Global and Societal Milestones Report

[Executive Summary]

May 2020

SAM
SECTOR SKILLS STRATEGY IN ADDITIVE MANUFACTURING

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The SAM (Sector Skills Strategy in Additive Manufacturing) project, aims to deliver a shared vision and collaborative skill solutions capable to foster and support the growth, innovation and competitiveness in the Additive Manufacturing (AM) sector, in close interactions with key sector stakeholders.
A key measure of success for SAM involves an accurate mapping of the AM sector's core global and societal developments until 2030, including all transformations that can direct and indirectly impact on the Additive Manufacturing Sector and Skills.
As a way to represent these challenges in a way that is immediately relevant to sector end-users and stakeholders, the consortium characterised Global and Societal Milestones that together with technological developments, current professional and profiles/skills roadmap are critical in ensuring that future skills needed in AM are properly mapped, this guaranteeing that a highly skilled workforce is ready for when the industry requires it.
The challenges analysed in the current document are aligned with those identified as priorities in the Europe 2020 strategy and thus reflected in the H2020 Programme, namely:

- Health, demographic change and wellbeing.
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bioeconomy.
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Secure societies - protecting freedom and security of Europe and its citizens.

Throughout the full version of the report, Global and Societal challenges, and their impact on AM in specific fields, are analysed in detail, thus making sure to align findings with European priorities, objectives and work areas. These findings are the baseline to define the key driving actions that shall be considered within the European AM skills strategy. Those actions refer to the **linkage of AM Skills with quality, standardisation, involvement with sectoral and non-sectoral players**, implementation of training according with the skills priorities, as well as the promotion of raise awareness among general public towards AM contributions to deal with the global and societal challenges.
The **optimization of AM processes, AM design, AM materials science, quality and post-processing** are the main key knowledge areas where skills demand is foreseen to have more impact on the AM sector and consequently on the global challenges. In general, it is expected a continuous development of these skills, at different levels, within the next 6 months, 2 years and 10 years in order to globally implement the AM technologies.
Particularly, there are skills on sustainability, circular economy, recycling, resource efficiency management, business models and economics in AM that appear as priorities from 2022 to 2030.

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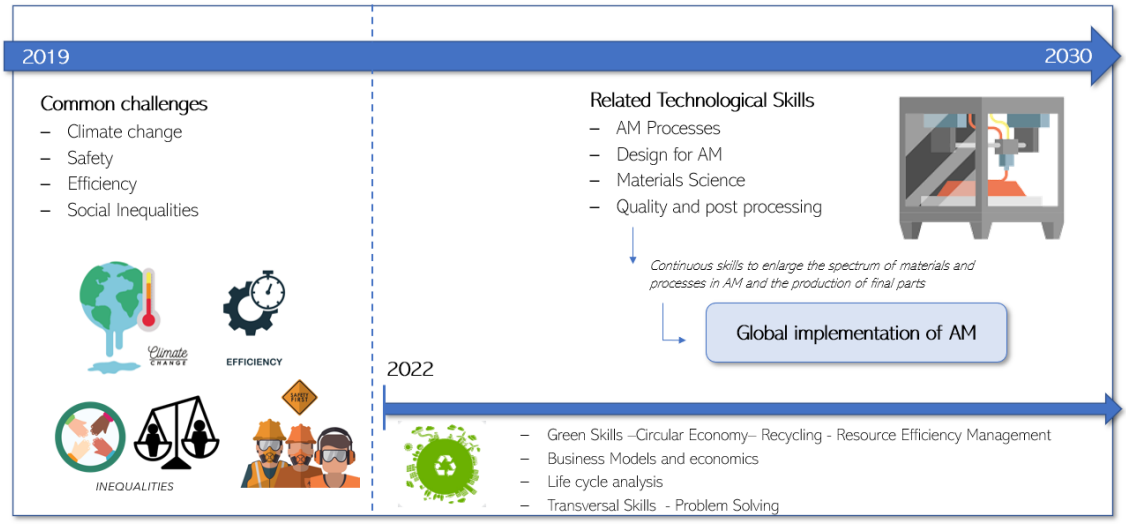

Figure 1 - Summary of challenges and required skills

These are the common skills mentioned as the main influence to enlarge the spectrum of materials and processes in AM and the production of final parts, the common milestone for the different sectors. However, specific challenges of the sectors may be addressed by specific skills.

Milestones have been defined in terms of technological requirements and its relationship with AM skills and other needs priorities:

- within the next 6 months (Real case scenarios),
- 2 years (Short-term scenarios) and
- 10 years (Foresight scenarios) for the selected challenges.

