



Learner Centric Advanced Manufacturing Platform



MEGA TRENDS IN ADMA

WPN° 3 Observatory



**Co-funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.



Co-funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.



This work is licensed by the LCAMP Partnership under a Creative Commons Attribution-NonCommercial 4.0 International License.

LCAMP partners:

TKNIKA – Basque VET Applied Research Centre, CIFP Miguel Altuna LHII, DHBW Heilbronn – Duale Hochschule, Baden-Württemberg, Curt Nicolin High School, AFM – Spanish Association of Machine Tool Industries, EARLALL – European Association of Regional & Local Authorities for Lifelong Learning, FORCAM, CMQE: Association campus des métiers et des qualifications industrie du future, MV: Mecanic Vallée, KIC: Knowledge Innovation Centre, MADE Competence Centre Industria 4.0; AFIL: Associazione Fabbrica Intelligente Lombardia, SIMUMATIK AB; Association HVC Association of Slovene Higher Vocational Colleges; TSCMB: Tehniški šolski center Maribor, KPDoNE: Kocaeli Directorate Of National Education; GEBKİM OIZ and CAMOSUN college.



Document summary

Document Type:	Public report
Title	Trends in advanced manufacturing and insights for vet (a view from the Basque country)
Author/S	Hervé DANTON
Reviewer	Camille LEONARD
Date	December 2024
Document Status	Final
Document Level	Confidential until its publication
Document Description	This document describes the main features of the trends in advanced manufacturing and insights for VET
Cite This Deliverable As:	Danton H. Mega trends in ADMA (LCAMP4.0 Deliverable D3.2 Decembre 2024)
Document Level	Public

Version management

Version	Date	Action
0.1	2023-06-15	Draft version, lay out defined
0.5	2023-09-15	Draft version with partners contributions
0.8	2023-10-30	Final version for internal revision
0.9	2023-11-14	Final version for revision process
0.95	2024-11-10	Approval by the steering committee
1	2024-12-09	Version to be uploaded to the EU portal



GLOSSARY AND/OR ACRONYMS

AI - Artificial Intelligence

AM - Advanced Manufacturing

Cedefop - European Centre for the Development of Vocational Training

CoVE - Centres of Vocational Excellence

EaFA - European Alliance for Apprenticeships

EC - European Commission

ECVET - European Credit System for Vocational Education and Training

EntreComp - The Entrepreneurship Competence Framework

EQAVET - European Quality Assurance in Vocational Education and Training

EQF - European Qualifications Framework

ESCO - European Skills, Competences and Occupations

ETF - European Training Foundation

EU - European Union

HE - Higher Education

HVET - Higher Vocational Education and Training

I4.0 - Industry 4.0

KET - Key Enabling Technology

OECD - Organisation for Economic Cooperation and Development

SME - Small and Medium Enterprises

SWOT - Strengths, Weaknesses, Opportunities, Threats

TVET - Technical and Vocational Education and Training

VET - Vocational Education and Training

WBL - Work Based Learning



CONTENT TABLE

- CONTENT TABLE 5
- EXECUTIVE SUMMARY 6
- 1. INTRODUCTION 7
- 2. TOPIC: MEGA TRENDS IN ADMA 8
 - 2.1 Mega trends in advanced manufacturing 8
 - 2.1.1 Main used Sources..... 8
 - 2.1.2 Main Data 10
 - 2.1.3 Data Analysis..... 13
- 3. CONCLUSION 29
- 4. REFERENCES 31
- 5. INDEX OF TABLES 34



EXECUTIVE SUMMARY

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

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

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

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

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

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

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



1. INTRODUCTION

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

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

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

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

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

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

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

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

The publication of a yearly report is planned.

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

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



2. TOPIC: MEGA TRENDS IN ADMA

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

These are topics that concern all or some of the stakeholders

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

2.1 MEGA TRENDS IN ADVANCED MANUFACTURING

Presentation and brief description of the topic.

- All FIELDS are covered / concerned.
- F1: Trends; F2: Impact on jobs; F3: Skills & Qualif; F4: Future Skills
- Topic number 1.1 Mega Trends.
- Geographical Scope: Europe.

2.1.1 MAIN USED SOURCES

Presentation and brief description of main Sources.

- All FIELDS are covered / concerned.
- F1: Trends; F2: Impact on jobs; F3: Skills & Qualif; F4: Future Skills
- Topic number 1.1 Mega Trends.
- Geographical Scope: Europe.
- Type of sources: newspapers, social network, European project, announcements, Scientific articles, Leading companies ...
- Language: English and French.



Table 1 : Main used sources

Identification	type of source: newspaper, website, databases	links	description	Geographical scope.	Sectorial scope
PUBLIC SOURCES					
CORDIS	European data base	https://cordis.europa.eu/search/fr?q=%27advanced%27%20AND%20%27manufacturing%27%20AND%20%27trends%27&p=1&num=10&srt=Relevance:decreasing		Europe	Multisector
TRAINING SOURCES					
EFVET	website	https://www.efvet.org/who-we-are/		Europe	Multisector
CETIM	website	www.cetim.fr https://www.cetim-engineering.com/		Mainly France	Multisector
MINALOGIC	website	https://www.minalogic.com/		EU & Regional France	iT
NCVER Australia	website	www.ncver.edu.au	National Centre for Vocational Education Research Informing and influencing the VET sector	World	Multisector
SKILLMAN	website	https://cordis.europa.eu/search/fr?q=%27advanced%27%20AND%20%27manufacturing%27%20AND%20%27trends%27&p=1&num=10&srt=Relevance:decreasing	European project	Europe	Multisector
PwC	website	www.pwc.com	for European commission	World	Multisector
ECCOE	website	https://eccoe.eu	European Credit Clearinghouse for Opening up Education	Europe	Multisector
CEDEFOP	website	www.cedefop.europa.eu/		Europe	Multisector
INDUSTRIAL SOURCES					
ECCP	website	https://clustercollaboration.eu/	European Cluster collaboration platform	Europe	Multisector
DELOITTE		https://www2.deloitte.com/us/en/insights/focus/industry-4-0.html		World	Multisector
E&Y	website	https://www.ey.com/en_ie/consulting/digital-manufacturing-technology		World	Multisector
i-scoop		https://www.i-scoop.eu/	Reporting on digital transformation, Industry 4.0, Internet of Things, and emerging technologies in context	World	Multisector



Identification	type of source: newspaper, website, databases	links	description	Geographical scope.	Sectorial scope
FORBES	Forbes Technology Council	https://www.forbes.com/		World	Multisector
MAC KINSEY		https://www.mckinsey.com/		World	Multisector

Context and limitations

The review was done on European, General and French sources, in French and English languages. So, the analysis will have to be completed in another step (next Report on next year), by extending the review at all National Sources we can gather.

Why relevant?

Relevant sources are ones mentioning the topic in their archives or documents. Some of our sources don't, or are not relevant, even, if in general, they could be interesting for other topics.

