D4.1. TRAINING REQUIREMENTS REPORT

UP-SKILLING FOR INDUSTRY 5.0 ROLL-OUT

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EXECUTIVE SUMMARY

There are nine companies connected to the project, all in various phases of new technology adaptation processes. The motives and contexts for each company vary since they have different challenges. The first phase of the project has been to identify focal technologies in each company. The work is on-going so the ambition with this report is to summarize the findings until now specifically considering the various training requirements. This project ambition is therefore to propose and develop pathways for integration of Industry 5.0 and craft skills for different case studies. The project will link the firm's strategic contexts to technology implementation and identify managerial competencies needed to succeed in the implementation choices to maintain and develop skilled work.

On example from the cases is when Augmented Reality (AR) technology was tested. The technology enables a structured process for technology transfer both internally (job rotation) and externally (technology transfer) in case of new business opportunities, i.e., taking over production for the OEM's aftermarket. This technology was new to the company and the test has been in two stages: In the first stage, the company's operator and CEO was introduced to the Hololens tool and one operator was then trained to set-up and run the system. In the second stage, the company focused on how to develop assembly instructions with AR. A small team with an information designer and an AR expert was formed to develop a mock-up. The design phase was a part of the training plan derived from the needs and technology choices. To be able to use this technology in the business process, a training session was needed in how to perform "knowledge capturing and codification". The competence management system with a focus on job rotation will also be improved using AR.

If we view the different cases side by side, top management involvement and a structured way of work seems to be the enablers. Technology development creates a steadily ongoing dynamic adjustment where it is important to see training and competence as a necessary part of the implementation process. However, this seems to be a big challenge in many companies. The trust in the new technologies also needs to be accompanied by the trust of the human, i.e., how to augment the person and the organisation and not dilute the work content or needs of skill. Change appears to be constant due to new technology. However, the same technology is available for all competitors. Hence, the competitive edge needs to come from the skills in the organisation where the human creativity and innovation ability adapting the technology. The concept of Industry 5.0 puts the human in a necessary system context where an Industry 4.0 structure, with the focus on technology adoption, and a well-developed learning development is crucial. The managements' understanding of the

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system affects the ability to embrace Industry 5.0 as a concept. There is therefore an ambition to develop management training where Industry 5.0 and company ambitions could meet.

The importance of context is very present in our case studies. The facilitated technology exploration and purchase process have led to some deeper learnings in many of the case companies. Despite the differences between the different companies, there are mutual questions that need to be considered on a contextual level. One is in what way the new technology a part of a larger new technology plan? Another is how competent the company is in Change management – the company's ability to implement new technologies and way of working at all levels. The design of the competence and training management system is also of interest. From the cases so far, there could be different processes or sub processes proposed that would be considered in the project. A few questions could be raised:

- What general processes in a company are affected by Industry 5.0?
- How could greater understanding of Industry 5.0 and an articulated process for new technology improve company behaviour and later abilities?
- In the same way that Lean production is based on guiding principles, what do basic Industry 5.0 principles look like in a company?
- How could different (skill-)roles be "dissected" due to new technology to find future appropriate positions (encounters, roles, role relationships, and networks) and job designs?
- Is there an "easy" way to monitor a company's progress and status? For example, what would an Industry 5.0 maturity index based on self-assessment look like?
- What would a generic process with external technology development partners look like?

These questions will be guiding future work.

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1. DESCRIPTION OF THE DOCUMENT

The report connects the results so far from WP 2 and 3 and uses the ethnographical report D2.1 and the technical report D3.1. There is also input from T4.1 - Digital outcomes and training requirements.

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2. APPROACH

2.1 The Up-skill project

There are nine companies connected to the project, all in various phases of new technology adaptation processes. The motives and contexts for each company vary since they have different challenges. The first phase of the project has been to identify focal technologies in each company. The work is on-going so the ambition with this report is to summarize the findings until now specifically considering the various training requirements.