The infographic below summarizes the relationship between the Global and Societal Challenges, the correspondent Milestones, defined as technical requirements, and related skills requirements for AM professionals in the identified sectors and scenarios:

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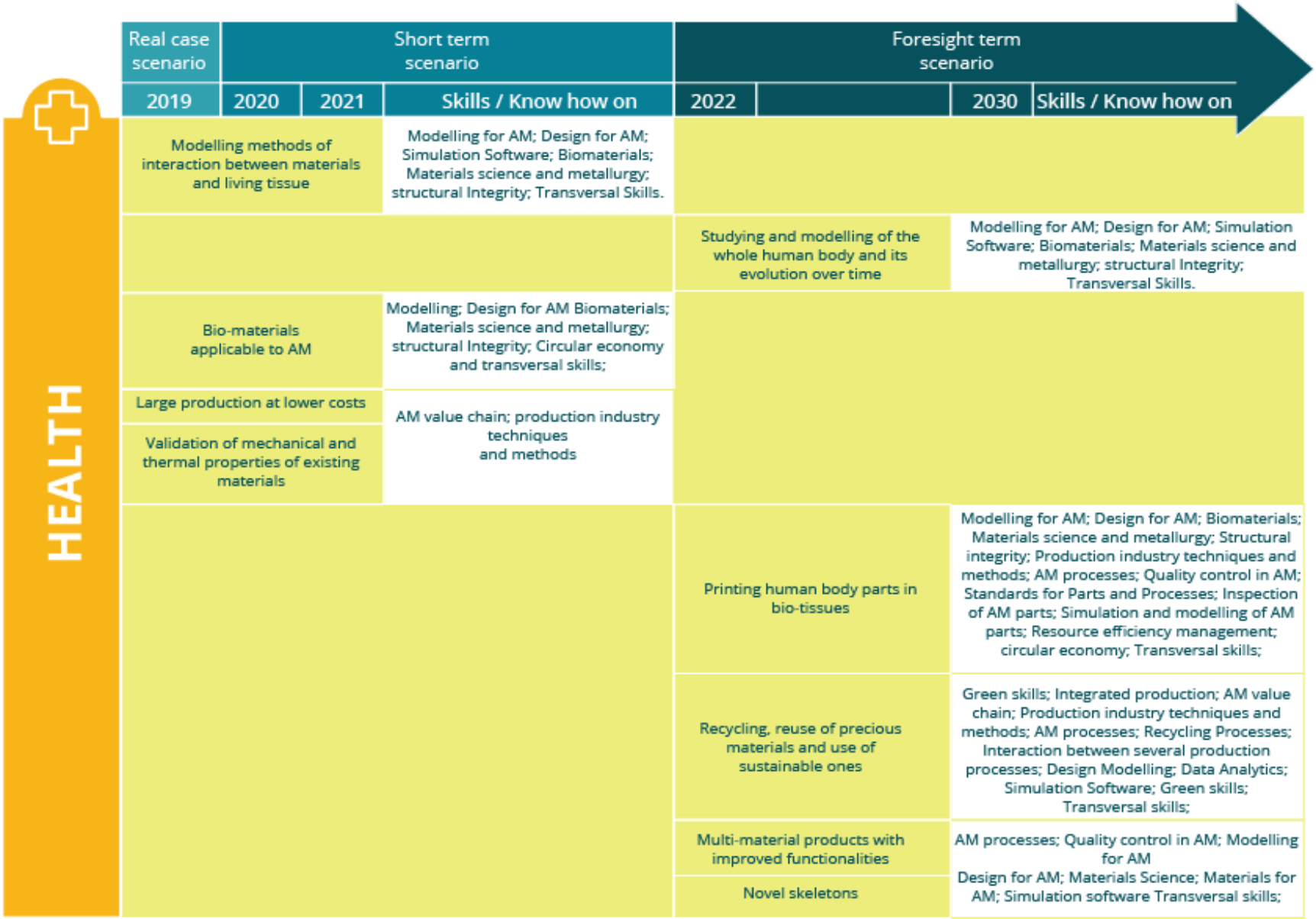