2.1.2 MAIN DATA

Table 2 : Presentation and brief description of DATA

Identification	Date	Topic name	Internet links
PUBLIC SOURCES			
CORDIS		ADMA Trans4mers	https://trans4mers.eu/
CORDIS		Why does the EU support research and innovation for advanced manufacturing?	https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/advanced-manufacturing_en
CORDIS		Making our Workforce Fit for the Factory of the Future	https://cordis.europa.eu/project/id/820701
CORDIS	closed 2017	Skill development and firm upgrading to sustain the competitiveness of the EU manufacturing sector	https://cordis.europa.eu/project/id/660022/reporting
CORDIS		FIT4FoF (Making our Workforce Fit for the Factory of the Future)	https://cordis.europa.eu/project/id/820701/reporting



Identification	Date	Topic name	Internet links
CORDIS		FIT4FoF (Making our Workforce Fit for the Factory of the Future)	https://www.fit4fof.eu/
Orgalim	June 2022	Seizing Europe's opportunity to lead the global manufacturing transformation	www.orgalim.eu
TRAINING SOURCES			
EFVET	2020	EXAM 4.0: Report on Most Relevant Trends for Advanced Manufacturing	https://examhub.eu/
EFVET	January 18, 2021	DTAM: A new EU project to facilitate the digital transformation in advanced manufacturing	https://efvet.org/dtam-a-new-eu-project-to-facilitate-the-digital-transformation-in-advanced-manufacturing/
CETIM	26/07/2022	« IIoT & artificial intelligence: two key tools to optimize your Manufacturing process »	https://www.cetim-engineering.com/free-webinar-iiot-artificial-intelligence-two-key-tools-to-optimize-your-manufacturing-process/
CETIM	18/12/2020	French Mechanical Industry supports the Future European Aerospace Research towards Green Aviation	https://www.cetim-engineering.com/french-mechanical-industry-supports-the-future-european-aerospace-research-towards-green-aviation/
MINALOGIC		SmartEnergy. Accélérez la transition énergétique	https://www.minalogic.com/smartenergy-accelerez-la-transition-energetique/
NCVER Australia		VET's response to Industry 4.0 and the digital economy: what works	www.ncver.edu.au
SKILLMAN	2021	Report On Vet Providers And Educational Challenges In Europe In The Field Of Advanced Manufacturing In The Transport Sector	Www.Skillman.Eu
PwC	janv-20	Curriculum Guidelines 4.0 Future-proof education and training for manufacturing in Europe	https://data.europa.eu/doi/10.2826/69418
ECCOE	July 2022	Quality criteria for credential description	https://eccoe.eu
CEDEFOP	2021	Understanding technological change and skill needsTechnology and skills foresight	
CEDEFOP	2021	Technological change and skill needsBig data and artificial intelligence methods	
CEDEFOP	2021	Understanding technological change and skill needsSkills surveys and skills forecasting	https://www.cedefop.europa.eu/en/publications/4197
INDUSTRIAL SOURCES			
CETIM	mars-18	le guide des technologies de l'industrie du futur	www.cetim.fr
WMF	2019	THE 2019 WORLD MANUFACTURING FORUM REPORT	https://worldmanufacturing.org/report/report-2019/
WMF	2021	THE 2021 WORLD MANUFACTURING FORUM REPORT	https://worldmanufacturing.org/report/report-2021/



Identification	Date	Topic name	Internet links
CORDIS	2017	Assesment of relevant technologies	-
CORDIS	2019	i4EU Handbiok	-
ECCP		CAMT - Centre for Advanced Manufacturing Technologies Poland:	https://clustercollaboration.eu/content/camt-centre-advanced-manufacturing-technologies
DELOITTE		Considering a greenfield manufacturing investment?	https://www2.deloitte.com/us/en/pages/operations/articles/greenfield-manufacturing.html
DELOITTE	23 Jun. 2022	he manufacturing talent shortage: how to appeal to younger workers	https://www2.deloitte.com/us/en/blog/human-capital-blog/2022/manufacturing-talent-shortage.html
DELOITTE		2023 Global Human Capital Trends	https://www2.deloitte.com/us/en/insights/focus/human-capital-trends.html
DELOITTE		Exploring the world of connected enterprises	https://www2.deloitte.com/us/en/insights/focus/industry-4-0/manufacturing-ecosystems-exploring-world-connected-enterprises.html
E&Y		How manufacturers can capture the knowledge of experienced workers	https://www.ey.com/en_ie/alliances/how-manufacturers-can-capture-the-knowledge-of-experienced-workers
E&Y		Why manufacturing is setting the bar for climate-related disclosures	https://www.ey.com/en_ie/climate-change-sustainability-services/why-manufacturing-is-setting-the-bar-for-climate-related-disclosures
i-scoop		Manufacturing and manufacturing technologies – evolutions in convergence	https://www.i-scoop.eu/industry-4-0/manufacturing-sector-manufacturing-technology-evolutions/
FORBES	04,04,2023	Trends Shaping Strategic Recruitment And New Hiring Trends	https://www.forbes.com/sites/forbestechcouncil/2023/04/04/trends-shaping-strategic-recruitment-and-new-hiring-trends/
FORBES		The Top 5 Manufacturing Trends In 2023	https://www.forbes.com/sites/bernardmarr/2023/03/29/the-top-5-manufacturing-trends-in-2023/
MAC KINSEY		Industry 4.0: Reimagining manufacturing operations after COVID-19	https://www.mckinsey.com/capabilities/operations/our-insights/industry-40-reimagining-manufacturing-operations-after-covid-19



Context and presentation

The review was done on European, General and French sources, in French and English languages. So, the analysis will have to be completed in another step by extending the review at all National Sources we can gather.

2.1.3 DATA ANALYSIS

Introduction:

Why does the EU support training and innovation for advanced manufacturing?¹

The manufacturing industry is an important driver of employment and prosperity in Europe. The sector accounts for: 28.5 million people employed in almost 2 million companies, out of which 99.2% are SMEs (small and medium sized companies).

The EU27 has 22% of the world's manufacturing output, yielding a trade surplus in manufactured goods of €421 billion annually. Research institutes and companies in Europe, in particular SMEs are key players in innovation. Manufacturing companies represent 64% of private sector research development expenditure and 49% of innovation expenditure in Europe.

Europe is strong in ADMA (advanced manufacturing) technologies, with the highest share of world patent applications and the highest number of venture capitalist backed firms.

ADMA (advanced manufacturing) represents a Key Enabling Technology for Europe. It uses new knowledge and innovative and cutting-edge technologies such as robotics, 3D printing, artificial intelligence that we will see inside this report, and high-performance computing and modelling, to produce complex products, for examples, machine tools, aircrafts and medical devices. It also optimises processes towards products having no defects, avoiding waste, reducing pollution, material consumption and energy use.

ADMA (advanced manufacturing) will contribute to a competitive, green, digital, resilient and human-centric manufacturing industry in Europe. It will be at the centre of a twin **ecological and digital transition**, being both a driver and subject to these changes.

The 2030 vision for Europe is to reinforce the global position Europe's manufacturing industry in terms of competitiveness, productivity, and technology leadership.

Disruption and transition.²

Global manufacturing and industry are still reeling from the disruption of recent years, with supply chain and workforce disruption still key issues. At the same time, the world is heading

¹ European Commission, « Advanced Manufacturing », 2021, https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/advanced-manufacturing_en.

