Skills and Occupational Profiles for Microelectronics

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Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

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Abstract

METIS (MicroElectronics Training Industry and Skills) is a Sector Skills Alliance, co-funded by Erasmus+, implementing a strategic approach to sectoral cooperation on skills aiming to bridge the microelectronics skills gap in Europe. It is a 4-year project from November 2019 to October 2023, involving 19 partners from 13 countries, coordinated by SEMI Europe: Industrials (Infineon, Bosch, X-Fab, Arcelik, Graphenea, Summa Semiconductor, Silicon Saxony), training & education organisations (TU Graz, IMEC academy, SBH Sudost, TU Sofia, USN, BME and IAL-FVG), social partners (WiTEC and EACG), a regulatory body (CIMEA), and a market research & intelligence firm (DECISION Etudes-Conseil).

The first step of the METIS project, in 2020, has consisted in building an EU sectoral skills strategy and a methodology to monitor and anticipate skills in the European microelectronics industry. A multi-stakeholder's approach has been adopted and 10 Focus Groups, 50 live interviews an online survey and market research have been carried out during the year 2020, leading to this report entitled "Skills and Occupational Profiles for Microelectronics".

This report provides a detailed description of the **skills needs of the European microelectronics industry**. This report describes the main mismatches on the current European microelectronics job market, identifies the most critical microelectronics skills and knowledge from the industry as well as their associated job profiles, and assesses the impact of emerging technologies on skills (I4.0, automotive innovations, etc.).

This report also provides the detailed occupational blueprints of the 21 job profiles the most sought-after by the European microelectronics industry: associated main skills, emerging skills, educational levels, duration to fill positions, etc.

This report assesses the needs in four specific sectors of the microelectronics industry: semiconductor design, semiconductor manufacturing processes, semiconductor manufacturing equipment and semiconductor materials.

This report also proposes **new occupational profiles for microelectronics**. This report assesses the existing ESCO profiles in microelectronics, identifies the possible new ESCO profiles and present four specific new ESCO profiles that have been added to the ESCO platform in October 2020.

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Executive summary

A. Methodology to monitor skills needs in the European microelectronics industry

METIS (MicroElectronics Training Industry and Skills) is a Sector Skills Alliance, co-funded by Erasmus+, implementing a strategic approach to sectoral cooperation on skills aiming to bridge the microelectronics skills gap in Europe. It is a 4-year project from November 2019 to October 2023, involving 19 partners from 13 countries, coordinated by SEMI Europe: Industrials (Infineon, Bosch, X-Fab, Arcelik, Graphenea, Summa Semiconductor, Silicon Saxony), training & education organisations (TU Graz, IMEC academy, SBH Sudost, TU Sofia, USN, BME and IAL-FVG), social partners (WiTEC and EACG), a regulatory body (CIMEA), and a market research & intelligence firm (DECISION Etudes & Conseil).

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Through the online survey, the focus groups and the interviews, **METIS has engaged 251 stakeholders from 159 organisations**.

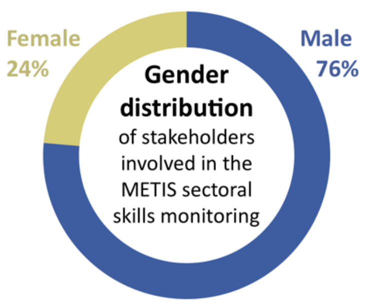
In total, METIS has engaged 30 of the largest European and global microelectronics companies as well as many mid-sized businesses and SMEs. In total, **companies engaged in METIS produce goods and services for €130B across the microelectronics value chain in 2019, corresponding to 20% of the global production across the microelectronics value chain. Furthermore, these companies provide more than 125 000 microelectronics jobs across Europe, corresponding to 30% of the European microelectronics workforce.**

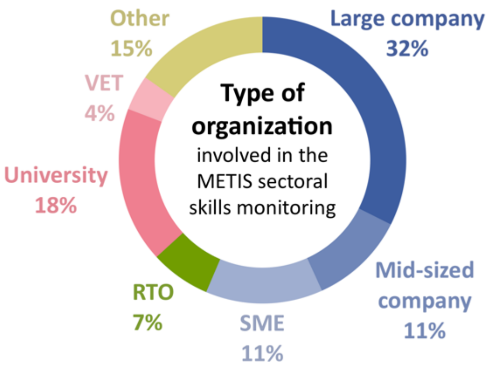
Education & training organisations engaged in the building of the METIS Skills Strategy represent nearly 5 000 students in microelectronics[1] across Europe.

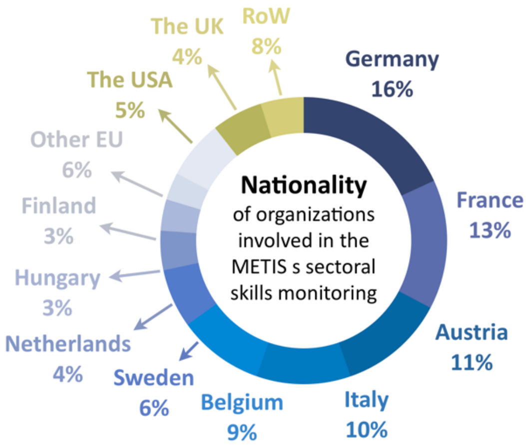
The entire electronics value chain has been involved, although 43% of the organisations engaged are companies from the microelectronics industry. C**ompanies represent 55% of the organisations engaged**, in majority large companies (32%). **90% of the organisations engaged in METIS are European** (82% part of the European Union).

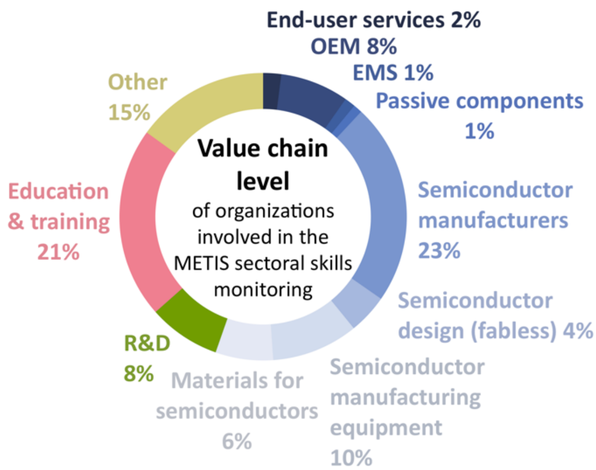
Finally, a specific effort has been made to have a **gender balance** among the stakeholders involved. In 2018, according to Eurostat, women accounted for 20% of the workforce of European Scientists and engineers involved in the industrial activities (that is excluding services). METIS has succeeded to engage 24% of females, that is slightly above the average of the sector.

[1] Students in courses where training related to microelectronics has a significant place.

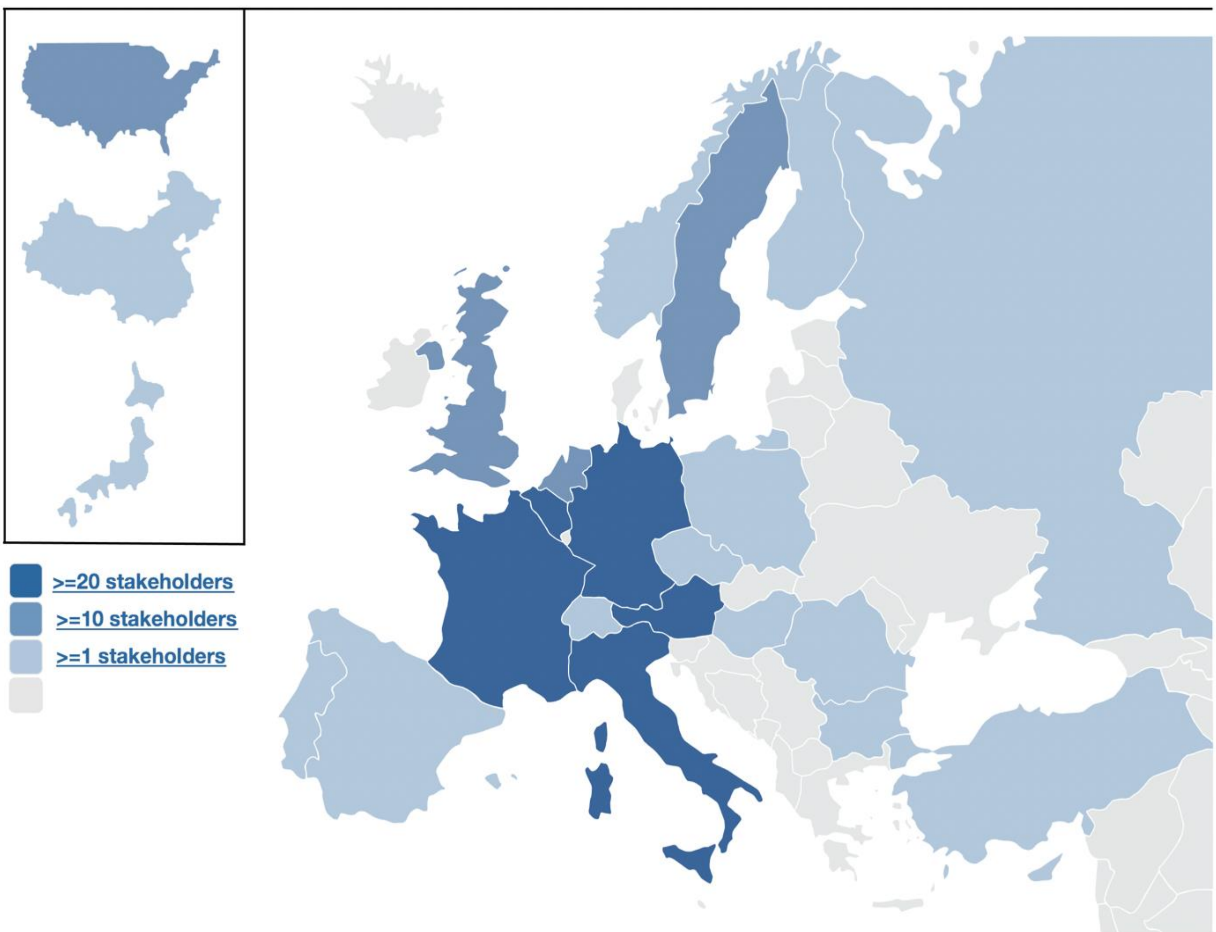








MAP – Stakeholders engaged in the METIS skills strategy



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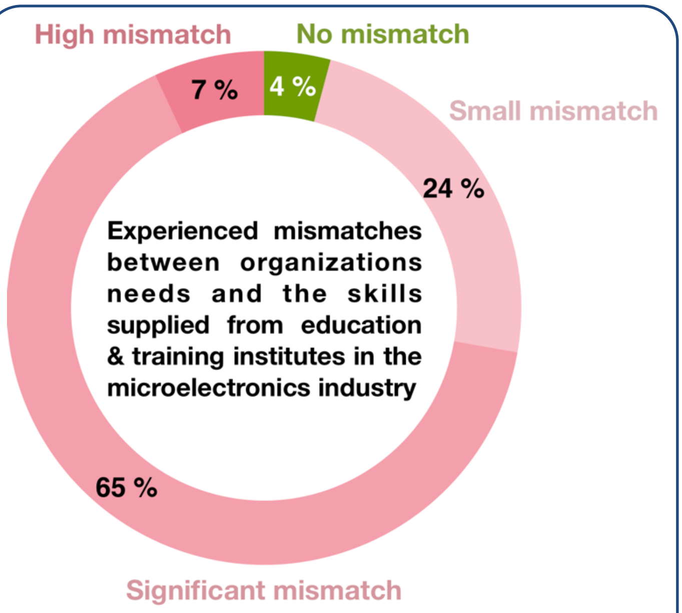
B. Identification of the main mismatches regarding microelectronics job profiles and skills

<u>96%</u> of the stakeholders consulted in the online survey experience mismatches between the needs of the microelectronics industry and the skills supplied from education & training institutions, and nearly **<u>75%</u>** experience significant mismatches.

They suffer at the same time from skills required for decades that are less and less available on the European market and from the emergence of numerous new skills due to the numerous digital innovations leading to new technologies and markets.

As a consequence, companies have greater difficulties in recruiting qualified workers with specific knowledge in microelectronics and increasingly use vocational training to re-skill or upskill their employees.



96% of the stakeholders interrogated experience mismatches between the needs of the microelectronics industry and the skills supplied from education & training institutions.

Source: Online survey (72 answers).

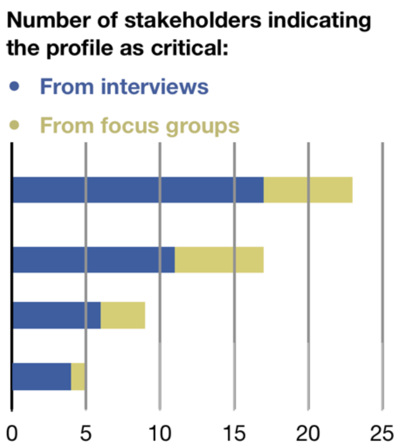
The four main mismatches identified by stakeholders are the following:

1. Needs for more fundamental knowledge and basics skills of manufacturing
2. Needs for more engineering profiles of generalists
3. Needs for more multidisciplinary cursus
4. Needs for more cursus dedicated to microelectronics

The table below shows the number of stakeholders that have put forward these mismatches.

Main mismatches between offer and demand experienced by the microelectronics industry

N°	Main mismatches	Skill / knowledge required at Educational level (EQF)	Number of stakeholders identifying this mismatch as one of the most critical (multiple choice allowed)		
			Interviews	Focus groups	TOTAL
1	Needs for more fundamental knowledge and basics skills of manufacturing	4-6	17	6	23
2	Needs for more engineering profiles of generalists	6-7	11	6	17
3	Needs for more multidisciplinary cursus	-	6	3	9
4	Needs for more cursus dedicated to microelectronics	-	4	1	5



Needs for more fundamental knowledge and basics skills of manufacturing.

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A very significant number of stakeholders report for recent graduates (both for technicians and engineering profiles) a lack of:

- Basic / Fundamental knowledge in microelectronics.
- Practical knowledge and skills associated to concrete production processes.

In other words, knowledge and skills that companies can immediately use and that corresponds to the fundamentals to work in the microelectronics industry.

On the contrary, recent graduates appears to have an in-depth knowledge in very specific topics, often linked to state-of-the-art research, probably as many courses are given based on research of the university.

Industrials pledge for a greater focus on these topics for all student, starting at the educational level EQF 4. These skills and knowledge should be fully mastered by any graduate aiming to work in the microelectronics industry at EQF levels 6 and 7.

This state of play also pushes companies to hire more graduates at the education level EQF 6 rather than at EQF 7, because they hire these graduates at lower salaries and then provide internal training oriented towards practical knowledge and skills associated to concrete production processes (2-12 months) so that they can work in the routinely manufacturing tools. MSc students have however better preparedness in manufacturing and are also more invested in material science, statistics, simulation, mathematics and physics. The main problem associated to this situation is that these BSc graduates are more difficult to work with on the long run than MSc graduates on average, when non-routine problems arise in manufacturing processes.

Examples of basic / fundamental / generalist knowledge:

- Basics of electrical engineering.
- Basics of analog and digital electronics: including analog circuit design and digital circuit design.
- Ability to design standard circuits: different basic building blocks (like how to design an LDO) and how to design them, the combination of building blocks to build measurement chains or power converters.
- Good fundamental knowledge in chemistry, physics, mathematics, and mechanism.
- Introduction to materials (traditional materials and emerging ones).

Examples of practical knowledge and skills linked to production processes:

- Design for production: Knowledge of the techniques to build robust, reliable and high-performance circuits or layout (as opposed to techniques to achieve the best specifications without looking at reliability, corners, etc.). Knowledge of design techniques to take into account temperature variation, technology variations and environmental effects.
- Ability to use industry standard tools for design and layout (Cadence, Synopsys, etc.).
- Ability to set up hardware, applied electronics.
- Knowledge of chopping techniques, instrumentation amplifiers, power down strategies.
- Knowledge of standardized processing equipment.
- Knowledge of standardized production processes.

- Knowledge of standardized testing techniques.
- Knowledge of standardized predictive/preventive maintenance services.
- Internal methodological competences (internal to companies).

The solutions proposed are:

- Reorienting microelectronics curricula towards BSCs focusing on fundamental knowledge and practical production skills and knowledge completed by integrated deeper MSc with interdisciplinary courses.
- Systematizing internships and/or apprenticeships at EQF 4 to 6 and extension of their average duration (minimum 4-6 months). Universities to be in charge of fundamental courses while companies to be charge of the teaching of the practical knowledge and skills associated to concrete production processes (especially thanks to their state-of-the-art machine tools that Universities might have difficulty to afford).
    - There is a similar problematic in research (EQF 8), as state-of-the-art machine tools for semiconductor production often cost more than €200M and Universities cannot afford to buy such machines. Research must be done in cooperation between Universities and companies to enable Universities' research to benefit from state-of-the-art machines.
- Generalizing the hiring of experts working in the industry as University professors.
- Focusing on practical / applied lessons rather than theoretical lessons at Universities.

Needs for more engineering profiles of generalists.

A significant number of stakeholders report a need (and a current shortage) for graduates with a good general knowledge in engineering, electronics and microelectronics. Over the last decades, they report a change in the training of graduates. In the past, the majority of graduates used to have a strong general knowledge but a lack of knowledge in specific areas (especially research areas). This trend has reversed over the years, and currently the majority of the graduates appears to lack strong fundamental knowledge but often have a deep knowledge in specific areas (digital design, layout, test topics, etc.), and especially research areas. Industrials often complains of this state of play as they need in majority profiles of « generalists » that can have a broad view and an ability to adapt to change (agility), although they also need a minority of specialists.

The solutions proposed are:

- Ensuring that both design and manufacturing engineers have a common general knowledge of both microelectronics design and microelectronics manufacturing.
- Focusing on teaching fundamental knowledge rather than emerging technologies: A strong education on the fundamentals (mathematics, physics, engineering, electronics and microelectronics), a basic knowledge of microelectronics manufacturing processes and god soft skills (agility, mobility, technical leadership and management skills), rather than attempts to teach the last technological evolutions to graduates.
- Developing "career long" education programs, including both initial and vocational trainings appears necessary to create skilled workers for the job profiles that are the most challenging (e.g., system architect).

Needs for more multidisciplinary cursus.

Multidisciplinary cursus systems are more and more needed by the microelectronics industry as microelectronics involves a greater diversity of knowledge than in the past: Electronics hardware, but also software, data analysis, knowledge of new materials, etc. These subjects are now highly interconnected, and a diversity of the profiles is needed within engineering teams to be able to combine all the required knowledge within a team.