Figure 2 - Milestones and related technological skills requirements for Health

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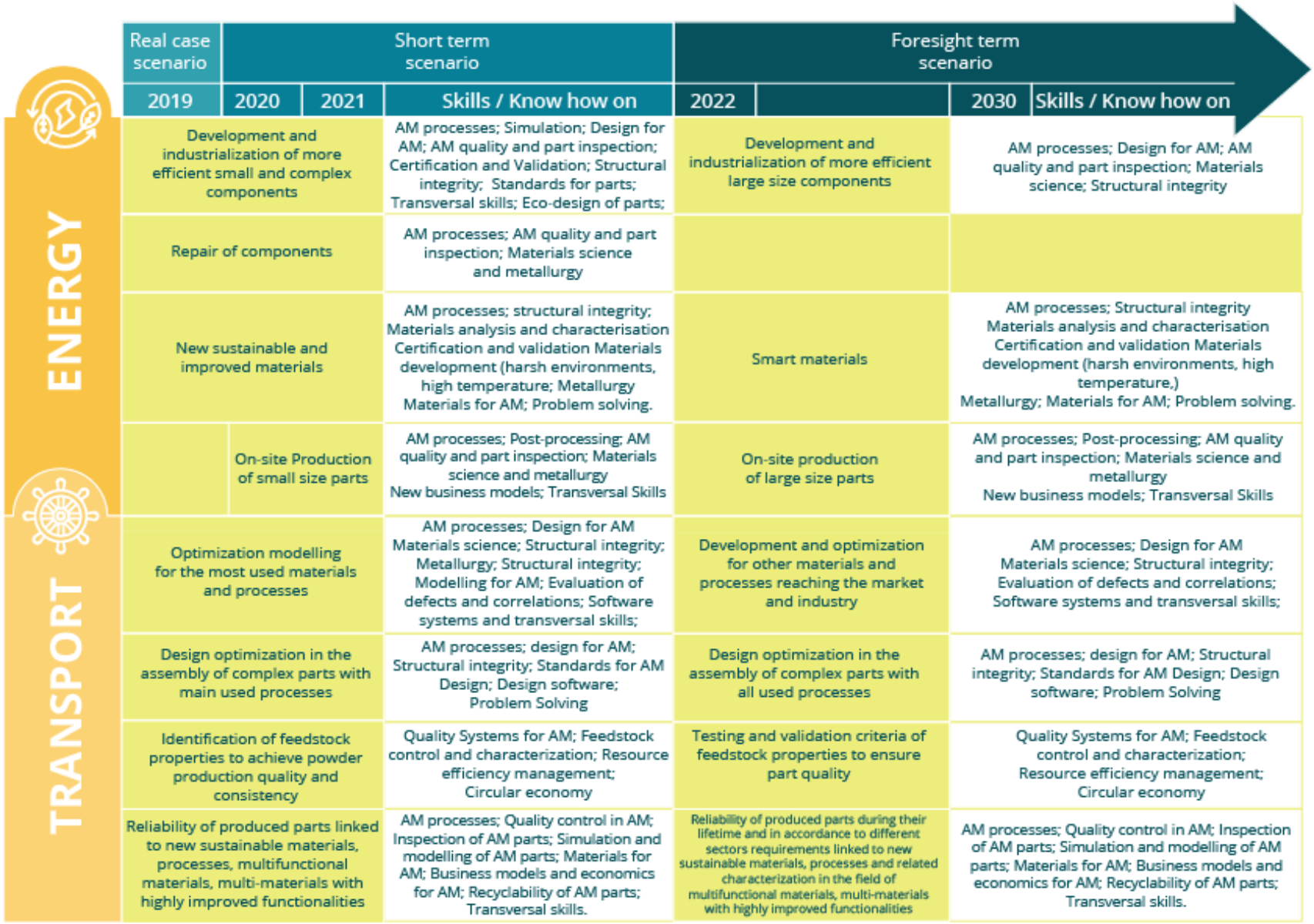

	Real case scenario	Short term scenario			Foresight term scenario			
	2019	2020	2021	Skills / Know how on	2022		2030	Skills / Know how on
ENERGY	Development and industrialization of more efficient small and complex components			AM processes; Simulation; Design for AM; AM quality and part inspection; Certification and Validation; Structural integrity; Standards for parts; Transversal skills; Eco-design of parts;	Development and industrialization of more efficient large size components			AM processes; Design for AM; AM quality and part inspection; Materials science; Structural integrity
ENERGY	Repair of components			AM processes; AM quality and part inspection; Materials science and metallurgy				
ENERGY	New sustainable and improved materials			AM processes; structural integrity; Materials analysis and characterisation Certification and validation Materials development (harsh environments, high temperature; Metallurgy Materials for AM; Problem solving.	Smart materials			AM processes; Structural integrity Materials analysis and characterisation Certification and validation Materials development (harsh environments, high temperature,) Metallurgy; Materials for AM; Problem solving.
ENERGY		On-site Production of small size parts		AM processes; Post-processing; AM quality and part inspection; Materials science and metallurgy New business models; Transversal Skills	On-site production of large size parts			AM processes; Post-processing; AM quality and part inspection; Materials science and metallurgy New business models; Transversal Skills
TRANSPORT	Optimization modelling for the most used materials and processes			AM processes; Design for AM Materials science; Structural integrity; Metallurgy; Structural integrity; Modelling for AM; Evaluation of defects and correlations; Software systems and transversal skills;	Development and optimization for other materials and processes reaching the market and industry			AM processes; Design for AM Materials science; Structural integrity; Evaluation of defects and correlations; Software systems and transversal skills;
TRANSPORT	Design optimization in the assembly of complex parts with main used processes			AM processes; design for AM; Structural integrity; Standards for AM Design; Design software; Problem Solving	Design optimization in the assembly of complex parts with all used processes			AM processes; design for AM; Structural integrity; Standards for AM Design; Design software; Problem Solving
TRANSPORT	Identification of feedstock properties to achieve powder production quality and consistency			Quality Systems for AM; Feedstock control and characterization; Resource efficiency management; Circular economy	Testing and validation criteria of feedstock properties to ensure part quality			Quality Systems for AM; Feedstock control and characterization; Resource efficiency management; Circular economy
TRANSPORT	Reliability of produced parts linked to new sustainable materials, processes, multifunctional materials, multi-materials with highly improved functionalities			AM processes; Quality control in AM; Inspection of AM parts; Simulation and modelling of AM parts; Materials for AM; Business models and economics for AM; Recyclability of AM parts; Transversal skills.	Reliability of produced parts during their lifetime and in accordance to different sectors requirements linked to new sustainable materials, processes and related characterization in the field of multifunctional materials, multi-materials with highly improved functionalities			AM processes; Quality control in AM; Inspection of AM parts; Simulation and modelling of AM parts; Materials for AM; Business models and economics for AM; Recyclability of AM parts; Transversal skills.