The Up-skill project starts with the background of the 4th Industrial Revolution (Industry 4.0-technologies) and the associated new technologies, such as Internet of Things, Big Data Analytics, and Advanced Robotics, that have enabled new levels of production capacity and efficiency. Industry 4.0 consist of general-purpose technology with applicability in a wide variety of settings that can diffuse widely across all sectors of industry with positive consequences. However, Industry 4.0 and automation is suspected to cause job cuts and wage deflation. Industry 5.0 as a concept, will bring added value to the technology and provides an objective to be human-centric and creating sustainability and resilience. Since the technologies also diffuses to all competitors, only skilled human labour will make the difference for an individual firm's competitiveness. The benefits of Industry 4.0 will not come to firms automatically since the strategic context in the different firms varies a lot. This project ambition is therefore to propose and develop pathways for integration of Industry 5.0 and craft skills for different case studies. The project will link the firm's strategic contexts to technology implementation and identify managerial competencies needed to succeed in the implementation choices to maintain and develop skilled work. The results will also support the preservation of cultural heritage in the form of craftsmanship skills that might otherwise be lost. This report contributes to the following Up-skill objectives:

3) Identify, and detail, good practices in organisations that continue to mobilize human skill, ingenuity, and creativity as a source of value and competitive advantage.
4) Examine the specific organisational and managerial competencies needed in contexts where skilled and creative roles meet autonomous, semi-autonomous and intelligent systems.
5) Develop pathways for integration of Industry 5.0 and craft skills for different case studies.
6) Test the developed pathways in related companies.

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2.2 Industry 5.0 – a policy description

The concept of Industry 5.0 has been introduced by the European Commission as part of the Green Deal to visualise, provide technical development, and new direction to Industry 4.0. A series of policy briefs have been published describing, explaining, and discussing what Industry 5.0 is, could or should be. This section is a reworked summary of three of these policy briefs [1, 2, 3].

There is a belief that industrial transformation is urgent and will be needed at all levels of government, economy, and society if Europe wants to build a path to future prosperity. Without this, it will be impossible for Europe to realise its ambition to become a more resilient, sustainable, circular, and regenerative economy while preserving and nurturing its competitiveness at the international level. Industry has a particular responsibility in this to include social, environmental, and societal considerations. The DG's Expert Group on the economic and societal impact of research and innovation (ESIR) argued that the emphases should be broadened to include not just profit (prosperity) but also people and the planet. This wider purpose constitutes three main core elements: human-centricity, sustainability, and resilience. Rather than taking emergent technology as a starting point and examining its potential for increasing efficiency, a human-centric approach to industry puts core human needs and interests at the heart of the production process. Technology should meet the needs of the worker. It also means making sure the use of new technologies does not impinge on workers' fundamental rights, such as the right to privacy, autonomy, and human dignity. For industry to respect planetary boundaries, it also needs to be sustainable, develop circular processes and reduce energy consumption and greenhouse emissions. The resilience-part of the concept refers to the need to develop a higher degree of robustness in industrial production, better equipping it to meet societies' requirements, avoiding disruption and ensuring it supports critical infrastructure in times of crisis. Industry 5.0 recognises the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the centre of the production process. The benefits for the worker could be the opportunities of new roles, safe and inclusive work environment, and the focus on skills, up-skilling and re-skilling. Benefits for Industry then will be an opportunity for attracting and retaining talent, enhanced resource efficiency for sustainability and competitiveness, and increased resilience.

There are, however, a few questions raised at present: 1) what does Industry 5.0 look like in the workplaces; 2) how can adoption be encouraged; and 3) how can progress towards achievement be measured? For industry this implies [2]:

- Transform their business models where sustainability is a natural component and driver of international competitiveness.
- Change the mind-set and economic approaches to policy, finance investment and corporate governance.

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- Redesign value chains to embrace new technological possibilities and sustainability, as well as circular economic and societal well-being.
- Find and implement metrics and indicators that allow measurement of progress.
- Bring digital and green properly together.

Hence, Industry 5.0 could be described as: “The vision of how industry could meet EUs expectations to reach necessary objectives towards sustainability, human-centricity, and resilience.”

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2.3 On training in industry today

Training has always been part of a competitive production system, but approaches have changed over the years. From a literature review on training in the fourth industrial revolution some important publications were found. In "Training the workforce for Industry 4.0" [4] Ninan et al. highlights the need for training and development in the 4th industrial revolution era and provides a distinction between traditional training methods and the next generation of training methods and tools. As a result, they have compiled the following table that describes now and then, providing a comprehensive overview of the shift.

