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ONE4ALL - Agile and modular cyber-physical technologies supported by data-driven digital tools to reinforce manufacturing resilience

Project nr: **101091877**

D1.1 Training programme and workforce safety

Version: 1.0

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ONE4ALL Consortium Partners

N.	Partner	Acronym	Country
1	IDENER RESEARCH & DEVELOPMENT (Coordinator)	IDE	ES
2	INNOPHARMA TECHNOLOGY	INO	IE
3	CRIT	CRIT	IT
4	EXELISIS	EXE	GR
5	UNIVERSITY OF SOUTHERN DENMARK	SDU	DEN
6	AUTOMATIONWARE	AUTO	IT
7	MADAMA OLIVA	MOL	IT
8	HOLOSS	HOLO	PT
9	TU DORTMUND UNIVERSITY	TUDO	DE
10	ORIFARM	ORI	CZ
11	KARLSRUHER INSTITUT FUER TECHNOLOGIE	KIT	DE

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Executive Summary

This deliverable (D1.1) describes how a training programme as well as workforce safety protocols will be developed within the ONE4ALL project. Both are crucial measures that will be taken to ensure the human-centricity of the technical ONE4ALL solutions to be developed. Therefore, D1.1 is to be seen as the first part of a series of four deliverables (D1.2, D1.3, D1.4) to describe the process according to the ONE4ALL solutions.

It is the intention to adapt the contents of both products to the context of the future use cases at Orifarm and Madama Oliva, which have already been selected. A mapping of digital maturity and corresponding gaps is an important first step for a proper adaption. Within the project, this is realised with the help of the *Digital Maturity and Sustainability Assessment Tool*: It uses group discussions to measures both the targets and the state of digital maturity within companies. In total, quantitative values are calculated for 70 different concepts of digital maturity and sustainability. Looking at first results of the tool from Orifarm and Madama Oliva, it becomes apparent that beneath technical topics, personnel-related topics are relevant too and the goals of the project are strongly depending on the involvement of employees.

Apart from that, the document contains further cornerstones that should be taken into account later in the concrete development of the safety protocols and the training programme along the planned ONE4ALL solutions in order to ensure human-centricity. An important source of reference are the *Criteria for good digital industrial work* that entail guiding principles for digital changes within companies, putting focus on the interfaces between human, technology, and organisation. Furthermore, the ethical and gender-related principles that constitute responsible research and project work that are described in D7.7 will be considered.

Furthermore, the first key points for the contents of both the safety protocols and the training programmes are already defined. Refering back to a skill categorisation, it is assessed whether technical, digital, methodological, personal, as well as social skills will probably be included into the training programme. Additionally, the intended process for defining / developing the safety protocols is also laid out in this deliverable.

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List of acronyms

3PL	Third Party Logistics
AGVs	Automated/Automatic Guided Vehicles
AI	Artificial Intelligence
AUTO	AutomationWare
AWTube	6 DOF robotic arm prototype
AWCombo	Robotic composition prototype of one AWTube and one AGV
BMS	Building Management System
CAPA	Corrective and Preventive Action
CMMS	Computerised Maintenance Management System
COA	Certificate of Analysis
CPV	Continued Process Verification
D	Deliverable
DCS	Distributed Control System
DMP	Data Management Plan
DMSA	Digital Maturity and Sustainability Assessment
DOF	Degree of Freedom
DSS	Decision Support System
DT	Digital Twin
EDI	Electronic Data Interchange
ELN	Electronic lab notebook
EOL	End of line
ERP	Enterprise Resource Planning
FPs	Finished Product
I5.0	Industry 5.0
IDE	Idener
INO	InnoGlobal
IOP	Intelligent orchestration platform
ISO/TS	International Organization for Standardization/Technical Specification
IT	Information technology
ITIL	Information Technology Infrastructure Library
LIMS	Laboratory information management system
MES	Manufacturing execution system
MOL	Madama Oliva
MPs	Material Product
NOx	Nitrogen oxides
ORI	Orifarm
OT	Operational technology
PAT	Process Analytical Technology
PCS	Process Control Systems
PLC	Programmable logic controller
PLM	Product life-cycle management
RCPM	Reconfigurable Cyber-Physical production Module
RE100	100% renewable energy
RFID	Radio-frequency identification
SCADA	Supervisory Control and Data Acquisition
SDMS	Scientific Data Management System
SMEs	Small and medium-sized enterprises
SOx	Sulfur oxides

TRL	Technology Readiness Level
TUDO	TU Dortmund University
WCS	Warehouse Control System

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1. Introduction

This deliverable 1.1 (D1.1) is the first of four reports which is directed towards developing a training programme and workforce safety protocols while considering gender and ethical issues. In the first stage of task 1.1, which is reported here, the Digital Maturity and Sustainability Assessment (DMSA) was carried out by InnoGlobal (INO). This guided self-assessment covered a broad range of Industry 5.0 topics. As the DMSA also refers to the dimension of People, Culture and Skills, it is aimed at delivering the basics for a training programme which will be delivered later on in the project (and be reported in the updates of the report, namely D1.2 in month 24, D1.3 in month 36 and D1.4 in month 48). While the DMSA is identifying the initial digital maturity of the workforce of the pilot cases Orifarm (ORI) and Madama Oliva (MOL), the need for improved (digital and non-digital) skills is then derived. The current situation of the pilot cases in terms of People, Culture and Skills is pointed out in this report. Based on that, recommendations for people related measures are proposed which are translated into requirements for training programmes, safety and health measures and gender/ethical issues.

As ONE4ALL is dedicated to the Industry 5.0 approach, human-centricity as a key dimension of it plays an important role within the project. To operationalise human-centricity, criteria are developed and translated into requirements in section 4.

In the next stage of the project, interviews with employees from ORI and MOL will be carried out to specify skill needs and other features of the development process to enable human-centric solutions (to be reported in D1.2).

Workforce safety is the second topic to be addressed in task 1.1. Preparing the safety protocols as a result of this task, firstly it was needed to identify the applications for the ONE4ALL solutions in the pilot cases. To this end, results from task 4.1 (led by AUTO) have been used. They include the description of the pilot cases as well as a list of applications for the ONE4ALL solutions and those who are selected for developing solutions. In this report the next steps to ensure workforce safety (such as risk analysis of the selected applications) are settled and described. In the updated reports (D1.2 and 1.3), these next steps will be implemented.

The third topic of task 1.1, gender and ethics, are considered by using the checklists of D7.7 [1] which have been provided to all project partners (as documents and as a webinar held in June 2023). Some gender and ethical issues are already addressed within the Digital Maturity and Sustainability Assessment (among the People, Culture and Skills dimension), others will be defined when specifying the applications in the pilot cases.

2. Digital maturity assessment tool

The section will introduce the Digital Maturity and Sustainability Assessment tool (DMSA) of InnoGlobal, which can be applied within companies. First, the idea of the tool will be generally described (section 2.1). This includes the benefits for the participating companies. Afterwards, the different components will be introduced (section 2.2). Thereby, it will also be briefly evaluated how the DMSA components correspond to the ONE4ALL targets, especially to the goal to follow a human-centric implementation approach.

This tool has already been applied to end-users (MOL and ORI) within ONE4ALL: The actual assessment consisted of nine 90-minute facilitated sessions for each company, spread over three days. Per day, three sessions of 90 minutes were conducted. First results of these sessions can be found in section 3.2.

2.1. General description

The InnoGlobal Digital Maturity and Sustainability Assessment tool specifically assists organisations in formulating an evidence-based strategy that considers their unique technological and organisational direction, roadmap and destination. With a greater understanding of where organisations sit in the adoption of advanced technologies, they are in a stronger position to set achievable targets and strategies for improvement.

InnoGlobal's Digital Maturity and Sustainability Assessment was carried out in 10 business functions across three streams of the business: primary and secondary value chain and sustainability. Subject matter experts from the companies were interviewed and guided through a series of questions relating to their business functions. Under each business function, the maturity and sustainability of the companies was evaluated against Industry 5.0 concepts. The scores awarded were calculated to determine an overall percentage score for each concept, each business function, across the 3 streams and to calculate an overall business score. These scores are compared at each level with companies defined targets.

The results of the survey combined with the inputs and rich discussion between InnoGlobal's and companies' SMEs have led to specific recommendations on potential next steps. A concluding section gives a detailed benchmarking assessment across the different areas, concepts and technologies.

Not all areas and technologies deliver equally to the bottom line. All organisations have finite resources. It is important that all Industry 5.0 initiatives are assessed against their bottom-line impact in order to prioritise resource allocation effectively.

The potential improvement actions should be referenced against the organisation's goals and strategy in order to determine priority of implementation. This is to ensure that time and effort spent on areas will address the company's unique issues and deliver maximum benefit.

Not all of the detailed concept by concept data can be shared in this public report due to company confidentiality requirements. Further sharing of this data can be arranged with an EU approved assessor on a case by case basis.

2.2. Components

2.2.1. Primary value chain concepts

InnoGlobal assessed four key areas in the primary value chain. InnoGlobal assisted the companies / SMEs in understanding and scoring each Industry 5.0 concept and technology (23 in total as shown in Figure 1). Companies were then asked to set a target for each concept over a 3-to-5-year time horizon. The results show the current state and compares that with the medium-term targeted goal.

Manufacturing Execution and Process Automation

This section covers all manufacturing operations, manufacturing control and process equipment. It includes manufacturing, packaging, weighing, cleaning, change-over, production process analytics, Statistical process control and batch records. Typical systems might include Manufacturing execution systems (MES), Distributed control systems (DCS), Supervisory Control and Data Acquisition (SCADA), Programmable logic controller (PLC), Process Analytical Technology (PAT), statistical process monitoring & control systems, automation systems, process information collection and data historian.

Lab, Metrology and Quality Management

This section covers quality and compliance management, quality test operations management and test control. Areas include lab execution, lab scheduling, Certificate of Analysis (COA), data archiving, stability, change management, Corrective and Preventive Action (CAPA), audit and inspection management, document management, customer complaint management, and batch release. Typical systems include Laboratory Information Management Systems (LIMS), Scientific Data Management Systems (SDMS), Electric Lab Notebook (ELN), Lab Execution Systems, data archiving, in-line/at-line testing on shop floor, Continued Process Verification (CPV), Quality Management System, and Document Management Systems.

Manufacturing Support

This section covers facility management and design, maintenance and instrument management. It includes: maintenance and calibration management, plant engineering, environmental monitoring, plant security, health & safety, building automation, utilities, energy management, process development, knowledge management. Typical systems include CMMS (Computerised Maintenance Management System), BMS, Utilities Controls, Drawing Management, Access Control (Badge Management), Environmental Monitoring, Learning Management

Production Planning and Supply Chain

This section refers to planning and scheduling, material handling and component management. It includes production planning and scheduling, warehouse, logistics, materials management, serialisation track and trace, components management, supplier integration, 3PL, distribution centre, cold chain. The typical systems are Product Life-Cycle Management (PLM), Enterprise Resource Planning (ERP), shop floor scheduling, Warehouse Control System (WCS), Material Handling Systems, automated warehouse, trade compliance, transportation management, Electronic Data Interchange (EDI), Radio-Frequency Identification (RFID), temperature monitoring, integration to supplier/shipper/3PL (Third Party Logistics) ERP.

Relevance and aggregate results

Figure 1 shows the 23 concepts of the Primary Value Chain as well as the related gaps between target and actual score (representing the scale of the future challenges identified by companies) aggregated across all companies where the tool has yet been applied. It is evident that the area *Manufacturing Execution and Process Automation* is of special importance, as the Reconfigurable Cyber-physical Production Module (RCPM) corresponds to the main target result of the ONE4ALL project. Interestingly, this item has the second-largest gap between target and the actual score of all Primary Value chain concepts.

Further concepts that are be relevant to the ONE4ALL solutions are *Digitally Enhanced Quality management*, *Decision Support systems*, *Integrated and Real Time Monitoring Systems*, as well as

Automated Manufacturing and Assembly. These concepts are predominantly upper half of the primary value chain concepts with the largest gap between targeted score and actual score.