In microelectronics, the traditional cursus starts with electrical engineering, mechanics or mechatronics followed by a specialization electronics and microelectronics. The multidisciplinarity consists offering in addition to these classic curricula dual curricula, as described in the table below:

Proposals for joint degrees / curricula for microelectronics

Fields of study	Proposals for joint degrees			
	1	2	3	4
Microelectronics / Electro-engineering / Mechanics / Mechatronics	V	V	V	V
Software / Data science / Informatics	V			
Chemistry / Material science (Polymers, etc.)		V		
Marketing, Sales and Communication			V	
Biology / Natural Science				V

- Data science / Informatics (especially for software engineers).
- Chemistry, polymer sciences (especially for process and material engineers).
- Material science (especially for process and material engineers).
- Biology / Natural Science.
- Cybersecurity (for experts in cybersecurity and eventually software engineers).

The profiles that are particularly affected by the need for multidisciplinarity are:

- Software engineers.
- Robotic engineers.
- Process engineers.
- Materials engineers.
- Expert in cybersecurity.

At the same time, profiles of microelectronics engineers that are specialists of traditional technologies and manufacturing processes are still needed but should represent a minority of the profiles.

Needs for more cursus dedicated to microelectronics.

A significant number of stakeholders report a need for curriculum in Europe dedicated to the microelectronics industry, involving teachers in specific areas such as MEMS, magnetic sensors, analog design, system design, etc.

Companies currently needs to provide internal trainings to up-skill graduates when they enter the microelectronics sector.

C. Identification of the skills and knowledge the most difficult to source

1) Technical skills

The table above shows the technical skills and knowledge described by stakeholders as the most critical for the European microelectronics industry today as well as their associated specific education levels (EQF).

These skills and knowledge are both the most sought after and the most difficult to find in different job profiles. In other words, these skills and knowledge are not the most sought after across profiles, all other things being equal, but the hardest to find among those sought after by companies.

Many of these skills are associated to digitization and can be considered as digital skills:

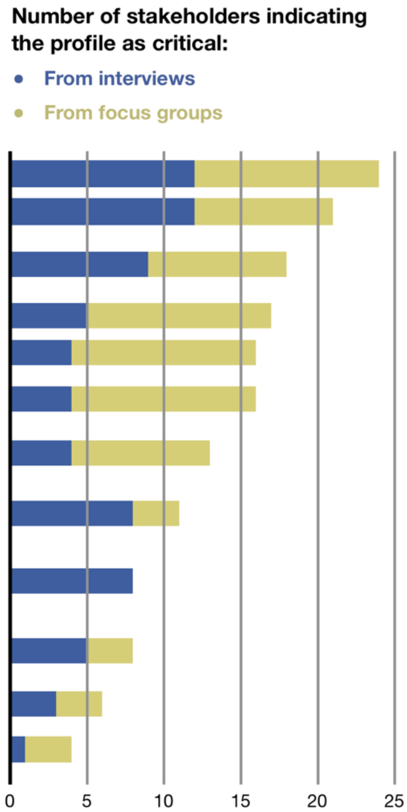
- Data analytics.
- Artificial Intelligence / Machine learning.
- Knowledge of applications (most of emerging applications being associated to digital transition, such as ADAS[2]).
- Security / Cybersecurity.
- Software skills.

Knowledge associated environmental awareness and the green transition are also identified as sought-after and difficult to find. They appear in 11th position.

[2] Advanced Driver Assistance Systems.

Main technical skills required today by the Microelectronics industry (1/2)

N°	Skill / Knowledge	Alternative names	Number of stakeholders identifying the skill/topic as one of the most critical (multiple choice allowed), across job profiles		
			Interviews	Focus groups	TOTAL
1	**Systems architectures**	System engineering	12	12	24
2	**Data analysis**	Big data	12	9	21
3	**Artificial Intelligence / Machine learning**	Especially for software engineers, test engineers and design engineers	9	9	18
4	**Knowledge of applications**		5	12	17
5	**Quality / reliability**		4	12	16
6	**Hardware / Software (HW/ SW) integration**	Hardware / Software co-design	4	12	16
7	**Security**	Security-by-design / Cybersecurity	4	9	13
8	**Knowledge of new materials**	Knowledge of new materials and their applications	8	3	11
9	**Software skills**	Shift from hardware to software affecting most of the profiles	8	0	8
10	**Analog design**	Analog / Analog IC / Mixed-signal / RF-IC design	5	3	8
11	**Environmental awareness**		3	3	6
12	**Social inclusion and diversity**		1	3	4



The <u>most critical</u> means both the most sought after and the most difficult to find in different job profiles.

Main technical skills required today by the Microelectronics industry (2/2)

N°	Skill / Knowledge	Alternative names	Skill / knowledge required at Educational level (EQF)	The skill / knowledge is mandatory / optional	
				Mandatory	Optional
1	**Systems architectures**	System engineering	7	System design engineer	Design engineer
2	**Data analysis**	Big data	6-7	All profiles	-
3	**Artificial Intelligence / Machine learning**	Especially for software engineers, test engineers and design engineers	6-7	Software engineers / Data scientists	Other profiles. Important for Design engineers, Test engineers
4	**Knowledge of applications**		7	Application engineers / Material engineers / Design engineers / System design engineers / Software engineers	Other profiles
5	**Quality / reliability**		6-7	Process engineers	Other profiles
6	**Hardware / Software (HW/ SW) integration**	Hardware / Software co-design	6-7	Design engineers / System design engineers / Software engineers	Other profiles
7	**Security**	Security-by-design / Cybersecurity	6-7	Expert in cybersecurity / Software engineers / Robotic engineers / Process engineers / Test engineer	Other profiles
8	**Knowledge of new materials**	Knowledge of new materials and their applications	6-7	Process engineers / Material engineers	Other profiles
9	**Software skills**	Shift from hardware to software affecting most of the profiles	6-7	Software engineers / Data scientists / Robotic engineers / Process engineers / Materials engineers / Power electronics engineers / RF engineers	Other profiles
10	**Analog design**	Analog / Analog IC / Mixed-signal / RF-IC design	7	Design engineers and especially analog design engineers	-
11	**Environmental awareness**		4	-	All profiles
12	**Social inclusion and diversity**		4	-	All profiles

The most critical means both the most sought after and the most difficult to find in different job profiles.

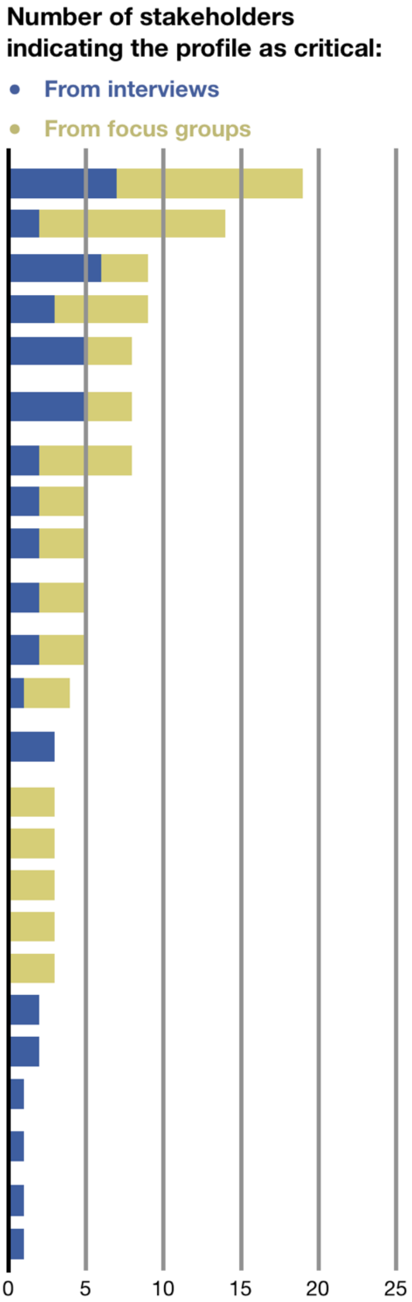
The report provides a detailed description of these skills and knowledge.

2) Soft skills

The table below shows the soft skills described by stakeholders as the most important for the European microelectronics industry today. They are not associated to specific education levels (EQF), and are required for all workers of the industry, especially for engineers (EQF 6-7).

Main soft skills required today by the microelectronics industry (1/2)

N°	Soft skill	Number of stakeholders identifying the skill/topic as one of the most critical (multiple choice allowed), across job profiles		
		Interviews	Focus group	TOTAL
1	**Teamwork**	7	4	19
2	**Creativity** (Innovation capacity)	2	4	14
3	**Communication** (Presentation)	6	1	9
4	**Complex problem solving**	3	2	9
5	**Management**	5	1	8
6	**Adaptability** (Agility, Mobility, Flexibility)	5	1	8
7	**Interdisciplinarity openess**	2	2	8
8	**Customer management**	2	1	5
9	**Language skills**	2	1	5
10	**Responsibility** (Empowerment, Accountability)	2	1	5
11	**Ability to link theory and practice**	2	1	5
12	**Intercultural openess**	1	1	4
13	**Technical leadership** (Critical thinking)	3		3
14	**Lean principles**	0	1	3
15	**Agile principles**	0	1	3
16	**Curiosity**	0	1	3
17	**Self-evaluation**	0	1	3
18	**Resilience**	0	1	3
19	**Self-confidence**	2	0	2
20	**Autonomy**	2	0	2
21	**Ability to do simple tasks quickly**	1	0	1
22	**Ability to handle different tasks at the same time**	1	0	1
23	**Ethics**	1	0	1
24	**Positive attitude**	1	0	1



Main soft skills required today by the microelectronics industry (2/2)

N°	Soft skill	Description
1	**Teamwork**	Cooperative, gets along with others, agreeable, supportive, helpful, collaborative. Students should learn Teamwork skills in real life project teams.
2	**Creativity** (Innovation capacity)	Design thinking. Ability to come up with new ideas, new designs, new technologies, new applications.
3	**Communication** (Presentation)	Ability to communicate, ability to present oneself, self-marketing, ability to explain in a few words complex topics to a non-expert. Cross-discipline communication. Technical presentation skills. Oral speaking capability, written, presenting, listening, clear speech & writing.
4	**Complex problem solving**	Analytical knowledge.
5	**Management**	Ability to lead a team, project management.
6	**Adaptability** (Agility, Mobility, Flexibility)	Ability and willingness to evolve, to change job, to adapt to new technologies and to receive vocational lifelong training. Life-long-learning mind-set. Ability to accept and adapt to changes.
7	**Interdisciplinarity openess**	Open mindset and ability to communicate with other discipline specialists.
8	**Customer management**	Patience when being in contact with customers, customer satisfaction minded. Courtesy, manners and respect to clients.
9	**Language skills**	Especially english.
10	**Responsibility** (Empowerment, Accountability)	Ability to take ownership of a task/activity, to be responsible for this and to assume the consequences. Accountable, reliable, gets the job done, wants to do well, conscientious.
11	**Ability to link theory and practice**	Ability to apply knowledge in practice.
12	**Intercultural openess**	Open mindset and ability to communicate with colleagues from the cultures.
13	**Technical leadership** (Critical thinking)	Ability to make decisions on a technical side, that is to choose a specific technology rather than an other one and to justify the choice, without being influenced by any new information. Common sense.
14	**Lean principles**	
15	**Agile principles**	
16	**Curiosity**	
17	**Self-evaluation**	Ability to self-evaluate ones own strengths and weaknesses.
18	**Resilience**	
19	**Self-confidence**	
20	**Autonomy**	Self-dependent working method, ability to work in autonomy. Self-disciplined.
21	**Ability to do simple tasks quickly**	Openness to simple tasks that needs to be done.
22	**Ability to handle different tasks at the same time**	
23	**Ethics**	Integrity – honest, ethical, high morals, has personal values, does what's right.
24	**Positive attitude**	Optimistic, enthusiastic, encouraging, happy.

D. Identification of the most critical microelectronics job profiles

The table below depicts the 21 job profiles identified as the most critical for the European microelectronics industry. The most critical job profiles are the job profiles that are defined as the most sough-after by the industry and the most difficult to fill.

The 21 job profiles identified as the most critical for the European microelectronics industry

N°	Job profile	Alternative names / Description	EQF at entry level	Number of stakeholders identifying the profile as one of the most critical (multiple choice allowed)			
				Interviews	Focus groups	Online survey	TOTAL
1	**Design engineer**	Designer	6-7	14	10	31	55
1.1	System design engineer	System designer, Product Architect, System Architect (HW/SW), System Development Engineer, HW/SW co-designer, System expert	7	6	9	0	15
1.2	Analog design engineer	Analog designer, Analog/Analog IC/Mixed-signal/ RF-IC Design Engineer	6-7	2	10	0	12
1.3	Digital design engineer	Digital designer	7	1	5	0	6
2	**Software engineer**	Controls and software engineer, Software developer, Solution engineer, Computer software engineer, Embedded/Firmware/Cloud software engineer, Software designer, Software design engineer	6-7	14	12	25	51
3	**Process engineer**	Manufacturing engineer	6-7	7	6	28	41
4	**Test engineer**	Component Verification & Validation Engineer / Lab-Verification & Validation Engineer / Field Service Engineer	6-7	6	5	24	35
5	**Maintenance technician**		5-6	4	9	18	31
6	**Robotic engineer**	Automation engineer	6-7	5	6	12	23
7	**Process technician**	Manufacturing technician	5-6	3	3	15	21
8	**Test technician**		5-6	3	6	10	19
9	**Manager or Director**		7-8	1	0	13	14
10	**Lead or supervisor**	Lab supervisor, shift leader	7-8	1	3	10	14
11	**Applications engineer**	Application engineering expert, Field applications engineer, Product development engineer, Product Manager, Requirement engineer, Industry 4.0 expert, Industrial power electronics expert, Supply chain manager with basic SC material knowledge	6-7	6	6	1	13
12	**Operator / Inspector**		5-6	1	3	5	9
13	**Marketing engineer**	Digital Marketing expert	7	2	3	3	8
14	**Material engineer**	Material experts, Specialist for new materials, Chemist	6-7	4	3	0	7
15	**Data scientist**	Dat analyst	6-7	6	0	0	6
16	**Quality engineer**	Quality expert, Requirement engineer, Reliability engineer. Understands both customers claims and technical fields. Coordinates quality assurance tasks, continuous improvement of processes, supplier quality (incoming material testing)	6-7	2	3	1	6
17	**RF engineer**		7	2	3	0	5
18	**Power electronics engineer**		7	2	3	0	5
19	**Hardware engineer**	PCB design & test engineer	6	1	3	1	5
20	**Expert in cybersecurity**	Similar to the security skills required for software engineer, but with a deeper knowledge level	7	0	3	0	3
21	**Maintenance engineer**		7	0	3	0	3

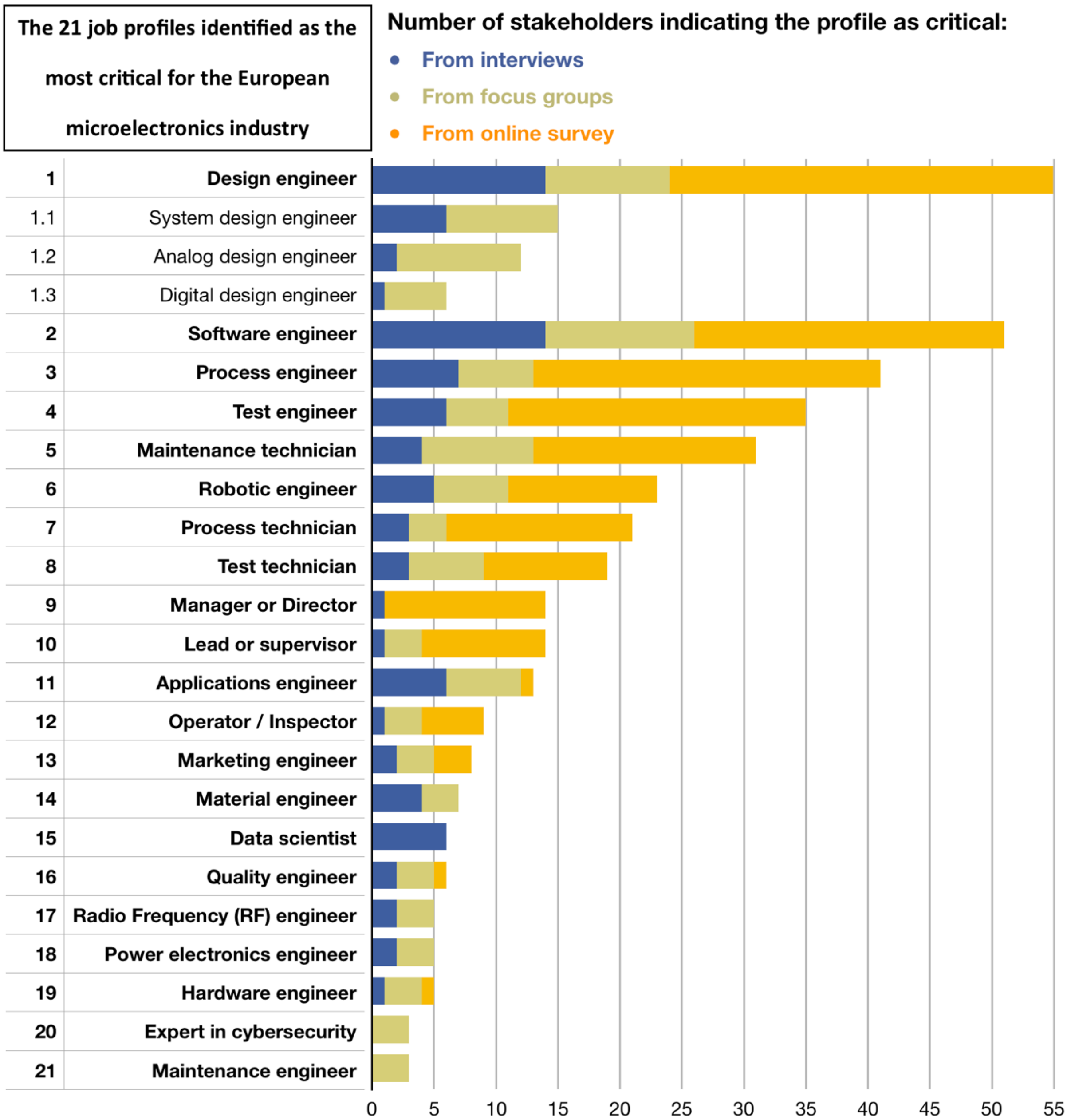
Other positions indicated as critical by a few stakeholders

- Optical engineer for semi metrology
- Package design engineer
- Mixed-signal test / verification engineer
- Mechanical engineer
- MEMS developer
- MEMS frontend expert

<u>Methodology note:</u>

The most critical job profiles are the job profiles that are:

- The most sough-after by the industry.
- The most difficult to fill.