Table 1. Training pre and in the fourth industrial revolution. Adapted from Ninan et al. [4]

Training in the pre IR 4.0 period	Training in the IR 4.0 period
Learning is a sequence of corporate schemes built around Learning and Development (L&D) - designed content and carried out by L&D approved experts.	Learning is an "environment" and an "experience" leveraging experts, materials and content sourced and recommended by internal experts, external communities, and other employees.
A corporate learning management system direct the learning environment – generally a large archive of courses.	The learning environment provides precisely what they need through a consumer website that delivers courses, content, videos and access to experts (including recommendation engines).
The business along with the L&D and compliance expert identifies the courses to be completed based on the role of employees.	Employees draw learning opportunities, and they navigate and access the same from within and outside the company.
The focus of the traditional methods is on internal training endorsed by the company.	External training is accessible through any online source.
Training professionals are not specialists, and they do everything from design to development, logistics and measurement.	Training professionals are experts who are excellent in their domain.
Training is conducted through a lecture-based model led by an expert.	Training is demonstrable, depending on case studies, experiential and flipped classroom.
Employees are guided by the experts to learn specific skills.	Employees learn through coaching and facilitation.
Organizations create complete, comprehensive, skill-based proficiencies that drive the learning agenda.	Organizations create high quality structures that outline wider capabilities.
The traditional 70:20:10 ratio is used which focuses on providing work	This type of organization plays a supporting role in the learning process

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experiences, sociability with others and the structured formal training in this kind of learning organization.	by expanding the 10 to cover both learning from within and outside, developing the 20 to incorporate internal and external networks, and redefining the 70 to embrace corporate, community and social experiences.

Generally, one could argue that these statements describe a shift from a top-down to a bottom-up perspective and that the lecture room is changed to the workplace setting to a higher degree. In the Up-skill project, training in connection to implementation of new technology is of interest. Viewpoints, barriers and success factors in implementation of Industry 4.0 are also of interest. From the literature, three literature review papers have been selected where the review has been made to present different viewpoints connected to Industry 4.0 technology adaptation. The main findings are presented below.

Identification of critical success factors for leveraging Industry 4.0 technology and research agenda: a systematic literature review using PRISMA protocol [5]
Sahoo et al. proposes the 12 most common critical factors, in ranked order from occurrence in the reviewed publications, that can be considered as the significant critical factors for successful implementation of Industry 4.0: 1) Training and development, 2) Organizational culture, 3) Top management support, 4) Organisational structure, 5) Innovation capability, 6) Technological infrastructure, 7) Security system, 8) Standardisation of procedures, 9) Financial resources, 10) Communication and cooperation, 11) Change management, and 12) Governance.

Organisational learning and Industry 4.0: findings from a systematic literature review and research agenda [6]
Belinski et al. present a construct between organisational learning and Industry 4.0 where three areas form a holistic model:

- Industry 4.0 structure: *Industry 4.0* (e.g. smart factory and products); *General industry* (e.g. changeable manufacturing systems, digital business engineering, Human-machine interaction), and; *Management* (e.g. Works participation, Production planning and control, Lean management).
- Technology adoption: Applications (e.g. Digital and human centred decision support, Ergonomics); Efficiency (e.g. Energy and resource efficiency); and Technology (e.g. XR, 3DP, IoT, Automation)
- Learning development: Competency and Skills (e.g. Competence development, Digital skills, Future skill demand); Education and Training (e.g. Active learning, Education, E-learning); and Industry and Academy (e.g. Experimental factories, Learning factories)

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Industry 4.0 and Lean Six Sigma Integration: A Systematic Review of Barriers and Enablers [7]
Macias-Aguayo et al. have identified twenty integration barriers within four different areas (Technological feasibility, operational viability, financial plausibility, and cultural Suitability), and highlights: 1) High implementation cost, 2) Long learning curve, and 3) Technology incompatibility as the main barriers.

Seventeen enablers in six different areas (External stakeholders' support, Interconnected IT systems, Big data analytics/AI, Strategic orientation, Collaborative culture, and Efficient operations) were found to facilitate and guarantee implementation success, highlighting: 1) investment in IT infrastructure and employee training, 2) stakeholder involvement, and 3) top management support.