Figure 3 - Milestones and related technological skills requirements for Transport and Energy

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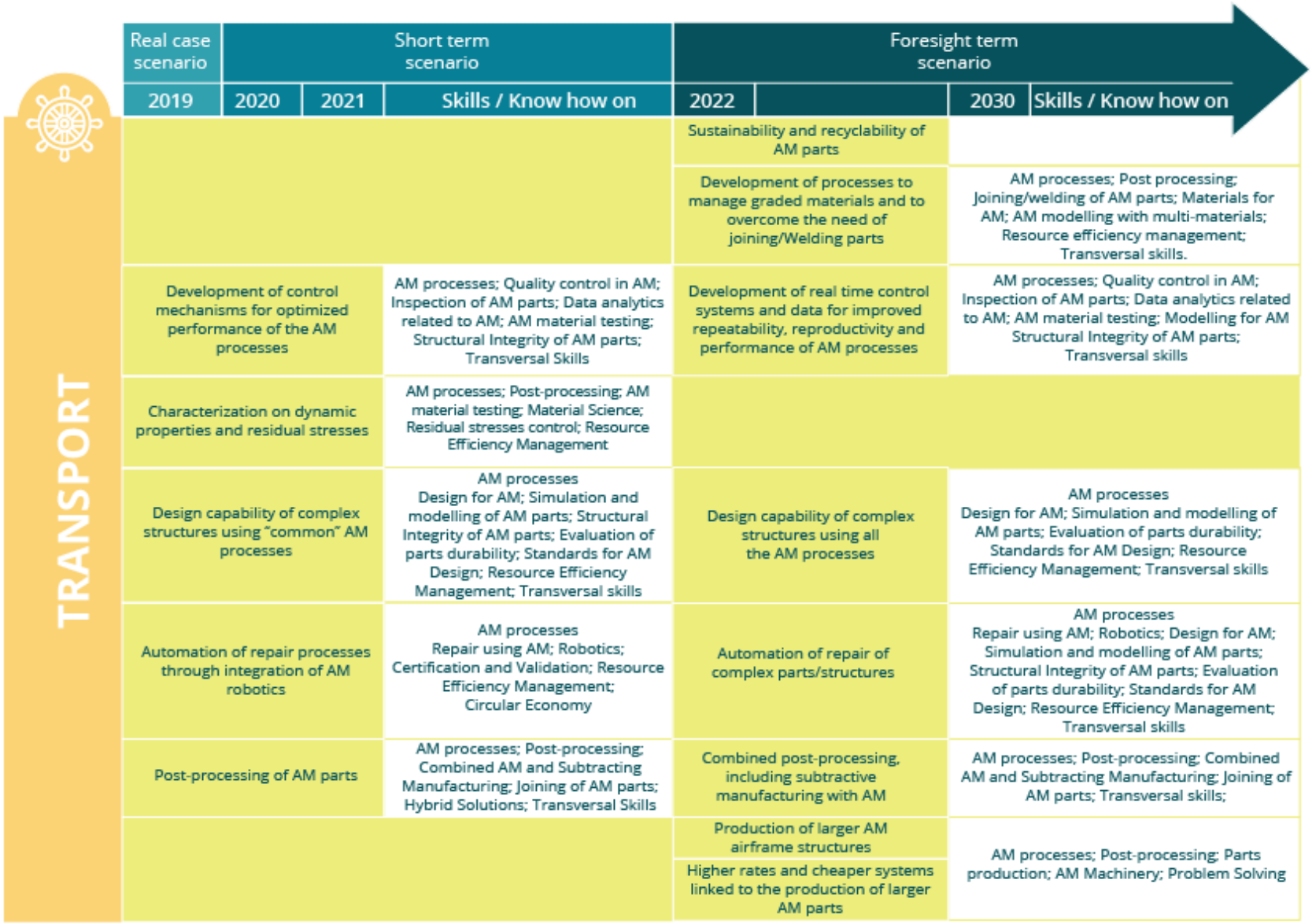