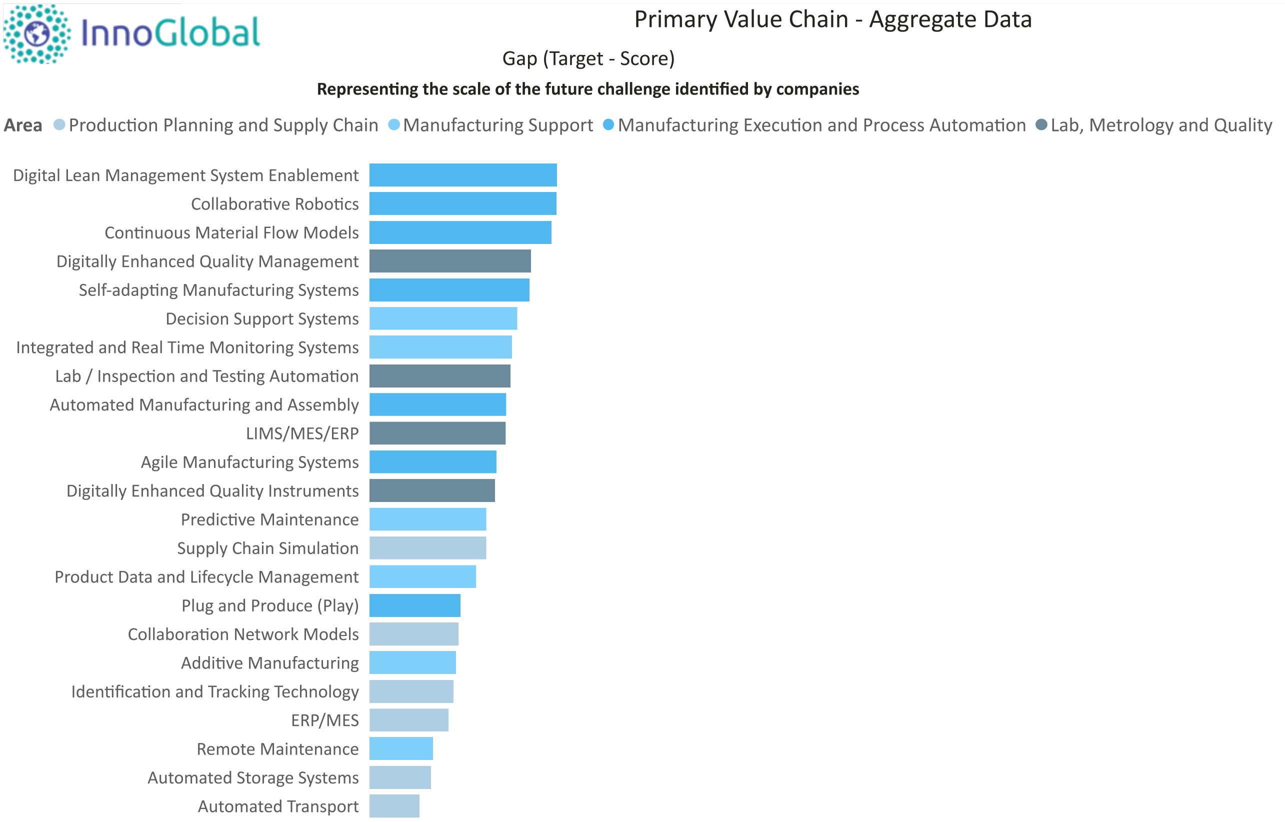

Figure 1: Aggregate DMSA results – Primary Value Chain – Gaps between targets and score

2.2.2. Secondary value chain concepts

InnoGlobal assessed three key areas in the secondary value chain (People culture and skills; Business insights and analytics; Systems interoperability, IT security and operations). InnoGlobal assisted the companies / SMEs in understanding and scoring each Industry 5.0 concept and technology (26 in total as shown in Figure 2). Companies were then asked to set a target for each concept over a 3-to-5-year time horizon. The results show the current state and compares that with the medium-term targeted goal.

People, Culture and Skills

This section refers to organisation capabilities, people centricity and organisation culture. It includes managing talent to support and evolve the digital plant vision and roadmap. It includes shop floor personnel and professional and IT staff, people metrics and integration of people metrics into digital plant monitoring and control systems. It covers culture and skills shift due to more integrated and complex systems and increased focus on data and analytics. Skills include Automation, IT Architecture, Delivery, Data Science, Service Ownership. Integration of people metrics into digital plant monitoring and control systems.

Business Insights and Analytics

This section covers data acquisition and governance, and data analytics with cognitive computing. It includes sophisticated predictive analytics to enable digital plant maturity. Typical systems include data aggregation, integration, and contextualisation, data analysis and visualisation systems.

Systems Interoperability, IT Security and Operations

This section covers IT security, infrastructure, operations and management and systems interoperability. It includes applying new security and IT infrastructure and operational processes to ensure data integrity and enable the integrated, adaptive digital plant, business process automation through key systems vertically integrated across S95 blueprint, supported by digital plant architectural blueprint and governance. Systems include secure manufacturing networks, WiFi, virtualisation, cloud, firewalls, advanced security tools, encryption, IT service management framework (e.g., Information Technology Infrastructure Library (ITIL)), high availability architecture, monitoring, disaster recovery, mobile, wearables, augmented reality, integration layers such as ERP-to-MES (Manufacturing Execution System) and MES-to-PCS (Process Control Systems), tools for data aggregation and integration, and systems models, with standard platforms at each level and accompanying information, infrastructure, and network architecture.

Relevance and aggregate results

Figure 2 shows the aggregated results of the Secondary Value Chain of the DMSA across all companies. Many concepts have a direct connection with the ONE4ALL solutions. Thereby, *Open Innovation and Collaboration*, *Role of the Operator*, *Data Consumption*, *Cultural Transformation*, *Diversity and Inclusion* and *Training 5.0* refer to non-technological aspects in the Area *People, Culture and Skills* that are relevant to the implementation of ONE4ALL solutions (cf. section 4). *Role of the Operator*, as well *as Open Innovation and Collaboration* stand out as topics of higher relevance.

More technical concepts that are potentially relevant and have high score gaps *include Data analysis and Analytics* (as the ONE4ALL solutions process real-world data to calculate their "behaviour") or *cyber-physical systems* (as the robotic solution will have non-physical and physical tasks).

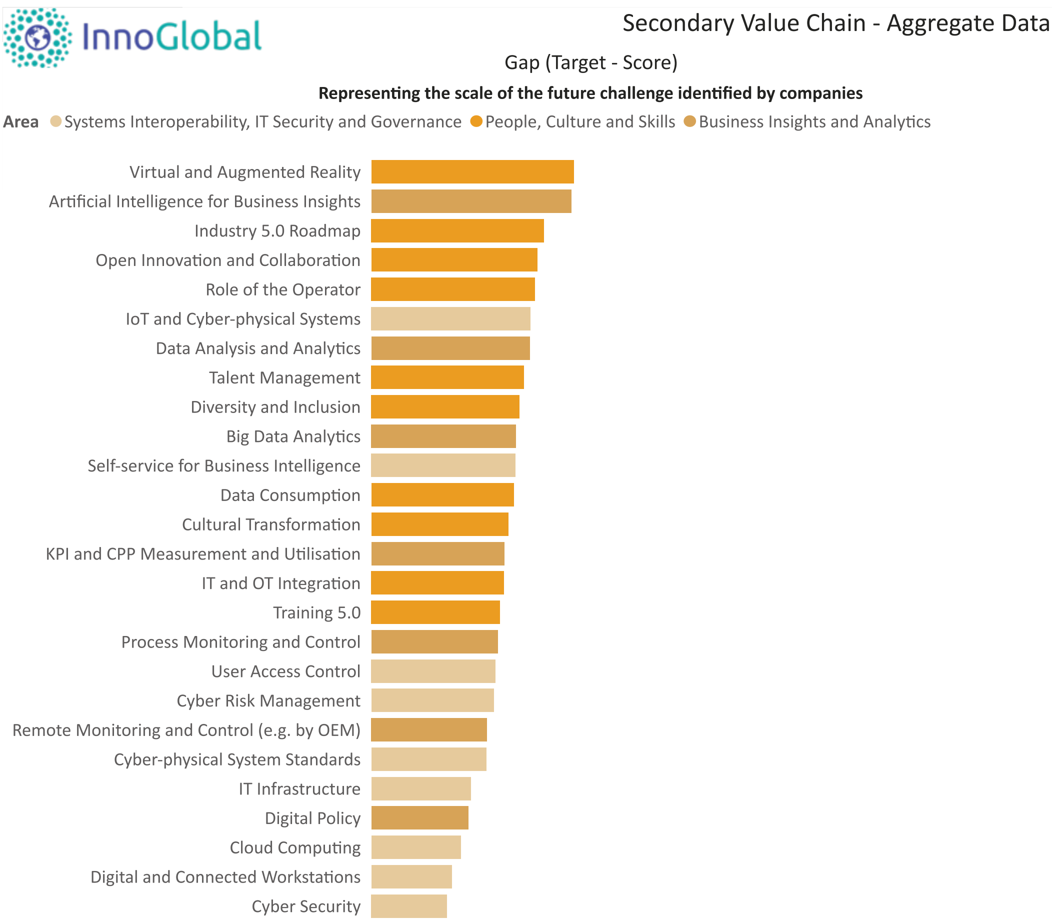

Figure 2: Aggregate DMSA results – Secondary Value Chain – Gaps between targets and score

2.2.3. Sustainability concepts

InnoGlobal assessed three key areas in Sustainability (Energy management; Climate action; Resource management) InnoGlobal assisted the companies SMEs in understanding and scoring each Industry 5.0 concept and technology (21 in total as shown in Figure 3). Companies were then asked to set a target for each concept over a 3-to-5-year time horizon. The results show the current state and compares that with the medium-term targeted goal.

Energy Management

This section covers energy policy, energy management systems, energy people task force, people training & awareness, energy projects, energy metrics, energy supply & renewables. Systems include BMS, Energy Monitoring Systems, SCADAs, PLCs, Power Distribution Monitoring System.

Climate Action

This section covers sustainability policy, climate commitments, leadership / advocacy, climate task force, climate training and awareness, climate supply chain, climate progress, and emissions management. It includes carbon usage, particulate emissions, NOx SOx, mitigation measures adoption, hazardous waste, circular economy, plastics and micro plastics, ESG policy, global initiatives, “reduce, reuse recycle”, RE100. Systems include BMS, SCADAs, PLCs, etc.

Resource Management

This section covers resource policy, resource tracking and reporting, resource task force, resource training and awareness, resource supply chain, resource research. It includes resource productivity, material footprint, waste, packaging, waste treatment, water, chemicals and gases. Systems include BMS, Resource Monitoring Systems, SCADAs, PLCs etc.

Relevance and aggregate results

Many of the sustainability-related Industry 5.0 concepts seem not play a direct role for the implementation of the robotic solution. However, it is noticeable that the gaps for *People/ Resources/ Climate Training & Awareness* are particularly high (see Figure 3). As the goal of the ONE4ALL project is to develop environmentally sustainable solutions, this seems to suggest to keep an eye on how sustainability can be guaranteed when collaboration between the employees and the ONE4ALL robotic solutions takes place.

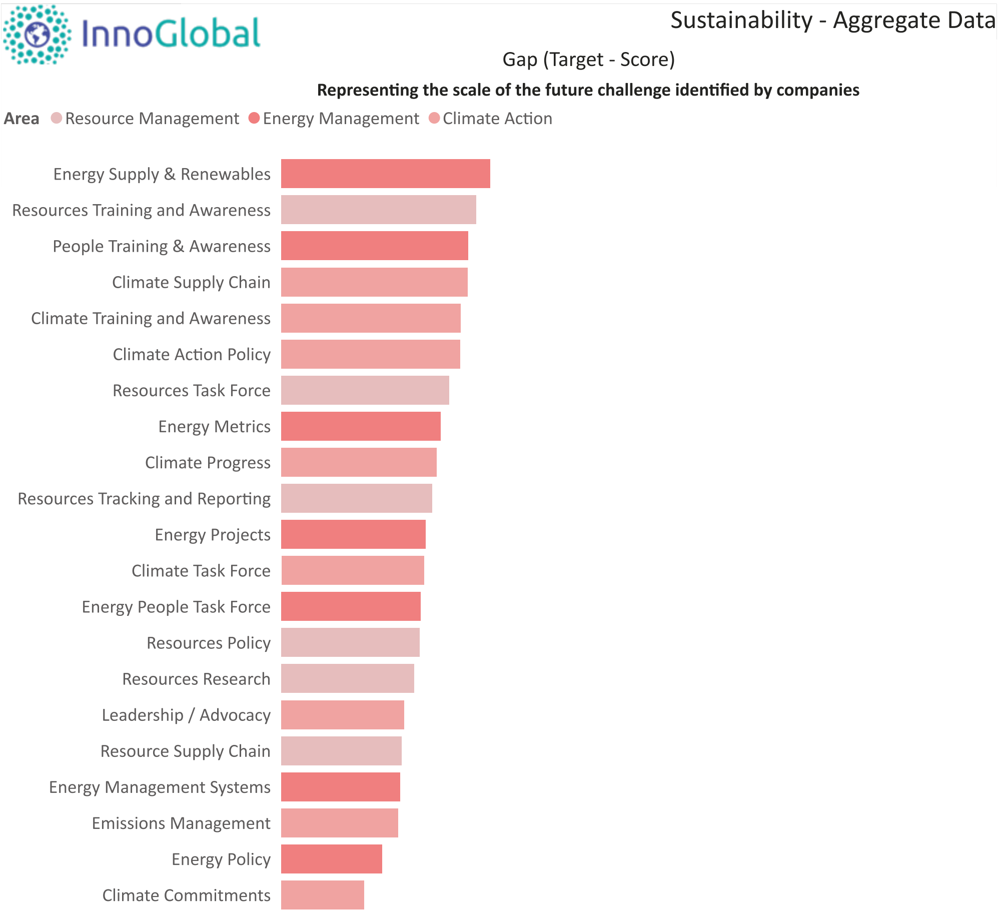

Figure 3: Aggregate DMSA results – Sustainability – Gaps between targets and score

3. Potential use cases and digital maturity at Madama Oliva and Orifarm

This section includes a first overall description of the potential use cases at Madama Oliva (MOL) and Orifarm (ORI) as elaborated in deliverable 4.1. The first step will be to exactly define the use cases which will be implemented in each factory: currently, there are still 2 different options to be evaluated for both MOL and ORI (as a reference refer to 3.1 and 3.2 descriptions). In the ONE4ALL project, digitally supported automation solutions are being developed as prototypes in two pilot applications. At the same time, these applications are being developed as digital twins that enable modelling and adaptation of the application solution. It will be estimated how the general people and culture issues (esp. on skills, safety, well-being, diversity) could apply to the use cases. By now, task 4.1 shows some general issues of human-centricity and gender and ethics which will be specified in the further course of T1.1.