² Bernard Marr, « The Top 5 Manufacturing Trends In 2023 », Forbes, 2023, <https://www.forbes.com/sites/bernardmarr/2023/03/29/the-top-5-manufacturing-trends-in-2023/>.



into a period of unprecedented economic uncertainty: unexpected and unpredictable. On the face of it, this seems to suggest slowing growth and declining profits.

According to Jacqueline Kehoe, project coordinator from Munster Technological University (Ireland), and Paulo Leitão from the Polytechnic Institute of Bragança, Portugal, for factories of the future, many jobs currently in demand such as big data analysts and cloud services specialists didn't exist 15 years ago, before industry 4.0. Then, data that we amassed on industry 4.0 technology trends, alongside the associated skills requirement, enabled to develop an upskilling analysis tools which identify which skills would help workers adopt new technologies.

The training framework is a fantastic achievement, allowing stakeholders to gather, in person or online, and design a training programme in hours, says Kehoe. Involving workers in its design exceeded employer expectations. Feedback about the results of the framework has been very positive, with all pilot partners indicating they will continue using it.

Advancing Industry 4.0 requires strong cooperation between ecosystem players, suppliers, operators of factories, plants, and warehouses^{3 4}.

The success of Digital Transformation is highly dependent on clear top-down governance. The right governance model provides appropriate levels of coordination and sharing for digital initiatives, in line with the company's structure, culture, and strategic priorities.

No matter the particularities, companies have to assess their vision of the industrial future and then decide how to move forward: pursuing existing strategies with reinforced strength or developing new strategic approaches to successfully emerge from the present uncertainty. Industry 4.0 force manufacturers to rethink how to create value, i.e. to rethink the back-end of their business models. Company leaders should decide on which fundamental drivers to base their business on in the future.

Company leaders thus have to focus on identifying additional skill sets needed for their particular vision of future. Next, they have to develop existing skills or to hire new employees to fulfil these requirements. In terms of people development, the focus should lie on enabling learning all along the career, with flexible working models and blended learning methods.

A major component of successful leadership in Industry 4.0 will be the ability to create a learning organization: the value over time of fact-based knowledge is becoming smaller and smaller in a sector driven by digital innovation. In this context, the attitude and capability to continuously learn will be vital. Company culture should be open and ready to share knowledge. The challenges that Industry 4.0 poses require continuous innovation and learning, which is dependent on people's capabilities.

Industry 4.0 requires a labour force with higher skill levels. Therefore, training and continuous professional development of employees are of major importance to succeed in the early stages of the transition towards digitalization (Kagermann et al., 2013).

The full digital integration and automation of whole manufacturing processes in the vertical and horizontal dimensions imply that workers will be responsible for a broader process scope and

³ « Home EXAM 4.0 », Exam 4.0, 18 mars 2022, <https://examhub.eu/>.

⁴ M FIT4FoF, « Making our Workforce Fit for the Factory of the Future », FIT4FoF, 2023, <https://www.fit4fof.eu/.arr>.



will need the ability to understand relations between processes, the information flows, and to cooperate ad-hoc in finding appropriate solutions for particular problems (Erol et al., 2016).

Most Relevant Trends for Advanced Manufacturing ⁵

Industry 4.0 implies components communication independently with the production system and, if necessary, initiate repairs themselves or reorder material, when people, machines, and industrial processes are intelligently networked.

In the factory in Industry 4.0, intelligent machines independently coordinate production processes; service robots support people in assembly, automated guided transport vehicles take care of logistics and material flow independently. Networking does not only take place within "intelligent factories", but across company and industry boundaries - between different actors in the economy: From medium-sized logistics companies to specialized technical service providers to creative start-ups.

The use of digital technologies in the industry will result in a multitude of new production processes, business models, and products. For example, a production line has no longer to be restricted to one product.

Mass-customization will have an impact on the design and product portfolio, supply chain management, and operations. This will change the requirements for industrial production or ADMA (advanced manufacturing). New manufacturing concepts and IT-technologies will make it possible to flexibly adapt processing stations to a changing product mix.

Contextualisation

Questions about megatrends⁶

The 2019 World Manufacturing Forum Report: Skills for the Future of Manufacturing aims to explore in detail the skills gap phenomenon widely felt in the sector, identify the top skills needed by manufacturing workers, outline the main mechanisms in skills assessments and development.

The rapid pace of technological innovation is continuously changing the skill sets required to effectively perform roles within manufacturing. The lack of, and inability to acquire the necessary skills and competencies amplify skill gaps in workers and as a result, the industry is having increased difficulty in finding the necessary talent to fill manufacturing roles.

The 2019 WMF Report examines the key evidence regarding the existence of skill gaps such as changing jobs in manufacturing, lack of required skills among workers, difficulty in finding talent.

Then, It analyses key underlying causes of the skills gap such as the introduction of ADMA (advanced manufacturing) technologies and automation, challenges in the education system, disconnect between companies and institutions, lack of efficient training programmes,

⁵ « Home EXAM 4.0 », Exam 4.0, 18 mars 2022, <https://examhub.eu>

⁶ WMF, « Report 2019: Skills for the Future of Manufacturing », World Manufacturing Foundation, 13 novembre 2019, <https://worldmanufacturing.org/report/report-2019/>.



misperceptions of manufacturing jobs, demographic trends such as ageing population, and the lack of versatile skill sets in workers. The impacts of the skills gap on competitiveness of the sector.

The 2019 WMF Report outlines the Top Ten Skills for the Future of Manufacturing that the WMF believes increasingly relevant for workers to stay competitive in the years to come. The skills have been identified keeping in mind the particularity of manufacturing and are intended to apply to a wide group of workers within the sector.

Identifying skills and competencies creates the impetus to identify the mechanisms to assess and develop those skills. The 2019 WMF Report outlines the importance of skills assessments and the need for sustainable Human Resource Management (HRM) strategies in companies.

Objectives / research question / problem statement:

Research question

Considering digital skills delivery within TVET (Technological Vocational Education & Training),⁷

- What would be relevant for the VET system?
- What would work or wouldn't work in the context?
- Should more digital skills-related elective units become core units?
- What criteria should be used to determine whether a unit is core or elective?
- Is embedding digital skills into courses feasible and how would it work?
- What elements constitute good practice in developing specific digital skills-related qualifications?
- Could modular training or shorter digital skills-related courses work in the VET system and are there any implications for quality?
- What are the implications for VET providers of a move to more digital forms of learning?

Considering Workforce development for VET educators,

- What are providers currently doing to assist VET educators to build digital skills capability and what could they do more of to facilitate this?
- Do VET educators need additional training in digital skills, either general or industry-specific, apart from maintaining industry currency?
- What approaches can be applied to ensure the integrity of competency-based assessment using digital tools?
- Do the elements described in the European Framework for Digitally Competent Educational Organisations (DigCompOrg) have relevant?

⁷ National Centre for Vocational Education Research, « NCVER », NCVER (National Centre for Vocational Education Research, 19 décembre 2022), <https://www.ncver.edu.au/>.



Advancing Industry 4.0 requirements⁸

Should it be:

- an innovation-driven one, based on a strong partner network and Smart Innovation processes, whilst outsourcing major physical production processes?
- an extremely agile production focusing on customized products in batch sizes of one, enabled by Smart Factories?
- an efficiency-driven one, with low prices and market-beating lead times, made possible by a Smart Supply Chain?
- a service-based one, transforming the manufactured product to serve only as of the source for valuable data and the door-opener to a wealth of Smart Services around it which form the actual value proposition?