Training is highlighted in all these studies as results from the literature reviews. They also highlight the importance of the role of top management. Apart from this, the details in the technology change per se are very important together with training and understanding in all levels of the organisation. One factor to be considered, is to include external support for technology training and education. The Belinski et al. construct model provides a holistic framework that could be used in different pathways.

On assessment of training needs
There are several levels of needs that could be explored and analysed – organisational, task, and individual needs [9]. On an organisational or production system level the gap is found between the new technology characteristics and the current production system set-up. What function does the new technology have? This is needed for the operational management to understand the technology in its context. The main question is: What changes are related to People, Technology and Organisation (including support functions such as maintenance, production planning, IT or HR)? Here, there could be a large spread of situations, from replacing a function with another (more advanced function) to a complete reconfiguration of a larger section of the manufacturing system with a new set of manufacturing capabilities, e.g., automating a manual process. The second level is on a task level and sits between the interface the new technology's workplace and the operator. This could be described in terms of Level of Competence, Level of Automation and Level of Information [10]. The third level is between the workplace and the person. This could be done in a competence matrix that could be used as a heat map [11, 12] describing the skill gap for each person and could also be aggregated to a team or even a on a company level.

The Flagship Factory – digital model [8]
Another framework for industry, digitalisation and transition to new skills is the Swedish Flagship Factory – Digital project. The six participating companies have in turn organised development workshops where they have taken each company's main challenges in the area as their starting point. Workshops addressed different aspects of skills development for operators with prepared questions in different industrial companies during a period of rapid digitalisation and development. The results of the project are summarised as a competence development model. The model consists of

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the components: *Employee*, *Management and Board*, *First Line Manager* and *Content, and methods for competence development*. There are more factors that need to be considered in a larger system context, but these four are central and interact with each other in the continuous systematic competence development work. Using this model, the following conclusions could be derived.

Employee

From the employee's perspective several union representatives in the Flagship Digital project state that if employees are informed early on and engaged, it contributes to the change process and increases openness to skills development. However, important to notice that Sweden has a strong culture of union cooperation with the company managements. The work also showed that utilising and requesting employees' domain knowledge from their daily work often contributes to better solutions from the beginning and run-in problems for new solutions can be avoided.

Top management

Management should express strategies on skills needs and development for the company to achieve its goals and remain relevant to its customers. However, these strategies need to be financed and be in line with technology development.
To use resources correctly, the skills gaps that exist need to be identified and also what content (both general and specific) skills development efforts should have. Competence mapping is therefore becoming increasingly important and industry skill validation can be a good tool for some companies to identify what skills employees have and what skills need to be developed.

1st line manager

In terms of both competence assessment and competence enhancement itself, the connection between the employee and management is crucial; from first-line managers and up. Many companies have regular employee dialogues, often about salary development, but these are also increasingly linked to skill development. Here the question needs to be asked: Do we give our first-line managers the right support, conditions, and follow-up tools for this activity to be systematic?

Content and methods for competence development

Learning is an "environment" and an "experience" leveraging experts, materials and content sourced and recommended by internal experts, external communities, and other employees. The chosen competence development methods and tools for learning are important for the effort to be effective. The wrong approach leads to wasted resources and wasted opportunity. It is a skill to understand and adapt methods of learning – and the field has developed rapidly. We must use the methods that work for the employee. Competence can be defined as an individual's ability to act in relation to a particular task or situation. It is very important that the line organisation receives well-managed support in these parts. It can be organised in different ways and needs to be adapted to the needs of the line organisation and keep up with its development and continuous new challenges. Interaction with external knowledge and education partners should be considered.

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3. The Company cases – training needs

Connecting to the different cases in the Up-skill project, it is important to separate the training into two categories. The first, information and awareness is primarily aimed at managers and supervisors. The second concentrate on the technical issues and competencies required to operate the technology. The former could also be used to give a broader understanding of the full range of the technologies and the possibilities they present going forward.

There are three main sources that have been combined to derive a plan for the different training needs of each of the cases:

- The ethnographical report from Work package 2 [13]
- The technical report from Work package 3 [14]
- Input from T4.1 - Digital outcomes and training requirements
- An interview survey with representation for each case.

Since the different companies have chosen different case studies and because they are in different phases in the new technology process the reporting below differs.

