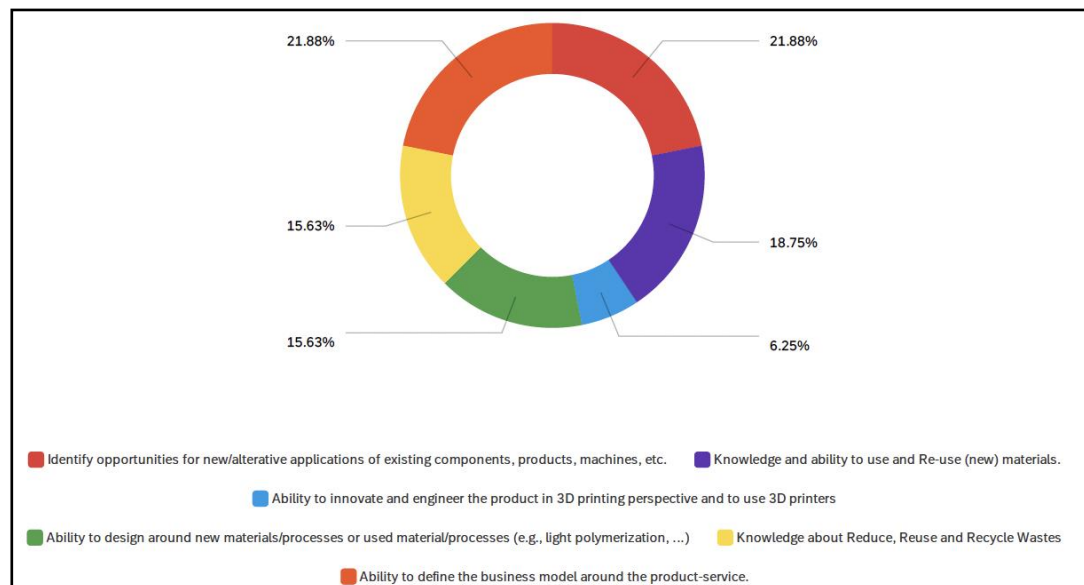
Operator 4.0

This job title (Figure *18*) is a role that is analyzed at the worker level. Crucial skills in this profile are about "Analytical skills to interpret data from operation – 40.74%" and "Use sensors, actuators, ports, antennas, HMI standards – 25.93%" which are mostly related to using new technologies and interpreting production data by workers.
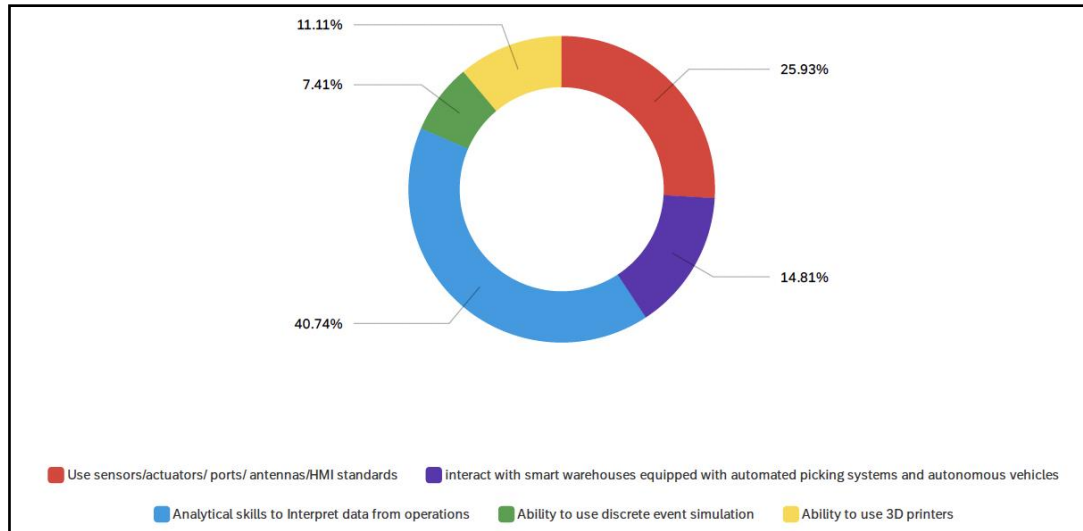
Figure 18 *Operator 4.0 - result of Voting survey - 1st Iteration*

5.2.2 Soft Skills

In addition to technical skills (which are mentioned In Section 5.1.3), Soft skills have been also analyzed at three different levels: Management, Professional, and Worker levels, which in the Table 2 you can see the results of the survey of project partners.