3.1. Description of use cases in the companies[1]

3.1.1. Orifarm

The company, which is based in the Czech Republic, can rather be classified as a value-chain inFigure 4 logistics within the healthcare sector, as its main tasks are the separation or repackaging of medicines. However, the focus is only on the outer packaging. The individual medicines are thus left sealed and not further separated. This circumstance makes the handling of the medicines easier and the actual process less time-consuming, which is also reflected in the job description on the shop floor. Technical skills are less in demand and less represented here. The tasks on the shop floor can certainly be seen as low-skilled work and can be carried out after short training phases. At the start of the project, the Orifarm (ORI) facilities were visited. As can be seen in Figure 4, ORI facilities are divided into different buildings, each one devoted to certain activities. The same way, their process is divided into diverse tasks, the goods are received, checked in terms of quality and repacked, registered into the internal ERP-System and afterwards stored. These new “products” are then prepared to be included in the orders from the customers.

Figure 4: Orifarm facilities

[1] This is a shortened and slightly adapted version of the description of use cases in D4.1 (forthcoming)

In the course of the execution of Task 4.1, careful analysis has been conducted to identify the most promising and strategically advantageous opportunities aligning with the objectives of the ONE4ALL project. All in all, five possible applications were discussed (for details, see [2]):

1. Pick & Place of Orifarm's standard boxes from a sorting point to the working cells
2. Bin-picking, i.e. automatically identifying and extracting items from pharma boxes after manual reworking with quality checks
3. Interaction with ERP and pharma boxes pick&place for customised orders
4. Moving plastic boxes for finished products (FPs, green) to shipping floor buffers and plastic boxes from material products (MPs) (grey) to warehouse
5. Assembling and rearranging the boxes

After weighing up these possible use cases, it was decided that the fourth option was the most feasible to implement, from the RCPM point of view: *Moving plastic boxes for FPs (green) to shipping floor buffers and plastic boxes from MPs (grey) to warehouse*. This application consists of fill in boxes with the variable products handled within ORI facilities and picking and placing those boxes (two different types) from a buffer to a pallet and vice versa in different points of the ORI's facilities (see Figure 5 and Figure 6).

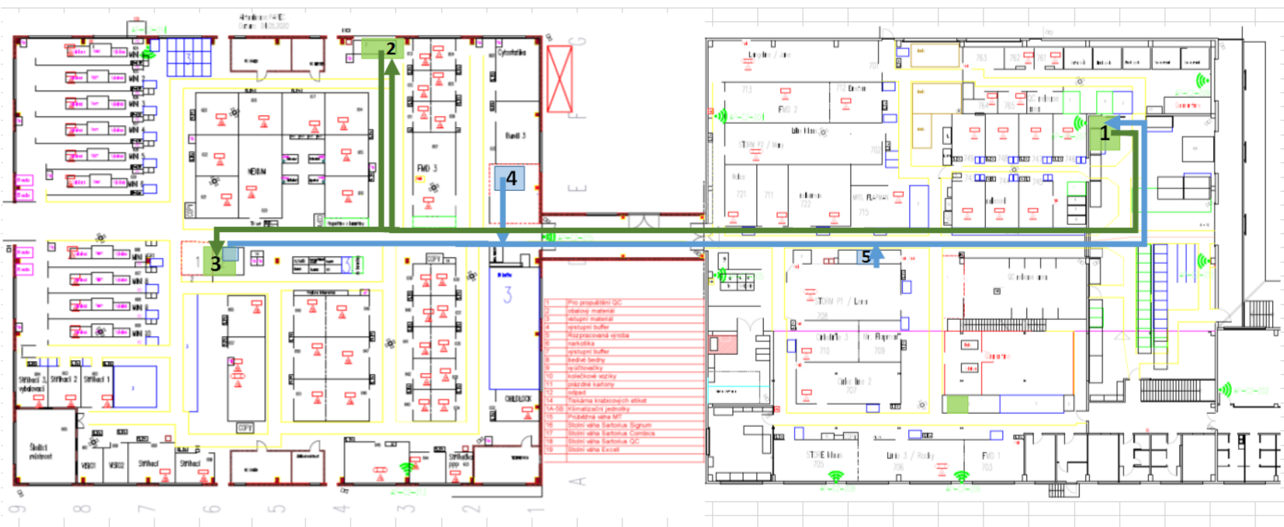

Figure 5: Application 4 intra-logistics layout.

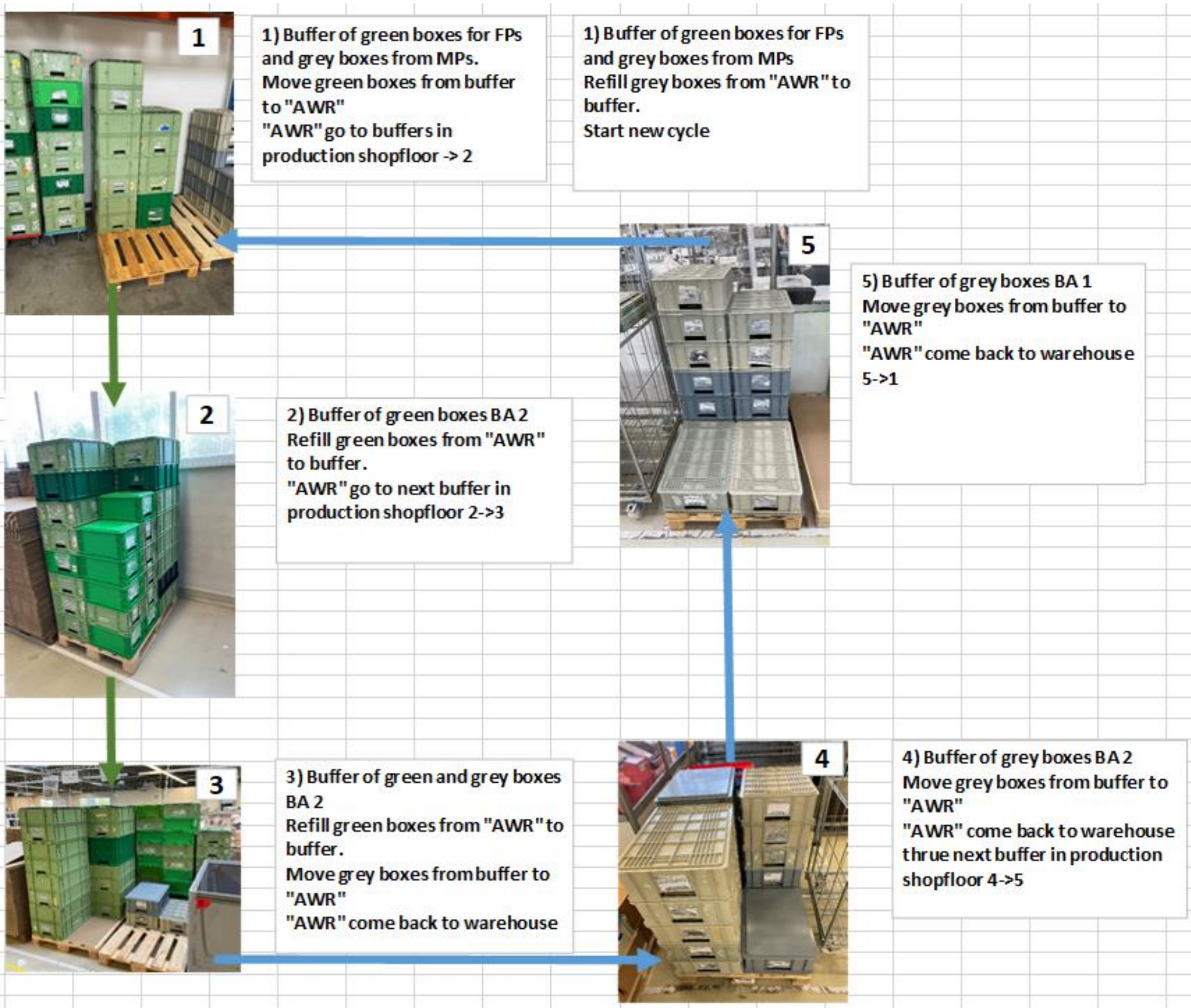

Figure 6: Application 4 intralogistics flow

In addition, the Intelligent Orchestration Platform (IOP) will be connected to the ERP system of ORI, as well as to the data-driven digital twins and the decision support system. In this sense, further support to management of orders and efficient scheduling of activities will be provided to ORI. ONE4ALL advanced digital technologies, such as the data-driven DTs, DSS, IOP and DMSA, will go beyond the RCPM activities proving their potential to enhance a variable manufacturing line efficiency such as ORI's. In conclusion, enabling the transition towards I5.0 covering all the aspects involved.

3.1.2. Madama Oliva

The company is based in Italy and belongs to the food industry. Its core business is the processing and packaging of olives from various countries of origin. The special requirements of food processing do not allow the company to use a cobot solution in all areas. Several virtual meetings as well as a visit to the facilities of Madama Oliva (MOL) on 7.3.2023 were used to identify possible end-user application for RCPM.

Figure 7 presents the workflow of the production process in MOL facility. Two phases were identified as possible application of the RCPM: The *sorting phase* as well as the *Distribution to the Packaging Machine (= End of line activities (EOL)*.

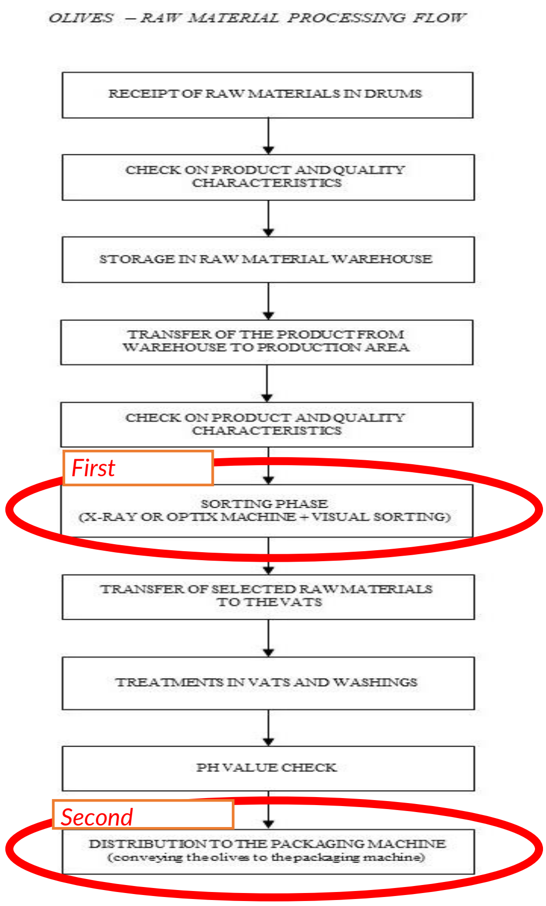

Figure 7: Madama Oliva products processing flow

The **sorting phase** consists of the selection of olives based on defect and colour characteristics on a sorting belt. This phase of the process involves the identification and removal of olives that do not conform to the quality standard while the flow of olives runs on a sorting belt. The belt is equipped with several lanes where the discarded olives must be divided and then classified by type and severity of defects, to be used in other production processes or definitively eliminated.

The sorting phase is divided into two stages. For the first stage of sorting, MOL currently uses an automatised method based on a conveyor belt for sorting olives according to their colour. The method integrates a vision system (Multi Scan machine) which identifies the defected olives and discards them. The second stage of the sorting task is successively performed by human operators who identify aesthetic defects of olives by visual checking (see Figure 8).

Figure 8: Olives' usual defects per different types of olives.

Two possible solutions for further automation are currently being considered:

One possible solution is applying a non-collaborative but reconfigurable robot. The intended delta robot is especially made for food applications and compatible with the environmental characteristics of the site and task requirements. Delta robot is the fastest parallel robot type, it works on 4 axes, it is made of stainless steel with a degree of protection IP67 to be compatible with the MOL's working conditions. It will be required to implement an improved vision system to accurately identify the type of olives, the defected olives and orchestrate the system through the IOP to select the suitable tools to pick the type of olives.