Figure 4- Milestones and related technological skills requirements for Transport

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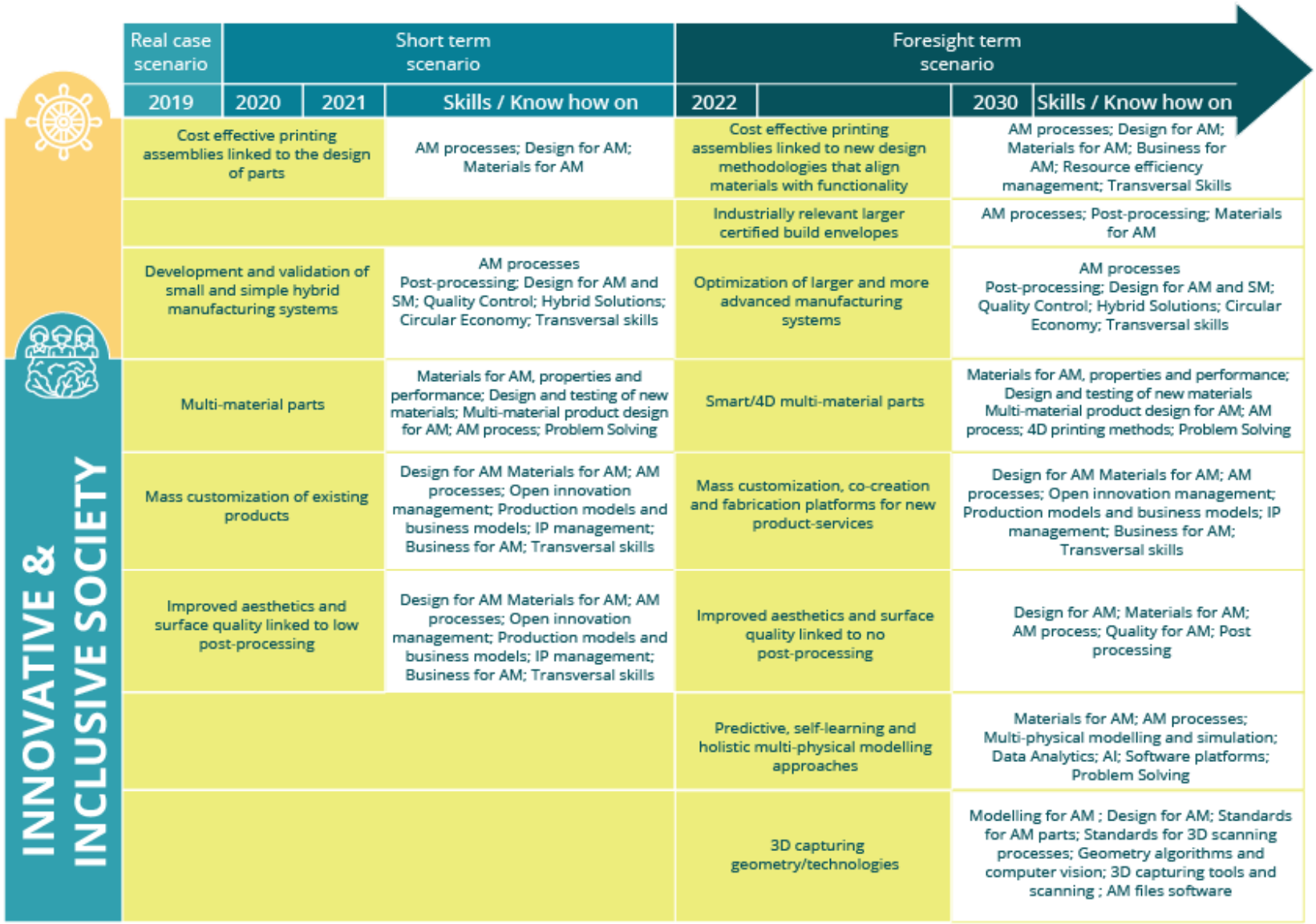

Real case scenario	Short term scenario			Foresight term scenario			
2019	2020	2021	Skills / Know how on	2022		2030	Skills / Know how on
Cost effective printing assemblies linked to the design of parts			AM processes; Design for AM; Materials for AM	Cost effective printing assemblies linked to new design methodologies that align materials with functionality			AM processes; Design for AM; Materials for AM; Business for AM; Resource efficiency management; Transversal Skills
				Industrially relevant larger certified build envelopes			AM processes; Post-processing; Materials for AM
Development and validation of small and simple hybrid manufacturing systems			AM processes Post-processing; Design for AM and SM; Quality Control; Hybrid Solutions; Circular Economy; Transversal skills	Optimization of larger and more advanced manufacturing systems			AM processes Post-processing; Design for AM and SM; Quality Control; Hybrid Solutions; Circular Economy; Transversal skills
Multi-material parts			Materials for AM, properties and performance; Design and testing of new materials; Multi-material product design for AM; AM process; Problem Solving	Smart/4D multi-material parts			Materials for AM, properties and performance; Design and testing of new materials Multi-material product design for AM; AM process; 4D printing methods; Problem Solving
Mass customization of existing products			Design for AM Materials for AM; AM processes; Open innovation management; Production models and business models; IP management; Business for AM; Transversal skills	Mass customization, co-creation and fabrication platforms for new product-services			Design for AM Materials for AM; AM processes; Open innovation management; Production models and business models; IP management; Business for AM; Transversal skills
Improved aesthetics and surface quality linked to low post-processing			Design for AM Materials for AM; AM processes; Open innovation management; Production models and business models; IP management; Business for AM; Transversal skills	Improved aesthetics and surface quality linked to no post-processing			Design for AM; Materials for AM; AM process; Quality for AM; Post processing
				Predictive, self-learning and holistic multi-physical modelling approaches			Materials for AM; AM processes; Multi-physical modelling and simulation; Data Analytics; AI; Software platforms; Problem Solving
				3D capturing geometry/technologies			Modelling for AM ; Design for AM; Standards for AM parts; Standards for 3D scanning processes; Geometry algorithms and computer vision; 3D capturing tools and scanning ; AM files software