The report provides detailed occupational profiles for these job profiles and describes the associated skills and knowledge, educational levels (EQF), etc.

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E. Proposition of new occupational profiles for microelectronics

METIS has proposed four new ESCO profiles linked to microelectronics that have been approved and integrated in the ESCO framework in October 2020:

I. **Microelectronics designer:** Focus on developing and designing systems, from the top packaging level down to the integrated circuit level. System-level understanding with analogue and digital circuit knowledge, integrating the technology processes. Overall outlook in microelectronic sensor basics.

II. **Microelectronics smart manufacturing engineer:** Microelectronics smart manufacturing engineers design, plan and supervise the manufacturing and assembly of electronic devices and products, such as integrated circuits, automotive electronics or smartphones, in an Industry 4.0 compliant environment.

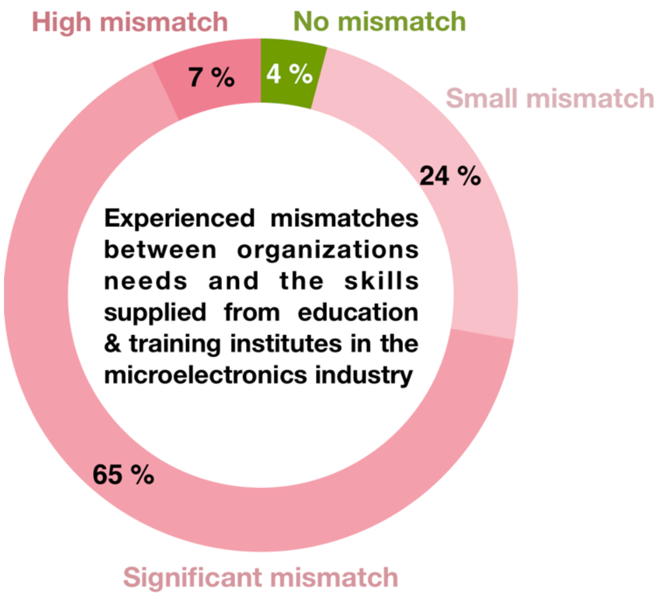
III. **Microelectronics materials engineer:** Design, develop and supervise the production of materials that are required for microelectronics and microelectromechanical systems (MEMS), and can apply them in these devices, appliances and products.

IV. **Microelectronics maintenance technician:** In charge of preventive and corrective maintenance in semiconductor manufacturing.

I. What skills are required by the European microelectronics industry and are difficult to source?

This chapter identifies the main trends affecting microelectronics skills & knowledge, present the current and future needs of the European microelectronics industry in terms of microelectronics job profiles, skills and knowledge and anticipate skills and occupational profiles.

A. Identification of the main mismatches regarding microelectronics job profiles and skills



96% of the stakeholders interrogated experience mismatches between the needs of the microelectronics industry and the skills supplied from education & training institutions.

Source: Online survey (72 answers).

<u>96%</u> of the stakeholders consulted in the online survey experience mismatches between the needs of the microelectronics industry and the skills supplied from education & training institutions, and nearly **<u>75%</u>** experience significant mismatches.

They suffer at the same time from skills required for decades that are less and less available on the European market and from the emergence of numerous new skills due to the numerous digital innovations leading to new technologies and markets.

As a consequence, companies have greater difficulties in recruiting qualified workers with specific knowledge in microelectronics and increasingly use vocational training to re-skill or upskill their employees.

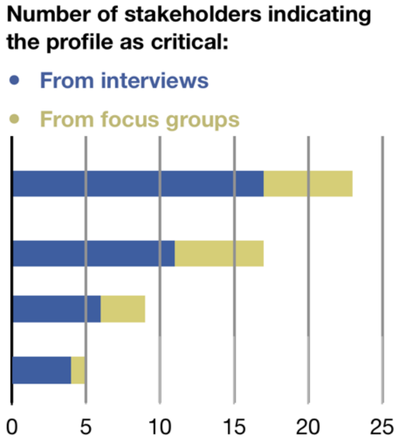
The four main mismatches identified by stakeholders are the following:

1. Needs for more fundamental knowledge and basics skills of manufacturing
2. Needs for more engineering profiles of generalists
3. Needs for more multidisciplinary cursus
4. Needs for more cursus dedicated to microelectronics

The table below shows the number of stakeholders that have put forward these mismatches.

Main mismatches between offer and demand experienced by the microelectronics industry

N°	Main mismatches	Skill / knowledge required at Educational level (EQF)	Number of stakeholders identifying this mismatch as one of the most critical (multiple choice allowed)		
			Interviews	Focus groups	TOTAL
1	Needs for more fundamental knowledge and basics skills of manufacturing	4-6	17	6	23
2	Needs for more engineering profiles of generalists	6-7	11	6	17
3	Needs for more multidisciplinary cursus	-	6	3	9
4	Needs for more cursus dedicated to microelectronics	-	4	1	5



1) Needs for more fundamental knowledge and basics skills of manufacturing

A very significant number of stakeholders report for recent graduates (both for technicians and engineering profiles) a lack of:

- Basic / Fundamental knowledge in microelectronics.
- Practical knowledge and skills associated to concrete production processes

In other words, knowledge and skills that companies can immediately use and that corresponds to the fundamentals to work in the microelectronics industry.

On the contrary, recent graduates appears to have an in-depth knowledge in very specific topics, often linked to state-of-the-art research, probably as many courses are given based on research of the university.

Industrials pledge for a greater focus on these topics for all student, starting at EQF 4. These skills and knowledge should be fully mastered by any graduate aiming to work in the microelectronics industry at EQF levels 6 and 7.

HTL (Höhere Technische Lehranstalt) schools (technical high schools in Austria) (EQF 5) are often depicted as more capable of providing graduates with good practical knowledge and skills linked to production processes.

This state of play also pushes companies to hire more graduates at the education level EQF 6 rather than at EQF 7, because they hire these graduates at lower salaries and then provide internal training oriented towards practical knowledge and skills associated to concrete production processes (2-12 months) so that they can work in the routinely manufacturing tools. MSc students have however better preparedness in manufacturing and are also more invested in material science, statistics, simulation, mathematics and physics. The main problem associated to this situation is that these BSc graduates are more difficult to work with on the long run than MSc graduates on average, when non-routine problems arise in manufacturing processes.

The solutions proposed are to:

- Reorient microelectronics curricula towards BSCs focusing on fundamental knowledge and practical production skills and knowledge completed by integrated deeper MSc with interdisciplinary courses.
- Systematize internships and/or apprenticeships at EQF 4 to 6 and extension of their average duration (minimum 4-6 months). Universities to be in charge of fundamental courses while companies to be charge of the teaching of the practical knowledge and skills associated to concrete production processes (especially thanks to their state-of-the-art machine tools that Universities might have difficulty to afford).
    - There is a similar problematic in research (EQF 8), as state-of-the-art machine tools for semiconductor production often cost more than €200M and Universities cannot afford to buy such machines. Research must be done in cooperation between Universities and companies to enable Universities' research to benefit from state-of-the-art machines.
- Generalize the hiring of experts working in the industry as University professors.
- Universities could dedicate more trainings to practical / applied lessons and less trainings to theoretical knowledge.

Basic / fundamental / generalist knowledge:

- Basics of electrical engineering.
- Basics of analog and digital electronics: including analog circuit design and digital circuit design.
- Ability to design standard circuits: different basic building blocks (like how to design an LDO) and how to design them, the combination of building blocks to build measurement chains or power converters.
- Good fundamental knowledge in chemistry, physics, mathematics, and mechanism.
- Introduction to materials (traditional materials and emerging ones).
- Principles of manufacturing.

Practical knowledge and skills linked to production processes:

- Design for production: Knowledge of the techniques to build robust, reliable and high-performance circuits or layout (as opposed to techniques to achieve the best specifications without looking at reliability, corners, etc.). Knowledge of design techniques to take into account temperature variation, technology variations and environmental effects.
- Ability to use industry standard tools for design and layout (Cadence, Synopsys, etc.).
- Ability to set up hardware, applied electronics.
- Knowledge of chopping techniques, instrumentation amplifiers, power down strategies.
- Knowledge of standardized processing equipment.
- Knowledge of standardized production processes.
- Knowledge of standardized testing techniques.

- Knowledge of standardized predictive/preventive maintenance services.
- Internal methodological competences (internal to companies).

2) Needs for more generalist engineering profiles

A significant number of stakeholders report a need (and a current shortage) for graduates with a good general knowledge in engineering, electronics and microelectronics. Over the last decades, they report a change in the training of graduates. In the past, the majority of graduates used to have a strong general knowledge but a lack of knowledge in specific areas (especially research areas). This trend has reversed over the years, and currently the majority of the graduates appears to lack strong fundamental knowledge but often have a deep knowledge in specific areas (digital design, layout, test topics, etc.), and especially research areas. Industrials often complains of this state of play as they need in majority profiles of « generalists » that can have a broad view and an ability to adapt to change (agility), although they also need a minority of specialists.

Ensure both design and manufacturing engineers have a common general knowledge of both microelectronics design and microelectronics manufacturing.

For many years, engineers working in the semiconductor industry has been divided into two groups:

- Manufacturing Engineer: people with semiconductors knowing how to make chips (manufacturing chips).
- Design Engineer: Engineers knowing how to design chips.

However, manufacturer flows need to respect design specification and at the same time the design community should know how manufacture processes works. Therefore, even engineer working in the semiconductor industry should be trained to know standardized processes of both design and manufacturing, although they may not be experts. At the EQF level 7 (master), Universities should ensure graduates have these basic knowledges.

Focus on teaching fundamental knowledge rather than emerging technologies.

Similarly, a significant number of stakeholders pushed the idea that the technological landscape is too complex and evolves at a too fast pace to enable the Education system to anticipate the needs of the industry. Some stakeholders also noticed that for some job profiles, it is too challenging to ask the education system to provide graduates (even at EQF 8) that are fully trained as it requires too many years of experience to develop the appropriate skills (e.g., skilled analog designer, skilled system architect).

These industrials would prefer the education system to focus on:

- A strong education on the fundamentals in mathematics, physics, engineering, electronics and microelectronics.
- Basics of manufacturing in Microelectronics
- Good soft skills:

- Agility / Mobility: Ability to evolve, to change job, to adapt to new technologies and to receive vocational training all along careers.
- Technical leadership: Ability (skill) to make decisions on a technical side, that is to choose a specific technology rather than another one and to justify the choice.
- Management skills: Ability to lead a team.

…rather than trying to anticipate the last technological evolutions and/or trying to train their graduates to very challenging job profiles.

Similarly, these industrials pledge for the development of specific "career long" education programs, that is education programs that includes both initial and vocational trainings, aiming to create skilled workers for the job profiles that are the most challenging (e.g., system architect): invest on skills on the long term through entire careers and train employees on-the-job.

3) Needs for more multidisciplinary cursus (interdisciplinarity)

Multidisciplinary cursus systems are more and more needed by the microelectronics industry as microelectronics involves a greater diversity of knowledge than in the past: Electronics hardware, but also software, data analysis, knowledge of new materials, etc. These subjects are now highly interconnected, and a diversity of the profiles is needed within engineering teams to be able to combine all the required knowledge within a team.

In microelectronics, the traditional cursus starts with electrical engineering, mechanics or mechatronics followed by a specialization electronics and microelectronics. The multidisciplinary implies replacing these initial curriculums by other fields:

- Material science (especially for process and material engineers).
- Chemistry, polymer sciences (especially for process and material engineers).
- Heat and mass flow sciences.
- Data science / Informatics (especially for software engineers).
- Cybersecurity (for experts in cybersecurity and eventually software engineers).

The profiles that are particularly affected by the need for multidisciplinary are:

- Software engineers.
- Robotic engineers.
- Process engineers.
- Materials engineers.
- Expert in cybersecurity.

At the same time, profiles of microelectronics engineers that are specialists of traditional technologies and manufacturing processes are still needed but should represent a minority of the profiles.

4) Needs for more cursus dedicated to microelectronics

A significant number of stakeholders report a need for more curricula in Europe dedicated to the microelectronics industry, involving teachers in specific areas such as MEMS, magnetic sensors, analog design, system design, etc.

Companies currently needs to provide internal trainings to up-skill graduates when they enter the microelectronics sector.

B. Identification of the skills and knowledge the most difficult to source

This chapter summarizes the skills and knowledge identified as the most critical for the European microelectronics industry. The most critical skills and knowledge are the ones that are defined as the most sough-after by the industry and the most difficult to fill.

Technical skills and soft skills have been distinguished. However, stakeholders interviewed within METIS have generally insisted on the importance of soft skills and most of the case consider them as important as technical skills.

1) Technical skills & knowledge

The table above shows the technical skills and knowledge described by stakeholders as the most critical for the European microelectronics industry today as well as their associated specific education levels (EQF).

These skills and knowledge are both the most sought after and the most difficult to find in different job profiles. In other words, these skills and knowledge are not the most sought after across profiles, all other things being equal, but the hardest to find among those sought after by companies.

Many of these skills are associated to digitization and can be considered as digital skills:

- Data analytics.
- Artificial Intelligence / Machine learning.
- Knowledge of applications (most of emerging applications being associated to digital transition, such as ADAS[3]).

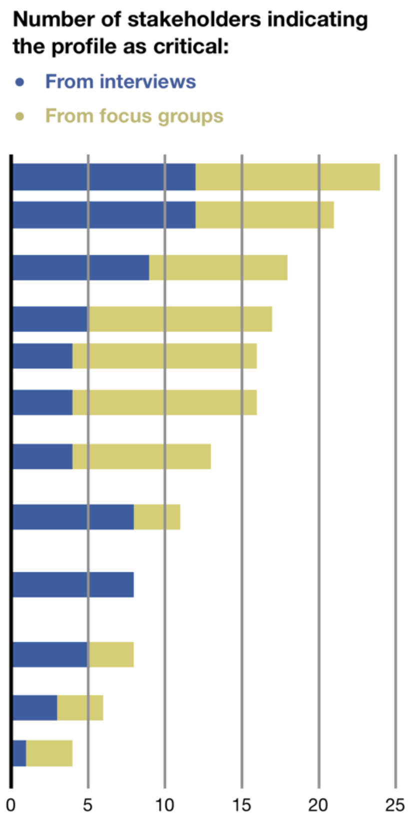
[3] Advanced Driver Assistance Systems.

- Security / Cybersecurity.
- Software skills.

Knowledge associated environmental awareness and the green transition are also identified as sought-after and difficult to find. They appear in 11th position.

Most critical technical skills required today by the Microelectronics industry (1/2)

N°	Skill / Knowledge	Alternative names	Number of stakeholders identifying the skill/topic as one of the most critical (multiple choice allowed), across job profiles		
			Interviews	Focus groups	TOTAL
1	Systems architectures	System engineering	12	12	24
2	Data analysis	Big data	12	9	21
3	Artificial Intelligence / Machine learning	Especially for software engineers, test engineers and design engineers	9	9	18
4	Knowledge of applications		5	12	17
5	Quality / reliability		4	12	16
6	Hardware / Software (HW/SW) integration	Hardware / Software co-design	4	12	16
7	Security	Security-by-design / Cybersecurity	4	9	13
8	Knowledge of new materials	Knowledge of new materials and their applications	8	3	11
9	Software skills	Shift from hardware to software affecting most of the profiles	8	0	8
10	Analog design	Analog / Analog IC / Mixed-signal / RF-IC design	5	3	8
11	Environmental awareness		3	3	6
12	Social inclusion and diversity		1	3	4



The most critical means both the most sought after and the most difficult to find in different job profiles.

Most critical technical skills required today by the Microelectronics industry (2/2)

N°	Skill / Knowledge	Alternative names	Skill / knowledge required at Educational level (EQF)	The skill / knowledge is mandatory / optional	
				Mandatory	Optional
1	**Systems architectures**	System engineering	7	System design engineer	Design engineer
2	**Data analysis**	Big data	6-7	All profiles	-
3	**Artificial Intelligence / Machine learning**	Especially for software engineers, test engineers and design engineers	6-7	Software engineers / Data scientists	Other profiles. Important for Design engineers, Test engineers
4	**Knowledge of applications**		7	Application engineers / Material engineers / Design engineers / System design engineers / Software engineers	Other profiles
5	**Quality / reliability**		6-7	Process engineers	Other profiles
6	**Hardware / Software (HW/ SW) integration**	Hardware / Software co-design	6-7	Design engineers / System design engineers / Software engineers	Other profiles
7	**Security**	Security-by-design / Cybersecurity	6-7	Expert in cybersecurity / Software engineers / Robotic engineers / Process engineers / Test engineer	Other profiles
8	**Knowledge of new materials**	Knowledge of new materials and their applications	6-7	Process engineers / Material engineers	Other profiles
9	**Software skills**	Shift from hardware to software affecting most of the profiles	6-7	Software engineers / Data scientists / Robotic engineers / Process engineers / Materials engineers / Power electronics engineers / RF engineers	Other profiles
10	**Analog design**	Analog / Analog IC / Mixed-signal / RF-IC design	7	Design engineers and especially analog design engineers	-
11	**Environmental awareness**		4	-	All profiles
12	**Social inclusion and diversity**		4	-	All profiles

The most critical means both the most sought after and the most difficult to find in different job profiles.

a. System architecture

An electronic system (or system on chip) is a small system that includes ICs (memory, logic) and external components on a PCB. Electronic systems are not “Cyber Physical Systems” (CPS). CPS are much bigger with embedded software, networks, and more complex.

Will become more and more important especially in line with the development of IoT and I4.0. Engineers with knowledge of the systems / co-design are also more and more required for automotive applications to reduce vehicle architecture costs and increase functionality by decreasing the number of discrete components and favoring the use of standardized microelectronic components and embedded systems and platforms.

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7.

Associated job profile:

- System design engineer
- Design engineer
- In the absence of a System expert, teamwork between application engineers, design engineers and other engineering job profiles.

Content / sub-skills and sub-knowledge:

- Knowledge of systems architectures (from IC to systems), system-on-chip and system-in-package. Interdisciplinary understanding of how the various system levels are interlinked and affect the overall performance
- Knowledge of the different types of microsystems (MEMS, MOEMS)
- Understanding of the whole design and product life cycle
- Ability to design both ICs, ASICs and systems, systems-on-chips, and system-in-package
- Ability to optimize architectures
- Ability to link and adapt design architectures to the end-using applications of systems (automotive, I4.0, etc.)