3.1 Case company A

3.1.1 Context

The products have a high engineering content and are produced in small numbers. There are few competitors globally, and the barriers to entry are high due to the quality requirements of the products. The site is organised in separate mechanical workshops rather than a production line manufacturing facility. Hence a functional layout. The company aims for a capacity increase for the next coming years by implementing new technology. [13]

The training management system is developed to a basic industry level and is coordinated by the local HR department.

3.1.2 Focal technology

Due to the objective of a capacity increase and the fact that many of the manufacturing cells are rather old, a better manufacturing monitoring system is needed. A MES-system was decided on and initially implemented during the pandemic. Now the system needs to be further developed to meet monitoring and control requirements. A dash-boarding of key production data will provide early warnings of issues and enable proactive actions to prevent or mitigate interruptions in production. [14]

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A part of the current implementation project is carried out as a Six Sigma Black-belt project. The goal statement is: To develop a scalable standard solution for the factory, so they will be able to improve performance and deliver on time to customers.
Training has been provided to all staff at the site on how to use the system. However, pedagogical skills to get staff onboard, and motivate operational staff to use the system as intended, are crucial. The perceived value of using the system differs between individuals. Competence or the pedagogical skills required for onboarding individuals, and for individualised practical training, are needed. [13]

3.1.3 Training need analysis

The core of the MES is to have a method to mirror/monitor manufacturing system performance. One fundamental key is that data is generated correctly. The machine operators have a key role to secure accurate data capturing. The data capturing could be done automatically but generally it needs to be verified and validated by the ones closest to the machine. For operators to produce the actual data, 'computing skills' related to logging, start and stop are required. Hence, there is a crucial need for the employees understanding of the system, not only how to operate it. [14]
Here different groups of people need different training/education – who should know what? The group to site – perspective is interesting and calls for attention to the need of the local change management to evaluate what are the required preconditions to be successful in larger change projects.

The following table is a suggested plan:

Training Title	Description	Target Audience	Training Prompt	Training Source
Manufacturing Control	Description of the system in place that covers quotation to delivery of a product Derivation of standard times Resource planning Rework	Tailored for: Management Planning Shop floor	When working system is fully defined	In House - Once the whole system is defined
Software training	ERP, MES, Dynamics 365	User Functions	When interconnected system is being defined	Software Vendors
Benefits Awareness	Benefits to the organisation Benefits to the individual The importance of accuracy and consistency in data collection.	Workforce	When total system is defined.	Operations management function
Dashboard - Definition	Defined Worker views Management views User types and scenarios	Work force and functions collaboration & definition.	This 'training' is for dashboard definition from users	In House champion dependant on in or outsourced dashboard creation - should be in house

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Dashboard Training	Training on functional implemented system	Workforce and other functions using data from the shop floor	When initial mock up is available (After data capture and data integrity are resolved)	In House champion dependent on in- or outsourced dashboard creation - should be in house
Systems training	The interactivity of constituent parts of a system to enable optimal function as a whole.	Operations and support functions	Draft system design - for consultation	In House
Change management	Avoiding change fatigue workforce as drivers, not passengers What success looks like from different perspectives	All	As soon as possible	External

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3.2 Case company B

3.2.1 Context

The company is an OEM. The site has been an example of the changing nature of industrial relations. In this respect the company has been a driver of change in the way a worker and workforce are managed to improve efficiency and reduce costs. The objective is to keep costs down while ensuring quality. Unlike previous approaches where potential suppliers of equipment are carefully researched and compared before any action is taken, the current approach is to move from 'problem' to 'trial' as quickly as possible, for instance by contracting with suppliers who they already are in business with. This way, testing takes place in situ, and, when applied more widely, the process of innovation overall is speeded up. [13]

3.2.2 Focal technology

The first selected technology is an automated floor marker. This work used to be done by the company's own employees but more recently has been outsourced. The outsourced company is based abroad, and the work is done manually. This comes at a significant cost each time the marker visits to do his work. Using this method also brings problems if a change is needed to the layout after it has been marked, as this necessitates a repeat visit. The opportunity to develop a technology that marks floors would mean that labour costs could be saved, and the technology could be built upon to do other things. A model is currently being trialled. [14]

The second chosen technology is based on another problem that has been identified as a candidate for automation. There is a repetitive handling process that involves moving heavy parts. The palletiser is a cobot and could work alongside operators.
Both innovations were shown to a wider team of the company and contractor employees as a way of socialising the idea and getting some initial responses, as well as buy-in from the 'decision makers' who own the budgets. It was also an opportunity for the vendors to see the parts be handled, and to gain better understanding of what the applications to make a more detailed proposal, and a more exact price.