Table 2 Soft Skills in Three different Levels

#	Field	Managers	Professionals	Workers
1	Teamwork	5.19%	9.86%	15.05%
2	communication	7.79%	8.45%	6.45%
3	Professional ethics	7.79%	4.23%	5.38%
4	Problem solving	5.84%	7.04%	10.75%
5	Critical thinking	7.14%	6.34%	6.45%
6	Innovation	7.14%	7.04%	4.30%
7	Emotional Judgment	4.55%	2.11%	0.00%
8	Speak second language	6.49%	6.34%	2.15%
9	Time managemnt	5.84%	7.75%	6.45%
10	Interpersonal skills	7.79%	9.86%	10.75%
11	Critical problem solving	5.84%	4.23%	6.45%
12	Digital literacy problem solving	3.90%	4.93%	3.23%
13	Self-managemnt	5.84%	8.45%	10.75%
14	Digital skills	2.60%	7.04%	8.60%
15	Ethical - Legal mindset	9.09%	3.52%	3.23%
16	Global Perspective	7.14%	2.82%	0.00%
		154	142	93

According to the answers received from the project partners, it can be concluded that skills related to "Internal and external organizational Communication, Ethical and legal mindset, Professional ethics, and Interpersonal Skills" are the most important soft skills at the management level.

Skills about "Teamwork, Internal and external organizational Communication, Interpersonal Skills, and Self-management in different situations" are the crucial skills at the professional level.

In addition, "Teamwork, interpersonal skills, Problem-solving mindset especially during crises, and self-management" at the labor level are more important than others.

Furthermore, as can be seen, Interpersonal skills is a common skill for all three levels, as well as Teamwork and self-management at professional and worker levels, which indicates the importance of these skills in the workplace.

5.2.3 Possessed and Needed survey

In order to assess the current situation of the project partners and also their future expectations in relation to the jobs introduced in D3.2 and Section 5 of this deliverable, the second survey entitled "Possessed and Needed" was asked of them, in this survey partners specify whether they need these skills in their company or were currently using them. To

display this information, a numerical range between 1 and 5 has been used, in which 1 depicts "basic level required" and 5 shows "expert level required". The most important purpose of this survey is to compare the AS-IS Situation and their target conditions, finding the gap between them and the possible activities of the partners to bridge these gaps. This survey was published in online mode[8] and in the following sections the results of its first iteration is depicted (based on the eight votes received).

Data Science Manager

Regarding this job profile, four out of eight industrial partners stated that they possessed it now or will need it in the near future. According to the Table 3, the skills introduced for this job are needed in these four partners at the intermediate to expert level or they already possessed them in these levels. According to the supplementary answer we received from these partners, it can be understood that two out of four have achieved the desired level so far by relying on the capabilities of the company itself. And other two stated that they feel the need for this job title and related skills soon, so they considered holding training courses as a suitable way to bridge this need. On the other hand, some of them pointed out that, they will need to improve and re-reskill the current situation in near future.

Table 3 Data Science Manager - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Develop and execute the data strategy according to business objectives	0.00%	0.00%	0.00%	25.00%	25.00%	50.00%	4
2	B: Knowledge about business processes	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
3	C: Communication with domain experts	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
4	D: Manage the data science team and resources	0.00%	25.00%	0.00%	0.00%	25.00%	50.00%	4
5	E: Knowledge about performance indicators	0.00%	0.00%	0.00%	50.00%	25.00%	25.00%	4
6	F: Knowledge about domain-specific processes	0.00%	0.00%	0.00%	50.00%	25.00%	25.00%	4

Data Scientist

Regarding "Data Scientist" role, as it is shown in Table 4, five out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 4, the skills introduced for this job are needed in these five partners at the intermediate to expert level or they already possessed them in this level. Based on the supplementary comments we received from these partners, it can be understood that four out of five have achieved the desired level so far by relying on the capabilities of the company itself or collaboration with partners, but they still need to improve. Also, one of these partners stated

---

[8] https://polimi.eu.qualtrics.com/jfe/form/SV_eKTRza9fo6ASgPs

that they feel the need for this job title and related skills soon, so they considered making collaboration with other project partners as a suitable way to bridge these gaps.