The main skills and knowledge associated are:

- Hardware / Software integration
- Knowledge of applications: Ability to associate designs and end-user applications of products; to adapt the design of a product to the end-user application
- Teamwork and communication
- Data analytics
- Multidisciplinarity

b. Data analysis

Data analysis skills and knowledge are increasingly required for nearly all profiles of the microelectronics industry today. They are especially important for data scientists and software engineers. Several companies report a lack of software engineers with good skills in data analysis.

Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7. Every graduate at EQF 6-7 should have received initial trainings in this field.

Associated job profile:

- Nearly all profiles.
- Mainly Data scientists, Software engineers and Test engineers.
- But also, any engineer dealing with hardware: Process engineers, RG engineers, Robotic engineers, etc.
- Etc.

Content / sub-skills and sub-knowledge:

- Data management: SQL, etc.
- Data visualization: Tableau, etc.
- Data integrity: Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
- Data Security & Privacy by design: Ability to ensure security of data & data privacy. Including IP protection.
- Data analysis: Ability to interpret and make sense of large volume of data. Knowledge of potential biased conclusion led by biased data.
- Machine learning / Artificial intelligence.
- Algorithm optimization. This skill is increasingly sought after by industrials.
- Performance Data Analysis: Analyzing performance data.

c. Machine learning / Artificial Intelligence

Knowledge and skills associated to machine learning are increasingly required for the majority of the profiles of the microelectronics industry today and will become more and more important, especially in line with the development of I4.0.

These are especially important for software engineers that much be trained to a diversity of AI tools so that they have a wide view of the topic. Tools such as Keras, Torch, Tensorflow, Colab, Jupyter, Python, Lua, Matlab…

Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7.

Associated job profile:

- Main profiles concerned: Software engineers and Data scientists.
- Also, very important for Test engineers, Design engineers, Process engineers and Material engineers.
- Etc.

Content / sub-skills and sub-knowledge:

- Ability to select and use the machine learning toolsets for manufacturing (design, automation, etc.), and/or ERP.
- General introduction course on AI (at EQF 4-5): Fundamental knowledge and understanding of AI tools.
- Understanding of how to replace basic skills in production by machine learning algorithms to increase competitiveness and to facilitate innovation.
- Understanding of the impact of AI applications: It can lead to an overfitted world for citizens and engineers/developers should be aware of the consequences of their developments. Application of AI will have impacts on the job market, and social and economic development.

d. Knowledge of applications

Content / sub-skills and sub-knowledge:

- Ability to link and adapt technical aspects of a product (materials to use, design architecture, type of connectivity tools to integrate, etc.), to its end-user market(s) and application(s) (I4.0, automotive, etc.).
- Knowledge of applications and associated technical requirements, to build solution-oriented products.

Illustrations:

- A good knowledge of ADAS tools, other automotive developments or Industry 4.0 applications can be required for system engineer experts but also for software engineers.
- A good knowledge of automotive applications and associated technical requirements is required for the development of magnetic sensors development for the automotive industry: Safety, standards, Requirement Management and Change & Configuration Management.
- A material engineer needs to be able to link specific requirements on new materials with applications (e.g., high quality of images).

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

- Specific courses should be dedicated to specific applications. For instance, Industry 4.0 could have dedicated courses and be taught as a concept as a whole, regrouping all its associated sub-topics. On the contrary, sub-topics required for Industry 4.0 (like virtual prototyping, big data analyses, machine learning techniques, VR and AR techniques, Quality 4.0, advanced manufacturing machines) are often taught in separate curricula, even under the management of different faculties in universities, making the links between the sub-topics less clear for students. All of the relevant sub-topics could be brought together under one curriculum, or specialization on EQF level 6-7, preferably on level 7.

Associated job profile:

- Application engineer
- Materials engineer
- System design engineer
- Design engineer
- Software engineer

The main skills and knowledge associated are:

- Teamwork and communication: Specially to optimize process transfer from lab to customer site.

e. Quality / reliability

Knowledge associated to quality / reliability (manufacturing quality control) is more and more needed by the microelectronics industry, especially to transfer prototypes into mass production.

Meanwhile, functional safety and reliability are increasingly important within manufacturing processes. For instance, reliability and functional safety are two of the four main domains where increased skills is required for microelectronics engineers in line with the development of automotive electronics, with security and cost management (according to the focus group on automotive organized by METIS).

- Reliability: The strong impulse in the search for improving the reliability of components, systems and, in particular, designs even more than in innovation itself. This makes the system design more and more difficult and also asks for advanced testing systems to assess the reliability of the components. This implies a greater importance of test technicians and engineers and their associated skills for microelectronics companies serving the automotive industry.
- Functional Safety (Quality): Vehicle safety is an aspect linked to the improvement of reliability and led to the introduction of Functional Safety and the ISO 26262.

Educational level (EQF): Associated skills and knowledge must be acquired for graduates at EQF level 7 (at EQF 6 is a plus, depending on profiles).

The main skills and knowledge associated are:

- Basic knowledge on quality engineering.
- Quality assessments (skill): Knowledge of the methodology of quality (Quality 3.0 and 4.0), and ability to use Quality tools (including quality tools associated to I4.0).
- Reliability analyses: Multidisciplinary knowledge in failure analyses, physics of failure.
- Robustness of microelectronics: Electromagnetic compatibility (EMC), electromagnetic interference (EMI), electrostatic discharge (ESD), aging, radiation hardness...
- Deep understanding of measurements and a physical sense of statistics.
- Analytical knowledge in reliability.
- Functional safety.

f. Hardware / Software integration

HW/SW integration is a skill depicted as very difficult to find and long to acquire (many years) by many stakeholders. Hardware and software co-design will become more and more important especially in line with the development of IoT and I4.0.

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profile:

- System design engineer
- Design engineer
- Software engineers

The main skills and knowledge associated are:

- Systems architectures: Thinking on full-system level becomes more important.
- Software on board: Adapting the electronics design optimization from software point of view.
- Data analytics.
- Teamwork and communication: Employees from many fields should be able to work together, including engineers from mechanical-, electrical-, and software engineering fields, e.g., to implement IoT and I4.0 software related requirements even in the early design phase of the electronics product.
- Multidisciplinarity.

g. Security

Skills associated to Security, Cybersecurity and Security-by-design will be very important for software engineers (EQF 6-7 engineers).

These skills will become more and more important in line with the development of I4.0, but also in line with automotive innovations. Security is one of the four main domains where increased skills is required in line with the development of automotive electronics (with reliability, functional safety and cost management), according to the focus group on automotive organized by METIS, especially as a tightening of the security rules applied to microelectronics in the Automotive segment is foreseen in Europe during the coming years and due to an increased external connectivity.

For a Test engineer, this will become more and more important equally from SW and HW side. From the aspect of test engineering concept, the testing of security on devices themselves (code, hardware) and the closeness of a system is becoming more and more important.

Educational level (EQF): Trainings to be provided from EQF 5 to 7. Associated skills and knowledge are very important for Expert in cybersecurity / Software engineers / Robotic engineers / Process engineers / Test engineer. Associated skills and knowledge are a plus for other engineering profiles.

Associated job profile:

- Expert in cybersecurity
- Software engineers
- Robotics engineers
- Process engineers
- Test engineer

Content / sub-skills and sub-knowledge:

- <u>Combined knowledge between hard and software necessary.</u>
- <u>Security by design</u> (Especially important for IoT and I4.0.): Know-how and applicability of secure protocols necessary.
- <u>Skills used for cyber-physical (production) systems</u> like diagram a network for security.
- <u>Cybersecurity:</u>
    - Advanced intrusion detection and prevention.
    - Advanced skills in forensics.
- <u>Reverse engineering for the prevention of industrial spying</u> (especially for test engineers).
- <u>Ability to investigate the possible failures originated from improper use of malicious codes</u> (highly for robotic engineers). Identify risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure
- <u>Data integrity</u>: Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
- <u>Data Security & Privacy by design:</u> Ability to ensure security of data & data privacy. Including IP protection.

- Safety issues.

h. Knowledges of new materials

New materials are becoming increasingly important in microelectronics: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, etc. Microelectronics engineers must have knowledge not just on traditional material engineering, but additionally on chemical and physical sciences (e.g., nanostructures).

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7. Process and material engineers graduated at EQF 6 and EQF 7 must both have received these trainings. These training are also a plus for other types of microelectronics engineers at EQF 6 and EQF 7.

The main skills and knowledge associated are:

- Knowledge of new materials: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, hight, gallium nitride. etc. Understanding of material properties, and the need to modify the integration flow.
- Knowledge in chemical and physical sciences (e.g., nanostructures). Basic knowledge in chemistry (missing in many curricula).
- Environmental awareness associated to traditional and new materials.
- Ability to link a material with production processes, product(s) specification(s) and end-user applications.

i. Software skills

Software skills are becoming more and more important for most microelectronics job positions: Robotic engineers, materials engineers, process engineers, power electronics engineers, RF engineers, etc. For instance, for RF and hardware engineers, software programming has become a very basic requirement in job descriptions currently. Up to the early 2000s’, microelectronics technological developments were very hardware intensive (70% hardware VS 30% Software). In the early 2020s’, this ratio as shift to ratio 70% for software and 30% for hardware. In certain technology (e.g., AI), software may be even more important than hardware in the semiconductor sector. However, in the semiconductor sector, many people may still not value skills in software as much as hardware, considering software skills as easier to learn which is not true as software engineering cover a very wide range of skills and knowledge.

Educational level (EQF): Trainings to be provided from EQF 5 to 7. Every graduate at EQF 6-7 should have received initial trainings in this field.

- Courses could be adapted to blend the interdisciplinary boundaries between microelectronics and software engineering.
- Importance to teach not only the last software technologies, but also older technologies that are the most largely used by the industry.

Associated job profile:

- Main profiles concerned: Software engineers and Data scientists.
- Robotic engineers.
- Process engineers.
- Power electronics engineers.
- RF engineers.
- Materials engineers.
- Etc.

Main skills and knowledge of the « software » trend:

- HW / SW integration. Includes for instance IT-OT Integration Management (such as implementation of IT architectures, platforms, components and operations technologies of industrial automation (OT) oriented towards Industry 4.0).
- Embedded software. Especially in Europe, knowledge in embedded software is increasingly important. Embedded Linux and RTOS knowledge and associated skills are among the most important and hard to find in the microelectronics sector.
- Python and C languages.
- Machine learning / Artificial Intelligence.
- Data Science Management / Data analytics: Design and implementation of Big Data architectures and software platforms (e.g., Hadoop or Data Lake). Especially important for IoT and I4.0.
- Security by design: Skills used for cyber-physical (production) systems like diagram a network for security, advanced intrusion detection and prevention, advanced skills in forensics and reverse engineering. Especially important for IoT and I4.0.
- Knowledge of algorithm and computational coding.
- Network infrastructure support for tooling.

j. Analog design

Also named Analog / Analog IC / RF-IC Mixed-signal design (analog-to-digital converters (ADC), digital-to-analog converters (DAC)).

Analog design is one of the skills for which the European microelectronics industry face the greatest shortage currently. A progressive but very significant shortage as emerge in the industry during the past 20 years for this profile, due to the aging workforce and the lack of new graduates trained in analog design. Even though there is the trend of digitalizing signals as fast as possible, there still remains this small part of "analog", where there are too few experts available within every company.

The shortage is particularly high for this job profile as it takes a particularly long time to develop good analog design skills and about 20 years to become good analog designer. This cannot only be done by education, but there are also many practical skills needed.

Educational level (EQF): Trainings to be provided from EQF 5 to EQF 7.

Associated job profile:

- Analog design engineer
- Design engineer

Content / sub-skills and sub-knowledge:

- Mixed Signal Design: Proficient with analogue and digital electronic design, noise, signal integrity, etc.

k. Environmental awareness

Environmental awareness and associated knowledge to support EU Green Deal and Circular Economy is a transversal topic composed of both hard and soft skills. It is increasingly required for nearly all profiles of the microelectronics industry today. They are especially important for process engineers and material engineers, to enable greener production. Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7. Every worker should receive initial trainings in this field.

Associated job profile:

- Almost all profiles concerned.
- Especially important for process engineers and material engineers.

Content / sub-skills and sub-knowledge:

- Circular economy: Circular economy in the design process to include already at design level the principle of green economy and green growth, as an industrial product's environmental performance is fixed up to 80% at the design stage.
    - Sustainability, recyclability and reusability of production: How to "green microelectronics production" for instance dealing with issues that relate to the processing of raw materials and disposal of industrial waste.
    - Ability to assess the environmental impact of a design.
- Environmental aspects associated to traditional and new materials.

- Energy efficiency of the manufacturing processes: How to minimize energy consumption and protect the environment through manufacturing processes.
- Artificial intelligence & sustainability: Specific course given to students aiming to work on cloud / edge computing and/or and artificial intelligence. The goal is to sensitize them to the energy consumption of AI and present good practices and alternative solutions.
- Sustainable development goals (SDG): (Maximum EQF 6) All engineers should be aware of challenges and understand that their work should contribute to SDGs.
- Introduction to climate change.

I. Knowledge of social inclusion and diversity

Environmental awareness and associated knowledge are increasingly required for nearly all profiles of the microelectronics industry today. They are especially important for process engineers and material engineers, to enable greener production.

Educational level (EQF): Trainings to be provided from EQF 4 to EQF 7. Such training would be a plus for any graduate at EQF 4-7.

Associated job profile:

- All profiles concerned.
- Especially engineers using Artificial Intelligence.

Content / sub-skills and sub-knowledge:

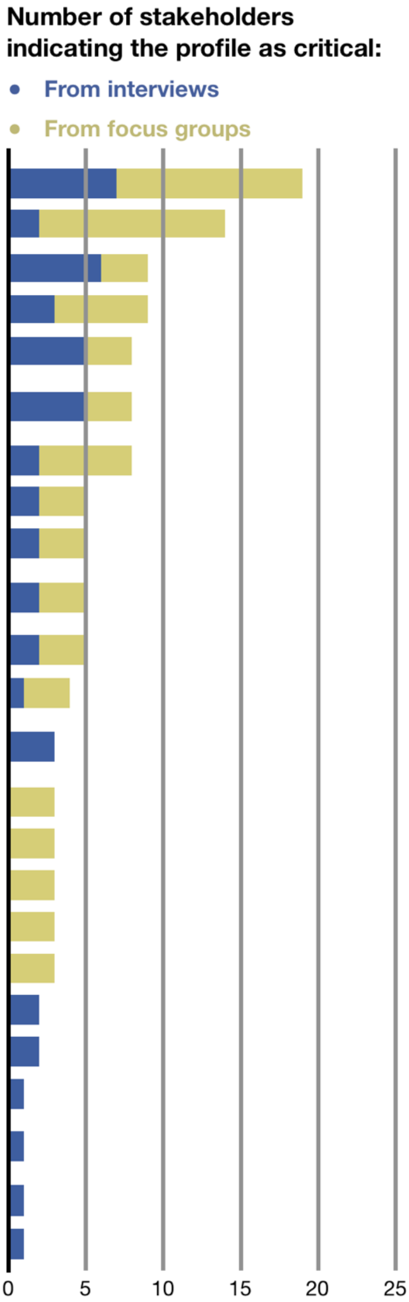
- Social inclusion and digitization: Sensitization to the potential social exclusion caused by digitization and especially artificial intelligence. All engineers should be aware that not everyone has the same digital skills. Systems and applications developed should serve for all groups of people, not only for certain groups. Regarding artificial intelligence, developers should be aware of the potential direct or indirect bias caused by AI that can discriminate certain minorities (such as ethnic groups). AI may also result in job losses, and developers should be aware of that.
- Diversity in electronics. Sensitization to the importance of diversity for teamwork: in terms of gender, but also of educational background and other criteria. A team should consist of people with diverse backgrounds as people with different backgrounds will see things differently.

2) Soft skills

The table below shows the soft skills described by stakeholders as the most important for the European microelectronics industry today. They are not associated to specific education levels (EQF), and are required for all workers of the industry, especially for engineers (EQF 6-7).

Main soft skills required today by the microelectronics industry (1/2)

N°	Soft skill	Number of stakeholders identifying the skill/topic as one of the most critical (multiple choice allowed), across job profiles		
		Interviews	Focus group	TOTAL
1	**Teamwork**	7	4	19
2	**Creativity** (Innovation capacity)	2	4	14
3	**Communication** (Presentation)	6	1	9
4	**Complex problem solving**	3	2	9
5	**Management**	5	1	8
6	**Adaptability** (Agility, Mobility, Flexibility)	5	1	8
7	**Interdisciplinarity openess**	2	2	8
8	**Customer management**	2	1	5
9	**Language skills**	2	1	5
10	**Responsibility** (Empowerment, Accountability)	2	1	5
11	**Ability to link theory and practice**	2	1	5
12	**Intercultural openess**	1	1	4
13	**Technical leadership** (Critical thinking)	3		3
14	**Lean principles**	0	1	3
15	**Agile principles**	0	1	3
16	**Curiosity**	0	1	3
17	**Self-evaluation**	0	1	3
18	**Resilience**	0	1	3
19	**Self-confidence**	2	0	2
20	**Autonomy**	2	0	2
21	**Ability to do simple tasks quickly**	1	0	1
22	**Ability to handle different tasks at the same time**	1	0	1
23	**Ethics**	1	0	1
24	**Positive attitude**	1	0	1



Main soft skills required today by the microelectronics industry (2/2)

N°	Soft skill	Description
1	**Teamwork**	Cooperative, gets along with others, agreeable, supportive, helpful, collaborative. Students should learn Teamwork skills in real life project teams.
2	**Creativity** (Innovation capacity)	Design thinking. Ability to come up with new ideas, new designs, new technologies, new applications.
3	**Communication** (Presentation)	Ability to communicate, ability to present oneself, self-marketing, ability to explain in a few words complex topics to a non-expert. Cross-discipline communication. Technical presentation skills. Oral speaking capability, written, presenting, listening, clear speech & writing.
4	**Complex problem solving**	Analytical knowledge.
5	**Management**	Ability to lead a team, project management.
6	**Adaptability** (Agility, Mobility, Flexibility)	Ability and willingness to evolve, to change job, to adapt to new technologies and to receive vocational lifelong training. Life-long-learning mind-set. Ability to accept and adapt to changes.
7	**Interdisciplinarity openess**	Open mindset and ability to communicate with other discipline specialists.
8	**Customer management**	Patience when being in contact with customers, customer satisfaction minded. Courtesy, manners and respect to clients.
9	**Language skills**	Especially english.
10	**Responsibility** (Empowerment, Accountability)	Ability to take ownership of a task/activity, to be responsible for this and to assume the consequences. Accountable, reliable, gets the job done, wants to do well, conscientious.
11	**Ability to link theory and practice**	Ability to apply knowledge in practice.
12	**Intercultural openess**	Open mindset and ability to communicate with colleagues from the cultures.
13	**Technical leadership** (Critical thinking)	Ability to make decisions on a technical side, that is to choose a specific technology rather than an other one and to justify the choice, without being influenced by any new information. Common sense.
14	**Lean principles**	
15	**Agile principles**	
16	**Curiosity**	
17	**Self-evaluation**	Ability to self-evaluate ones own strengths and weaknesses.
18	**Resilience**	
19	**Self-confidence**	
20	**Autonomy**	Self-dependent working method, ability to work in autonomy. Self-disciplined.
21	**Ability to do simple tasks quickly**	Openness to simple tasks that needs to be done.
22	**Ability to handle different tasks at the same time**	
23	**Ethics**	Integrity – honest, ethical, high morals, has personal values, does what's right.
24	**Positive attitude**	Optimistic, enthusiastic, encouraging, happy.