A second solution can be implemented modifying the existing conveyor belt adding to it a system to check also the aesthetic defects of olives and automatising the discarding of defected olives (e.g., using compressed air to blow the olives). This solution does not include a RCPM or a robot, but an automation system combined with the vision system developed by INO and Idener (IDE).

The **end of line (EOL)** activities play a crucial role in the final stages of product handling and preparation. These activities primarily involve the careful handling, quality checks, and efficient palletisation of various packages that contain a wide range of products. Among the most common packages encountered in EOL activities are trays, pouches, jars, and pails, each varying in size and shape (as shown in Figure 9). The typology and quality requirements of the products is traced through a SKU code. Every code is associated with a different product and each one requires different checks, hence different activities. So far, the code is registered manually and is not yet implemented a digital system to handle them. Nevertheless, MOL plans to digitalise their facilities in this sense and implement an ERM system. Currently, those activities are performed manually by human operators.

Figure 9: Example of EOL products.

For the end of line activities, the RCPM will handle and check the quality of multiple types of products which come in different sizes. This will require the auto-reconfiguration of the RCPM to adapt to each product. The types of packages with their related format and sizes, the estimated throughput in a year and other features, have already been shared by MOL.

3.2. First results: Digital workforce maturity at Madama Oliva and Orifarm

The results of the DMSA provide companies with a very broad and detailed overview of the primary value chain, secondary value chain and sustainability and the individual considerations described therein. Therefore, this overview offers the possibility to take a closer look at individual details. The subject of the deliverable presented here is primarily a description of the initial situation (current state)in the core areas of practical implementation in the two case companies. In this context, the focus is on the establishment of RCPMs in the companies. At least, one of the solutions is to be integrated in both companies for this purpose, which is based on the technical solution from Automationware (AWCombo). However, it is not sufficient to solely describe the technical solution, as this can only be seen as one part of a joint implementation in the sense of a consideration as a socio-technical system. In particular, the joint optimisation of all areas of the socio-technical system (Human-Technology-Organisation) must be considered, as the pure integration of a technical solution falls far short, especially in the face of the demand for human-centred solutions[2].

In addition to the numerous considerations in primary value chain and sustainability the DMSA also made very close reference to the area of people-cultural skills (secondary value chain). This is an area that is particularly able to depict the questions that are central about the company-wide embedding of technology in the previous organisational processes and the inclusion of employees in this process.

In both companies, a technical solution for explicit problems in the production process is to be used within the framework of ONE4ALL. An essential part of this integration is not only the description of the technical starting point and the associated search for a solution, but also the recording of the associated organisational framework conditions and the description of the jobs to be found in these areas up to now and the skills linked to them. The use of RCPM deliberately focuses on the cooperation of human labour and a robotic solution. Such cobot systems are a disruptive innovation for the companies involved, as such technical solutions have not been used before. As automation solutions have been used to a limited extent, so far, the employees in both companies have had little contact with automation solutions or even robotics. It can therefore be assumed that the involved companies are facing significant challenges – not only by the introduction of the *technological* part of such solutions, but also regarding the integration into previous work environments and work processes, which can also be seen in DMSA. Both companies see a particular need for further training in this context and have also recognised that the introduction will put a strain on employees. On the other hand, investments in such solutions for SMEs still carry the risk of high financial expenditures, which could potentially lead to high financial risks and significantly worsen profitability. SMEs are therefore particularly interested in solutions that offer a reliable and economically viable solution.

The following, more detailed description of the results is to be understood in terms of an initial outline for the situations in the companies and thus as a momentary impression. The periodic updating of the use cases will take place in the further course of the project. However, it will be based on the structure of the initial description and thus deal in particular with the central topics presented here.

The case description and the framework conditions of the companies can be found in section 3.1. There, the technical solutions are also discussed in more detail, although they cannot be considered in isolation. The DMSA makes a very important contribution to this, as it measures the overall digital maturity and sustainability situation in each company.

3.2.1. Orifarm

The following three figures show the summarised results of Orifarm DMSA. The gap between the actual score and the target score (in a five years time window) clearly show the areas in which Orifarm sees the main challenges. In the following, the main results are discussed and the connection to the ONE4ALL project is established. After the basic presentation of the use case in the section 3.1.1, the challenges will now be shown in more detail.

[2] A more detailed description of the approach used here can also be found in [3], where the central features and characteristics are described in detail and their effects explained.

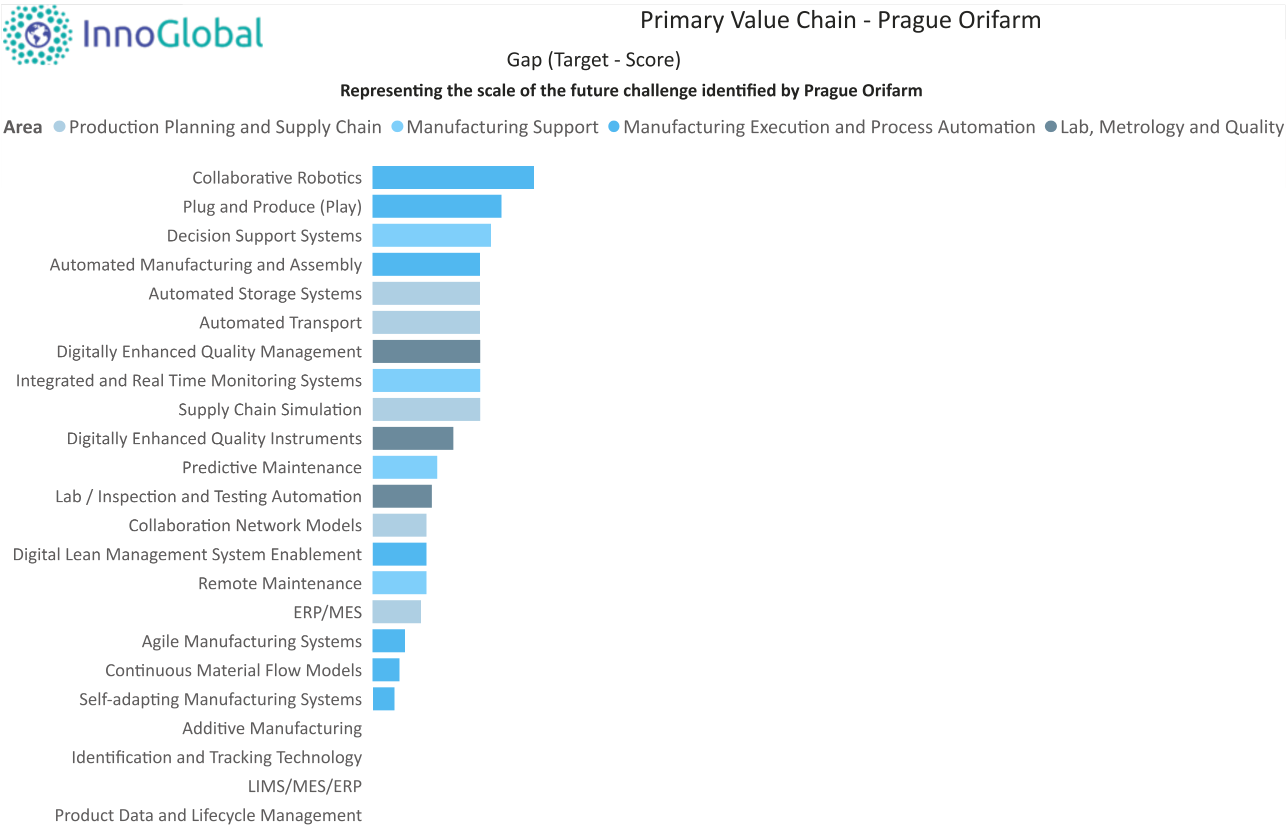

Figure 10: Primary Value Chain – Orifarm

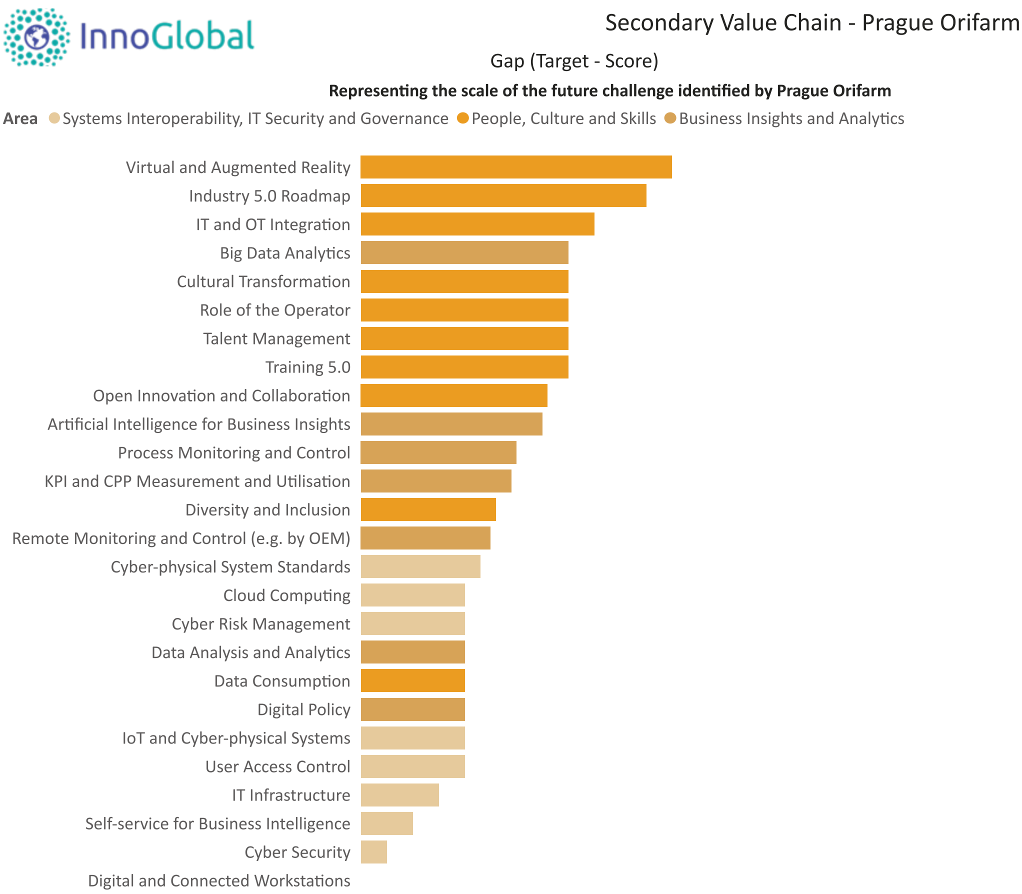

Figure 11: Secondary Value Chain – Orifarm

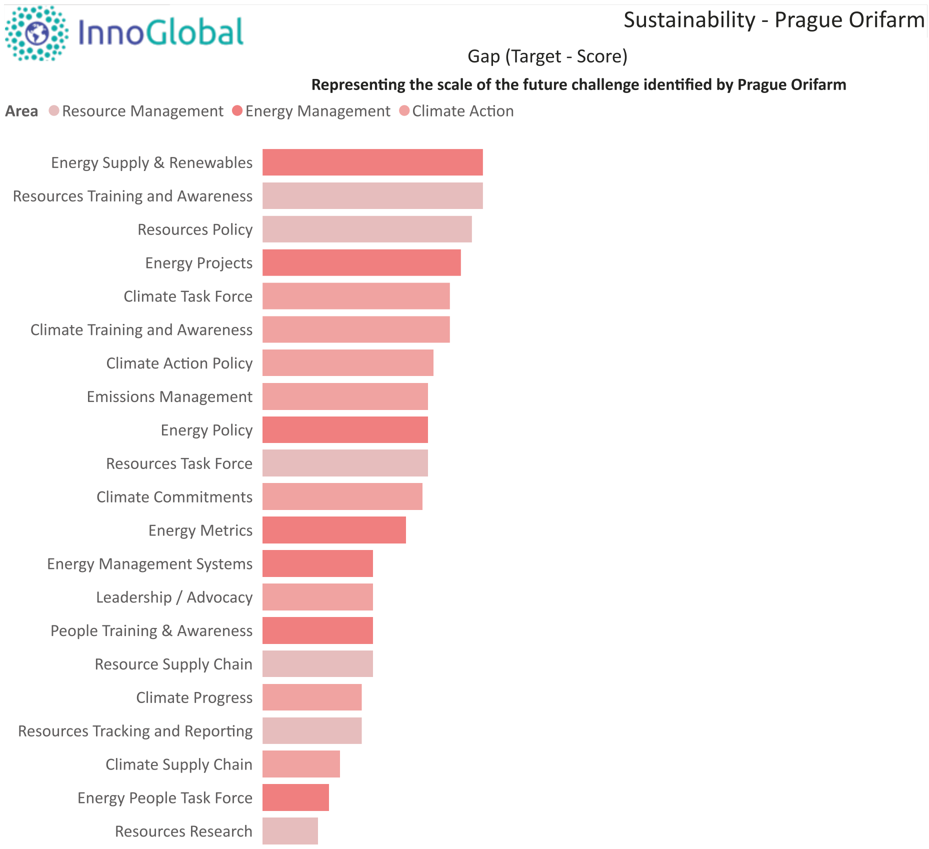

Figure 12: Sustainability – Orifarm

A fundamental problem in the introduction of automation is the set-up times for individual work tasks. The batch sizes processed in the company per individual work order are too small to be able to push ahead with cost-covering automation. The necessary set-up times would take longer than the actual work task. In addition, the necessary technical solutions are very expensive and offer neither the desired flexibility nor the cost savings that would speak for their introduction. Although there are hardly any opportunities to implement a technical solution in the actual core area of packaging, this can be implemented in the broader area of internal transport. For example, the delivery and removal of medicines can be controlled via driverless transport systems (see Figure 10, Automated Transport), which can help to ensure that the individual work tasks do not have to be interrupted by necessary transport and/or search tasks. At the same time, a better (digital) overview can also be achieved with the connection of this technical solution to the company software (ERP, MES). The transmission of data in real time can thus enable faster decision-making processes (see Figure 10, Decision Support Systems), as process progress is made digitally recordable.