Figure 5 - Milestones and related technological skills requirements for Innovation and Inclusive Society

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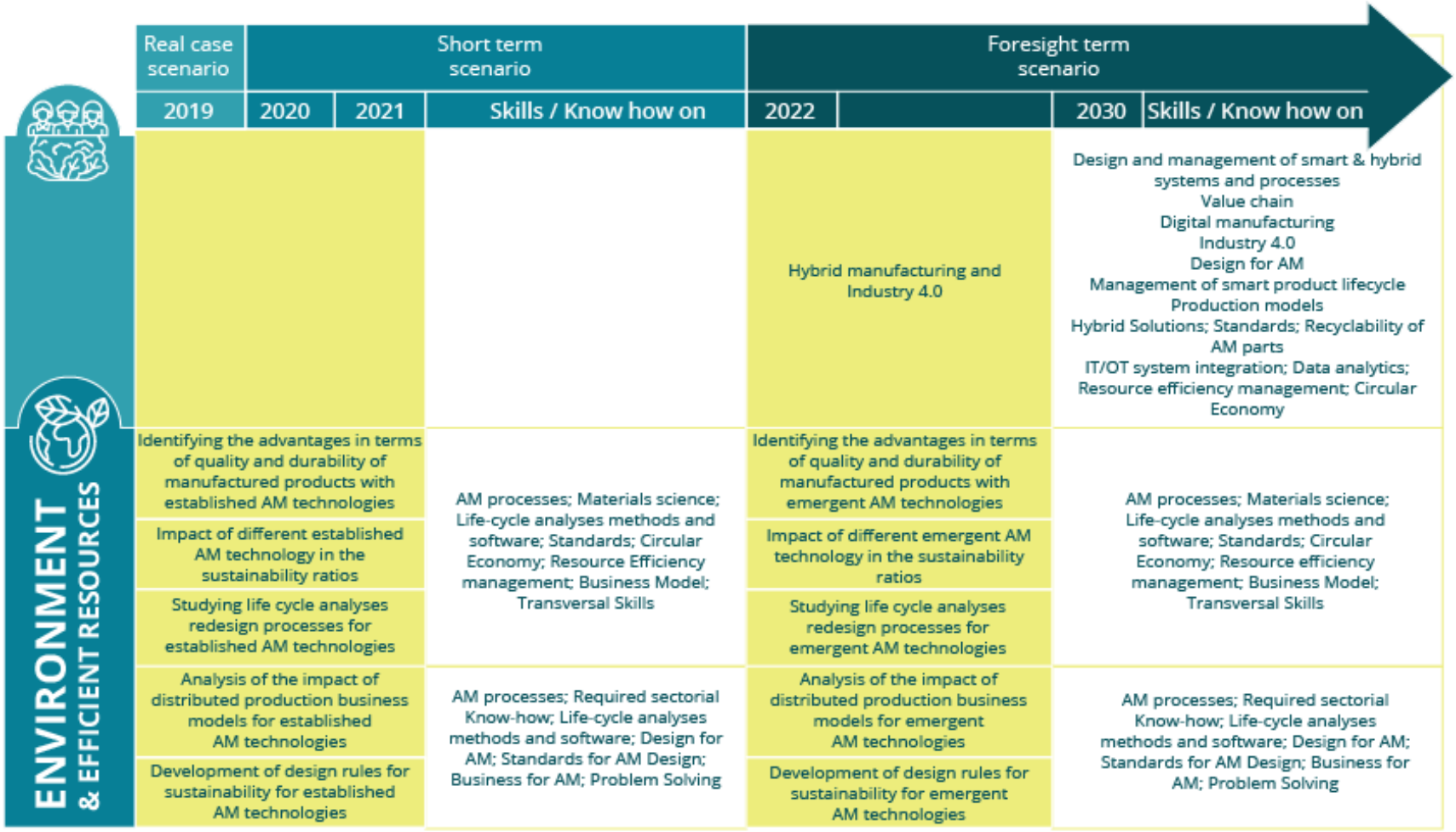