A significant number of companies with an international workforce consider European workers as in general better than the other regions in terms of soft skills: e.g., more self-confident and independent, with a better ability to turn theory into practice…

Europe cultural approach in training is also highly appreciated as European education systems tend to teach more theoretical and methodological aspects than applications compared to other regions. In Europe, teaching is focusing on the underlying theory, explanation of methodologies for solving different problems. Teachers would ask students then to come up with their own procedures for solving problems and lead them towards increasingly sophisticated ways of solving a given problem. In contrast, in other educational systems such as the American one, the teaching is focusing on learning terms and practicing procedures. Teachers would present definitions of terms and demonstrate procedures for solving specific problems. Students would then be asked to memorize the definitions and practice the procedures.

Finally, in parallel to the new expectations of companies in terms of soft skills for graduates, expectations from candidates & students towards the industry have also changed.

- Career paths and flexibility become more important:
    - Part-time work
    - Teleworking
    - Possibility to take a long break
    - Possibility to contribute (full or part time) to non-profit (organizations) programs
- Willingness to make impact in the world, giving sense to the work.

C. Identification of the most critical microelectronics job profiles

1) Overview of the most critical profiles

a. Key results

The table below depicts the 21 job profiles identified as the most critical for the European microelectronics industry. The most critical job profiles are the job profiles that are defined as the most sough-after by the industry and the most difficult to fill.

The 21 job profiles identified as the most critical for the European microelectronics industry

N°	Job profile	Alternative names / Description	EQF at entry level	Number of stakeholders identifying the profile as one of the most critical (multiple choice allowed)			
				Interviews	Focus groups	Online survey	TOTAL
1	**Design engineer**	Designer	6-7	14	10	31	55
1.1	System design engineer	System designer, Product Architect, System Architect (HW/SW), System Development Engineer, HW/SW co-designer, System expert	7	6	9	0	15
1.2	Analog design engineer	Analog designer, Analog/Analog IC/Mixed-signal/ RF-IC Design Engineer	6-7	2	10	0	12
1.3	Digital design engineer	Digital designer	7	1	5	0	6
2	**Software engineer**	Controls and software engineer, Software developer, Solution engineer, Computer software engineer, Embedded/Firmware/Cloud software engineer, Software designer, Software design engineer	6-7	14	12	25	51
3	**Process engineer**	Manufacturing engineer	6-7	7	6	28	41
4	**Test engineer**	Component Verification & Validation Engineer / Lab-Verification & Validation Engineer / Field Service Engineer	6-7	6	5	24	35
5	**Maintenance technician**		5-6	4	9	18	31
6	**Robotic engineer**	Automation engineer	6-7	5	6	12	23
7	**Process technician**	Manufacturing technician	5-6	3	3	15	21
8	**Test technician**		5-6	3	6	10	19
9	**Manager or Director**		7-8	1	0	13	14
10	**Lead or supervisor**	Lab supervisor, shift leader	7-8	1	3	10	14
11	**Applications engineer**	Application engineering expert, Field applications engineer, Product development engineer, Product Manager, Requirement engineer, Industry 4.0 expert, Industrial power electronics expert, Supply chain manager with basic SC material knowledge	6-7	6	6	1	13
12	**Operator / Inspector**		5-6	1	3	5	9
13	**Marketing engineer**	Digital Marketing expert	7	2	3	3	8
14	**Material engineer**	Material experts, Specialist for new materials, Chemist	6-7	4	3	0	7
15	**Data scientist**	Dat analyst	6-7	6	0	0	6
16	**Quality engineer**	Quality expert, Requirement engineer, Reliability engineer. Understands both customers claims and technical fields. Coordinates quality assurance tasks, continuous improvement of processes, supplier quality (incoming material testing)	6-7	2	3	1	6
17	**RF engineer**		7	2	3	0	5
18	**Power electronics engineer**		7	2	3	0	5
19	**Hardware engineer**	PCB design & test engineer	6	1	3	1	5
20	**Expert in cybersecurity**	Similar to the security skills required for software engineer, but with a deeper knowledge level	7	0	3	0	3
21	**Maintenance engineer**		7	0	3	0	3

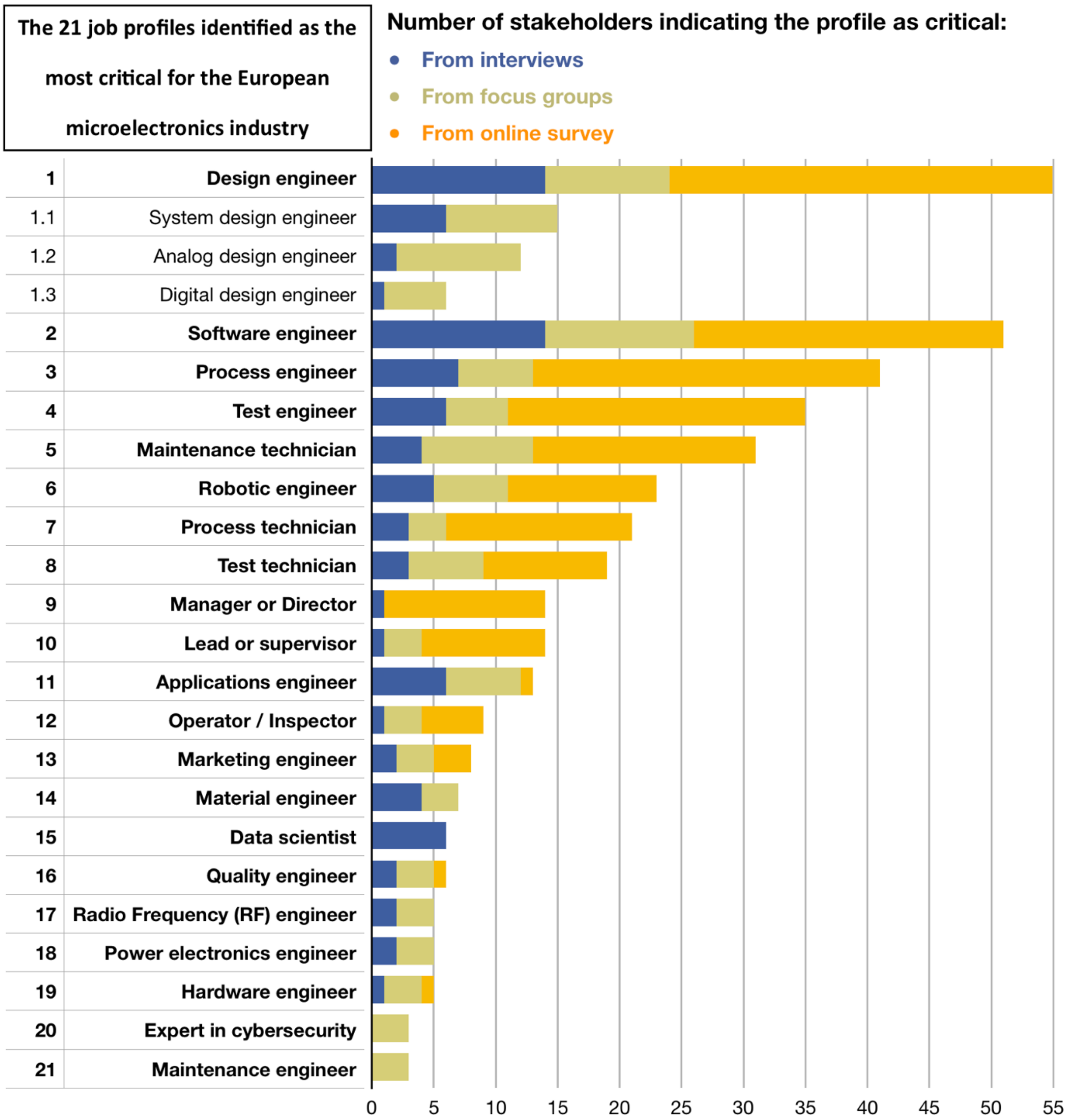
Other positions indicated as critical by a few stakeholders

- Optical engineer for semi metrology
- Package design engineer
- Mixed-signal test / verification engineer
- Mechanical engineer
- MEMS developer
- MEMS frontend expert

<u>Methodology note:</u>

The most critical job profiles are the job profiles that are:

- The most sough-after by the industry.
- The most difficult to fill.

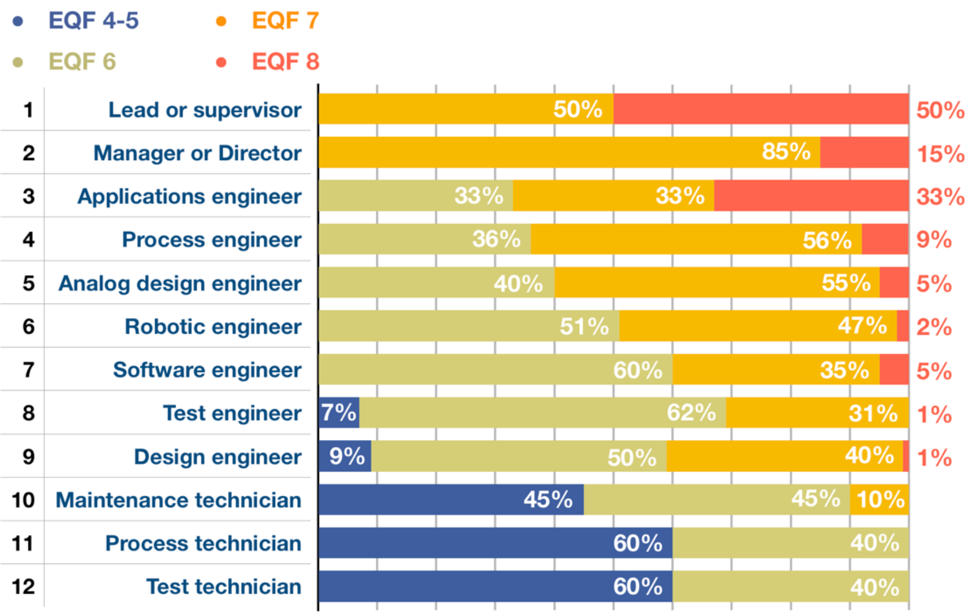


The 21 job profiles identified as the most critical for the European microelectronics industry
Number of stakeholders indicating the profile as critical:
From interviews
From focus groups
From online survey
1 Design engineer
1.1 System design engineer
1.2 Analog design engineer
1.3 Digital design engineer
2 Software engineer
3 Process engineer
4 Test engineer
5 Maintenance technician
6 Robotic engineer
7 Process technician
8 Test technician
9 Manager or Director
10 Lead or supervisor
11 Applications engineer
12 Operator / Inspector
13 Marketing engineer
14 Material engineer
15 Data scientist
16 Quality engineer
17 Radio Frequency (RF) engineer
18 Power electronics engineer
19 Hardware engineer
20 Expert in cybersecurity
21 Maintenance engineer
0 5 10 15 20 25 30 35 40 45 50 55

Educational level associated to job profiles (EQF)

	Minimum EQF level required at the entry level	Empirical distribution of EQF levels within companies				
		4	5	6	7	8
Lead or supervisor	7	0 %		0 %	50 %	50 %
Manager or Director	7	0 %		0 %	85 %	15 %
System design engineer	7	-	-	-	-	-
Digital design engineer	7	-	-	-	-	-
MEMS developer	7	-	-	-	-	-
Marketing engineer	7	-	-	-	-	-
Radio Frequency engineer	7	-	-	-	-	-
Power electronics engineer	7	-	-	-	-	-
Design engineer	6	9 %		50 %	40 %	1 %
Analog design engineer	6	0 %		40 %	55 %	5 %
Software engineer	6	0 %		60 %	35 %	5 %
Expert in cybersecurity	6-7	-	-	-	-	-
Data scientist	6-7	-	-	-	-	-
Process engineer	6	0 %		36 %	56 %	9 %
Material engineer	6-7	-	-	-	-	-
Quality engineer	6-7	-	-	-	-	-
Test engineer	6	7 %		62 %	31 %	1 %
Robotic engineer	6	0 %		51 %	47 %	2 %
Applications engineer	6	0 %		33 %	34 %	33 %
Hardware engineer	6	-	-	-	-	-
Maintenance technician	4	45 %		45 %	10 %	0 %
Process technician	4	60 %		40 %	0 %	0 %
Test technician	4	60 %		40 %	0 %	0 %
Operator / Inspector	4	-	-	-	-	-

Empirical distribution of EQF levels within companies:



b. Foresight Exercise

The main profiles that are gaining the most importance due to with the technological and market evolution within the microelectronics industry over the past years and for the coming years are:

- Software engineers, data scientists and experts in cybersecurity: in line with the growing importance of software in microelectronics.
- Application engineers: in line with the growing number of innovative and complex applications with their own specificities and associated technical requirements.

c. Average duration to fill position

For certain profiles, some stakeholders have indicated average duration to fill positions, although there is a high variability between countries and regions in Europe.

On average across the microelectronics industry, it takes 3-6 months to fill a position at the entry level.

Expert profiles appear particularly difficult to find. It takes often several years to fill a position and recruiters have to consider the whole world to find them.

Among the expert profiles depicted by companies as particularly hard to find, one may find:

- Digital physical design engineer.
- Analog layout engineer.
- System design engineer.
- Analog design engineer.

The results by job profiles are presented in the table below.

Average duration to fill a position (in months)

Level of seniority	Entry	Mid	Senior
Digital physical design engineer	24	-	-
Analog layout engineer	>12	-	-
Manager or Director	12	> 12	> 12
Test engineer	3-6	6-9	12-24
Test technician	3	12-18	24
Process technician	1-4	9-12	12-24
Process engineer	2-4	6-8	10-12
Analog design engineer	3	6-8	10-12
Digital design engineer	3	6-8	10-12
Software engineer	2-3	6	8
Applications engineer	2-3	4-5	6-7
Lead or supervisor	1-3	3-8	12-18
Design engineer	0-2	6	10
Maintenance technician	1	5	9
Operator inspector	1	3	6
RF engineer	<1	-	-
Hardware engineer	<1	-	-
Robotic engineer	-	-	-

d. Average duration to train a hire till he/she becomes productive

For certain profiles, some stakeholders have indicated average duration to train a hire till he/she becomes productive, although there is a high variability between countries and regions in Europe. Across the job profiles, the key trends are the following:

- High variability across the job position.
- Longer time for management positions and higher time for technical positions requiring expertise.
- Academics (EQF 6-7) have an ability to learn on average faster than technicians (EQF 4-5).

According to the stakeholders interviewed, it takes from 1 to 18 months for a graduate in microelectronics at the entry level to become productive, and 10 months on average. It takes 2-5 years for a graduate at the entry level to become senior: independent, able to understand the full spectrum of the company's activity and to create new technologies. This duration drops to 3-6 months for a candidate hired from an already senior position. Finally, it takes up to 20 years to become a senior analog design engineer according to some industrials.

The results by job profiles are presented in the table below.

Average duration to train a hire until he/she becomes productive (in months)

	Months			Additional trainings for the hire to become productive
	Entry	Mid	Senior	
Lead or supervisor	> 24	> 12	6-12	
Maintenance technician	>24	24	12	
Test technician	24	6	12	
Analog design engineer	18-24	-	-	
RF engineer	<18	-	-	
Digital design engineer	12-24	-	-	
Test engineer	12-18	12-18	6	
Process engineer	> 12	9	6	
Process technician	12	7	3-4	
Software engineer	6-12	4-6	2-4	Knowledge of the specifies of microelectronics, especially hardware. HW/SW integration…
Applications engineer	6-12	3-8	1-6	
Design engineer	6-12	7	3	
Robotic engineer	6	-	-	
Digital physical design engineer	-	-	-	Internal trainings to tools for design and layout (Cadence, Synopsys, etc.).
Analog layout engineer	-	-	-	Use of external courses with IC Mask design for more advanced technologies and layout techniques.
Operator inspector	-	-	-	
Hardware engineer	-	-	-	

2) Main occupational blueprints: Detailed description of key microelectronics job profiles

In this chapter, the 5 most critical job profiles identified are described in detail as well as their associated skills, knowledge and educational levels (EQF).

The occupational blueprints of the other job profiles studied can be found in annex 2.

Profiles are ranked by order of criticality.

a. Design engineer

A design engineer is in charge of developing new hardware components and systems and modelling for performance simulations.