However, this possibility of using data is closely linked to the workplaces on the shop floor and thus also to the employees there. At the same time, there are certain risks involved in recording and analysing data. If personal data is collected, it needs to be protected in a special way. This must be taken into account when setting up the digital tools, such as the digital twins and the DSS. Security and privacy aspects of the data handled by the IOP and its modules, will be intrinsic of the development as part of T3.2 activities led by SDU. Additionally, the partners leading the digital tools development will collaborate on the settling of the security & privacy protocols, as well as aligning with them. The demand for better data collection and the subsequent possible data evaluation require the smoothest possible integration at the shop floor level (see Figure 11, IT and OT Integration). The results of the DMSA show that a coordinated and functioning introduction of digital control instruments will lead to company-wide success. An essential recommendation is therefore also such a coordinated process. However, while the DMSA focuses primarily on technical and digital elements (but not exclusively), the employees are to be placed more in the focus at this point. After all, digital processes and changes in the previous production process are difficult to implement without the employees. This is especially true in the present case, as the workers have to interact with the envisaged transport systems and thus have a significant influence on workflows and the entire production and integration process. In this case, the employees should first be informed about the upcoming changes (first step) and the necessary cuts in existing work processes should be clearly pointed out. Linked to this is the description of improvements for the workers (second step). Both together lead to a fundamental understanding of the change process (see Figure 11, Industry 5.0 Roadmap), which meets the central requirement that only through such an understanding can the required overview of the digital change become possible (cf. [1]; section 2.2: *Human agency and oversight*). In a third step, the feedback of the employees should be recorded and the entire further process should be designed in such a way that this feedback can be recorded and perceived at any time. The possibility of involving employees offers several advantages for the company. On the one hand, it can also be used to initiate a process of change within the company. If there has been little employee involvement so far, the technical change in question can be used to establish such a process. On the other hand, possible ideas from the employees can be taken up, which can lead to further improvements. After all, it is the workers on site who are the experts of their own process. Finally, the demand for acceptance of the changes by the employees can be constantly met. Often this last step is neglected or only considered at the beginning of a change process (it is considered here as can be seen in Figure 11, Cultural Transformation). However, acceptance cannot be established only once, but must be understood as a process [4] that is endlessly ongoing [5].

Furthermore, a recommendation closely related to the points just described can be derived from the results of the DMSA. The formulation of a clear strategy (see Figure 11, Industry 5.0 Roadmap) involving all stakeholders (at all levels) and the establishment of a line of development. Above all, the clear and explainable goal should be taken into account. The development of such a goal should be based on the input of all those involved, which in the context considered here puts the focus on the employees in particular. The fact that the feedback from the employees is also taken into account when defining the goals can also lead to a broad acceptance within the company. A circumstance that can also have a positive influence on further changes. However, the analysis of work processes and workplaces is also linked to the definition of goals and an implementation strategy [6]. The changes in production processes presented here will have a significant impact on certain jobs (which still have to be identified). In this context, it is to be expected that further training for employees is required. Be it to understand the new safety aspects or to establish new work processes. In addition to the impact on the shop floor, however, the impact on other levels in the company must also be considered. Are new qualifications needed here? Can these be achieved through further training, or do new hires have to be used? Answering these questions then addresses another key recommendation from the DMSA. The fundamental analysis of the previous skills of the employees in the affected areas and the analysis of whether and how these skills are to be developed (see Figure 11, Training 5.0 and Talent Management). Based on these results, different training methods and formats can then be developed to close the identified gaps. At least in the area of safety requirements, comprehensive training in the direct handling of the transport systems must be carried out here, as the requirements in handling such systems are very high. In addition, training in understanding these new systems must also be provided, as this is the only way to achieve the central requirement of an overview and understanding (cf. [1]) of these new processes.

In addition to these central results from the human resources area, other - originally technical - results also make clear how important the use of knowledge and involvement of employees are for the implementation of Industry 5.0 changes. For example, the targets in the areas of energy optimisation and the improvement of resource management can be achieved primarily through the establishment of so-called task forces in these areas (see Figure 12, Training and Awareness and Climate (and

Energy) Task Force). A recommendation that is also found in the DMSA. This underlines the special focus on the human factor in the upcoming change processes in the company. However, it also makes clear that these goals can be achieved and maintained more quickly and sustainably with commitment, further qualification and constant exchange. Conceived training concepts should therefore also be adapted to this area and enable employees to make an active contribution to achieving these goals (see Figure 12, People Training and Awareness). In addition, the establishment of such task forces supports not only the active involvement of workers but also the actual subject matter itself, which in turn makes it more likely that the goals set for resource conservation and energy reduction will be achieved.

3.2.1. Madama Oliva

Also, in the case of Madama Oliva, the following three figures show the results from the primary value chain, secondary value chain and sustainability of the DMSA. Analogous to the Orifarm case, the challenges that the company sees for itself are described. They are now examined in more detail below and the connection to the OEE4ALL project is established. After the basic presentation of the use case in the section 3.1.2, the challenges will now be shown in more detail.