Table 4 Data Scientist - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Identify and interpret relevant data sources	0.00%	0.00%	20.00%	0.00%	60.00%	20.00%	5
2	B: Ability to use a programming language (R, Python)	0.00%	0.00%	0.00%	0.00%	20.00%	80.00%	5
3	C: Mathematical and statistical models Knowledge	0.00%	0.00%	0.00%	20.00%	0.00%	80.00%	5
4	D: Use of machine learning, Bayes classifier, Deep Learning techniques, and OR methods	0.00%	0.00%	0.00%	0.00%	40.00%	60.00%	5
5	E: Knowledge about domain-specific processes	0.00%	0.00%	20.00%	20.00%	20.00%	40.00%	5
6	F: Communicate with domain experts	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
7	G: Use of optimization algorithms	0.00%	0.00%	0.00%	20.00%	20.00%	60.00%	5

Data Science Architect

In this role, six out of eight partners stated that they possessed it now or will need it in the near future. According to the Table 5, the skills introduced for this job are needed in these six partners at the upper intermediate and expert levels or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood that five out of six have achieved the desired level so far by relying on the capabilities of the company itself or collaboration with internal and external partners. Also, one of these partners stated that, there is no need to create a permanent job position like this and they can hire that person for a short period of time when needed.

Table 5 Data Science Architect - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5
1	A: Ability to select software platforms for big data (Hadoop, Data Lake)	0.00%	0.00%	0.00%	0.00%	20.00%	36.36%
2	B: Knowledge about big data architectural standards	0.00%	0.00%	0.00%	0.00%	40.00%	18.18%
3	C: Ability to select hardware platforms for big data (performances, costs,…)	0.00%	0.00%	0.00%	66.67%	20.00%	18.18%
4	D: Ability to integrate data universe	0.00%	0.00%	0.00%	33.33%	20.00%	27.27%

Data Engineer

Regarding this profile, as it is shown in Table 6, five out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 6, the skills

introduced for this job are needed in these five partners at intermediate to expert levels or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood that four out of five have achieved the desired level so far by relying on the capabilities of the company itself or up-re skilling activities, but they still need to improve.

Table 6 Data Engineer - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Knowledge about data storage and query languages	0.00%	0.00%	0.00%	0.00%	40.00%	60.00%	5
2	B: Ability to use cloud computing	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
3	C: Develop data models and workflows	0.00%	0.00%	0.00%	20.00%	40.00%	40.00%	5
4	D: Ability to maintain security, quality, integrity, safety, and availability of data	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	5
5	E: Ability to integrate new data technologies into existing systems	0.00%	0.00%	0.00%	0.00%	20.00%	80.00%	5

Visual Data Designer

In this Job profile, as it is shown in

Table 7, four partners out of eight stated that they possessed its skills now or will need it in the near future. According to the votes received can be concluded that the level which partners are currently at or need to reach is in the intermediate to expert levels. On the other hand, according to the additional comments received by partners, it can be understood that two out of four have achieved the desired level so far by relying on the capabilities of the company itself or up-re skilling activities, but they still need to improve. Also, two of these partners stated that they feel the need for this job title and related skills soon, so they considered holding training courses and hiring new personnel as a suitable way to bridge these gaps.

Table 7 Visual Data Designer- Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Develop vector graphics, scientific illustrations, and icons (maps, charts, diagrams)	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
2	B: Ability to understand complex information	0.00%	0.00%	50.00%	25.00%	0.00%	25.00%	4
3	C: Develop insightful and engaging data analytics view	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
4	D: Visualize the huge and complex volume of data	0.00%	0.00%	25.00%	25.00%	25.00%	25.00%	4
5	E: Create infographics (maps, charts, diagrams)	0.00%	0.00%	0.00%	0.00%	25.00%	75.00%	4
6	F: Develop interface and interaction to increase user experience	0.00%	0.00%	0.00%	0.00%	50.00%	50.00%	4
7	G: User experience analysis, design, and evaluation	0.00%	0.00%	0.00%	25.00%	50.00%	25.00%	4

Remote Workers

For this role, three out of eight partners stated that they possessed its skills now or will need it in the near future. According to the Table 8, the skills introduced for this job are needed in these three partners mostly at intermediate and expert levels or they already possessed them in this level. Based on the supplementary comments we received from these partners, it can be understood that two of them have achieved the desired level so far by relying on the capabilities of the company itself. Of course, they still need to improve and believe training course could be the most important method. Also, one of these partners stated that they feel the need for this job title and related skills soon specially to avoid being caught unawares in unexpected crises like Covid-19.