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 30 companies • 4 universities • 1 other organisation • 2 focus groups
Number of design engineers employed by companies	> 15 000
Number of students in design engineering trained by Universities	Around 2330 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	9%	50%	40%	1%

	Entry / Junior Level	Mid-level	Senior level
Seniority of profiles recruited in the next 12 months	98%	1%	1%
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Easy to find (3/10)	Difficult to find (5/10)	Difficult to find (8/10)
Average duration to fill a vacant position	0-2 months	6 months	10 months
Average duration of the training of new hires till they become productive	6-12 months	7 months	3 months
Minimum educational level	EQF 6		

Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

Rank: From the most common to the less common field of study	Field of study of the workforce
1	- Microelectronic engineering
2	- Electromechanical engineering - Electronic engineering - Software engineering
3	- Information and computer engineering - Information technology
4	- Physics - Mathematics
5	- Chemistry - Biomedical engineering - Advanced material science - Mechatronic

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for design engineers' candidates at the entry level is EQF 6. Therefore, the skills described below must be acquired once students reach the EQF level 6.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
Mandatory knowledge / skill					
1	Proficient with analogue and digital electronic design, RF design, power supply design; knowledge in analytical tools such as ETAP, schematic, spice simulation; understanding in hardware description languages, e.g., VHDL	Not needed	9%	Not needed	10%
		Easy to find	16%	Fairly important	20%
		Difficult to find	19%	Important	13%
		Very difficult to find	**56%**	**Very important**	**57%**
2	Familiar with design for manufacturing, design for assembly, design for test, design for inspection approaches, optimize complex and advanced designs for manufacturability	Not needed	0%	Not needed	0%
		Easy to find	17%	Fairly important	24%
		Difficult to find	30%	Important	27%
		Very difficult to find	**53%**	**Very important**	**48%**
3	Machine learning / Artificial Intelligence	Not needed		Not needed	
		Easy to find		Fairly important	
		Difficult to find	50%	Important	

		Very difficult to find	**50%**	**Very important**	**100%**
4	Data analysis skills	Not needed		Not needed	
		Easy to find		Fairly important	
		Difficult to find	**100%**	Important	
		Very difficult to find		**Very important**	**100%**
5	Uses computer-aided design (CAD) and computer-assisted engineering (CAE) software to create prototypes, engineering drawings (drafting) & engineering designs	Not needed	0%	Not needed	0%
		Easy to find	**67%**	Fairly important	29%
		Difficult to find	15%	Important	23%
		Very difficult to find	19%	**Very important**	**48%**
6	System design: understand the whole architecture	Not needed		Not needed	
		Easy to find		Fairly important	
		Difficult to find		Important	
		Very difficult to find	**100%**	**Very important**	**100%**
7	Software-Hardware integration	Not needed		Not needed	
		Easy to find		Fairly important	
		Difficult to find		Important	
		Very difficult to find	**100%**	**Very important**	**100%**
8	Proficient with Statistical Signal Analysis, signal detection and estimation	Not needed	8%	Not needed	7%
		Easy to find	33%	Fairly important	39%
		Difficult to find	**29%**	**Important**	**21%**
		Very difficult to find	29%	Very important	32%
9	Virtual prototyping	Not needed		Not needed	
		Easy to find		Fairly important	
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find		Very important	

10	Knowledge in control systems using PID loops, embedded Firmware, Object Oriented languages: C, C++, C#, Java	Not needed	8%	Not needed	7%
		Easy to find	**52%**	Fairly important	41%
		Difficult to find	32%	**Important**	**17%**
		Very difficult to find	8%	Very important	34%
11	Familiar with software tools for design testing, like Matlab, JMP, Datapower, National Instruments LabView, Cadence, ADS	Not needed	8%	Not needed	7%
		Easy to find	**46%**	Fairly important	32%
		Difficult to find	25%	**Important**	**29%**
		Very difficult to find	21%	Very important	32%
12	Proficient with electrical testing and troubleshooting, lead detailed functional analyses of prototypes	Not needed	4%	Not needed	3%
		Easy to find	**41%**	Fairly important	42%
		Difficult to find	30%	**Important**	**19%**
		Very difficult to find	26%	Very important	35%
13	Collaborate with manufacturing engineers, system engineers and product specialists	Not needed	4%	Not needed	3%
		Easy to find	**57%**	Fairly important	43%
		Difficult to find	25%	**Important**	**20%**
		Very difficult to find	14%	Very important	33%
Optional knowledge / skills					
14	Assess the usability, environmental impact and safety of a design, lead feasibility studies and testing on new and modified designs	Not needed	9%	Not needed	7%
		Easy to find	26%	**Fairly important**	**46%**
		Difficult to find	**43%**	Important	21%
		Very difficult to find	22%	Very important	25%
15	Analytical knowledge in reliability, Ansys, Nastran, RCCA and Six Sigma approaches	Not needed	18%	Not needed	15%
		Easy to find	32%	**Fairly important**	**50%**
		Difficult to find	**27%**	Important	15%
		Very difficult to find	23%	Very important	19%

16	Prepare equipment and construction specifications, documentation of design and systems, single-line diagrams, schematic (elementary) diagrams, interconnecting (connection) diagrams, panel layouts & connection diagrams (assembly drawings), bills of material	Not needed	4%	Not needed	3%
		Easy to find	**52%**	**Fairly important**	**48%**
		Difficult to find	22%	Important	19%
		Very difficult to find	22%	Very important	29%
17	Collect and analyse data from tests on prototypes, conduct risk assessments, FMEA/DFMEA and design reviews	Not needed	4%	Not needed	3%
		Easy to find	**44%**	**Fairly important**	**45%**
		Difficult to find	36%	Important	21%
		Very difficult to find	16%	Very important	31%
18	Support product development plans (schedule, product cost, meeting design inputs)	Not needed	4%	Not needed	3%
		Easy to find	**52%**	**Fairly important**	**55%**
		Difficult to find	28%	Important	21%
		Very difficult to find	16%	Very important	21%
19	Knowledge in communication protocol/ hardware interface, such as RS232, RS485, CAN, Ethernet, USB, SPI, I2C, Flash, EEPROM, ADC/DAC, WiFi/Bluetooth	Not needed	14%	Not needed	12%
		Easy to find	**45%**	**Fairly important**	**42%**
		Difficult to find	23%	Important	19%
		Very difficult to find	18%	Very important	27%
20	Familiar with Agile hardware & software development practices and tools, Scrum processes	Not needed	17%	Not needed	15%
		Easy to find	**54%**	**Fairly important**	**44%**
		Difficult to find	13%	Important	15%
		Very difficult to find	17%	Very important	26%
21	Technical presentation, report writing, intermediate skills in MSOffice and SAP	Not needed	8%	Not needed	7%
		Easy to find	**73%**	**Fairly important**	**53%**
		Difficult to find	15%	Important	20%

		Very difficult to find	4%	Very important	20%

Foresight exercise: The skills that will gain the most importance by 2025 for this profile

Name of the skill	Description
Proficiency design	Proficient with analogue and digital electronic design, RF design, power supply design; knowledge in analytical tools such as ETAP, schematic, spice simulation; understanding in hardware description languages, e.g., VHDL. Needed additional skill to this point: EMC simulations.
CAD design	Uses computer-aided design (CAD) and computer-assisted engineering (CAE) software to create prototypes, engineering drawings (drafting) & engineering designs. The skill linked to the ability to use CAD is increasingly important because most of the design today is done with CAD tools.
Teamwork, collaboration	Teamwork in CAD design aspects will be more and more important! The time of polyhystors is over, specific professional knowledge should meet in teamwork and collaboration! Collaborate with manufacturing engineers, system engineers and product specialists.
Embedded software	Embedded software knowledge and skills as well as programming in Object Oriented languages.

i. System design engineer

An electronic system (or system on chip) is a small system that includes ICs (memory, logic) and external components on a PCB. Electronic systems are not "Cyber Physical Systems" (CPS). CPS are much bigger with embedded software, networks, and more complex.

A system design engineer creates the required design and related documentation of the relevant design area (System level Modeling and Validation) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.

This job profile will become more and more important especially in line with the development of IoT, I4.0 and automotive applications (to reduce vehicle architecture costs and increase functionality by decreasing the number of discrete components and favoring the use of standardized microelectronic components and embedded systems and platforms). System design engineers are among the 5 most wanted job profiles today for within the semiconductor design business (Focus group organized by METIS on Semiconductor design).

Multidisciplinary is required for a skilled system design engineer.

Educational level (EQF): 7.

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 3 companies • 1 university • 1 focus group
Number of system design engineers employed by companies	Unknown
Number of students in system design engineering trained by Universities	1985 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	0%	0%	100%	0%

	Entry / Junior Level	Mid-level	Senior level
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Very difficult to find (9/10)		
Minimum educational level	EQF 7		

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for system designers' candidates at the entry level is EQF 7. Therefore, the skills described below must be acquired once students reach the EQF level 7.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
1	Knowledge of system architectures.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
2	Hardware / Software integration.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%

		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
3	Communication and teamwork.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
4	Big data. Familiar with databases (e.g., SQL), big data technologies (e.g., Spark, Dask), machine learning algorithms	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	50%	Important	0%
		Very difficult to find	**50%**	**Very important**	**100%**
5	System design thinking / System Level Modeling and Validation	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
6	Leading system level problem solving	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
7	Integration of different components of system	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	**Important**	**100%**
		Very difficult to find	**100%**	Very important	0%
8		Not needed	0%	Not needed	0%

	Familiar with Agile Hardware & Software development practices and tools, Scrum processes	Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find	0%	Very important	0%
9	Knowledge in simulation tools such as circuit simulators, schematic, spice simulation, analog behavioral modelling, Veriloga, VHDL-AMS, spice modelling	Not needed	-	Not needed	-
		Easy to find	-	Fairly important	-
		Difficult to find	-	Important	-
		Very difficult to find	-	Very important	-

ii. Analog design engineer

Design engineer (EQF 7) specialized in Analog / Analog IC / RF-IC Mixed-signal design (analog-to-digital converters (ADC), digital-to-analog converters (DAC)). An analog design engineer defines and creates the required design and related documentation of the relevant design area (analog and mixed-signal design) in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing. Analog design engineers are among the 5 most wanted job profiles today for within the semiconductor design business (according to the focus group organized by METIS on Semiconductor design).

Analog design engineers are one of the few profiles for each the European microelectronics industry face the greatest shortage. A progressive but very significant shortage as emerge in the industry during the past 20 years for this profile, due to the aging workforce and the lack of new graduates trained in analog design. Even though there is the trend of digitalizing signals as fast as possible, there still remains this small part of "analog", where there are too few experts available within every company. In particular, many ASIC analog designers are needed by the European microelectronics industry for many different products (Sensors, Power, References, Auxiliary blocks, etc.).

The shortage is particularly high for this job profile as it takes a particularly long time to develop good analog design skills and about 20 years to become good analog designer. This cannot only be done by education, but there are also many practical skills needed. Therefore, this profile is often disregarded by students as there is a long time needed to become senior compared to other profiles. In comparison to e.g., VHDL (VHSIC Hardware Description Language), after one year it is easy to become a specialist, but it is very hard to reach that in one year of analog design practices.

Dedicated courses are required in Universities in Mixed Signal Design, the most important skill required for analog designers: Proficient with analogue and digital electronic design, noise, signal integrity, etc.

In addition to skills and knowledge required for design engineers, the main associated knowledge to analog design engineer is "Analog design".

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint

METIS
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Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

Number of stakeholder(s)	• 1 university • 1 focus group
Number of analog design engineers employed by companies	-
Number of students in analog design engineering trained by Universities	1850 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	0%	40%	55%	5%

	Entry / Junior Level	Mid-level	Senior level
Minimum educational level	EQF 6		

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for analog designer engineers' candidates at the entry level is EQF 6. Therefore, the skills described below must be acquired once students reach the EQF level 6.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
Mandatory knowledge / skill					
1	**Concept/ Top Level Design.** Knowledge of specific methods and tools to implement models for building blocks present in low to medium complexity projects: For low to medium complexity projects, have conceptual knowledge of the full design, including digital, memories, sensor models. Able to perform risk assessment on block level. Block level and/or sub-system design specification including validation, coaching of design implementation tasks, Coherence of different building blocks.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
2		Not needed	0%	Not needed	0%

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	Design Review. Able to present designed chip and performed simulations during the design review.	Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
3	**Design Verification**. Verification strategy, test bench setup, AMS verification.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
4	**Layout and back annotation**. Be able to simulate a schematic including layout extracted parasitics. Advanced knowledge of technology and parasitics. Knowledge of external factors influencing floorplan and top-level layout (grounding strategy, temperature gradients…) Knowledge of Design Rules impacting top level layout and floorplan. Able to estimate area of blocks at concept design	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
5	**Design Implementation**. Be able to implement low to medium complexity analog building blocks while taking into account all external influences. Knowledge of the requirements of other subprocesses on the design implementation: i.e., Design for reliability Design for test Design for FA… Understanding of ESD and EMC, know and follow guidelines regarding both issues. Able to estimate design time needed for blocks present in low to medium complexity projects. Proficient with analogue and digital electronic design, RF design, power supply design; knowledge in analytical tools such as ETAP, schematic, spice simulation; understanding in	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	**Important**	**100%**
		Very difficult to find	**100%**	Very important	0%

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	hardware description languages, e.g., VHDL, Experience with Cadence and/or Synopsys tools. Domains: low-power/high-voltage/high-sensitive/RF/NFC, modeling on IP- and subsystem level.				
6	Knowledge in simulation tools such as circuit simulators, schematic, spice simulation, analog behavioral modelling, Veriloga, VHDL-AMS, spice modelling.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	50%
		Difficult to find	0%	**Important**	**0%**
		Very difficult to find	**100%**	Very important	50%
7	Power management innovations	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find	0%	Very important	0%
8	Proficient with analogue and digital electronic design, noise, signal integrity, etc.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
9	Knowledge in testing of integrated circuits and design for testability	Easy to find	-	Fairly important	
		Difficult to find	-	**Important**	
		Very difficult to find	**-**	Very important	
		Very difficult to find	0%	Very important	0%
Optional knowledge / skills					
10	Collaborate with manufacturing engineers, layouters, test engineers, digital designers,	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%

	system engineers and product specialists.	Very difficult to find	-	Very important	0%
11	Familiar with Characterization and Measurement Equipment in Lab, e.g.: Signal Generator, Oscilloscope, etc.	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
12	Technical presentation, report writing, intermediate skills in MSOffice, LaTeX and SAP.	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
13	System design thinking	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
14	Familiar with process specific characteristics of analog circuits (Parasitics, Matching, PVT variations, corner, monte carlo...)	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
15	Prepare and define IC design specifications, documentation of design and systems	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
16	Assess the safety of a design, lead feasibility studies and testing on new and modified designs	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%

17	Control system knowledge	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
18	Familiar with System on Chip, System in a Package, heterogeneous integration	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
19	Analytical knowledge in reliability, functional safety, EMC, EMI, ESD, aging, radiation hardness, etc.	Not needed	-	Not needed	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%
		Easy to find	-	**Fairly important**	**100%**
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%

b. Software engineer

Up to the early 2000s', microelectronics technological developments were very hardware intensive (70% hardware VS 30% Software). In the early 2020s', this ratio as shift to ratio 30% for software and 70% for hardware, generating a high need for software engineers. Software engineer (EQF 6-7 engineers) is for instance the most important job profile in line with the development of I4.0. Software engineers are also identified as among the 5 most wanted job profiles today by the semiconductor design industry (according to the focus group organized by METIS on Semiconductor design).

Software engineers are responsible for the complete software development lifecycle (code and test). It includes creating the required design and related documentation of the relevant design area (Software design), in order to contribute to the achievement of the projects' targets in terms of product specification, cost, quality and timing.

Skilled software engineers are identified as the most difficult profile to find on the job market by many companies interviewed.

Software graduates (software programmers) often do not have any hardware knowledge and software companies often offer higher salaries, so it is hard to recruit them. On the contrary, engineers in electronics hardware are often not so good in programming.

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 12 companies • 3 universities • 1 focus group
Number of software engineers employed by companies	> 1800 software engineers
Number of students in software engineering trained by Universities	> 360 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	0%	60%	35%	5%

	Entry / Junior Level	Mid-level	Senior level
Seniority of profiles recruited in the next 12 months	80%	10%	10%
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Easy to find (4/10)	Fairly difficult to find (6-7/10)	Hard to find (8-9/10)
Average duration to fill a vacant position	2-3 months	6 months	8 months
Average duration of the training of new hires till they become productive	6-12 months	4-6 months	2-4 months
Minimum educational level	EQF 6-7		

Rank: From the most common to the less common field of study	Field of study of the workforce
1	- Information technology - Software engineering
2	- Electromechanical engineering - Mechatronic

3	- Information and computer engineering - Microelectronic engineering
4	- Physics - Mathematics
5	- Chemistry - Biomedical engineering - Advanced material science

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for software designers' candidates at the entry level is EQF 6. Therefore, the skills described below must be acquired once students reach the EQF level 6.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
Mandatory knowledge / skill					
1	Hardware / Software integration: Conduct unit and integration tests, validate the software implementation, create test strategies, approaches, test scenarios and test ideas. Includes for instance IT-OT Integration Management (such as implementation of IT architectures, platforms, components and operations technologies of industrial automation (OT) oriented towards Industry 4.0).	Not needed	10%	Not needed	10%
		Easy to find	10%	Fairly important	10%
		Difficult to find	20%	Important	30%
		Very difficult to find	**60%**	**Very important**	**50%**
2	Machine learning	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	Important	50%
		Very difficult to find	0%	**Very important**	**50%**
3	Proficient with objected oriented, structure/procedural, functional, imperative programming,	Not needed	0%	Not needed	0%
		Easy to find	10%	Fairly important	20%
		Difficult to find	**50%**	**Important**	**50%**

	fundamental design principles behind a scalable application	Very difficult to find	40%	Very important	30%
4	Understand source code management tools such as Git, and the workflows associated with them (branching and merging)	Not needed	0%	Not needed	0%
		Easy to find	10%	Fairly important	30%
		Difficult to find	**50%**	**Important**	**50%**
		Very difficult to find	40%	Very important	20%
5	Cybersecurity / Security. Identify risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure	Not needed	0%	Not needed	0%
		Easy to find	10%	Fairly important	40%
		Difficult to find	**60%**	Important	20%
		Very difficult to find	30%	**Very important**	**40%**
6	Develop software code in C, Visual C, C++, C#, .NET, Java, JavaScript, Python, Matlab	Not needed	0%	Not needed	0%
		Easy to find	30%	Fairly important	20%
		Difficult to find	25%	**Important**	**40%**
		Very difficult to find	**45%**	Very important	40%
7	Plan and execute software version upgrade releases and custom interfaces, utilize other platform's APIs and open-source utilities for fully integrated solutions.	Not needed	0%	Not needed	0%
		Easy to find	33%	Fairly important	40%
		Difficult to find	**33%**	**Important**	**40%**
		Very difficult to find	33%	Very important	20%
		Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find	0%	Very important	0%
8	Knowledge of hardware (Multidisciplinary knowledge). Software engineers should be given knowledge on hardware such as silicon design. Software graduates (software programmers) do not have any hardware knowledge and software companies often offer	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find	0%	Very important	0%

	higher salaries, so it is hard to recruit them. On the contrary, engineers in electronics hardware are often not so good in programming.				
9	Knowledge of applications: Especially connectivity applications.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	**100%**	**Important**	**100%**
		Very difficult to find	0%	Very important	0%
Optional knowledge / skills					
11	Familiar with application development and operational procedures, CSS, jQuery, web architectures and technologies (HTTP, REST), cloud development tools (Jenkins, Sumo, New Relic)	Not needed	0%	Not needed	0%
		Easy to find	15%	**Fairly important**	**50%**
		Difficult to find	**60%**	Important	25%
		Very difficult to find	25%	Very important	25%
12	Familiar with databases (e.g., SQL), big data technologies (e.g., Spark, Dask). Design and implementation of Big Data architectures and software platforms (e.g., Hadoop or Data Lake).	Not needed	0%	Not needed	0%
		Easy to find	45%	**Fairly important**	**50%**
		Difficult to find	**55%**	Important	40%
		Very difficult to find	0%	Very important	10%
13	Familiar with Agile software development practices and tools, Scrum processes, ASPICE compliant developing	Not needed	0%	Not needed	0%
		Easy to find	33%	**Fairly important**	**50%**
		Difficult to find	**33%**	Important	20%
		Very difficult to find	33%	Very important	30%
14	Prepare, read and understand software logic diagrams, read and understand vendor software design specifications	Not needed	0%	Not needed	0%
		Easy to find	30%	**Fairly important**	**80%**
		Difficult to find	**60%**	Important	10%
		Very difficult to find	10%	Very important	10%
15		Not needed	20%	Not needed	15%

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	Manage cost and time constraints, develop best practices, routines and innovative solutions to improve software development yield	Easy to find	0%	**Fairly important**	**70%**
		Difficult to find	**60%**	Important	15%
		Very difficult to find	20%	Very important	0%
16	Understand server operating systems and infrastructure support, web deployment and support for both Windows and Linux operating systems	**Not needed**	**33%**	**Not needed**	**25%**
		Easy to find	**33%**	**Fairly important**	**38%**
		Difficult to find	17%	Important	38%
		Very difficult to find	17%	Very important	0%
17	Lead design, development and testing of software components	**Not needed**	**20%**	**Not needed**	**20%**
		Easy to find	0%	**Fairly important**	**30%**
		Difficult to find	**40%**	Important	20%
		Very difficult to find	30%	Very important	30%
18	Technical presentation, report writing, intermediate skills in MSOffice and SAP	**Not needed**	**40%**	**Not needed**	**35%**
		Easy to find	**50%**	**Fairly important**	**45%**
		Difficult to find	10%	Important	10%
		Very difficult to find	0%	Very important	10%
19	Collaborate with design engineers, system engineers and product managers, act as liaison with manufacturers and vendors of software and application products	**Not needed**	**35%**	**Not needed**	**30%**
		Easy to find	**45%**	**Fairly important**	**20%**
		Difficult to find	10%	Important	20%
		Very difficult to find	10%	Very important	30%
20	Provide project stakeholders with information relevant to or intended to influence decisions on development delivery	**Not needed**	**50%**	**Not needed**	**45%**
		Easy to find	10%	Fairly important	35%
		Difficult to find	30%	Important	10%
		Very difficult to find	10%	Very important	10%

The skill number 14 in the above table is considered as important and difficult to find but is not required at the entry level. It is required after a few years of experience.