Real case scenario	Short term scenario			Foresight term scenario			
2019	2020	2021	Skills / Know how on	2022		2030	Skills / Know how on
				Hybrid manufacturing and Industry 4.0		Design and management of smart & hybrid systems and processes Value chain Digital manufacturing Industry 4.0 Design for AM Management of smart product lifecycle Production models Hybrid Solutions; Standards; Recyclability of AM parts IT/OT system integration; Data analytics; Resource efficiency management; Circular Economy	
Identifying the advantages in terms of quality and durability of manufactured products with established AM technologies			AM processes; Materials science; Life-cycle analyses methods and software; Standards; Circular Economy; Resource Efficiency management; Business Model; Transversal Skills	Identifying the advantages in terms of quality and durability of manufactured products with emergent AM technologies		AM processes; Materials science; Life-cycle analyses methods and software; Standards; Circular Economy; Resource efficiency management; Business Model; Transversal Skills	
Impact of different established AM technology in the sustainability ratios				Impact of different emergent AM technology in the sustainability ratios			
Studying life cycle analyses redesign processes for established AM technologies				Studying life cycle analyses redesign processes for emergent AM technologies			
Analysis of the impact of distributed production business models for established AM technologies			AM processes; Required sectorial Know-how; Life-cycle analyses methods and software; Design for AM; Standards for AM Design; Business for AM; Problem Solving	Analysis of the impact of distributed production business models for emergent AM technologies		AM processes; Required sectorial Know-how; Life-cycle analyses methods and software; Design for AM; Standards for AM Design; Business for AM; Problem Solving	
Development of design rules for sustainability for established AM technologies				Development of design rules for sustainability for emergent AM technologies			

Figure 6 - Milestones and related technological skills requirements for Energy

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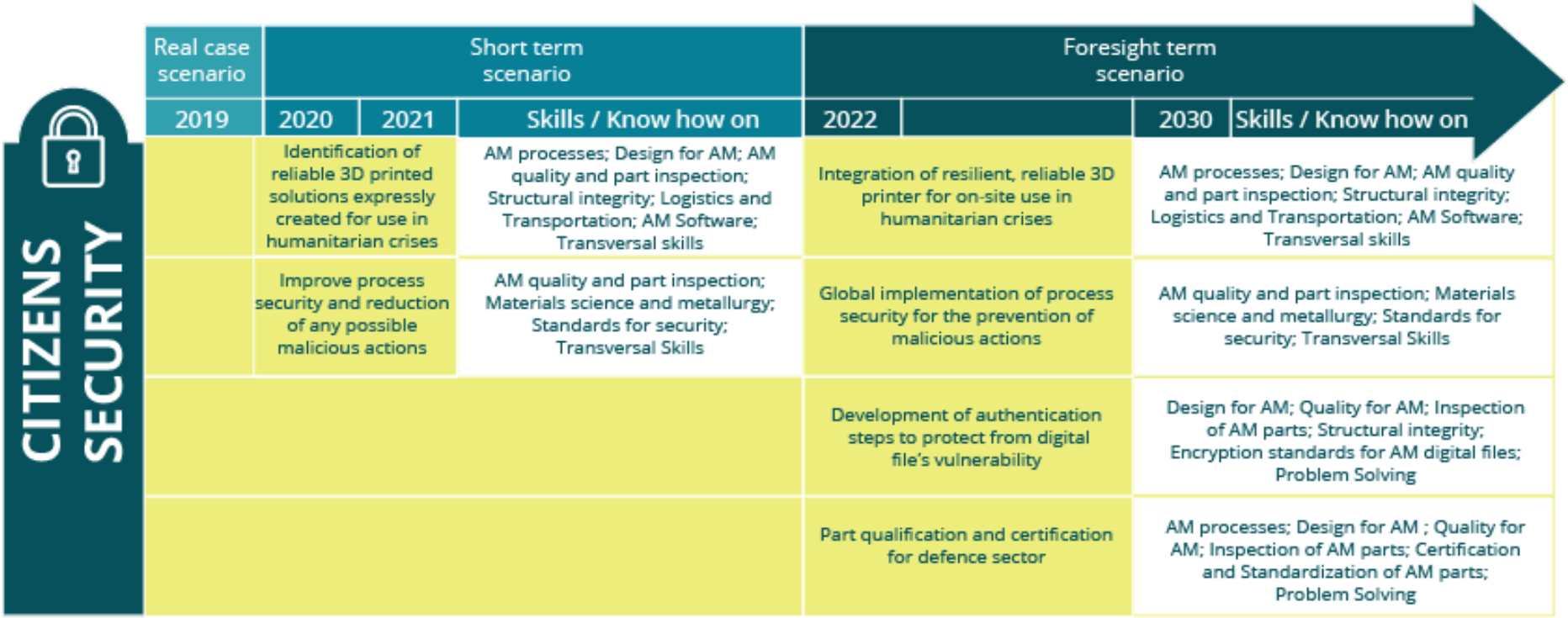

Figure 7 - Milestones and related technological skills requirements for Citizens Security

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The full report produced by the SAM consortium can be accessed in full here. However, a number of conclusions based on the above are important to highlight at this stage, when it comes to the technical requirements and related skills for AM professionals:

- For all sectors Skills and Know-how related with AM Processes, Modelling, Design, materials science and metallurgy and structural integrity, Quality control and Inspection of AM parts remain relevant for the next years;
- Health: Skills and Know-how related to Green skills and Recycling Processes were identified for a future perspective, being the sector focused on the expansion of the spectrum of materials and processes, as well as on the production of real human body parts;
- Energy: it is expected to increase large parts production after small components production steadiness;
- Transport: investment in Skills and Know-how related with post processing and business skills is expected to increase, as the sector is expected to focus on the expansion of the spectrum of materials and processes;
- Consumer Goods: it is safe to expect that skills and know-how related with Open innovation management, Production models and business models and IP management will be in high demand in the following years to come;
- Environment & Efficient Resources: throughout the next years skills and know-how related with Life-cycle analysis methods and software will be in high demand;
- Citizens Security: The overall expected AM service for the society's prosperity

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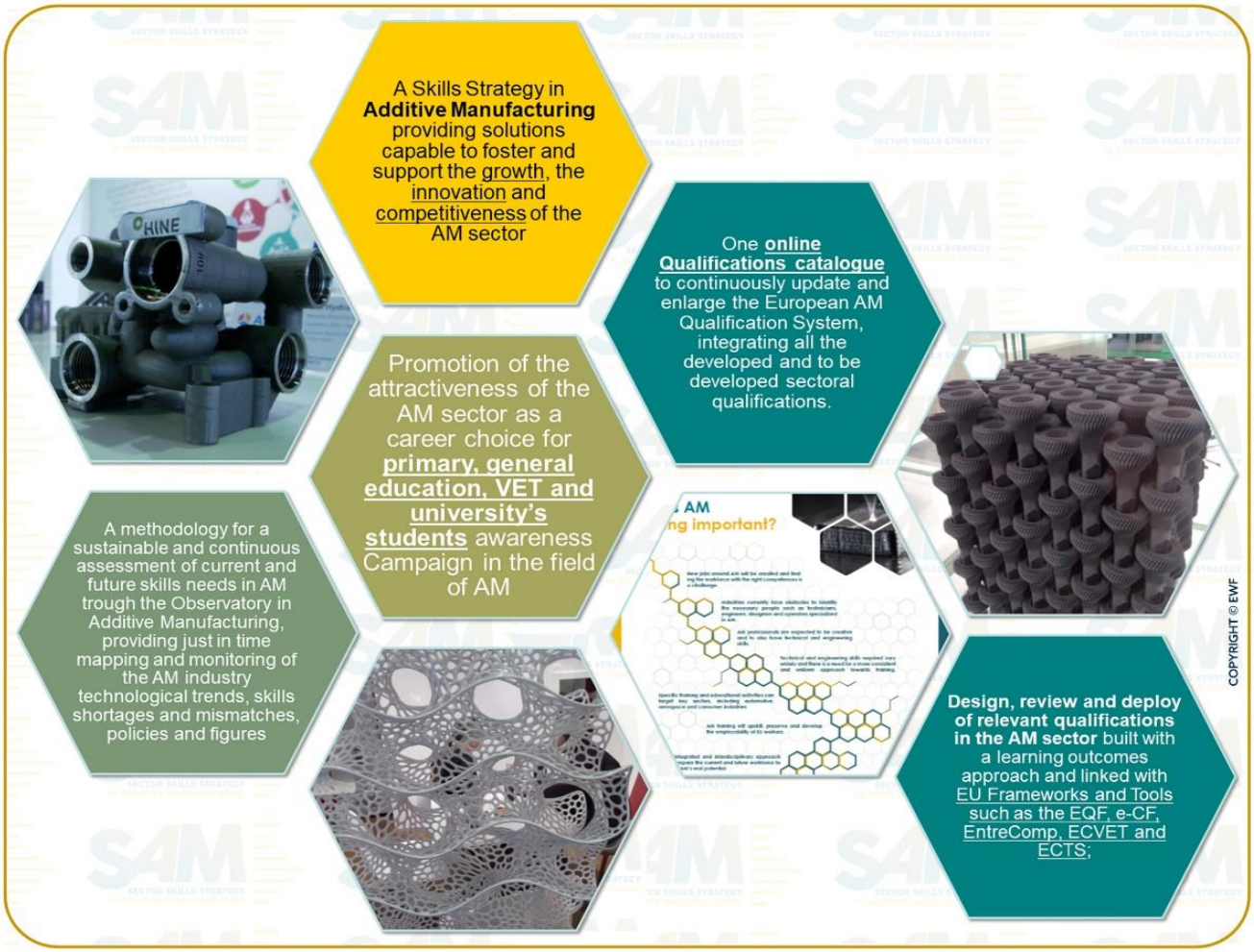
SAM is developing an European Observatory in AM that is identifying and anticipating the right skills and deliver them to the Industry/Companies through a solid network of European Training Centers

About the Project



Erasmus+ Sector Skills Alliances

Sector: Additive Manufacturing

Participants and Countries: 9 countries: Belgium (EWF, EPMA, CECIMO, Materialise), Germany (LZH Laser Akademie), Greece (Panepistimio Patron), France (EC Nantes), Italy (POLIMI), United Kingdom (MTC, Brunel University, Spain (IDONIAL, Lortek, AITIIP), Portugal (ISQ, FavoriteAnswer); Ireland (IMR).

Project duration: 4 years (1.01.2019 – 31.12.2020)

Website: www.skills4am.eu

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