Table 8 Remote Worker - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Use applications to increase sensory, remote, and cognitive abilities	33.33%	0.00%	0.00%	0.00%	33.33%	33.33%	3
2	B: Interpret quantitative data, graphs (KPIs), and 3D digital models	0.00%	33.33%	0.00%	33.33%	0.00%	33.33%	3
3	C: Understand and use additive manufacturing technologies and mathematical models	33.33%	33.33%	0.00%	0.00%	0.00%	33.33%	3
4	D: Perform scenario analysis to evaluate and prepare for possible interventions	0.00%	0.00%	0.00%	33.33%	33.33%	33.33%	3

Resilience Manager

Regarding this job profile, three out of eight industrial partners stated that they possessed it now or will need it in the near future. According to the Table 9, the skills introduced for this job are needed in these three partners at the intermediate to expert levels or they already possessed them in these levels. According to the supplementary comments we received from these partners, it can be understood that one out of three have achieved the desired level so far by relying on the capabilities of the company itself. And other two stated that they feel the need for this job title and related skills soon, so they considered holding training courses, hiring new personnel, and up-re skilling activities as suitable ways to bridge this need.

Table 9 Resilience Manager - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Understand the impact of emerging technologies on business (e.g., distributed systems, …)	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	3
2	B: Rapidly adapt technological innovations to business and Supply Networks	0.00%	0.00%	0.00%	0.00%	33.33%	66.67%	3
3	C: Redesign the production process end-to-end, improving it with the introduction of new technologies 4.0.	0.00%	33.33%	0.00%	0.00%	0.00%	66.67%	3
4	D: Foresee elements of flexibility, when necessary, in redesigning production processes	0.00%	0.00%	33.33%	33.33%	33.33%	0.00%	3
5	E: Engage and dialogue with stakeholders, trade unions first and foremost, to better manage change related to the introduction of new technologies	0.00%	0.00%	0.00%	0.00%	66.67%	33.33%	3
6	F: Collaborate with other players (including those from outside the company) and integrate them into the value chains	0.00%	0.00%	0.00%	33.33%	0.00%	66.67%	3
7	G: Anticipate business requirements and end-user needs	0.00%	0.00%	0.00%	33.33%	0.00%	66.67%	3

Repurposing supervisor

Regarding this job profile, Table 10only one answer was received, and according to the supplementary comments, it can be understood that it needs the skills related to this job at the intermediate to expert levels. In addition, it pointed out that based on company conditions the most appropriate way to bridge these gaps will be up-re skilling activities.

Table 10 Repurposing supervisor - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Identify opportunities for new/alternative applications of existing components, products, machines, etc.	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	1
2	B: Knowledge and ability to use and Re-use (new) materials	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
3	C: Ability to innovate and engineer the product in 3D printing perspective and to use 3D printers	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	1
4	D: Ability to design around new materials/processes or used material/processes (e.g., light polymerization, …)	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
5	E: Knowledge about Reduce, Reuse and Recycle Wastes	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	1
6	F: Ability to define the business model around the product-service	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	1

Operator 4.0

In this role, four out of eight partners stated that they possessed it now or will need it in the near future. According to the Table 11, the skills introduced for this job are needed in these four partners at the intermediate to expert levels or they already possessed them in these levels. Based on the supplementary comments we received from these partners, it can be understood that two out of four have achieved the desired level so far by relying on the capabilities of the company itself. In addition, one of them stated that they feel the need for this job title and related skills soon, so they considered holding training courses as a suitable way to bridge this need. Also, one of these partners stated that, there is no need to create a

permanent job position like this and they can hire that person for a short period of time when needed.