Findings:

Five statements are emerging from sources and data analysis:

- More connected companies and more IA inside processes
- Development of cybersecurity and standards
- More Human-centered concerns in technologies 4.0
- Greener ADMA and Energy transition in ADMA
- Introduction of circular economy in ADMA.

Exploring the world of connected enterprises⁹

The marriage of advanced manufacturing techniques with information technology, data, and analytics is driving another industrial revolution—one that invites manufacturing leaders to combine information technology and operations technology to create value in new and different ways.

Re-imagining Manufacturing after pandemic and economic crisis

Business

The first step is a clear articulation of the company's desired future state, which is linked to business strategy and goals rather than the technology with the greatest buzz.

⁸ « Home EXAM 4.0 », Exam 4.0, 18 mars 2022, <https://examhub.eu>

⁹ Brenna Sniderman, Monika Mahto, et Mark Cotteleer, « Industry 4.0 and Manufacturing Ecosystems », Deloitte Insights, 23 février 2016, <https://www2.deloitte.com/content/www/us/en/insights/focus/industry-4-0/manufacturing-ecosystems-exploring-world-connected-enterprises.html>.



Outlining a clear business case becomes more complicated when expanding beyond the four walls of the factory, but is even more important. For example, supply-chain integration reaps savings when factoring in hidden costs that often are not explicitly accounted for. Understanding these issues helps organizations formulate a positive business case that will convince suppliers to embark on an integration journey.

Technology.10

Many, if not most, companies will want to assess their current IT systems, upgrading them to deliver the horsepower that advanced use cases in digital and analytics depend on—particularly to support the Internet of Things. A scalable, obsolescence-resistant IT stack is essential. Similarly, upgrades of suppliers' IT systems might be required for end-to-end horizontal integration of data.

For upgrading the IT tech stack and implementing multiple use cases, companies can leverage external technology providers by creating an ecosystem of partners that can help them execute the digital transformation. Partnership models can vary among outsourcing, acquisitions, and strategic alliances, with successful ecosystems integrating a mix of start-ups and established technology and service providers.

Trends and change management in the five functional areas of Industry

4.0.

An "I4.0 functional area" summarizes the applications in the company related to Advanced Manufacturing management processes (Zhong et al., 2017). They can be understood as cross-functions or I4.0 core processes within corporate divisions and are valid such as production, logistics, and maintenance functions.

The five "I4.0 functional area" are:

- Data acquisition and processing
- Assistance systems
- Networking and integration
- Decentralization and Service orientation
- Self-organization and autonomy.

Data acquisition and processing¹¹ form the basis for Industry 4.0. The functional area includes the collection and evaluation of data on processes, quality, products, means of production, employees as well as their environment. Central for Industry 4.0 is the IT-based data acquisition of a customer, product, production, and usage data. In the functional area of data acquisition and processing, the key focus is on discontinuous data evaluations, e.g. the

¹⁰ Mayank Agrawal et al., « Industry 4.0: Reimagining manufacturing operations after COVID-19 | McKinsey », McKinsey, 29 .02. 2020, <https://www.mckinsey.com/capabilities/operations/our-insights/industry-40-reimagining-manufacturing-operations-after-covid-19>.

¹¹ CEDEFOP, « Understanding Technological Change and Skill Needs: Big Data and Artificial Intelligence Methods », CEDEFOP, 12 avril 2021, <https://www.cedefop.europa.eu/en/publications/4198>.



consideration of the overall plant effectiveness down to big data analysis. The goal is a constant process or quality improvement.

Key elements:

- Sensor technology / RFID / barcode
- (big data) analysis & Ai
- Documentation and data management
- Simulation (product, production, plants, from candle to cradle method as Meman Project¹², etc.)

Data security: Assistance systems aim to make it as easy and quick as possible for the employee, anytime, anywhere to provide the information required on the shop floor. In the functional area of assistance systems all technologies are summarized, to support and enable the employees in the execution of their work and get them concentrated on their core tasks. These are in particular, technologies for the provision of information such as visualization systems, mobile devices, tablets, and data glasses or tools that perform calculations or provide support in the human-machine interaction.

Key elements:

- Visualization, augmented reality
- Mobile devices
- Human-machine interaction
- 3D printing / scan / prototypes.

Simulation (product, production etc.): The networking and integration between departments within a company (vertical integration) but also between different companies (horizontal integration) is a central element of the Industry 4.0 vision. The goal of digital networking is to improve collaboration, coordination, and transparency across the divisions as well as along the delivery and value chain. The functional area includes cross-departmental cooperation within the company and cross-company cooperation in value creation networks. It includes the approaches of cloud computing and the internet of things.

Key elements:

- Vertical and horizontal integration
- Flexible networking of systems, processes, and products
- Cloud computing
- Internet of Things & Ai.

¹² « MEMAN Home », MEMAN, 2018, <http://www.meman.eu/>.



French Cetim experts¹³ focus on how innovation, based on the use of industrial internet of things and artificial intelligence tools, generate values and reduce the capital and operating expenses.

Decentralization & service orientation is the key driver for changing Industry 4.0 business models. Industry 4.0 induces the change from central control to decentralized process responsibility and from product orientation to customer/service orientation. The functional area decentralization and service orientation, therefore, include the modularization of products and processes, decentralized control, and the change to a service orientation. Decentralization enables clear coordination and makes complexity manageable as the control task no longer has to be done in one place only.

Key elements:

- Apps, web service
- New business models
- Service orchestration
- Decentralized control
- Versatility.

In the **Self-organization and autonomy functional area**, the vision of Industry 4.0 – that the intelligent ‘system’ controls its own production – becomes reality. Technologies and processes are combined, which carry out an automatic data evaluation, and based on the results the systems react independently. Such control loops can be used for example, for self-configuration and self-optimization of systems up to complete self-organization. The ability to self-organize and control is an important characteristic of cyber-physical systems, that communicate with each other in addition to the collection, evaluation, and storage of data and having an own identity and interact with their surroundings. Examples of such autonomous systems are intelligent, flexible driverless transport systems (AGVs) solutions in intralogistics or intelligent containers, triggering automatic reordering.

Key elements:

- Control loops / self-organization
- Self-configuration / optimization
- Cyber-physical systems
- Process monitoring.

The Institutions' Future Scenario ¹⁴

¹³ Cetim, « Free Webinar: « IIoT & Artificial Intelligence: Two Key Tools to Optimize Your Manufacturing Process » - Cetim Engineering % », *Cetim Engineering* (blog), 26 juillet 2022, <https://www.cetim-engineering.com/free-webinar-iiot-artificial-intelligence-two-key-tools-to-optimize-your-manufacturing-process/>.

¹⁴ « Home EXAM 4.0 », Exam 4.0, 18 mars 2022, <https://examhub.eu>



The institution's task will not only be to develop or further develop the education and training profiles for I4.0 in cooperation with the world of work involved, but also to promote the establishment of new forms of learning in HVET/VET institutions and companies.

One way to make the various qualifications transparent, understandable and comparable is to describe them in terms of learning outcomes.