3.2.3 Remarks from testing phase

The way the marking technology is being conceptualised and designed is described as 'a donkey and saddle approach' by the new innovation lead. The moving vehicle is the donkey, and the 'intelligent' saddle could be designed flexibly to accommodate a variety of different functions. The donkey plus saddle approach also enables opportunities for securing IP, by protecting the combination of technologies brought together.

Early demonstrations of the palletizer in a factory setting point to some adjustments that staff working on the line may have to make, in terms of avoiding direct contact with the cobot.

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The new approaches being implemented at the company for facilitating and managing innovation are of significant interest to this project.

Training needs will be considered during the implementation phase.

3.3 Case company C

3.3.1 Context

The company is a smaller contract manufacturer. The company's business model is described as "Low volume – High mix". This strategy affects the business and its workers in many ways, on a company level this could be categorized in terms of variety and flexibility. The way of organising the work processes may set the framework for workers' possibility to take initiative and express creativity, but also management's expectations of worker flexibility. This can be related to the company's need to retain and develop experienced craftsmanship despite the implementation of a digital production system. A consequence of this plan is the need to maintain skills and competences that are relevant to the manufacturing and assembly of products as well as to troubleshoot and improve existing third-party offerings. This includes skill in handling, setting up, using, and servicing old production machines, but also professional knowledge of how old products are being produced and why assembly needs to be done in certain prescribed ways - regardless of whether the product owner or manufacturer has left any instructions regarding this. Thus, this is also the reason why the company competes with quality in three levels: the skills of the employees, the accuracy of manufacturing and the craftsmanship of assembly, i.e., knowledge that includes know-how about the whole manufacturing process. [13]

The objective is to eliminate one level of management, i.e., the 1st line manager's presence in the practical work and task distribution function – these functions need to be transferred to the workers. The company have a competence management system on a basic level as a part of the quality management system (ISO 9001). It interconnects with the manual production control system. Training is mostly performed in-house by other more experienced operators.

3.3.2 Focal technology

There are two technologies in process: 1) a CNC machine centre and, 2) Augmented reality (AR) glasses for, initially, instruction applications and later, for (perhaps) maintenance instructions for the CNC.[14]

3.3.3 Training needs assessment

The organisation is traditional and lacks experience of introducing new (more advanced) technology. Both technologies (CNC and AR) are new to the company. CNC is more complex as it also connects to CAD/CAM. There is a familiarity with CAD

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but not with CAM. AR/Hololens is more a "plug-and-play" technology and although the technology itself is complex, it is "easy" to use.

With regards to AR, the case is a combination of two major management system processes: 1) Technology capture, codification, and transfer, and 2) Assembly instruction development. In both processes, it is important to have high user involvement. It is too early to estimate how the AR-introduction will affect the work but it will enable job-rotation and the opportunity for the 1st line manager to interact with the workers regarding work and training planning within their competence management system.

For the CNC the following training programme should be considered.

Training Title	Description	Objectives	Target Audience	Prompt	Provider
Technology Overview	To appraise the audience of the technologies and their requirements and capabilities	To give an overview of what can and cannot be achieved with the technology. To give an overview of the skills required to maintain and operate the technology. To indicate the running costs and downtime to be expected within production. To outline a future roadmap for business expansion	Senior and middle management	This should ideally be carried out prior to the upgrade project's commencement.	Subject specialist
Maintenance	Training on the specifics of maintaining the technology	To clearly explain and demonstrate all routine maintenance procedures. To give an understanding of the critical signs of wear and tear. To instruct and train the maintenance department on simple repair procedures.	Maintenance personnel	Machine sign off	Machine Vendor