Other skills and knowledge indicated as important:

- Knowledge of building technologies.
- Knowledge of digital systems.
- Knowledge of verifications methods.
- Advanced debug capabilities: Implementation and debugging on microcontrollers.
- Network infrastructure support for tooling.

Foresight exercise: The 6 skills that will gain the most importance by 2025 for this profile

N°	Name of the skill	Description
1	Hardware / Software integration	Conduct unit and integration tests, validate the software implementation, create test strategies, approaches, test scenarios and test ideas
2	Machine learning	Knowledge on Artificial Intelligence: CI, machine learning techniques. Improved education for better software engineering in control field, focusing on using different tools. Different tools mean a wider aspect of knowledge. Tools such as: Keras, Torch, Tensorflow, Colab, Jupyter, Python, Lua, Matlab…
Embedded 3 + 6	Embedded software knowledge and skills as well as programming in Object Oriented languages.	Knowledge in control systems using PID loops, embedded Firmware, Object Oriented languages: C, C++, C#, Java. To carry out the professions one must have solid knowledge of embedded software knowledge and skills as well as programming in Object Oriented languages. Especially in Europe, knowledge in embedded software is increasingly important. Embedded Linux and RTOS knowledge and associated skills are among the most important and hard to find in the microelectronics sector.
5	Cybersecurity	Identify risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure.
12	Data analysis	Familiar with databases (e.g., SQL), big data technologies (e.g., Spark, Dask). Design and implementation of Big Data architectures and software platforms (e.g., Hadoop or Data Lake). Especially important for IoT and I4.0.
-	CAD design	Uses computer-aided design (CAD) and computer-assisted engineering (CAE) software to create prototypes, engineering drawings (drafting) & engineering designs. The skill linked to the ability to use CAD is increasingly important because most of the design today is done with CAD tools.

c. Process engineer

The main skills and knowledge associated are (see the chapter on the main skills):

- Software skills.
- Data analysis.
- Knowledge of applications.
- Machine learning / Artificial Intelligence.
- Environmental awareness.
- Security.

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 33 companies • 1 university • 1 other organisation • 3 focus groups
Number of process engineers employed by companies	> 5000
Number of students in process engineering trained by Universities	> 150 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	0%	36%	56%	9%

	Entry / Junior Level	Mid-level	Senior level
Seniority of profiles recruited in the next 12 months	63%	20%	17%
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Easy to find (5/10)	Difficult to find (7/10)	Very difficult to find (10/10)
Average duration to fill a vacant position	2-4 months	6-8 months	10-12 months
Average duration of the training of new hires till they become productive	> 12 months	9 months	6 months

Minimum educational level	EQF 6

Rank: From the most common to the less common field of study	Field of study of the workforce
1	- Electromechanical engineering - Mechatronic - Microelectronic engineering
2	- Information technology - Biomedical engineering
3	- Mathematics - Basic electrical engineering - Mechanical construction
4	- Software engineering - Information and computer engineering - Chemistry - Advanced material science
5	- Physics

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for process engineers' candidates at the entry level is EQF 6. Therefore, the skills described below must be acquired once students reach the EQF level 6.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
Mandatory knowledge / skill					
1	Deep knowledge in semiconductor- and electronics assembly technologies, competence in related quality standards (e.g., IPC).	Not needed	14%	Not needed	14%
		Easy to find	18%	Fairly important	28%
		Difficult to find	25%	Important	10%
		Very difficult to find	**43%**	**Very important**	**48%**
	Knowledge of new materials. Understanding of properties of the new materials, required changing of the integration flow. Knowledge of processes of the	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%

	new materials. Hight, silicon, garbitol, gallium nitride. Approximately 50 % from knowledge for silizium can be used for new materials. Need specialists for new materials.	**Very difficult to find**	**100%**	**Very important**	**100%**
2	Security in digitalized production.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	Important	0%
		Very difficult to find	-	**Very important**	**100%**
3	Environmental awareness.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	Important	0%
		Very difficult to find	-	**Very important**	**100%**
4	Familiar with design for manufacturing, design for assembly, design for test, design for inspection.	Not needed	12%	Not needed	12%
		Easy to find	12%	Fairly important	42%
		Difficult to find	**40%**	**Important**	**12%**
		Very difficult to find	36%	Very important	35%
5	FMEA – failure mode and effect analyses – procedures, RCA – root cause analyses.	Not needed	12%	Not needed	11%
		Easy to find	32%	Fairly important	37%
		Difficult to find	**28%**	**Important**	**19%**
		Very difficult to find	28%	Very important	33%
6	Assure the operation of automatic manufacturing lines, preventing and troubleshooting of machine failures, manufacturing equipment downtime reducing.	Not needed	8%	Not needed	7%
		Easy to find	12%	Fairly important	39%
		Difficult to find	**52%**	**Important**	**14%**
		Very difficult to find	28%	Very important	39%
7	Analysis of process outputs, improvements of processes.	Not needed	-	Not needed	0%

		Easy to find	-	Fairly important	0%
		Difficult to find	**-**	**Important**	**100%**
		Very difficult to find	-	Very important	0%
8	Data analysis and IT application: Can apply complex data analysis tools.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	**-**	**Important**	**100%**
		Very difficult to find	-	Very important	0%
9	Total quality management, statistical process controls, six-sigma techniques, PDCA.	Not needed	12%	Not needed	11%
		Easy to find	**40%**	Fairly important	29%
		Difficult to find	20%	**Important**	**18%**
		Very difficult to find	28%	Very important	43%
Optional knowledge / skills					
10	Capacity planning, capacity management, scheduling, makespan reducing.	Not needed	14%	Not needed	13%
		Easy to find	36%	**Fairly important**	**52%**
		Difficult to find	**41%**	Important	22%
		Very difficult to find	9%	Very important	13%
11	Manage new product introduction into manufacturing.	Not needed	12%	Not needed	12%
		Easy to find	24%	**Fairly important**	**42%**
		Difficult to find	**28%**	Important	19%
		Very difficult to find	36%	Very important	27%
12	Design inspections and tests for addressing end product quality (e.g., from mechanical point of view).	Not needed	8%	Not needed	8%
		Easy to find	24%	**Fairly important**	**42%**
		Difficult to find	**36%**	Important	19%
		Very difficult to find	32%	Very important	31%
13		Not needed	4%	Not needed	4%

	Environmental and life-time tests, theoretical background of reliability.	Easy to find	32%	**Fairly important**	**50%**
		Difficult to find	**40%**	Important	19%
		Very difficult to find	24%	Very important	27%
14	Prepare operational plans and instructions.	Not needed	0%	Not needed	0%
		Easy to find	52%	**Fairly important**	**67%**
		Difficult to find	**43%**	Important	17%
		Very difficult to find	4%	Very important	17%
15	Coordinate pilot manufacturing, documentation of manufacturing experiences.	Not needed	4%	Not needed	4%
		Easy to find	28%	**Fairly important**	**50%**
		Difficult to find	**48%**	Important	23%
		Very difficult to find	20%	Very important	23%
16	Engineering drawing (drafting) & engineering design.	Not needed	14%	Not needed	14%
		Easy to find	33%	**Fairly important**	**55%**
		Difficult to find	**29%**	Important	5%
		Very difficult to find	24%	Very important	27%
17	Logistic and supply management of manufacturing lines.	Not needed	13%	Not needed	12%
		Easy to find	**58%**	**Fairly important**	**64%**
		Difficult to find	25%	Important	8%
		Very difficult to find	4%	Very important	16%
18	Plan and supervision of maintenance tasks.	Not needed	24%	Not needed	23%
		Easy to find	**38%**	**Fairly important**	**50%**
		Difficult to find	24%	Important	5%
		Very difficult to find	14%	Very important	23%
19	Technical presentation, report writing, intermediate skills in MSOffice and SAP.	Not needed	4%	Not needed	4%
		Easy to find	**65%**	**Fairly important**	**67%**

		Difficult to find	26%	Important	13%
		Very difficult to find	4%	Very important	17%
20	Collaboration with other engineering departments (e.g., design engineers, test engineers, system engineers).	Not needed	8%	Not needed	8%
		Easy to find	**50%**	**Fairly important**	**46%**
		Difficult to find	25%	Important	19%
		Very difficult to find	17%	Very important	27%
21	Edge computing.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	100%
		Difficult to find	-	Important	0%
		Very difficult to find	-	Very important	0%

Foresight exercise: The 2 skills that will gain the most importance by 2025 for this profile

N°	Name of the skill	Description
1	Knowledge of new materials	Understanding of properties of the new materials, required changing of the integration flow. Knowledge of processes of the new materials. Hight, silicon, garbitol, gallium nitride. Approximately 50 % from knowledge for silizium can be used for new materials. Need specialists for new materials.
2	Collaboration & teamwork	

d. Test engineer

A test engineer is in charge of verifying and validating a software or an application thanks to automated, manual, performance and other tests.

The main skills and knowledge associated are (see the chapters dedicated to these skills):

- Machine learning / Artificial Intelligence.
- Data analysis.
- Security.

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 11 companies • 2 universities • 1 other organisation • 3 focus groups
Number of test engineers employed by companies	> 1000
Number of students in test engineering trained by Universities	150 students

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	7%	62%	31%	1%

	Entry / Junior Level	Mid-level	Senior level
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Easy to find (5/10)	Difficult to find (8/10)	Very difficult to find (9/10)
Average duration to fill a vacant position	3-6 months	6-9 months	12 months
Average duration of the training of new hires till they become productive	12-18 months	12-18 months	6 months
Minimum educational level	EQF 6		

Rank: From the most common to the less common field of study	Field of study of the workforce
1	- Microelectronic engineering
2	- Physics - Information and computer engineering - Software engineering
3	- Mechatronic - Mathematics
4	- Chemistry - Advanced material science
5	- Biomedical engineering - Electromechanical engineering - Information technology

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for test engineers' candidates at the entry level is EQF 6. Therefore, the skills described below must be acquired once students reach the EQF level 6.

N°	Skill	Difficulty to find the skill (in percentage of answers)		Importance of the skill (in percentage of answers)	
Mandatory knowledge / skill					
1	Analytic & Problem-Solving Skills.	Not needed	2%	Not needed	0%
		Easy to find	33%	Fairly important	29%
		Difficult to find	17%	Important	14%
		Very difficult to find	**50%**	**Very important**	**57%**
2	Programming Automatic Test Equipment (ATE) - using C, C++, Java, Python, LabVIEW or Smalltalk.	Not needed	11%	Not needed	10%
		Easy to find	22%	Fairly important	20%
		Difficult to find	**33%**	Important	20%
		Very difficult to find	33%	**Very important**	**50%**
3	Test Station Setup - troubleshooting, maintenance & calibration.	Not needed	0%	Not needed	0%
		Easy to find	43%	Fairly important	25%
		Difficult to find	**14%**	Important	25%
		Very difficult to find	43%	**Very important**	**50%**
4	Lead Test Development Process.	Not needed	0%	Not needed	0%
		Easy to find	14%	Fairly important	33%
		Difficult to find	**43%**	Important	11%
		Very difficult to find	43%	**Very important**	**56%**
5	Security issues in product level: Security / Cybersecurity /	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%

	Security-by-design / Reverse engineering.	Difficult to find	-	Important	0%
		Very difficult to find	-	**Very important**	**100%**
6	Technical Presentation & Report Writing.	Not needed	0%	Not needed	0%
		Easy to find	**50%**	Fairly important	43%
		Difficult to find	17%	Important	0%
		Very difficult to find	33%	**Very important**	**57%**
7	Design for test (DFT) techniques.	Not needed	25%	Not needed	22%
		Easy to find	2%	Fairly important	11%
		Difficult to find	25%	**Important**	**22%**
		Very difficult to find	**50%**	Very important	44%
8	Competencies in Analog electronics.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	29%
		Difficult to find	50%	**Important**	**29%**
		Very difficult to find	**50%**	Very important	43%
9	Design of software modules for test equipment in C, C# and Visual Basic.	Not needed	14%	Not needed	13%
		Easy to find	14%	Fairly important	38%
		Difficult to find	**43%**	**Important**	**13%**
		Very difficult to find	29%	Very important	38%
10	Proficient with RF Test Equipment - Network Analyzers, Spectrum Analyzers and Signal generators.	Not needed	0%	Not needed	0%
		Easy to find	33%	Fairly important	38%
		Difficult to find	**50%**	**Important**	**25%**
		Very difficult to find	17%	Very important	38%
11	Define Test Competencies & Practice - cooperation with concept, design and lab verification engineers.	Not needed	0%	Not needed	0%
		Easy to find	33%	Fairly important	14%
		Difficult to find	**33%**	**Important**	**43%**

		Very difficult to find	33%	Very important	43%
12	CRM - developing / maintaining internal & external customers' needs.	Not needed	0%	Not needed	0%
		Easy to find	25%	Fairly important	40%
		Difficult to find	**50%**	**Important**	**20%**
		Very difficult to find	25%	Very important	40%
13	Performance Data Analysis - analyzing performance data - leveraging databases (SQL) and visualization tools (Tableau).	Not needed	0%	Not needed	0%
		Easy to find	43%	Fairly important	33%
		Difficult to find	**43%**	**Important**	**44%**
		Very difficult to find	14%	Very important	22%
14	Automatic Test Pattern Generation (ATPG) and Diagnostics.	Not needed	33%	Not needed	25%
		Easy to find	**33%**	Fairly important	35%
		Difficult to find	0%	**Important**	**13%**
		Very difficult to find	33%	Very important	38%
15	Yield & Bin Pareto Analysis using JMP, Datapower or O+, Synopsis, YieldHub, other tools.	Not needed	14%	Not needed	11%
		Easy to find	**71%**	Fairly important	0%
		Difficult to find	14%	**Important**	**44%**
		Very difficult to find	0%	Very important	44%
16	Competences in JEDEC, MIPI and other high-speed test standards.	Not needed	0%	Not needed	0%
		Easy to find	**50%**	Fairly important	40%
		Difficult to find	25%	**Important**	**20%**
		Very difficult to find	25%	Very important	40%
17	Competencies in Digital electronics.	Not needed	0%	Not needed	0%
		Easy to find	**50%**	Fairly important	43%
		Difficult to find	17%	**Important**	**14%**
		Very difficult to find	33%	Very important	43%

18	Artificial Intelligence	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
19	Transfer knowledge: Ability to apply theoretical knowledge into manufacturing context (DOE, FMEA, SPC, etc.).	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
20	Communication: Ability to negotiate and communication on business and technical topics.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
	Virtual prototyping.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
	System simulation.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
Optional knowledge / skills					
21	Project Management - Lean, Scrum, Agile etc.	Not needed	0%	Not needed	0%
		Easy to find	**50%**	**Fairly important**	**57%**
		Difficult to find	33%	Important	14%
		Very difficult to find	17%	Very important	29%

Other skills and knowledge indicated as important:

- Debugging and coordinating of validation tests.
- Aligning with different domains e.g., software, test and development team within the project.

Foresight exercise: The skills that will gain the most importance by 2025 for this profile

N°	Name of the skill	Description
1	Data analysis skills & Artificial Intelligence knowledge	Performance Data Analysis - analyzing performance data - leveraging databases (SQL) and visualization tools (Tableau).
2	Proficiency design	Proficient with analogue and digital electronic design, RF design, power supply design; knowledge in analytical tools such as ETAP, schematic, spice simulation; understanding in hardware description languages, e.g., VHDL. In the sector, knowledge and skills related to analog and digital electronics are fundamental. Proficient with RF Test Equipment - Network Analyzers, Spectrum Analyzers and Signal generators. ability to testing HF, IIOT, 5G devices.
3	Knowledge of semiconductor	-
4	Customer communication	-

e. Maintenance technician

A maintenance technician is in charge of ensuring all test equipment are operational and calibrated.

The main skills and knowledge associated are (see the dedicated chapters among the main skills):

- Introduction to materials (traditional materials and emerging ones).
- Knowledge of processing equipment.
- Basic knowledge of production processes (especially semiconductors).