It is widely understood at the institutional and world of work level, that the overall competence for mastering digital/ advanced manufacturing cannot be summarised in one person or one training profile. Digitization and Advanced Manufacturing require increased collaboration in mixed teams. The development and establishment of team-related competences and skills are a major challenge for training and education. To this end, new forms of education, training, and further training are to be developed that enable accompanying training of specialists at all levels. Institutional learning in seminars will be complemented by situational and experimental learning in labs and during apprenticeships. Continuing education and training are to be established in an everyday part of the work in an entrepreneurial context and established through appropriate offers for all ages and training levels.

Cybersecurity in ADMA¹⁵

With Industry 4.0, there is a change in progress in manufacturing systems, provided by the development of communication and information technologies, adding an intelligence component in manufacturing plants, through the possibility of connectivity and interaction throughout the production chain (intelligent manufacturing systems or cyber-physical systems). However, this new paradigm has an extremely sensitive component, which is the question of the security of the data that is transferred and of the production processes itself.

Re-imagining Manufacturing after pandemic and economic crisis

Few digital transformations can succeed without putting people at the center. Four factors provide crucial support¹⁶.

- **Governance.** A digital transformation without a clear owner can end up as an orphan. A cross-functional team and governance structures then help ensure quick execution.
- **Top-management commitment.** Transformations are more likely to take hold when they are driven by top leaders, with a compelling change story to help mobilize the organization. To keep the momentum from flagging, leaders can celebrate quick wins—as well as failures that help the company learn to fail fast and learn fast.

¹⁵ Armando Araújo de Souza Junior et al., « The State of Cybersecurity in Smart Manufacturing Systems: A Systematic Review », *European Journal of Business and Management Research* 6, n° 6 (16 décembre 2021): 188-94, <https://doi.org/10.24018/ejbmr.2021.6.6.1173>.

¹⁶ Agrawal et al., « Industry 4.0: Reimagining manufacturing operations after COVID-19 | McKinsey ».



- **Digital capability acquisition.** Skills gaps can be addressed by hiring where necessary, as well as by upskilling existing employees to fulfil even advanced digital roles, such as analytics translator, data engineer, data scientist, or IoT architect.
- **New ways of working.** Implementing agile working methodologies empowers teams with the tools, processes, and best practices for achieving success in a digital world.

Trends Shaping Strategic Recruitment and New Hiring Trends¹⁷

The HR industry is being shaped by a number of emerging trends, including advancements in technology, cost savings, globalization, work-life balance, access to a wider pool of candidates, environmental concerns, resilience, business continuity and, most recently, behavioral science

Z Generation, Younger Workers and new ways of training^{18 19}

While younger workers have grown up as digital natives, a significant section of the workforce needs to be upskilled in the use of the latest technologies. Specialists call to increase awareness and knowledge about the benefits of digitalisation, as well employers to increase staff engagement in managing their own skills development. This can be supplemented with support for the sharing of industry best practice training initiatives, especially shorter and modular versions.

Acquiring new skills and competencies require inventive approaches and collaboration among different actors. While approaches such as outsourcing and novel recruitment methods are prevalent, we have to focus on training and education to develop the skills and competencies in the manufacturing workforce.

Different mechanisms are identified such as educational design, use of technology to improve learning outcomes such as digital learning platforms, mobile learning, virtual and augmented reality and (**collaborative**) learning factories (to see on specific TOPIC 1.7.6 & 1.7.7.). Interventions will ensure the participation of older workers, women and other lesser-represented groups.

2023 Global Human Capital Trends ²⁰

¹⁷ Raghu Misra, « Council Post: Trends Shaping Strategic Recruitment And New Hiring Trends », Forbes, 2023, <https://www.forbes.com/sites/forbestechcouncil/2023/04/04/trends-shaping-strategic-recruitment-and-new-hiring-trends/>.

¹⁸ FIT4FoF, « Making our Workforce Fit for the Factory of the Future », FIT4FoF, 2023, <https://www.fit4fof.eu/>.

¹⁹ WMF, « Report 2019 ».

²⁰ Deloitte, « 2023 Global Human Capital Trends », Deloitte Insights, s. d., <https://www2.deloitte.com/us/en/insights/focus/human-capital-trends.html>.



- **Framing the challenge.** Think like a researcher: Organizations and workers should activate their curiosity, looking at each decision as an experiment that will expedite impact and generate new insights.
- **Charting a new path.** Co-create the relationship: Organizations and workers will need to learn to navigate this new world together - co-creating new rules, new boundaries, and a new relationship.
- **Designing for impact.** Prioritize human outcomes: Organizations should create an impact not only for their business, their workers, or their shareholders but for the broader society as well.

Manufacturing talent shortage: how to appeal to younger workers ²¹

Top three considerations of those surveyed from the younger generation related to manufacturing jobs:

- **Flexibility.** 63% of the surveyed younger workforce are likely to consider a career in the manufacturing industry if offered more flexibility in shift timings and locations. Manufacturers should continue to implement additional programs, such as shift swapping, flexible core hours, and reducing overtime requirements, among others.
- **Focus on career growth and development.** 60% of the surveyed younger workforce indicated that having a clear growth path is one of the factors that would encourage them to choose a manufacturing job. Yet, the study emphasizes that recent science, technology, engineering, and math graduates may not recognize the opportunity the manufacturing industry can provide them to use their skills and build a career path and so are less inclined to pursue a career in manufacturing. Employers could work with potential hires to provide greater emphasis on programs to build digital and technical skillsets.
- **Well-being.** According to this analysis, well-being has become an increasingly important aspect of workforce experience in the last year. Manufacturers can address well-being by increasing investments in transforming the physical working environment, including the actual workspace, tools, and equipment.
- **Diversity, equity, and inclusion (DE&I).** 33% of the surveyed workforce selected the ability to be their authentic self as one of the most important factors in their workplace experience. According to a recent Deloitte report, the current generation is the most

²¹ Deloitte, « Addressing Manufacturing Talent Shortage », Deloitte United States, 23 juin 2022, <https://www2.deloitte.com/us/en/blog/human-capital-blog/2022/manufacturing-talent-shortage.html>.



ethnically and racially diverse generation in history. Having a robust DE&I strategy that factors in an organization's influence across the workforce, marketplace, and society can be an effective way to attract younger workers.

The opportunity exists for manufacturers to capitalize on this moment and deliver many of the things younger workers want: flexible work schedules, defined career pathways, and greater support for well-being and DE&I. By listening to this next generation of the workforce, manufacturing can capture a greater share of prospective employees and lay the groundwork for a strong industry future.

How manufacturers can capture the knowledge of experienced workers ²²

Digital presents a massive opportunity for manufacturers to capture experienced workers' knowledge. When a manufacturer builds models that combine shop floor data with the intuition of knowledge workers, it can generate truly powerful insights.

Understanding technological change and skill needs ²³

The skills required by jobs are diverse and multidimensional, and they can be specified in potentially infinite levels of details. No survey or study can capture all skills involved in a particular job because any description of what a job entails can always be enriched with further details. There is also a tension between detail and comparability across occupations: very detailed measures tend to be occupation-specific, while overly general measures risk being weakly informative. The key is to measure transversal skills and to devise measures pitched at a mid-level of generality that are relevant across a range of occupations. It should also include a reasonably concise checklist of more specific requirements, such as an inventory of digital skills, which are particularly relevant for research and policy. Most of the interest in skills and job-skill requirements typically focuses on a division of the concept at a most general level into cognitive, interpersonal, and manual skills.