Table 11 Operator 4.0 - Possessed and Needed – survey

#	Field	N/A	1	2	3	4	5	Total
1	A: Interact with smart warehouses equipped with automated picking systems and autonomous vehicles	25.00%	0.00%	0.00%	50.00%	25.00%	0.00%	4
2	B: Ability to use discrete event simulation	50.00%	25.00%	0.00%	25.00%	0.00%	0.00%	4
3	C: Analytical skills to Interpret data from operations	0.00%	0.00%	0.00%	75.00%	0.00%	25.00%	4
4	D: Use sensors/actuators/ ports/ antennas/HMI standards	25.00%	0.00%	0.00%	25.00%	25.00%	25.00%	4
5	E: Ability to use 3D printers	50.00%	0.00%	0.00%	25.00%	0.00%	25.00%	4

5.3 Gap identification and Suggested actions

In this section, we go to the next step of the method introduced in chapter 3. After introducing the related jobs and skills in the first step and implementing & analyzing the surveys that were explained in the section 5.2.3 and finding the gaps among the project partners, we will now introduce training activities that can help partners to strengthen their required skills in the introduced job profiles.

In this step, first of all, three levels "Awareness", "Foundations", and "Extended Know-How" were considered which Awareness refers to general knowledge and information to get familiar to the subject, Foundation refers to basic useful information with more detail compared to awareness level, and Extended Know-How refers to a range of information that can help audience to increase their level of knowledge and understand of how to use the technology. Then, each of the training courses that were introduced in "I4MS Catalogue of Trainings" (https://i4ms.eu/trainings/) and "POLIMI open knowledge" (www.pok.polimi.it/) were analyzed and the correlation between jobs and related skills and these courses at three levels were defined (Table 12)

Table 12 Database of Training Activities

Matrix: relation between courses and Roles 1 - Awareness 2 - Foundations 3 - Extended Know-How		Provider	I4MS	PoK– Politecnico di Milano	PoK– Politecnico di Milano
		Course name	AI Opportunities for SMEs	Artificial Intelligence - An Overview	Artificial Intelligence and legal issues
Data Science Manager					
	Knowledge about domain specific processes		1	1	
	Knowledge about business processes		2		1
	Communication with domain experts				
	Manage the data science team and resources			1	
	Knowledge about performance indicators				1
	Develop and execute the data strategy according to business objectives		1	1	1
Data Science Architect					
	Ability to integrate data universe			1	
	Select software platforms for big data (Hadoop, Data Lake)			1	
	Knowledge about big data architectural standards				1
	Select hardware platforms for big data (performances…)			3	
Data Scientist					
	Identify and interpret relevant data sources			1	
	Use a programming language (R, Python)				
	Communicate with domain experts				
	Mathematical and statistical models' knowledge			3	
	Knowledge about domain-specific processes			1	
	Use of machine learning, Bayes classifier, Deep Learning techniques and OR methods		3		
	Use of optimization algorithms		1	1	

(Left vertical labels: DATA Science Management New Roles & Professions)

In this database, all nine jobs that were introduced in the previous sections and their related skills are covered and the Table 12 is just a part of this database to show how it works. For example, in the first column of the courses, we have the "AI Opportunities for SMEs" which is presented by "I4MS Catalogue of Trainings". This course is held in the context of new technology, especially "Artificial intelligence" and in connection with the "Data science management Roles and Professions" provides explanations in awareness level for "Knowledge about domain specific process" and "Develop and execute the data strategy according to business objectives" skills, Knowledge in Foundation level for "Knowledge about business processes" skill. Also, its main focus is on "Use of AI, machine learning, and Deep learning techniques" skill which provides an information Extended Know-How Level. It should be noted that this database is open source, which means that if the partners were able to improve their required skills using other training activities, they can add to this file so that other partners can get acquainted with it.

6 Ethical Issues

In order to coordinate the surveys implemented in this deliverable with the ethical issues mentioned in D7.1, the confirmation form on behalf of the POLIMI team has been placed in the annex section, and here are some of its crucial points.

Goals of the Task/Activity Involving Humans: The activity's goal is to collect data from Eur3ka partners using two assessment models developed in WP3 for skills and performance, respectively. The ultimate goal of these assessment models is to assist partners in becoming aware of their current state and embarking on structured improvement paths. The assessment models will be applied internally to the consortium in WP5, while the community will be expanded in WP6.