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Operator Training	To enable the machine operator to effectively run the machine	To provide an understanding of the machine controls To provide a thorough explanation of the controller To give a basic understanding of ISO G-Code To explain the processes of machine set-up To instruct on the setting of tool descriptions and dimensions To cover in detail the role of and use of localised origins and Euclidean Co-ordinate frames To explain the importance of programme verification and how this is carried out	Machine Operators and shop floor managers	Machine sign off	Machine vendor/Third party specialist
Programmer Training	Generic CNC programming course	Covering 3D modelling Provide competency in the use of CAM software. Give an understanding of tooling. Demonstrate how to maintain resource data libraries. Provide competency in the process of programme verification Give the programmer an appreciation of co-ordinate systems, origins and frames. Ensure the programmer understands the importance of jig design. Cover the uses of on machine probing.	CNC Programmer	Machine installation	CAM System vendor

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3.4 Case company D

3.4.1 Context

The company is a smaller OEM. Their competitive advantages lie with their flexible production processes, excellent quality, and close, long-term customer relationships. They have a highly skilled labour force who, when confronted with a problem, will use their versatile skill set and often substantial experience to find a solution. The primary challenge is lack of access to skills and risk of skill loss due to an aging workforce. This has led to a focus on skill replacement technologies, rather than alternative paths to recruitment. Currently, production is a very manual process with low automation degree, and little use of IT in the offices and in the manufacturing system. The workforce is seen as a critical asset that need to be 'treated right'. Overall, managerial control exerted over workers is rather low. However, there is a sense of community in the company through an affinity with 'old' manual skills as opposed to skills related to operating new technologies. [13]
The training procedures are managed by the 1st line manager when it is necessary.

3.4.2 Focal technology

After testing and evaluating several technologies a decision was made to purchase a Water Jet Cutter. The machine itself could be seen as "plug and play" technology. However, there are some choices to be made regarding the company's IT-system and software due to the workflow process and implementation. [14]

3.4.3 Training needs assessment

There are a few challenges that could be solved partly by working with the management and through different training events such as: 1) how to handle the lack of access to skilled people and other challenges when recruiting skilled workers, 2) to find a way to 'modernise', though this sits uncomfortably with the broader culture in the company and, 3) to find a way to meet the desire to improve efficiency/productivity. For the focal technology the training needs are:

Training Title	Description	Objectives	Target Audience	Prompt	Provider
Operator Training	To enable the machine operator to effectively run the machine	To provide an understanding of the machine controls	Machine Operators and shop floor managers	Machine sign off, 24th Nov	Machine vendor at
Software integration	To find ways to integrate different software	To understand and how to analyse the SW situation regarding workflows in a future state	Shop floor manager and necessary IT resources	Ideally before the WJC is in place.	LUN/TWI

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3.5 Case companies E and F

One group of companies in the Up-skill project have a different role and are not beneficiaries in the same way as the other partner companies. This affects the interaction with each company.

3.5.1 Context E

The company produces high quality office accessories, both standard and customised. A large proportion of the revenue derives from exports. Each item includes 200 passages, and the production is organised on a lean basis through an EPR (Enterprise Resource Planning) software, introduced in 2008. Along the production site, technological solutions collaborate with human tasks or workers monitor the machine. Materials, tools, and documents are distributed by a robot on wheels (AGV). The main goal is to maintain the competitiveness of the firm and be able to invest enough to strengthen the business and pass it to future generations. [13]

3.5.2 Focal technology E

Technological investment and changes within the organisation have had multiple objectives, including the reduction of manufacturing time and increasing the production. There is an array of technology opportunities that the company is considering. There is a steady ongoing process of refining and optimising the production flow where the workers are in the centre. Technological investment aims to sustain competitive advantage through the standardisation of procedure, and this is particularly evident in the efforts to codify tacit knowledge through the codification of tasks. The case embraces a continuous process of identifying new technology, to implement the most efficient one. [13]

3.5.3 Context F

The company produces handmade products and accessories – an artisanal company. The raw material is fundamental and sourced within the country. The value is added mainly by humans and the quality of material used. The barriers for competitors are very high but the competition has increased. The business strategies rely on short-term steps for achieving the goal of being more efficient. The most important is to codify the micro-tasks for increasing production and make every action more efficient and effective. The management are concerned with the generational turnover, due to the age of many workers. The reasons are twofold: 1) older workers possess a wide tacit knowledge, and 2) it is very hard to be attractive to young workers. [13]

3.5.4 Focal technology F

In sum, technological solutions (such as MES and tablets) have been implemented to support the management to improve the level of productive efficiency. An ongoing process of continuous monitoring and improvement drives technology adoption. [13]