Interpersonal or 'soft' skills have proven to be weakly conceptualised, as they also often include more purely attitudinal and motivational aspects of work orientations (Moss and Tilly, 2001). By contrast, cognitive and manual skills tend to be more concisely measured and are usually associated with robust labour market outcomes for individuals.

²² EY, « How Manufacturers Can Capture the Knowledge of Experienced Workers », EY, 15 septembre 2021, https://www.ey.com/en_ie/alliances/how-manufacturers-can-capture-the-knowledge-of-experienced-workers.

²³ CEDEFOP, « Understanding Technological Change and Skill Needs: Skills Surveys and Skills Forecasting », CEDEFOP, 12 avril 2021, <https://www.cedefop.europa.eu/en/publications/4197>.



Education and training for manufacturing in Europe ²⁴

The main emphasis still needs to be put on the technical skills forming the core of this profession. Those include the ability to interact with human-machine interfaces, data management skills, and specialised and interdisciplinary knowledge of technologies and processes. However, rapidly advancing technology requires a general mind-set for continuous improvement and lifelong learning. It is no longer just about what one knows, but increasingly about one's ability to adapt to continuously changing circumstances and to constantly advance one's knowledge and skills. Focussing on technical skills only is thus not enough. Other crucial non-technical skills refer, among others, to critical thinking, creativity, communication skills and ability to work in teams.

There is a need for creating hands-on opportunities within education systems, as well as close collaboration of business and educational institutions. Additionally, there is a need for offering learners real-world experience, exposing them to real challenges and advancements of industry and focussing on real-world application of skills. Finally, special attention needs to be paid to the developing and elevating micro-credentialing programs for students and workers and exploring new/alternative forms of education and training.

Some existing tools are now developed:

Skill development and firm upgrading to sustain the competitiveness of manufacturing sector ²⁵

SkillUp contributed to research on skills in manufacturing sectors in European advanced economies in the following aspects:

Theory: SkillUp provides a systematic view of new trends manufacturing and services for Industry 4.0. SkillUp develops a new conceptual framework in terms of types of workers of today and tomorrow. It connected so-far distant literatures on global value chain with learning and skills development in relation to upskilling and upgrading in advanced economies. The research defined a systemic, inter-disciplinary view of a fragmented literature on the global reorganisation of production activities in the manufacturing industries in advanced economies.

Empirics: SkillUp provides rigorous research and evidence-based findings on which skills are needed for today and tomorrow's jobs.

Methods: SkillUp tackles limitation of standard methods by using new methodologies by allowing methods that accept the equifinality of different combinations, and possible redundancy of elements.

²⁴ Executive Agency for Small and Medium-sized Enterprises (European Commission) Now known as et al., *Skills for Industry Curriculum Guidelines 4.0: Future Proof Education and Training for Manufacturing in Europe* (LU: Publications Office of the European Union, 2019), <https://data.europa.eu/doi/10.2826/69418>.

²⁵ « Periodic Reporting for period 1 - SkillUp (Skill development and firm upgrading to sustain the competitiveness of the EU manufacturing sector) | H2020 | CORDIS | European Commission », HORIZON 2020, 17 septembre 2017, <https://cordis.europa.eu/project/id/660022/reporting>.



Making our Workforce Fit for the Factory of the Future : FIT4FoF ^{26 27}

Increased introduction of digital technologies into manufacturing is leading to increased automation. Estimates indicate that the potential for automation in predictable physical work is at 33% followed by 22% in data collection and 11% in data processing.

The increased globalisation in manufacturing also introduces requirements in terms of team work, intercultural and language capabilities, the need to deal with shorter production cycles, and changes in demographics requiring workers to stay active for longer.

Europe faces considerable challenges in addressing future skills needs. From the perspective of the workforce the issues are increasingly complex where current training and educational solutions are discrete and lack interconnections and are largely dissociated from work activities. Growing gaps in knowledge and know-how make it increasingly challenging to adapt, work proactively and contribute to innovations.

FIT4FoF aims at addressing a range of these issues by analysing current skills initiatives, better to understand how to address workers' needs, analysing technology trends across six industrial areas of robotics, additive manufacturing, mechatronics/machine automation, data analytics, cybersecurity and human machine interaction, to define new job profiles, which will inform education and training requirements.

FIT4FoF develops a new education and training framework, which places workers (women and men) at the centre of a co-design and development process that recognises and addresses their skills needs.

By applying educational approaches based on Communities of Practice, FIT4FoF empowers workers to be drivers of the design, development and delivery of their own upskilling programmes.

FIT4FoF develops Alliances of Communities of Practice to broaden the approach across Europe, creating replication strategies enabling educational/training design and development practices to be transferred between regional communities across Europe.

FIT4FoF focuses on engaging workers in the design of upskilling programmes for the manufacturing sector. Their partners identified a catalogue of 117 emerging new job profiles, developed a repository of existing upskilling initiatives and captured this within a novel Upskilling Analysis Tool to support the rapid analysis of the upskilling needs.

To answer these needs, FIT4FoF places workers at the centre of a collaborative process using co-design, to changes the dynamic between employers and educators in a manner enables the voice of the employee/learner to be amplified.

²⁶ Cordis, « Co-designed training for factory of the future jobs | FIT4FoF Project | Results in brief | H2020 | CORDIS | European Commission », Cordis, 31 décembre 2021, <https://cordis.europa.eu/article/id/436472-co-designed-training-for-factory-of-the-future-jobs>.

²⁷ Cordis, « Making our Workforce Fit for the Factory of the Future | FIT4FoF Project | Fact Sheet | H2020 | CORDIS | European Commission », Cordis, 31 décembre 2021, <https://cordis.europa.eu/project/id/820701>.



As an easy-to-use process, it becomes possible for companies, clusters, and other stakeholders to design and execute their own upskilling programs using the project toolkit to adapt for industrial context, language, culture and needs.

Considering a greenfield manufacturing investment? ²⁸

As every industry faces unique market forces, global manufacturing is experiencing four paradigm shifts: enhanced market competition, supply chain and workforce disruption, evolving customer tastes, and new sustainability expectations. Turn these challenges into opportunities by developing greenfield manufacturing sites with smart factory solutions.

Why manufacturing is setting the bar for climate-related disclosures ²⁹

The majority of manufacturing companies scores highly for coverage of the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. Most companies are beginning to provide information on their approach to incorporating scenario planning as part of their climate strategy development.

French Mechanical Industry supports the Future European Aerospace Research towards Green Aviation ³⁰

Aeronautics must respond to three challenges – environmental, economic and societal – that require and justify an unprecedented R&T effort.

This sector is strongly committed to the energy transition and the reduction of its environmental impacts. In response to market expectations, the manufacturing tool must evolve in technicality and productivity to reduce acquisition and operating costs while preserving margins. The Supply Chain, especially SMEs, must continue to develop its skills in a highly competitive environment.