It should be noted that the goal of these surveys is the entire organisation, rather than a single person (individual). In this manner, a representative from each organization fills out surveys regarding the overall performance and skills of the organization.

Methods of research: The research methods will include both pre-existing surveys and interviews with survey participants to investigate their responses gleaned from the survey.

Subjects recruited for the study: The subjects involved in the first iteration of the models are the industrial partners who are actively participating in WP5. The survey and subsequent interviews will be centred on the industrial entity rather than the individual.

It should be mentioned that the recruitment took place during the Eur3Ka project's bi-weekly meetings, asking people if they were willing to participate in the surveys, and the people involved were asked to provide their answers while agreeing not to share the results externally. Nonetheless, no questions about privacy or security were asked of participants.

7 Future Steps

Some of the plans that should be considered in the future in order to complete the process related to "Performance and People - workforce training" are as follow:

- Implement the second iteration of the method to analyze the TO-BE conditions and compare it with the AS-IS situations of project partners and record them in D5.4 which will be considered as a second version of the D5.3 report.

- Identify main Key Performance Indicators (KPIs) at a pilot area level beyond the factory pilot insights to measure performance and facilitate replication and public communication.

- Complete databases of training activities by gathering information from project partners.

- Holding an internal workshop to show the analyses performed and the proposed activities to cover the gaps, as well as holding external workshops related to the performance and the people dimension in relation to WP6 activities.

8 Conclusions

The results of this deliverable can be divided into two main categories: Performance dimension and People dimension results. On one hand, the performance part was structured to investigate both the current maturity of companies (AS-IS situation) and the TO-BE desired scenario in keeping under control a set of indicators looking at the 6 dimensions which were considered fundamental not only in I4.0 projects but also for resilience-monitoring purposes.

On the other hand, the people dimension "skills and workforce training" presents the list of emerging new skills and job requirements and, eventually, a prioritization for critical ones, as well as their need and availability in project experiments, regarding the digital transformation and technology growth.

In this regard, after reviewing previous studies conducted in both dimensions and introducing the 6Ps, Performance and People dimensions model (aimed at supporting manufacturing companies in defining its current level of digital maturity), were defined. In addition, one survey in performance dimension and two surveys related to prioritizing skills dedicated to each profile according to experiments' conditions and analyzing experiments' current situation and their expectation for the future regarding identified job profiles and skills were implemented.

The performance survey presented quite heterogeneous results among the participants but also among the different performances. The main aspect that emerged was the higher maturity in keeping under control supply chain performances in respect with the others. This result might be influenced by the common knowledge about the need to monitor the stakeholders along the value chain to anticipate possible detrimental effects on the core business. The other performances, especially those related to environmental and social aspects, are not currently mature but it is a shared view of the need to improve in the future.

The voting survey, which was conducted online to examine the opinions of project partners regarding the skills assigned to each job profile and their prioritization, received 14 votes; based on these votes, the skills for each profile were prioritized in order of importance for project partners. In addition, another crucial goal of this survey was to identify skills that were not completely relevant to the jobs introduced, "based on partners' points of view"; however, an interesting result of the feedback was that; the skills assigned to each job were correctly identified and no needed to be eliminated for next steps (second Iteration).

The needed and possessed survey, which was asked of the experiments to examine their current situation in relation to the jobs and skills introduced, received eight votes. (It should be noted that the target group of this survey was manufacturing companies (internal project partners)), After reviewing and analyzing the received responses, the existing gaps related to the skills became apparent, which the important result obtained from the analysis of the responses is this; most of the partners believed that the crucial solutions to cover the existing gaps in relation to the jobs and skills are the creation of cooperation with project partners for up-re skilling as well as the use of training courses to get acquainted with new jobs and skills and improving current level of skills. Furthermore, Since use of training courses was one of

the important strategies to cover the job and skill gaps in experiments, As the second step in the first iteration for people dimension, list of training activities (from I4MS catalogue of training, and POLIMI open knowledge website), field of training, level of information they provide to the audience (awareness, foundation, and extended know/how) were also offered to partners, so that they have the possibility to use these training courses to improve their skills in the field of introduced jobs.

The second iteration of these surveys will be conducted in the next months of the project (due to M24), where the content of the surveys will change slightly, and the main questions will be designed for analysis TO-BE situation.