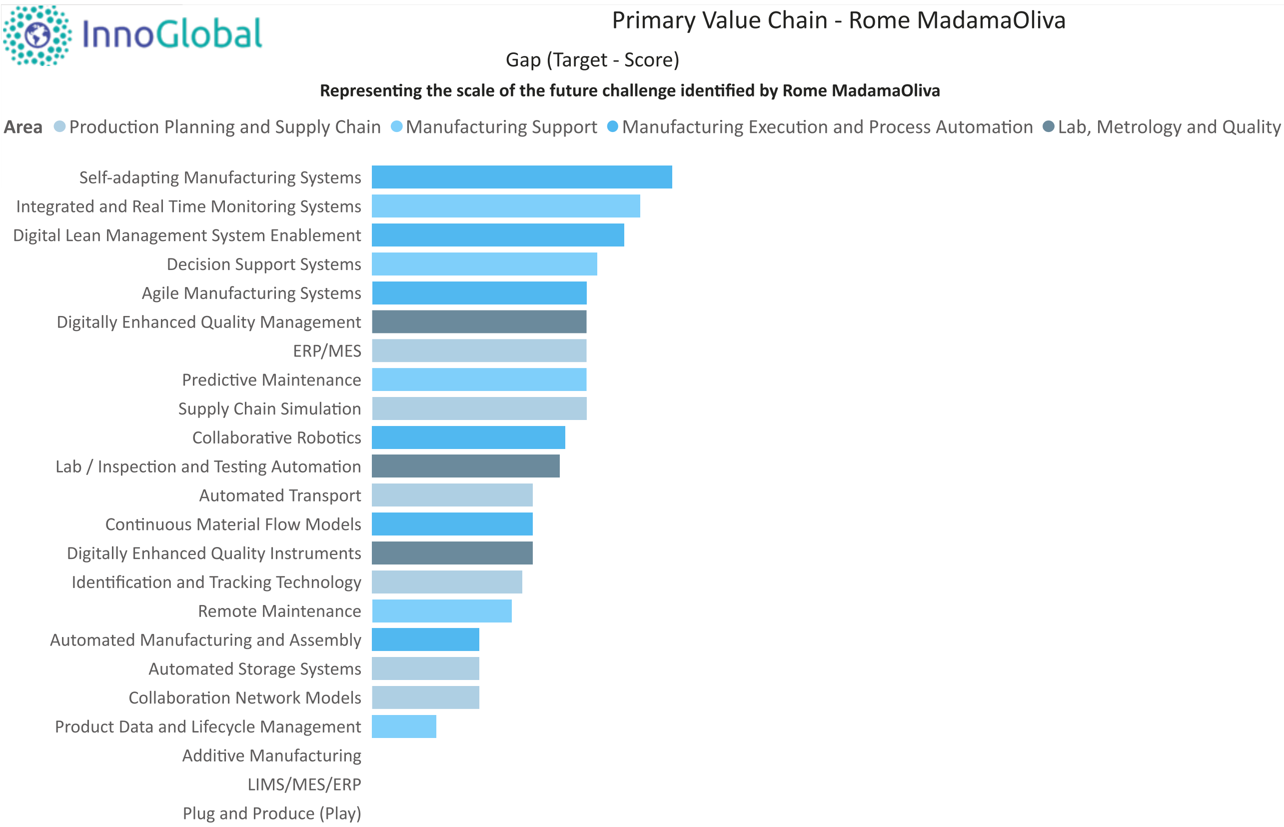

Figure 13: Primary Value Chain – Madama Oliva

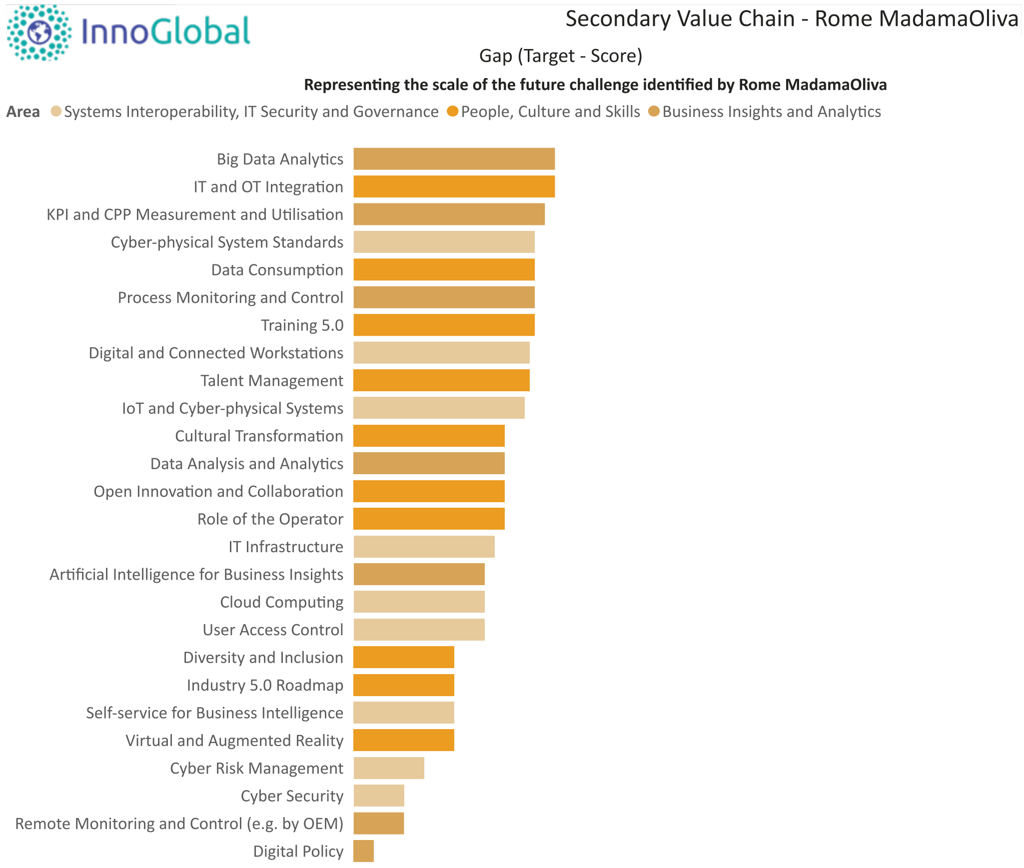

Figure 14: Secondary Value Chain – Madama Oliva

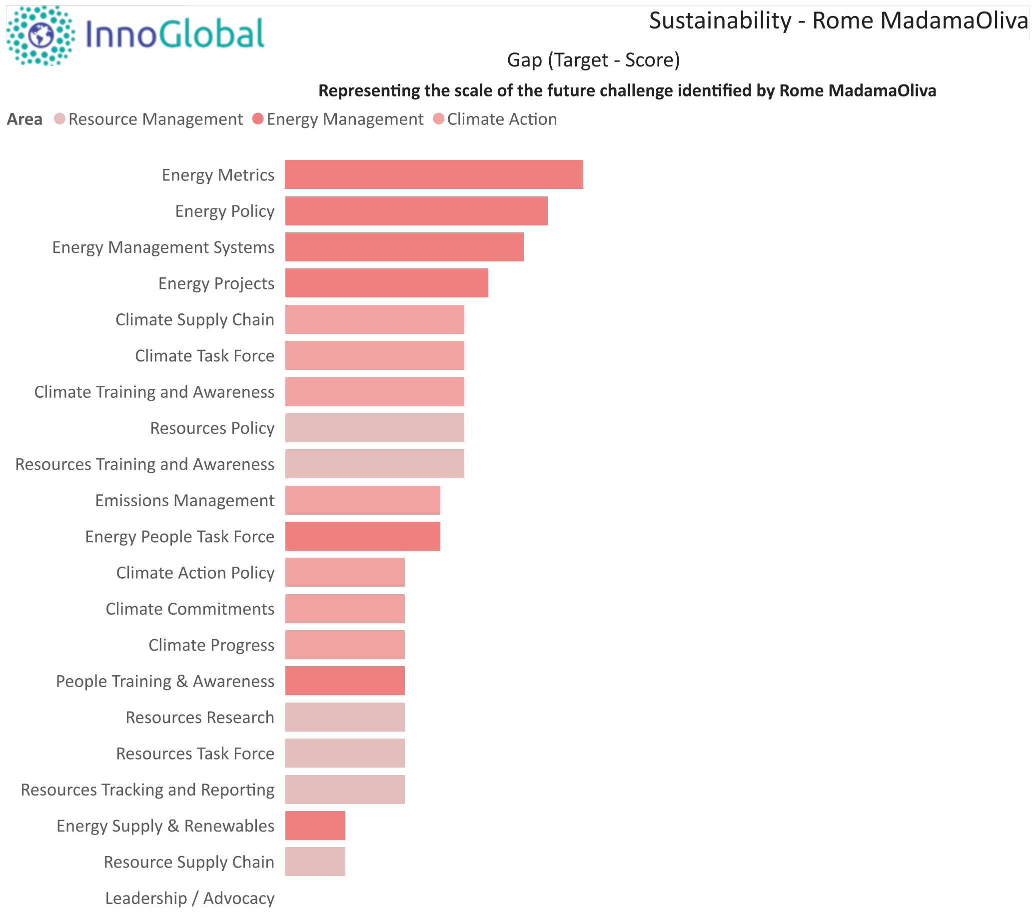

Figure 15: Sustainability – Madama Oliva

The specific requirements of food processing do not allow the company to use a robotic solution in all areas. For example, in some areas of production, environmental conditions can lead to rapid failures of such solutions. Therefore, the company will pursue a two-part solution in the project (cf. section 3.1.2). In the area of sorting olives, there will be a "classic" automation solution that also takes into account the requirements for the necessary speed of the previous process (camera system). In the area of packaging, the company is aiming for a robotic solution that will be in collaboration with the employees working there.

The company is therefore faced with two fundamental challenges. The use of a robotic solution (see Figure 13, Collaborative Robotics) and the reduction of stress for the workers (salty and wet/slippery environment). The solution to the two-part mechanisation is therefore an adapted strategy that takes into account the company's prerequisites. Although in ONE4ALL the focus will be mainly on RCPM's, the solution used here in sorting - which is rather to be seen as a classical automation - will also have to be considered, as this solution will also be part of the change strategy in the company and will also provide real-time data that will allow a better control of the production process. Both systems will provide important data for the future production process, which, after analysis, will lead to better control of the overall process - a circumstance that is increasingly becoming a central factor in the company, which was also shown in the DMSA (see Figure 13, Integrated and Real Time Monitoring/ Decision Support Systems).

Data acquisition, storage, analysis and processing are becoming more important in the increasingly digitalised working environment of modern production companies. This is a challenge that is also recognised by SMEs and can and should be integrated more and more into decision-making processes. At the same time, the multitude of data can also be used for simulations in order to test plants or make extreme situations representable. Madama Oliva already uses a large amount of its own data and is planning a better consolidation of all data in order to be able to use it for decision-making (see Figure 13, Integrated and Real Time Monitoring/ Decision Support Systems/ ERP and MES). The company has invested heavily in this in recent years and wants to continue this trend. However, the stronger focus on data-based decisions is also linked to the fact that this data is firstly available and secondly can also be interpreted or understood by human users. A requirement that was also evident in the DMSA. In order to be able to meet this challenge, the company is primarily planning further training (see Figure 14, Training 5.0). Here, the results of the DMSA, which focused on technical and digital variables, can be expanded to include the personnel component. With the increasing digital control, other or additional skills will be necessary for employees in the future. The analysis of future skill needs is therefore a key recommendation from the DMSA and should be considered in medium-term planning. At the same time, the existing staff is to be prepared for the new challenges through training, which is also found in the DMSA. The development of a strategy (roadmap) geared towards this should therefore be seen as an important factor (see Figure 14, Industry 5.0 Roadmap). Only on the basis of good strategic planning can such extensive changes be tackled. Building on this, it is possible to use suitable KPIs to assess how the measures are developing and where any adjustments need to be made. A recommendation that is also found in the DMSA.

In this case, too, it becomes apparent that the formulation of a resilient strategy is an essential factor in such changes as a basic assumption. This also addresses several challenges. The clear formulation of the goal can provide the end point. The intermediate steps can then be derived, from the starting point, and intermediate goals can also be named, which can also be made measurable (KPI's). At the same time, the employees who are part in the development process are to be identified, as they need to be involved in the process (see Figure 14, Role of the Operator).

This case also shows that the involvement of employees makes a significant contribution to achieving the goals set. Analogous to the previous case, recommendations are also found here that identify employees as a central factor in the more technical objectives. Especially in questions of energy optimisation and improvement of resource handling the recommendations are the same (see Figure 15, Training and Awareness and Climate (and Energy) Task Force/People Training and Awareness.) This makes it clear once again that the major challenges in the integration of Industry 5.0 solutions can only be met if the employees are included as a central factor in the joint optimisation mentioned above and defined in this way. This seems to be the key to sustainable change - also in the companies involved.

3.3. Summary

The results of the DMSA can be used in many ways by companies and provide a very good and detailed overview. In addition, an initial broad discussion has already been initiated in the preparation of this presentation. The DMSA process includes active discussion between INO subject matter experts and the company SMEs on actual and targeted scores for each of the 70 concepts. This method encourages and supports initial engagement with the change and transformation process. At the same time, the inherent demand for a broad involvement of all stakeholders has been met. This first step will have to be deepened with the involvement of the employees in the next stage.

In addition to the numerous rather technical questions about their own company and the resulting recommendations, there are also original personnel-related topics which - due to the interpretation of the DMSA - are less in focus, but occupy an important space in both companies (see Figure 10 to 15). As has been shown, the desired change in the companies with regard to technical solutions is based on the premise of energy and resource efficiency cannot be achieved without close involvement of the employees. This will have to be looked at more closely in the further course of the project and, in particular, will closely accompany the integration of the technical solutions in ONE4ALL. The effects will be empirically examined on the basis of the selected use cases and integrated into the overall picture.

4. Requirements to Human-Centricity in ONE4ALL solutions

ONE4ALL aims to boost manufacturing plants' transformation, especially SMEs, towards industry 5.0 (I5.0) which is based on the key-dimensions human-centricity, sustainability and resilience. While WP1 is addressing the human and sustainability impact of ONE4ALL, task 1.1 is focused on human-centricity as the first key dimension of Industry 5.0. Deliverable 4.1 shows that and how human-centricity is generally considered in the technological development of RCPMs, the IOP and the DTs & DSS. However, to meet the requirements of human-centricity, they have to be defined carefully, so that they can be considered specifically in ONE4ALL solutions. According to the current stage of the project, the Digital Maturity and Sustainability Assessment (DMSA, by INO) and the description of use cases and their potential ONE4ALL applications (by AUTO and IDE), preliminary requirements on human-centricity are defined here.

ONE4ALL uses the approach of socio-technical solutions, which is based on extensive research since the 1950´s [7] and further adapted to Industry 4.0 technologies [8, 9]. This research has come along with a list of 8 criteria for decent digital work in industries [10], which will be used here as a structure for human-centric requirements in ONE4ALL (see section 4.1). These requirements form the basis for developing training programmes, workforce safety protocols and considering ethical issues which will be presented in updated reports (D1.2, 1.3., 1.4) as the project progresses.

In section 4.2, it has been described further requirements from the use cases (as stated in the DMSA process) along the criteria safety and health and further ethical requirements (on gender, diversity and inclusion, data privacy).

In section 4.3, insights from 4.1 and 4.2 are taken up and translated into requirements for training programmes which will be developed in the further course of the project.

4.1. Criteria for good digital industrial work

The basis of the principles of good digital industrial work presented here is a combination of criteria from labour science with central considerations on the socio-technical design spaces of digitalisation. The aim is to harmonise classic requirements for human work design with the new possibilities of technical solutions to optimise the overall system.

It should be noted, however, that the criteria should be understood as ideal-typical and are the result of numerous research studies and empirical findings in companies of different sizes. The aim was to develop a catalogue of criteria that can be used by companies of different sizes and in different sectors. The core element of this development of criteria was (and is) the introduction and use of digital technologies. These criteria reflect the ideal situation of human-centric implementation of technologies in companies. In the practice of small and medium sized companies with specific processes, constraints and requirements, the criteria have to be customized to the specific situation of an SME.

However, they are very helpful to operationalised what is meant by a human-centric design of Industry 5.0 solutions. They represent a broad corridor that enables companies to set their own priorities and to position themselves within the corridor defined by the criteria.

For the consideration of the use cases in ONE4ALL, this also means that the fulfilment of all criteria cannot or should not necessarily be demanded. The specific framework conditions in the use cases have so far only been roughly defined. With the actual implementation in the companies, it will become clear which special features are present in the individual cases and how these correspond to the understanding of the requirements formulated here. It may be possible that individual criteria cannot be included to full extent, so that they can only be included in part in a meaningful way.

However, they show a direction for designing and implementing Industry 5.0 solution. But it will always be necessary to critically examine why individual criteria should not be included. In the further course of the project, TUDO will therefore accompany and continuously check the implementation process in the use cases in this respect.

Table 1: Criteria for good industrial work according to [10]

Adaptivity	Describes the essential point of adapting technical or digital systems to people (and not vice versa) and to the specific working conditions.
Transparency	Describes the illustration and explanation of the technical systems for humans in order to enable a mental model for the employees. The aim is to make the systems transparent to people and to preserve specific human abilities.
Complementarity	Describes the situation-dependent division of functions between humans and technologies, whereby the ultimate control lies with the human, who should be supported to make decisions.
Holism	Describes the respective activities as complete and a stress-reducing mixture of tasks. At the same time, there should be opportunities for scope of action and a certain degree of self-regulation.
Polyvalence	Describes a systematic change of tasks within the job design of each worker and calls for interdisciplinary communication, which supports the opportunities for employees for learning on the job.
Acceptance and participation	Describes the involvement of employees through appropriate participation procedures. Especially in the redesign of digitalised work systems.
Decentralised control loops	Describes a shift from centralised information processing to decentralised provision of information. By supporting decision-making of empowered workers/teams, work is becoming more quickly, flexibly and agilely.
Optimisation of interfaces	Describes cross-company networking and the development of flexible and organisational forms. In addition, the personal responsibility of the employees is emphasised. Especially in the coordination and agreement with adjacent areas.

The dimensions for good industrial work presented in Table 1 are intended to support the introduction of automated and digital work systems. They serve as a detailed record and enable an employee-oriented perspective and the work process when implementing the planned changes in the respective company. The orientation towards the described criteria ensures that not only technical but also employee-related requirements are included in the implementation of new technologies. In particular, the criterion of ***adaptivity*** underlines the central requirement of adaptation to people, which is often reinterpreted by developers of technological solutions. Technical systems are often primarily oriented towards technological feasibility, which often leads to people having to adapt to these processes. With the logic introduced here, this (central) point is oriented towards the human component in the production process. This is a requirement that is central to the orientation towards Industry 5.0 (human centricity). Not only the individual workplaces are considered, but also the cooperation and communication within (and partly across) companies. This is a circumstance that relates to essential points of the DMSA. The point of the internal task force for the areas of energy, environment and resources was emphasised in the workshops, especially in the third value chain. The active involvement of employees is seen as an important factor in achieving the goals set in the areas of energy, environment and resources, and it is recommended that employees should be more involved in this area in order to create responsibilities. At the same time, this can also underline the great importance of these topics for cooperation within the company. If employees are involved in these issues and feel that they are noticed, many individual measures and rather small changes can work together and also offer economic savings opportunities. At the same time, the acceptance and participation of the employees can be promoted and continuously maintained.