SmartEnergy project: Accelerate the energy transition ³¹

This MINALOGIC Innovation cluster project aims at companies in the world of Smart Energy: to develop innovative solutions at the crossroads between digital and energy, and to support

²⁸ Deloitte, « Greenfield Manufacturing », Deloitte, Deloitte United States, s. d., <https://www2.deloitte.com/us/en/pages/operations/articles/greenfield-manufacturing.html>.

²⁹ Mathew EY, « Manufacturing Sets Bar for Climate-Related Disclosures », EY, 1 juin 2020, https://www.ey.com/en_ie/climate-change-sustainability-services/why-manufacturing-is-setting-the-bar-for-climate-related-disclosures.

³⁰ Fanny, « French Mechanical Industry Supports the Future European Aerospace Research towards Green Aviation - Cetim Engineering % », *Cetim Engineering* (blog), 18 décembre 2020, <https://www.cetim-engineering.com/french-mechanical-industry-supports-the-future-european-aerospace-research-towards-green-aviation/>.

³¹ Minalogic, « SmartEnergy. Accélérez la transition énergétique », Minalogic, 21 avril 2020, <https://www.minalogic.com/smartenergy-accelerez-la-transition-energetique/>.



energy efficiency and performance, energy and ecological transition, intelligent distribution of energy, Smart Grids, etc.

Tools are now developed:

DTAM³²: A new EU project to facilitate the digital transformation in advanced manufacturing.

DTAM creates an Integral Training Curriculum for EU technicians to deploy and manage digital tools in Smart Manufacturing.

iT4.0 report on Industry4.0 for Ecological Transition³³

This European ERASMUS project aims to present Industry 4.0 technologies to help Ecological Transition.

Circular economy³⁴

The focus is based on digital technologies potential to enable circular manufacturing, and policy and other enablers for circular manufacturing.

The circular economy paradigm is becoming increasingly relevant as more and more companies realise the real value and profitability of this new, more sustainable way of doing business. The circular economy relies on several strategies that extend the product life cycle through reusing, recycling, remanufacturing, and redesigning circular products and materials, with a view to reducing waste. This Report identifies key drivers to the circular economy, which include global initiatives such as the UN Sustainable Development Goals and other policy developments, innovation, collaboration across stakeholders, and business drivers. However, challenges need to be addressed such as the uptake of new business models, adequate standards and laws, and financial incentives, among others. Nevertheless, the benefits for manufacturers are profound, such as increased economic opportunities for manufacturers, a reduction in waste, the creation of more and better jobs, and a contribution to alleviating climate change.

Digital technologies are an important catalyst to achieve circularity in manufacturing value chains. Digitally enabled circular manufacturing supports three key objectives: resource efficiency, waste reduction, and reduced emissions. As outlined in the Report, digital technologies can support the transition to circular manufacturing at the firm level - which includes product development, production, and new business models - as well as at the network level.

The transition to circular manufacturing is a priority for many governments globally. Regional and national strategies to promote circularity vary in ambition, approach, and the emphasis put

³² « DTAM: A New EU Project to Facilitate the Digital Transformation in Advanced Manufacturing - European Forum for Vocational Education & Training », 18 janvier 2021, <https://efvet.org/dtam-a-new-eu-project-to-facilitate-the-digital-transformation-in-advanced-manufacturing/>.

³³ « Project iET 4.0 », iet 4.0, s. d., <https://iet40.eu/>.

³⁴ WMF, « Report 2021: Digitally Enabled Circular Manufacturing », World Manufacturing Foundation, 1 juillet 2021, <https://worldmanufacturing.org/report/report-2021-digitally-enabled-circular-manufacturing/>.



on the enabling role of digital technologies. The Report identifies key enablers for the circular manufacturing transition. Enablers at the consumer level include environmental awareness, increasing trust and transparency in relation to service providers, convenience and accessibility of sustainable products, and digital literacy. At the company level, enablers include demand for sustainable products, digital technologies, and circular skills, among others. At the value chain level, there is a need to improve data sharing, enhancing infrastructure and networks, and standardisation of requirements.

3. CONCLUSION

So, five statements are mega trends for Advanced Manufacturing:

- Companies and SMEs will be more and more connected and there will be more IA inside technological processes
- Cybersecurity will spread off everywhere
- Human will be in the centre of Advanced Manufacturing
- ADMA will become greener and greener and Energy transition will develop in Advanced Manufacturing
- Circular economy will be introduced at each step in Advanced Manufacturing.

1. Companies and SMEs will be more and more connected and there will be more IA inside technological processes

Companies working in Advanced Manufacturing are and will become more and more connected, using more and more 4.0 Technologies, with a great introduction of Artificial Intelligence, as for Predictive Maintenance (To see in Specific Topic on Predictive Maintenance). They will be more connected inside their own company, and they will be more connected between them.

Training and present or future courses will have to take into account these technological mega-trend.

2. Cybersecurity will spread off everywhere

So, cyber threads will be more and more pregnant, because of more connected companies, strong developments in IA and digital tools, inside companies and between them.

Cybersecurity will be strategic, to see on Specific Topic. Training and present or future courses will have to take into account these mega-trend, in each credential.

3. Human will be in the centre of Advanced Manufacturing

Industry 4.0 is introducing IA and digital tools, inside companies and between them for more than 15 years in Europe. More recently, due to developments in several countries, Human is becoming a real subject in the heart of Industry 4.0, at the point that some people use the new concept of Industry 5.0. Maybe it is more a 4.1 evolution of Industry 4.0. To discuss.



4. ADMA will become greener and greener and Energy transition will develop in Advanced Manufacturing

One of new and other evolution of Industry, and of Advanced Manufacturing, is the greening of them, with a strong commitment of Energy Transition, to accompany Ecological Transition.

This evolution could be either 4.2 one of Industry 4.1 if Human-centered evolution is 4.1. Or either reverse number. Consecutively, Industry 4.0 is becoming more Human-centered and greener. Training and present or future courses will have to take into account these evolutions.

5. Circular economy will be introduced at each step in Advanced Manufacturing.

Last and newer other evolution of Industry, and of Advanced Manufacturing, could be the introduction of circular economy inside them.

This evolution could be either 4.3 one of Industry 4.0, if Human-centred and greening evolution are 4.1 and 4.2 ones. Training and present or future courses will have to take into account these mega trending evolutions.