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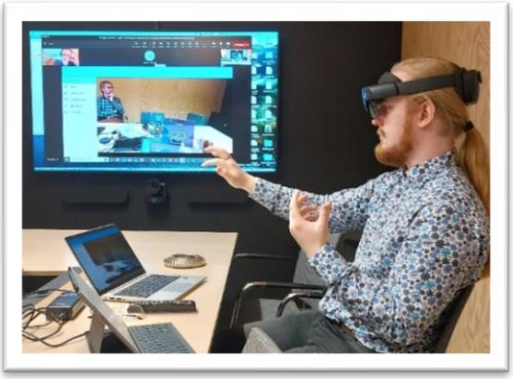
3.5.5 Training needs E and F

The two cases are similar in many senses. We follow the companies and learn from their inbuilt drive to be more competitive. However, from the early findings of the research we now see a need to find ways to both assess and to view changes made from an Industry 5.0-perspective. Both companies have an ongoing general process of finding new technologies. This process is important to capture, describe and analyse from an Industry 5.0-perspective and this procedure also interacts with the companies' ways of dealing with competence issues, i.e., the competence management system. The managements' ability to drive these technology implementation projects is obviously a great contextual factor in need of greater understanding. Training strategies should have two goals: 1) enhance human-technology interaction and, 2) support management towards a more sustainable and people-focused technological transition. Training courses should be devoted to update technological skills of workers regarding how to use technologies.

3.6 An example from one case company



Augmented Reality (AR) technology was tested in this example. The technology enables a structured process for technology transfer both internally (job rotation) and externally (technology transfer) in case of new business opportunities, i.e. taking over production for the OEM's aftermarket.
This technology was new to the company and the test has been set up in two stages:
In the first stage, the company operator and CEO were introduced to the Hololens-tool and one operator was then trained to set-up and run the system. In the second stage, the company focused on how to develop assembly instructions with AR. A small team with an information designer and an AR expert was formed to develop a mock-up. The design phase was a part of the training plan derived from the needs and technology choices. To be able to use this technology in the business process, a training session was needed on how to perform "knowledge capturing and codification". The competence management system with a focus on job rotation will also be improved using AR.

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4. Implications for industry - towards pathways for Industry 5.0

If we view the different cases side by side, top management involvement and a structured way of work seems to be the enablers with Company B as a role model. Technology development creates a steadily ongoing dynamic adjustment where it is important to see training and competence as a necessary part of the implementation process. However, this seems to be a big challenge in many companies. The trust in the new technologies also needs to be accompanied by the trust of the human, i.e., how to augment the person and the organisation and not dilute the work content or needs of skill. Change appears to be constant due to new technology. However, the same technology is available for all competitors. Hence, the competitive edge needs to come from the skills in the organisation where the human creativity and innovation ability adapting the technology. The concept of Industry 5.0 puts the human in a necessary system context where an Industry 4.0 structure, with the focus on technology adoption, and a well-developed learning development is crucial. The managements' understanding of the system affects the ability to embrace Industry 5.0 as a concept. There is therefore an ambition to develop management training where Industry 5.0 and company ambitions could meet.

The importance of context is very present in our case studies. The facilitated technology exploration and purchase process have led to some deeper learnings in many of the case companies. Despite the differences between the different companies, there are mutual questions that need to be considered on a contextual level. One is in what way the new technology a part of a larger new technology plan? Another is how competent the company is in Change management – the company's ability to implement new technologies and way of working at all levels. The design of the competence and training management system is also of interest. From the cases so far, there could be different processes or sub processes proposed that would be considered in the project. A few questions could be raised:

- What general processes in a company are affected by Industry 5.0?
- How could greater understanding of Industry 5.0 and an articulated process for new technology improve company behaviour and later abilities?
- In the same way that Lean production is based on guiding principles, what do basic Industry 5.0 principles look like in a company?
- How could different (skill-)roles be "dissected" due to new technology to find future appropriate positions (encounters, roles, role relationships, and networks) and job designs?
- Is there an "easy" way to monitor a company's progress and status? For example, what would an Industry 5.0 maturity index based on self-assessment look like?
- What would a generic process with external technology development partners look like?

These questions will be guiding future work.

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