The concept of ***transparency*** addresses another fundamental point. A counterpart to this can also be found in D7.7 [1, chapter 2.2, p. 13]. Namely, the demand for a transparent and open design of work systems or technical (digital) change (in ONE4ALL: AI systems). Only if such applications are also designed in a clear and understandable way can the employees on site use the system and be supported in their work actions.

Complementarity also links to D7.7 [1, chapter 2.2, p. 13] and the special challenges of AI in production systems. This refers to the division of functions between humans and technologies, whereby the decision-making authority should lie with humans. The digital systems should be used here to support decision-making. There are also links here to the results of the DMSA in the two companies, which consider the role of the employees on the shop floor (Role of the Operator) to be a special factor and see integration of technology as a challenge that should not be underestimated. At the same time, the companies are also concerned with the increasing use of data (Data Consumption) and the respective provision of this data for decision support on site (cf. Decentralised Control Loops). The role of employees in such production systems can also be described with the demand for *complementarity*. What is meant by this is support for the employees that is tailored to the situation through digital technologies, which is already being advanced in both companies. What is important here is that human decision-making must be the measure of all things. In other words, the decision-making authority lies with the people while the digital system only supports them. The development of the data-driven digital twins and smart distributed decision support system (WP2) in the course of the project will open up the possibility of taking a closer look here - in the use cases. The fact that monotonous work tasks have a higher degree of stress and are prone to errors can already be regarded as established knowledge.

With the demand for the ***holistic*** nature of work tasks, this is once again underlined here. At the same time, there is the demand for work tasks to be as complete as possible. This also offers the possibility that the demand for transparency can be met if the individual work tasks can be understood as completed. In modern production environments based on the division of labour, this is not always fully feasible - a factor that also seems to apply to the previous interpretation of the use cases. As already mentioned in the introduction, this criterion must therefore be considered in the further course of implementation in the use cases in a correspondingly adapted way. Although the repetitive activities appear at first glance to be rather counterproductive for the criterion described here, they must also always be seen in the context of the respective framework conditions. Nevertheless, work tasks can meet the demand for freedom of action and reduction of stress if they are carried out alternately or are supported by technical solutions, such as those developed within ONE4ALL. This basic approach can be found in both use cases (cf. chapter 3.1), as physical stresses (lifting, carrying) are to be reduced. Special strains due to given production environments (wet, salty) should also be avoided. In the use cases, it will then be necessary to consider how exactly the changed production steps are designed and to what extent the demand for holism can be met. In order to be able to design production processes as openly and flexibly as possible, employee's acknowledgement and training to control the novel solutions is key.

The demand for ***polyvalence*** addresses an essential factor. Open and flexible production processes - as required by this criterion - require a broad knowledge of the processes from more than one employee. A high degree of substitutability (within individual teams) then achieves that burdens are reduced, learning is encouraged and internal communication is promoted. In this way, future changes can also be implemented more quickly and the willingness to learn can be increased. Of course, this requirement cannot be fully implemented if the production processes are long and complex, which is not to be assumed in the use cases of ONE4ALL so far. Nevertheless, it should also be made clear here that all criteria cannot be fully applied to the case companies and must be adapted to the actual conditions. However, this requirement can also be met in smaller procedures and guide the use cases and future users on how to fulfil them. Companies also become more robust when individual employees are absent and more flexible when it comes to troubleshooting.

Changes in work processes always interfere with previous and familiar structures. Employees often react with rejection to such changes. However, this is neither new nor unexpected. Triggers can be fears of job loss or changes in general. Changing the familiar abruptly and without explanation is therefore often met with resistance. In particular, far-reaching changes, such as those associated with the requirements of digitalisation and Industry 5.0, which in part also require an adjustment of previous corporate cultures, are burdensome for companies. It is therefore hardly surprising that companies are paying particular attention to this and it can already be seen in the DMSA (Cultural Transformation). In order to dissolve this resistance - which can also be threatening for companies - or to counter it, the demand for ***acceptance and participation*** is considered as a central factor. It can therefore be seen as central, as the acceptance of changes is the decisive point in the digital transformation. If employees are not actively involved and the changes are explained clearly, transparently and also open to change (possibility of adapting the systems based on employee feedback), this can lead to internal rejection, which runs counter to the corporate goals of greater efficiency and effectiveness.

For SMEs, depending on the investment volume, this can also threaten their existence if changes are boycotted or sabotaged. This is further underlined by the demands for transparency, complementarity and holism. They all promote employee acceptance and put the focus on the employees. If this is complied with, changes are implemented more quickly and the employees' knowledge about their own production steps is also used. However, it is important to note that creating and maintaining acceptance must be a continuous and adaptive task in order to be secured on an ongoing basis. Only then can an advantage be seen in future changes, if then changes and their implementation have already been "learned" and can be implemented quickly through the active participation of the employees. The fact that this point has already been partially taken into account is also shown by the results of the DMSA, which recorded this point as a developmental necessity (People training & awareness).

With the use of digital technology and more data at all levels, it must also be ensured that this data is available in the right time at the right place and can also be used there to support decisions. The demand for ***decentralised control loops*** takes this into account. Centralised models seem too complex and too sluggish for this. Moreover, they promote the concentration of data in only one place, which in turn contradicts decentralised usability. If data in changed and digitally driven production processes is to be used locally to support decision-making, it must be available and interpretable there. In addition to the actual provision, employees are also required who can understand and use this (processed) data. In the company workshops on the DMSA, the special importance of data was explicitly emphasised (data analytics, big data), but at the same time it was also stressed that employees must increasingly be able to provide data as well as use, understand and interpret it (data consumption). Currently, employees do not have these skills required and must be developed in the future. A result that is also reflected in the DMSA (Training 5.0) and shows the special focus but also the challenges for the companies. With increasing digitalisation and the increased use of data as an important instrument for control, the number and importance of interfaces is also increasing.

Hierarchical structures for control quickly reach their limits and a more network-like structure is required. This, in turn, leads to more interfaces between individual areas and departments, which, however, require not only a clear definition but also active design. The demand for the ***continuous optimisation of interfaces*** is therefore only consistent and necessary, as otherwise the possibilities of (digital) networking remain unused. In addition to the continuous optimisation, persons responsible for the interfaces must also be appointed to shape the interdepartmental cooperation on their own responsibility.

With regard to the decentralised control loops, the IOP aims for a distributed and modular architecture. On the one hand, it enables the data gathering from distributed sources, both internal (modules within the IOP) and external (use cases). On the other hand, it facilitates the reconfiguration and adaptation of the infrastructure to any changes required, in order to ensure the best performance. Lastly, as reflected by the continuous optimisation of interfaces, multiple user interfaces will be developed within WP3. Each one focuses on a module and aims to clearly present all the information gathered and to assess the users. Moreover, the users will have access to an internal help desk (developed in T1.4), with the addresses both the technical and social aspects and includes the training program resources from WP1. In conclusion, an understanding of how the IOP and all the modules work, will be facilitated.

Within the framework of a short excursion, an example will be used to show how the re-organisation of a production line can take place and succeed in a socio-technical understanding. The criteria of good digital work were used as a starting point.

<u>Excursus – Example application</u>

In order to make clear how successful such an alignment can be, a short example application from a previous research project is presented here.

The example company produces office chairs in two separate production lines at its location in southern Germany. On the one hand, there is a production line for a medium price segment, which is primarily oriented towards large turnover volumes and high quantities. Here, numerous automation technologies (feeding of parts, transport of the finished chairs, packaging and palletising) are already integrated. Before the project began, the production line for high-quality office chairs faced a high demand that could not be met with the current layout. The previous form of production ran according to the principle: One Man - One Chair and provided for each employee to carry out all steps on the chair. This led to long production times and physically stressful work steps for the employees (lifting and carrying the partially and fully assembled chairs) and frustrating search times (individual orders, search for individual parts, constant coordination with colleagues about the order and chaotic storage). This form of production was therefore both inefficient for the company and stressful (physically and mentally) for the workers. The starting point here was the consideration of a combined solution, which on the one hand allowed for more pieces and at the same time would lead to an improvement in working conditions. The aim was to be able to meet demand and at the same time support the difficult search for suitable new employees. The latter increasingly posed major challenges for the company, which the redesign was intended to address.

So, this line was completely removed and planning began from scratch (principle: empty hall). First of all, all work steps were recorded and analysed. Together with labour scientists and the employees, possible divisions of the previously prevailing work processes were discussed and implemented. First of all, the initial processes before the conversion were recorded and the employees presented the necessary improvements from their point of view. Together with the system supplier and the labour scientists, possible implementations were discussed, evaluated and finally a solution was selected, which was then implemented. Numerous relief possibilities through assisted lifting or automated transport (AGVs) between pre-assembly and final assembly as well as into the warehouse were thus implemented. The entire production process is now digitally controlled and can also be mapped (digital twin). At the same time, it is designed in such a way that almost every employee can influence and understand it via the central control system. After only a short training period, this process can be overviewed. The individual work steps are now more subdivided, but can be carried out by every employee, with constant rotation being common practice (and desired) by the employees. The use of digital technologies to map, control and analyse is geared towards supporting workers, but also allows for very good analysis and pre-planning across the organisation.

The results show that careful planning and integration of new technologies combined with strong worker participation can be possible and also successful. At the same time, such planning also manages to consider employees as a central variable. The planning is, so to speak, created "around the employees", which does not have to be in contradiction to yield and profit. Although such planning is more time-consuming, it pays off in later application. They then allow for shorter training and/or integration times and create a stable process that is supported by everyone.

In summary, these criteria can be seen as central requirements for the design of digitalised work systems. In particular, the focus of Industry 5.0 on human centricity again clearly underlines the consideration of the human workforce in digital systems. At the same time - in the sense of a socio-technical view - the optimisation of the entire system (joint optimisation) is to be considered [11], whereby the central requirement of focusing on the human being as the central starting point of the considerations should be followed. The short digression to the case study underlines once again that the orientation of production processes to these criteria is fundamentally possible and successful. At the same time, a factor that should not be underestimated in the implementation of new technology can be addressed, which the two companies have formulated in the DMSA (IT and OT Integration). This refers to the actual implantation of IT and OT in existing production systems, the smooth running of which depends heavily on the design of the work systems and the participation of the employees.

4.2. Ethical and gender issues (s. D7.7)

Human-centred ONE4ALL solutions need to fulfil ethical, gender and diversity-related requirements. As will be explained in more detail below, these requirements should already be specifically addressed in the design phase of the solutions.

An important basis for this is the collection of requirements that can be found in D7.7 [1, see Table 1 for a summary of the key issues addressed]. Furthermore, the deliverable and the subsequent webinar in May 2023 lay out how the implementation of these aspects can be ensured in the project. Within task 1.1, it will be assessed to what extent the criteria are relevant for the development of solutions in the use cases and to what extent they are met. This will be facilitated by checklists developed in D7.7 [1]: these lists are intended to remind those carrying out the project of the relevance of these topics as well as to provide reviewers with clues to possible shortcomings.

Table 2: Key elements of D7.7

Ethics in scientific research and publications	➢ Research integrity ➢ Data protection and privacy ➢ Artificial Intelligence ➢ Health and Safety ➢ Environmental protection
Technical ethical aspects	➢ Especially: "Ethics Guidelines for Trustworthy AI"
Inclusion & Diversity	➢ Intersectional approach
Gender	➢ Gender balance in decision-making ➢ Gender in research content ➢ Gender balance in consortium

During the development of the ONE4ALL solutions, the general requirements will be translated into requirements that are directly linked to the organisation-specific and technical characteristics. The following subchapters (4.2.1 and 4.2.2) will explain, how these issues will be realised.

4.2.1. Requirements for safety and health issues

Based on the DMSA (task 1.1) and the description of use cases (task 4.1), it is then outlined which general safety requirements are or have to be applied (e.g. ISO/TS, CE label etc.). Health issues will be addressed as workers are currently exposed a wet and salty working environment at MOL while the implementation of robotic solutions and technologies could reduce this exposition. In ORI there are not heavy impact health issues or environmental conditions. However, the introduction of a robotic solution in the production area could help in relieving the daily operations of workers (e.g., eliminating lifting and searching activities, relieving workers from physical load by AGVs). This requires a joint optimisation of technologies, people and organisation (as pointed out in section 4.1 on requirements for human-centric solutions).

Despite of the RCPM and ONE4ALL project are based on the interaction between robots and humans, it is mandatory to remember that proposed robotic solutions should reach a TRL6 aiming a TRL7 but always referring to a prototype both for robots and intelligent management system. Starting from the word "prototype", it is clear that all the safety precautions shall be undertaken to avoid any accident and collision with human workers. Together with the Management of MOL and ORI, after the use case specification will be finally defined, it will be essential to define how integrating the robotic solutions in their actual working environment both in term of space, human sources and existing rules. Again, this requires an alignment of technology, workers and organisation. Supported by TUDO (covering the social aspects), AUTO will document the results in safety protocols.