4. REFERENCES

- ADMA TRANS4MERS. « ADMA TRANS4MERS », s. d. <https://trans4mers.eu/>.
- Agrawal, Mayank, Karel Eloot, Matteo Mancini, et Alpesh Patel. « Industry 4.0: Reimagining manufacturing operations after COVID-19 | McKinsey ». McKinsey, 29 février 2020. <https://www.mckinsey.com/capabilities/operations/our-insights/industry-40-reimagining-manufacturing-operations-after-covid-19>.
- CAMT. « CAMT - Centre for Advanced Manufacturing Technologies | European Cluster Collaboration Platform ». CAMT, s. d. <https://clustercollaboration.eu/content/camt-centre-advanced-manufacturing-technologies>.
- CEDEFOP. « Understanding Technological Change and Skill Needs: Big Data and Artificial Intelligence Methods ». CEDEFOP, 12 avril 2021. <https://www.cedefop.europa.eu/en/publications/4198>.
- . « Understanding Technological Change and Skill Needs: Skills Surveys and Skills Forecasting ». CEDEFOP, 12 avril 2021. <https://www.cedefop.europa.eu/en/publications/4197>.
- Cetim. « Free Webinar: « IIoT & Artificial Intelligence: Two Key Tools to Optimize Your Manufacturing Process » - Cetim Engineering % ». *Cetim Engineering* (blog), 26 juillet 2022. <https://www.cetim-engineering.com/free-webinar-iiot-artificial-intelligence-two-key-tools-to-optimize-your-manufacturing-process/>.
- . « French Mechanical Industry Supports the Future European Aerospace Research towards Green Aviation - Cetim Engineering % ». *Cetim Engineering* (blog), 18 décembre 2020. <https://www.cetim-engineering.com/french-mechanical-industry-supports-the-future-european-aerospace-research-towards-green-aviation/>.
- . « Le Cetim, centre technique de la Fédération des industries mécaniques ». Cetim, s. d. <https://www.cetim.fr/>.
- Cordis. « Co-designed training for factory of the future jobs | FIT4FoF Project | Results in brief | H2020 | CORDIS | European Commission ». Cordis, 31 décembre 2021. <https://cordis.europa.eu/article/id/436472-co-designed-training-for-factory-of-the-future-jobs>.
- . « Making our Workforce Fit for the Factory of the Future | FIT4FoF Project | Fact Sheet | H2020 | CORDIS | European Commission ». Cordis, 31 décembre 2021. <https://cordis.europa.eu/project/id/820701>.
- . « Periodic Reporting for period 1 - SkillUp (Skill development and firm upgrading to sustain the competitiveness of the EU manufacturing sector) | H2020 | CORDIS | European Commission ». HORIZON 2020, 17 septembre 2017. <https://cordis.europa.eu/project/id/660022/reporting>.
- Deloitte. « 2023 Global Human Capital Trends ». Deloitte Insights, s. d. <https://www2.deloitte.com/us/en/insights/focus/human-capital-trends.html>.
- . « Addressing Manufacturing Talent Shortage ». Deloitte United States, 23 juin 2022. <https://www2.deloitte.com/us/en/blog/human-capital-blog/2022/manufacturing-talent-shortage.html>.



- . « Greenfield Manufacturing ». Deloitte. Deloitte United States, s. d. <https://www2.deloitte.com/us/en/pages/operations/articles/greenfield-manufacturing.html>.
- . « Industry 4.0 and Manufacturing Ecosystems ». Deloitte Insights, s. d. <https://www2.deloitte.com/content/www/us/en/insights/focus/industry-4-0/manufacturing-ecosystems-exploring-world-connected-enterprises.html>.
- « DTAM: A New EU Project to Facilitate the Digital Transformation in Advanced Manufacturing - European Forum for Vocational Education & Training », 18 janvier 2021. <https://efvet.org/dtam-a-new-eu-project-to-facilitate-the-digital-transformation-in-advanced-manufacturing/>.
- ECCOE. « Home ECCOE ». ECCOE, 30 novembre 2022. <https://eccoe.eu/>.
- European Commission. « Advanced Manufacturing ». European Commission, 2021. https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/advanced-manufacturing_en.
- Executive Agency for Small and Medium-sized Enterprises (European Commission) Now known as, PwC, Kristina Dervojeda, Anton Koonstra, Marte Andresen, Naveen Srivatsav, et Jan Willem Velthuisen. *Skills for Industry Curriculum Guidelines 4.0: Future Proof Education and Training for Manufacturing in Europe*. LU: Publications Office of the European Union, 2019. <https://data.europa.eu/doi/10.2826/69418>.
- EY. « How Manufacturers Can Capture the Knowledge of Experienced Workers ». EY, 15 septembre 2021. https://www.ey.com/en_ie/alliances/how-manufacturers-can-capture-the-knowledge-of-experienced-workers.
- EY, Mathew. « Manufacturing Sets Bar for Climate-Related Disclosures ». EY, 1 juin 2020. https://www.ey.com/en_ie/climate-change-sustainability-services/why-manufacturing-is-setting-the-bar-for-climate-related-disclosures.
- FIT4FoF. « Making our Workforce Fit for the Factory of the Future ». FIT4FoF, 2023. <https://www.fit4fof.eu/>.
- iet 4.0. « Project iET 4.0 », s. d. <https://iet40.eu/>.
- i-SCOOP. « Manufacturing and Manufacturing Technologies - Evolutions in Convergence ». i-SCOOP, s. d. <https://www.i-scoop.eu/industry-4-0/manufacturing-sector-manufacturing-technology-evolutions/>.
- Junior, Armando Araújo de Souza, José Luiz de Souza Pio, Jô Cunha Fonseca, Marcelo Albuquerque de Oliveira, Otávio Cesar de Paiva Valadares, et Pedro Henrique Souza da Silva. « The State of Cybersecurity in Smart Manufacturing Systems: A Systematic Review ». *European Journal of Business and Management Research* 6, n° 6 (16 décembre 2021): 188-94. <https://doi.org/10.24018/ejbmr.2021.6.6.1173>.
- Marr, Bernard. « The Top 5 Manufacturing Trends In 2023 ». Forbes, 2023. <https://www.forbes.com/sites/bernardmarr/2023/03/29/the-top-5-manufacturing-trends-in-2023/>.
- MEMAN. « MEMAN Home ». MEMAN, 2018. <http://www.meman.eu/>.
- Minalogic. « SmartEnergy. Accélérez la transition énergétique ». Minalogic, 21 avril 2020. <https://www.minalogic.com/smartenergy-accelerez-la-transition-energetique/>.



- Misra, Raghu. « Council Post: Trends Shaping Strategic Recruitment And New Hiring Trends ». Forbes, 2023. <https://www.forbes.com/sites/forbestechcouncil/2023/04/04/trends-shaping-strategic-recruitment-and-new-hiring-trends/>.
- Orgalim. « Europe's Technology Industries ». Orgalim, s. d. <https://orgalim.eu/home>.
- Research, National Centre for Vocational Education. « NCVER ». NCVER. National Centre for Vocational Education Research, 19 décembre 2022. <https://www.ncver.edu.au/>.
- Skill Man. « Home Skill Man ». skillman.eu, 26 janvier 2023. <https://skillman.eu/>.
- Sniderman, Brenna, Monika Mahto, et Mark Cotteleer. « Industry 4.0 and Manufacturing Ecosystems ». Deloitte Insights, 23 février 2016. <https://www2.deloitte.com/content/www/us/en/insights/focus/industry-4-0/manufacturing-ecosystems-exploring-world-connected-enterprises.html>.
- WMF. « Report 2019: Skills for the Future of Manufacturing ». World Manufacturing Foundation, 13 novembre 2019. <https://worldmanufacturing.org/report/report-2019/>.
- . « Report 2021: Digitally Enabled Circular Manufacturing ». World Manufacturing Foundation, 1 juillet 2021. <https://worldmanufacturing.org/report/report-2021-digitally-enabled-circular-manufacturing/>.
- Exam 4.0. « Home EXAM 4.0 », 18 mars 2022. <https://examhub.eu/>.



5. INDEX OF TABLES

Table 1 : Main used sources	9
Table 2 : Presentation and brief description of DATA.....	10





Learner Centric Advanced Manufacturing Platform



**Co-funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.