9 Annex

EUR3KA SURVEY – Requirement No. 1 from WP7

Partner: POLIMI

Involvement of human participants

Table 13 Requirement No. 1

Aims of the Task /activity that involve humans
Please provide a brief summary in language comprehensible to a lay person or non-expert. Full details must be provided in the description/protocol submitted with this application The activity aims to collect data from Eur3ka partners based on the application of two assessment models, **respectively on skills and performances**, that have been developed in WP3. This assessment models have the final goal to support partners in becoming aware about their current state and to undertake structured improvement paths. In WP5 the assessment models are applied internally to the consortium, while in WP6 the community is going to be expanded. It should be noted that, in these surveys, the goal is the whole organisation and the focus is not on one person (individual). In this way, a representative from each organization fills-in the surveys in relation to the performance and skills of the whole organization.
Which methods of research involving or affecting humans will be executed (e.g. interviews, experiments, observations, workshops, trainings)? The methods of research are going to be both surveys, already developed, and interviews with the same participants of the survey to investigate their responses gathered from the survey.
How many subjects will be recruited to the study (by group if appropriate)? Regarding the first application of the models, the subjects involved are the industrial partners who are actively participating in WP5. The survey and the subsequent interviews are going to be focused on the industrial entity and not on the person.

Will any of the subjects be from the following vulnerable groups -	YES/ NO
Children under 18	No
Adults with learning or other disabilities	No
Very elderly people (+80)	No

Healthy volunteers who have a dependent or subordinate relationship to investigators (e.g., **employee – employer relationship**)	Yes
Other vulnerable groups	No

If YES to any of the above, please specify and justify their inclusion

The assessment was aimed at investigating the current state of **performance monitoring and skills development** in the companies and was performed through the survey to collect their responses. A representative who employed in internally to the consortium companies and has enough information about skills and performance of whole organization can fill out the surveys.

Inclusion and exclusion criteria

Please indicate, with reasons, the inclusion and or exclusion criteria for the research activity.

The other typologies were not needed for this study

Please describe how and where recruitment will take place

The recruitment took place during the bi-weekly meeting of the Eur3Ka project asking people whether they were willing to take part to the survey.

Please indicate the informed consent procedures that will be implemented for the participation of humans

The people involved were asked to provide their answers ensuring them to not share externally the results. Nevertheless, no privacy and security related data were asked to participants

Do the proposed methods of research generate potential safety risks for the participating persons or researchers? If yes, which measures are planned to ensure safety and reduce potential risks?

No risks arise from the application of the model

Can the safety of persons at any time be guaranteed? If no, why?

Yes

Based on your national legal framework or internal policy, are you required to obtain an Ethics Approval for the above-mentioned activities?

No

References

1. Romero, David, Johan Stahre, Lisa Larsson, and Anna Ohrwall Ronnback. 2021. "Building Manufacturing Resilience through Production Innovation." In *2021 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2021 - Proceedings*. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICE/ITMC52061.2021.9570204.

2. Spaltini, Marco, Federica Acerbi, Marta Pinzone, Sergio Gusmeroli, and Marco Taisch. 2022. "Defining the Roadmap towards Industry 4.0: The 6Ps Maturity Model for Manufacturing SMEs." *Procedia CIRP* 105: 631–36. https://doi.org/10.1016/j.procir.2022.02.105.

3. World Manufacturing Forum's ten skills for the future of manufacturing World

4. Manufacturing Forum - https://worldmanufacturing.org/

5. https://worldmanufacturing.org/wpcontent/uploads/WorldManufacturingForum2020_Report.pdf

6. World Economic Forum, 2020, The Future of Jobs Report, October 2020.

7. Osservatorio Industria 4.0 - Politecnico di Milano

8. Ace factories, White paper on Human-centred factories from theory to industrial practice. Lessons learned and recommendations, 2019.

9. World Economic Forum, 2020, The Future of Jobs Report, October 2020.

10. https://polimi.eu.qualtrics.com/jfe/form/SV_eajGqrsgnsIGufY

11. https://polimi.eu.qualtrics.com/jfe/form/SV_eKTRza9fo6ASgPs

12. https://i4ms.eu/trainings/

13. https://www.pok.polimi.it/