For these reasons, a list of activities as drafted below is proposed (carried out by AUTO together with ORI and MOL, supported by the social aspects provided by TUDO).

After the definition and the approvals of the use cases for both ORI and MOL, the next steps are:

- Analysis of the safety protocols (if available) already adopted in both factories.
- Risk assessment and analysis for each application.
- Definition of the working area for each solution in conjunction with safety rules and protocols existing in ORI and MOL.

- Evaluation of the feasibility about the integration of the robotic solutions with the safety assessment and protocols in ORI and MOL.
- Once defined the working areas, definition of procedures to be followed by the personnel.
- Definition of physical/mechanical barriers to segregate humans by robots.
- Evaluation of residual risks and how to limit them.
- Write training procedures for each use cases bearing in mind that only trained personnel can access the area.

An important prerequisite of using the robotic solution safely is a workforce that has the right skills to use it and work collaboratively with it. The results of the DMSA show potential safety risks, which can then be tackled with the help of training programmes (see section 4.3).

4.2.2. Requirements for gender and ethical issues

From an ethical point of view, the integration of the employee perspective is perhaps the most important prerequisite to realise human-centricity within the ONE4ALL solutions – especially as employees have to apply these solutions in their everyday work. To think about their role and also to involve them right from the beginning is also an important part of the criteria for good digital industrial work (see section 4.1). Within the project, employee participation is supported, for example, with the help of the Digital Maturity and Sustainability Assessment (see sections 2 and 3) as well as with further interviews to be conducted during the course of the project.

The results of the Digital Maturity and Sustainability Assessment have already revealed gaps in digital maturity in the participating companies with regard to topics such as "Diversity and Inclusion", "Role of the Operator", as well as "Open Innovation and Collaboration". This seems to make it all the more important to consider ethical and gender-related issues when developing the ONE4ALL solutions. A preliminary selection of possible focus topics has already been identified and partly discussed:

- **Ensuring adaptivity, transparency and complementarity in Human-Technology relation**
  The ultimate goal of developing a ONE4ALL solution should be a possible seamless integration of the technical solution into existing operational structures and processes. A poor acceptance of the solutions by employees would mean a potential risk for reaching the project goals. As described in section 4.1, the solutions should be adapted to the employees (*adaptivity*), the solution should be familiar and known to the employees (*transparency*) and employees and machines should find an appropriate functional division of tasks (*complementarity*). Ethical principles like ensuring "Human agency and oversight" while applying Artificial Intelligence [1, p. 13] as well as generally ensuring respect to research participants can be met in this way.
- **Implementing data protection in the IOP and its modules**
  As required by the advanced digital tools within the project, the IOP developed within WP3 will gather data from multiple sources. A data driven digital twin (DT) as well as a smart distributed DSS is being developed as part of WP2. Both digital tools need information / data about the real world in order to function. This may include static object data, but also dynamic process data including data on single working steps. It must be clarified whether this data contains personal data and thus whether employee monitoring could possibly take place. As a consequence, the collection of and access to this data should be restricted as much as possible. Within task 3.2 security & privacy protocols will be identified and defined that will be implemented on the IOP to ensure the data protection. Further on it will be aligned with the Data Management Plan (DMP – D7.8).

- **Ensure participation of people with different genders / identities etc.**
  Regardless of personal attributes like gender, physical restrictions etc., employees currently working in the operating area of the ONE4ALL solutions should also be able to work there in

the future. The *participation* of employees, as also emphasised within the criteria for good digital industrial work, should therefore be applied with special attention to gender and diversity-related differences.

- **Ensuring trustworthy AI**
  As a cross-cutting theme, the seven requirements for trustworthy AI (see D7.7, pp. 13-14) should be met. This includes aspects already mentioned above (diversity aspects, data security, human agency and oversight, safety), but also societal and environmental well-being as well as the accountability of the technical solutions for effects they cause. Those aspects will be considered from the technical point of view in WP3 during the development of the IOP and the integration of its modules, specifically within T3.2.

In the further course of the work on this deliverable, the ethical and gender diversity-related prerequisites for human-centricity are to be further formulated and specified.

4.3. Requirements for a training programme (from 4.1 and 4.2)

A training programme for the ONE4ALL solution is – beside the safety protocols – a main product of deliverable 1.1. In this first (out of four) reports presenting results from task 1.1, the spotlight is on requirements for a training programmes. Those requirements are based on the DMSA and the description of pilot cases and selected applications for RCPM. The DMSA presents the need for training as perceived by experts of the involved use cases ORI and MOL. The use case description shows where the ONE4ALL solution will be implemented and which process steps will be changing. Based on these two inputs, the following draft for training-related requirements has been developed.

The necessity of developing training programmes in ONE4ALL arises from two rationalities: On the one hand, it can be generally said that a human-centric solution based on the criteria for good digital industrial work (see section 4.1) will change working steps, job tasks and therefore skill requirements.

On the other hand, a need for further training can also be concretely seen with regard to the two companies ORI and MOL: In both cases, there was a clear gap between the current status of *Training 5.0* and the envisaged score in the DMSA. This result of the DMSA, underlined by statements of experts in DMSA workshops, shows a general need for training to mitigate the mentioned gaps. The next step will be to analyse the potential changes in the related areas of application, especially which working steps will be changing (e.g. new task allocation between RCPM and operators, need for programming and maintaining the RCPM), which job profiles will be affected by the changes (e.g. operators, maintenance, quality management) and how job tasks will be changing (e.g. shift from operating to supervising). Based on these identified changes, potential skill gaps will be identified and training programmes can be designed to close the expected gaps.

Having in mind the criteria for good industrial work as a guiding principle, the technological change of the robotic solution should lead to a readjustment of the relationship between human, organisation and technology.

That comprehensive understanding of technological changes with different levels of employees involved usually requires that different categories of skills are covered. The DMSA gives a good overview on the specific technology-related skill requirements for an Industry 5.0 ready production side. However, also some transversal skill requirements are covered, e.g. new requirements on leadership / advocacy related to Climate action, Open Innovation and Collaboration, Diversity and Inclusion. As well as cultural transformation.

To identify the scope of skills which are required for a human-centric solution, a classification of skills which was developed within the EU funded BEYOND 4.0 project is used (see Figure 16). BEYOND 4.0 puts a focus on the fact that digitalisation takes more than pure technological understanding and knowledge to make a technology work within an organisation [12, pp. 8-10]. It differentiates digital, and non-digital (i.e. personal, social and methodological) transversal skills as well as job-specific skills which could be required by Industry 5.0 solutions.

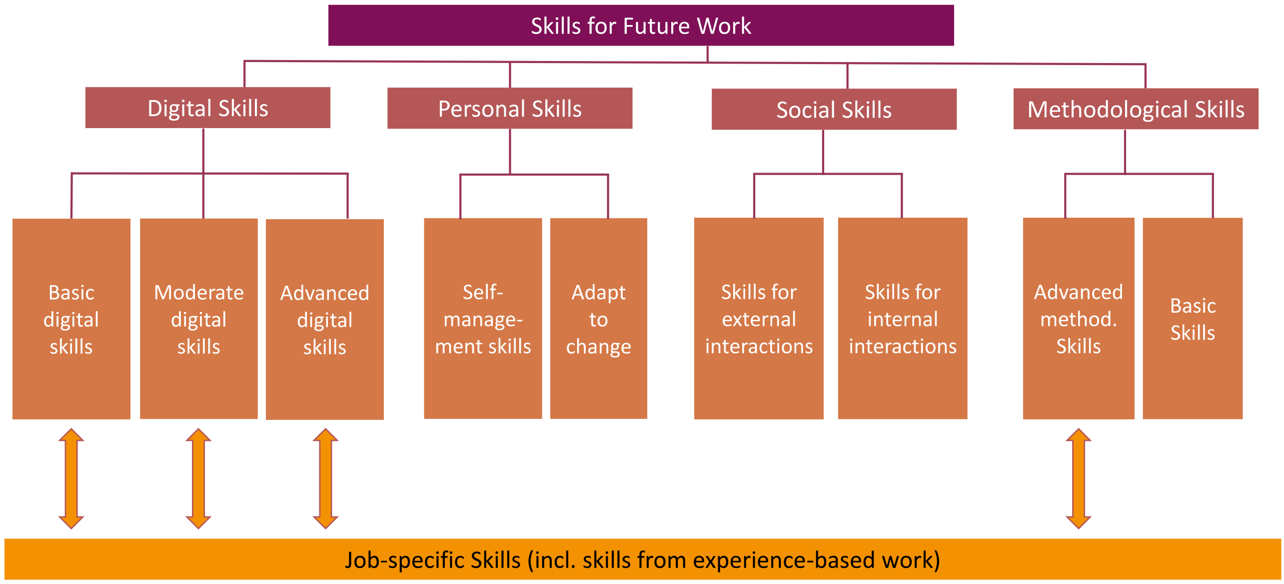

Figure 16: BEYOND 4.0 Skills classification. Source: [12]

The ONE4ALL training programme will therefore not only cover the more specific skills related to the technological application, but also transversal skills. While the specific changes of working steps and job tasks should be analysed before identifying new skill needs it can be expected that the potential use cases and application might require the following categories of skills:

- As the job tasks will be changing needs for new job-specific (**technical skills**) might arise;
- Programming the RCPM and using of IOP and its tools offer (e.g. DTs, DSS), as planned within the ONE4ALL project, will require new **digital skills**;
- To make best use of technologies and to improve processes, **methodological skills** such as problem-solving and creative thinking will be required by some job profiles;
- The staff members will experience a change in their usual work routines. It requires **personal skills**, especially the ability to adapt to change that is crucial to master this change. Employees should not only learn how the technology works, but they should also be prepared to change the working routines.
- During further course of the project it will be analysed whether and to what extent need for **social skills** will be changing (in case of new collaboration between employees).

The applications of the ONE4ALL solutions have to be analysed in detail before concrete skill requirements can be identified which should be met by training programmes. However, the above-mentioned skills categories and the examples for potential application to ONE4ALL give an impression of what scope of skills and training programmes are under discussion.

5. Conclusion and Outlook

This report (deliverable 1.1) presents the first step in the process of developing training programmes, safety protocols and considering gender and ethical issues. The next steps will be carried out with the following deliverables 1.2, 1.3. and 1.4 presenting results of task 1.1 at different stages of the ONE4ALL project (month 24, 36 and 48).

As part of WP 1 which is dedicated to human and sustainability impact assessment, it highlights criteria for a human-centric and sustainable-centred implementation of ONE4ALL solutions. Against this background, requirements for a training programme, safety protocols and ethical issues have been developed.

The Digital Maturity and Sustainability Assessment (DMSA) is an important starting point for human-centred implementation (general concepts in section 2, company-specific findings in section 3). It is focused on Industry 5.0 concepts covering (advanced) technologies, but also non-technical concepts of organisation, people, culture and skills. In the DMSAs, the current situation of the companies, Orifarm and Madama Oliva, was precisely recorded and development paths were identified - from a technological, organisational and human perspective (section 3). Both pilot companies, potential ONE4ALL applications and involved sub-processes are also described in section 3.1. These descriptions give a general impression of the areas, for which training programmes and safety protocols are to be developed.

In both cases, besides technical hurdles (such as salty/wet working environments & food handling, small batch sizes), organisational and human challenges also exist. In the DMSAs, the importance of adequate training for employees who have had little contact with automation and robotic solutions was emphasised. E.g., the handling of data, requires the necessary skills for interpretation. Also, safety & health and other ethical issues (such as diversity and inclusion) represent areas of improvement in both companies.

Based on the description and the self-assessment of the companies, requirements for training, safety and other ethical issues are presented in section 4. They reflect general requirements which have been derived from the findings shown in section 3 and criteria for good digital industrial work which are presented in section 4.1 to operationalise the concept of human-centricity as key concept of Industry 5.0.

Against this background, general requirements for ethical issues are shown. Explicit attention must be paid to the physical health and safety of employees. Safety protocols will be developed in the course of the project to ensure this. The safety protocols will be adapted to the specific conditions at the production sites and the work processes. Section 4.2.1 shows a process how these requirements can be specified for the sub-processes and ONE4ALL solutions to be implemented in the pilot companies. 4.2.2 includes requirements on further ethical issues which will be specified in the further course of the project.

Another outlook is given how a training programme will be developed in the further course of the project (section 4.3). This requires an analysis of how the planned ONE4ALL solutions can affect the work processes of the employees - and which job profiles are specifically affected. Once these changes have been identified, also through discussions with employees, concrete skill gaps can be identified, which are then addressed by the training programmes. To this end, a skill categorisation, which is based on previous research in the BEYOND4.0 project [12], will be used. It is expected that not only the need for technological skills will change, but also the need for transversal skills (e.g. social or personal skills). However, these needs can only be identified in detail in an analysis of the changed work processes.

In this respect, the T1.1 work that will be documented in the successors of this deliverable (D1.2 (due in month 24), D1.3 (due in month 36), D.1.4 (due in month 48) consists mainly in a concretisation of the presented contents.

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