Occupational blueprint

Representativeness of stakeholders involved in the design of the occupational blueprint	
Number of stakeholder(s)	• 10 companies • 3 focus groups
Number of maintenance technicians employed by companies	> 1000

Educational level of hires

	Certificate / diploma (EQF 4-5)	Bachelor degree / BSc (EQF 6)	Master degree (EQF 7)	PhD (EQF 8)
Educational level of hires	45%	45%	10%	0%

	Entry / Junior Level	Mid-level	Senior level
Seniority of profiles recruited in the next 12 months	10%	30%	60%
Level of difficulty to find skilled candidates on a scale of 0 to 10 (10 is the maximum)	Easy to find (3/10)	Difficult to find (7/10)	Very difficult to find (9/10)
Average duration to fill a vacant position	1 month	5 months	9 months
Average duration of the training of new hires till they become productive	> 2 years	2 year	1 year
Minimum educational level	EQF 4		

Rank: From the most common to the less common field of study	Field of study of the workforce
1	- Electromechanical engineering
2	- Microelectronic engineering
3	- Mechatronic
4	- Information and computer engineering - Information technology - Physics - Chemistry - Mathematics - Software engineering - Biomedical engineering - Advanced material science

Skills that are both the most needed and the most challenging to find at the entry level.

The minimum educational level required for maintenance technicians' candidates at the entry level is EQF 5-6. Therefore, the skills described below must be acquired once students reach the EQF level 5-6.

N°	Skill	Difficulty to find the skill (in percentage of answers)	Importance of the skill (in percentage of answers)
Mandatory knowledge / skill			

1	Introduction to materials (traditional materials and emerging ones).	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
2	Knowledge of processing equipment.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
3	Basic knowledge of production processes (especially semiconductors).	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
4	Knowledge of standardized testing techniques.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
5	Knowledge of predictive/preventive maintenance services.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	0%
		Difficult to find	0%	Important	0%
		Very difficult to find	**100%**	**Very important**	**100%**
6	Assure the uninterrupted, safe operation of manufacturing lines and availability of production machines, operating equipment.	Not needed	0%	Not needed	0%
		Easy to find	0%	Fairly important	10%
		Difficult to find	13%	Important	10%

		Very difficult to find	**88%**	**Very important**	**80%**
7	Maintenance (daily, weekly, yearly), calibration and troubleshoot of manufacturing lines, machines, equipment.	Not needed	0%	Not needed	0%
		Easy to find	14%	Fairly important	10%
		Difficult to find	29%	Important	30%
		Very difficult to find	**57%**	**Very important**	**60%**
8	Analyse and repair machine failures.	Not needed	0%	Not needed	0%
		Easy to find	13%	Fairly important	20%
		Difficult to find	25%	Important	10%
		Very difficult to find	**63%**	**Very important**	**70%**
9	Inspect and prevent failures of technological procedures; reduce the downtime.	Not needed	0%	Not needed	0%
		Easy to find	13%	Fairly important	18%
		Difficult to find	25%	Important	18%
		Very difficult to find	**63%**	**Very important**	**64%**
10	Suggest development to prevent recurring problems in manufacturing.	Not needed	11%	Not needed	11%
		Easy to find	11%	Fairly important	11%
		Difficult to find	11%	Important	11%
		Very difficult to find	**67%**	**Very important**	**67%**
11	Read maintenance instructions and plans; TPM – total productive maintenance.	Not needed	0%	Not needed	0%
		Easy to find	33%	Fairly important	27%
		Difficult to find	**33%**	Important	18%
		Very difficult to find	33%	**Very important**	**55%**
12	Report and document maintenance and repair work.	Not needed	14%	Not needed	10%
		Easy to find	14%	Fairly important	20%
		Difficult to find	**43%**	Important	20%
		Very difficult to find	29%	**Very important**	**50%**

13	Coordinate the operators in shift.	Not needed	29%	Not needed	22%
		Easy to find	29%	Fairly important	22%
		Difficult to find	**43%**	**Important**	**33%**
		Very difficult to find	0%	Very important	22%
14	Basic skills in ERP (enterprise resource planning) systems to record performed repairs and maintenances.	Not needed	29%	Not needed	10%
		Easy to find	0%	Fairly important	10%
		Difficult to find	**29%**	**Important**	**40%**
		Very difficult to find	43%	Very important	40%
15	Knowledge in health and safety regulations.	Not needed	14%	Not needed	13%
		Easy to find	14%	Fairly important	38%
		Difficult to find	**57%**	**Important**	**13%**
		Very difficult to find	14%	Very important	38%
16	Cooperate with stock department and engineering departments.	Not needed	0%	Not needed	0%
		Easy to find	20%	Fairly important	57%
		Difficult to find	**60%**	**Important**	**14%**
		Very difficult to find	20%	Very important	29%
17	Work instruction / documentation: Able to understand and perform task following the work instruction; Able to understand and use technical documentation; Able to analyse equipment signals (alarms, SPC/FDC).	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
18	Innovation: Partner in support of innovative Equipment Engineering Methods.	Not needed	-	Not needed	0%
		Easy to find	-	Fairly important	0%
		Difficult to find	-	**Important**	**100%**
		Very difficult to find	-	Very important	0%
19		Not needed	29%	Not needed	11%

	Manage service stock, materials and consumables for repair and maintenance.	**Easy to find**	**29%**	Fairly important	22%
		Difficult to find	14%	**Important**	**33%**
		Very difficult to find	29%	Very important	33%
20	Using relevant lean tools, keep workplace in proper order, 5S.	Not needed	14%	Not needed	11%
		Easy to find	**43%**	Fairly important	22%
		Difficult to find	29%	**Important**	**22%**
		Very difficult to find	14%	Very important	44%
21	Basic knowledge in Word, Excel, Outlook.	Not needed	0%	Not needed	0%
		Easy to find	**67%**	Fairly important	38%
		Difficult to find	33%	**Important**	**25%**
		Very difficult to find	0%	Very important	38%
Optional knowledge / skills					
22	Prepare drafting and validate modification on repaired components.	Not needed	14%	Not needed	14%
		Easy to find	0%	**Fairly important**	**43%**
		Difficult to find	**43%**	Important	14%
		Very difficult to find	43%	Very important	29%

D. Identification of the emerging technologies and markets impacting job profiles and skills

The microelectronics sector and the skills required for its workers have enormously evolved in the last years due to innovation waves. This trend will pursue in the coming decades.

The Moore's Law has been the most impactful technological trend for the past 50 years, leading to cost reduction of computational power and miniaturization of microelectronics. For instance, in 2001, 8-bit microprocessors with 64 kb of memory were used in white goods. In 2011 those figures were 1 GHz for TV with 4 GB of memory. However, the Moore's Law is coming to an end. Ever rising investment and R&D costs are required to progress in the Moore's Law and the "last node" (1 nanometer chip), should be produced by 2030.

Over the coming decade and for Europe especially, innovation drivers for the microelectronic sector should come from More than Moore developments.

Through the online survey, interviews and focus groups, METIS has proposed a list of emerging technologies, asking stakeholders (138 in total) to indicate for each technology:

- If the technology is currently having *No impact / A small impact / A large impact* on the skills required for the microelectronics workforce.
- If the associated skills and knowledge are *Easy / Difficult to find* currently on the European job market.

The results are summarized in the tables below. It appears that the four trends that are having the greatest impact on the skills required by the microelectronics industry (with associated skills currently difficult to find on the European job market), are:

1. Big data & Artificial intelligence.
2. Power management innovation
3. Cybersecurity & Security by design.
4. Connectivity innovations.

Technologies assessed in METIS

Technology	Description
Big data & Artificial Intelligence	Machine-learning algorithms, data management & analysis tools, associated Hardware/Software integration.
Power management innovations	Conversion, power harvesting solutions… enabling low power IC's and better energy efficiency.
Security / Cybersecurity by design	Security / Safety / Privacy issues. Hardware skills (reverse engineering, etc.). Software skills (Intrusion detection and prevention, forensics, investigation of possible failures originated from improper use of malicious codes). Ability to design a diagram of a network for security. Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
Connectivity	5G / 6G / RF / IoT communication architectures.
Advanced packaging	SiP, Fan-In, Fan-Out, WL CSP, Advanced IC substrates (Flip chip-based packages), Stacking technologies (2.5D & 3D), embedded die.
MEMS/NEMS	Micro Electro Mechanical Systems (MEMS) / Nano Electro Mechanical Systems (NEMS).
Photonics innovations	Photonics Integrated Circuits, photonic sensors, silicon photonics, photonic interconnections…
Edge computing	Bringing computation and data storage closer to the location where it is needed, to improve response times and save bandwidth.
Environmental awareness	E.g. circular economy regulatory package…
Emerging non-volatile memories	PCM (stand-alone & embedded), stand-alone MRAM, STT-MRAM (Stand-alone & embedded), RRAM (Stand-alone & embedded), nanotube RAM and Ferroelectric Non-Volatile FET).

Impact of emerging technologies on skills needs

	No impact	Small impact	Large impact
Artificial Intelligence	21 %	22 %	**57 %**
Power management innovations	28 %	22 %	**50 %**
Security / Cybersecurity by design	37 %	16 %	**48 %**
Connectivity	27 %	25 %	**48 %**
Advanced packaging	31 %	24 %	**46 %**
MEMS/NEMS	20 %	**35 %**	44 %
Photonics innovations	33 %	**26 %**	41 %
Edge computing	41 %	**15 %**	44 %
Environmental awareness	**40 %**	26 %	34 %
Emerging non-volatile memories	**46 %**	17 %	38 %

Answers in percentage of respondents.

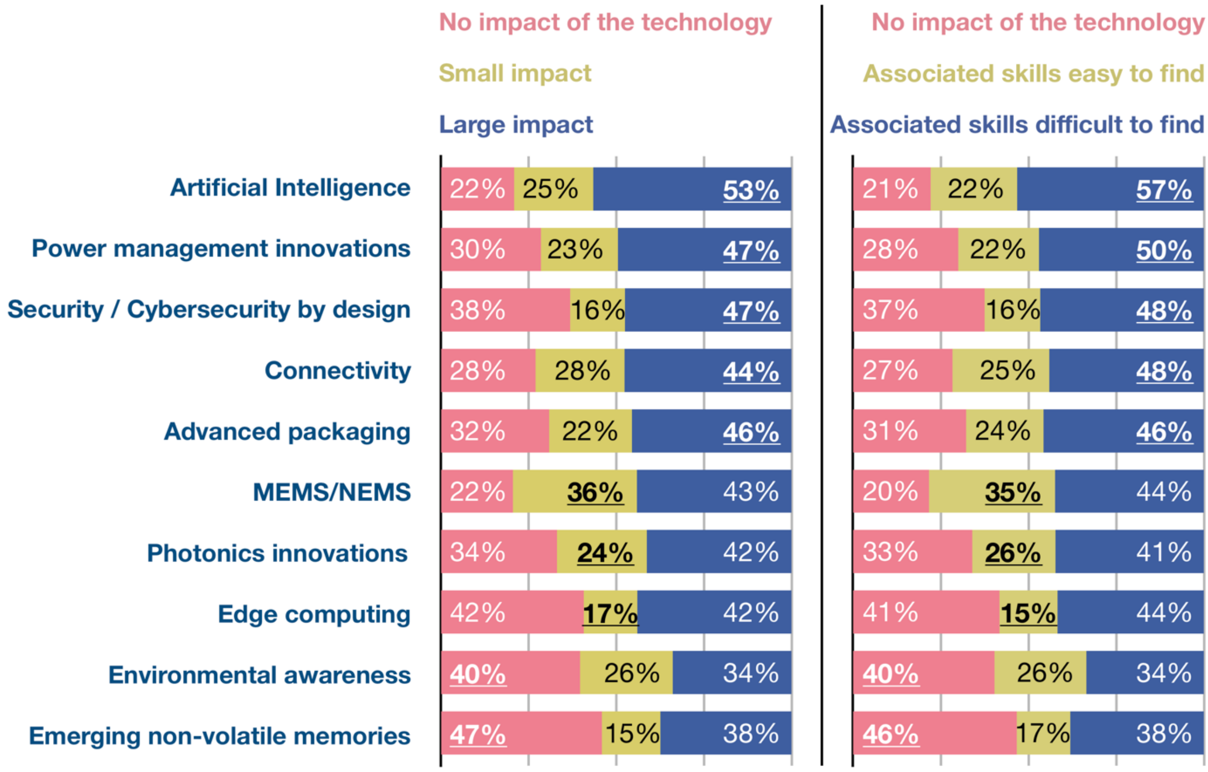
Source: Interviews, Focus groups and online survey (total number of respondents: 138)

Difficulty to find the associated skills / knowledge

	No impact	Easy to find	Difficult to find
Artificial Intelligence	22 %	25 %	**53 %**
Power management innovations	30 %	23 %	**47 %**
Security / Cybersecurity by design	38 %	16 %	**47 %**
Connectivity	28 %	28 %	**44 %**
Advanced packaging	32 %	22 %	**46 %**
MEMS/NEMS	22 %	**36 %**	43 %
Photonics innovations	34 %	**24 %**	42 %
Edge computing	42 %	**17 %**	42 %
Environmental awareness	**40 %**	26 %	34 %
Emerging non-volatile memories	**47 %**	15 %	38 %

Answers in percentage of respondents.

Source: Interviews, Focus groups and online survey (total number of respondents: 138)



Answers in percentage of respondents
Total number of respondents: 138

II) Proposition of new occupational profiles for microelectronics

1) Mapping of the current microelectronics ESCO profiles, knowledges and skills

METIS has mapped the existing ESCO profiles, skills and knowledge linked to microelectronics in mid 2020. The tables below show the results.

Table: Existing ESCO profiles linked to Microelectronics in mi-year 2020

ESCO profile	Hierarchy
Integrated circuit design engineer	2 Professionals 21 Science and engineering professionals 215 Electrotechnology engineers 2152 Electronics engineers electronics engineer microelectronics engineer integrated circuit design engineer
Microsystem engineer	2 Professionals 21 Science and engineering professionals 215 Electrotechnology engineers 2152 Electronics engineers electronics engineer microsystem engineer
Component engineer	2 Professionals 21 Science and engineering professionals 214 Engineering professionals (excluding electrotechnology) 2149 Engineering professionals not elsewhere classified application engineer component engineer
Microelectronics engineering technician	3 Technicians and associate professionals 31 Science and engineering associate professionals 311 Physical and engineering science technicians

Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

	3114 Electronics engineering technicians electronics engineering technician microelectronics engineering technician
Electronics drafter	3 Technicians and associate professionals 31 Science and engineering associate professionals 311 Physical and engineering science technicians 3118 Draughts persons Drafter electronics drafter
Automation engineering technician	3 - Technicians and associate professionals 31 - Science and engineering associate professionals 311 - Physical and engineering science technicians 3119 - Physical and engineering science technicians not elsewhere classified automation engineering technician
Semiconductor processor	8 Plant and machine operators and assemblers 82 Assemblers 821 Assemblers 8212 Electrical and electronic equipment assemblers electronic equipment assembler semiconductor processor
Precision device inspector	7 - Craft and related trades workers 75 - Food processing, wood working, garment and other craft and related trades workers 754 - Other craft and related workers 7543 - Product graders and testers (excluding foods and beverages) 7543.10 - product quality inspector precision device inspector

Table: Existing ESCO knowledge linked to Microelectronics in mid-year 2020

Existing ESCO knowledge linked to Microelectronics in mid-year 2020	
• Electronics	• Microsensors
• Nanoelectronics	• Microoptics
• Semiconductors	• Micromechanics
• Microelectronics	• Microelectromechanical systems
• Microprocessors	• MOEM
• Microassembly	• Microsystem test procedures
• Integrated circuits	• Electronic test procedures
• Integrated circuit types	• Electronic equipment standards

Table: Existing ESCO skills linked to Microelectronics in mid-year 2020

Existing ESCO skills linked to Microelectronics in mid-year 2020	
• Design integrated circuits	• Assemble microelectronics
• Design microelectronics	• Assemble microelectromechanical systems
• Maintain microelectronics	• Model microelectronics
• Maintain microelectromechanical systems	• Inspect semiconductor components
• Perform test run	• Load electronic circuits onto wafers
• Test sensors	• Imprint circuit design onto wafers
• Test microelectronics	• Package microelectromechanical systems
• Test semiconductors	• Design microelectromechanical systems
• Test microelectromechanical systems	
• Develop electronic test procedures	• Develop microelectromechanical system test procedures

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2) Potential new ESCO profiles for the microelectronics industry

The figure below shows the existing ESCO hierarchy of profiles, the existing ESCO profiles linked to microelectronics and compare them to the profiles identified by METIS as essential for today's microelectronics industry.

Black= Existing ESCO profiles

Light blue= Existing ESCO profile identified by METIS as critical for the microelectronics industry

Dark blue= Profile identified by METIS as critical for the microelectronics industry with no corresponding ESCO profile

Green= Four new ESCO profiles proposed by METIS and integrated in 2020 in the ESCO framework

2 Professionals

- **21 Science and engineering professionals**
  - 214 Engineering professionals (excluding electrotechnology)
    - 2141 Industrial and Production Engineers
    - 2142 Civil Engineers
    - 2143 Environmental Engineers
    - 2144 Mechanical Engineers
    - 2145 Chemical Engineers
    - 2146 Mining Engineers, Metallurgists and Related Professionals
    - 2149 Engineering Professionals Not Elsewhere Classified
      - 2149.2 Application engineer
      - 2149.9 Material engineers
      - 2149.13 Robotics engineer
      - 2149.14 Test engineer
  - 215 Electrotechnology engineers
    - 2151 Electrical engineers
    - 2152 Electronics engineers
      - 21521 electronics engineers
        - 21521.1 - computer hardware engineer
        - 21521.2 - flight test engineer
        - 21521.3 - instrumentation engineer

21521.4 - language engineer

21521.5 - medical device engineer

21521.6 - microelectronics engineer => Opportunity to adapt the profile to have a broader definition of microelectronics engineer

215216.1 Integrated circuit design engineers

215216.2 Microelectronics analog designer

215216.3 Microelectronics software engineer

215216.4 Microelectronics test engineer

215216.5 Microelectronics robotic engineer

215216.6 Microelectronics applications engineer / specialist

215216.7 Microelectronics marketing engineer

215216.8 Security-by-design specialist

21521.7 - microsystem engineer

21521.8 - optoelectronic engineer

21521.9 - satellite engineer

21521.10 - sensor engineer

21521.11 – Microelectronics designer (systems)

21521.12 – Microelectronics materials engineer

21521.13 – Microelectronics smart manufacturing engineer

21521.14 – Microelectronics quality engineer

21521.15 - Power electronics engineer

21521.16 - RF engineer

2153 Telecommunications engineers

25 Information and communications technology professionals

251 Software and Applications Developers and Analysts

2514 Applications programmers

25142 ICT application developer

25142.1 Embedded systems software developer

252 Database and Network Professionals (METIS: Data scientist)

3 Technicians and associate professionals

31 Science and engineering associate professionals

311 Physical and Engineering Science Technicians

3114 Electronics engineering technicians

31141 electronics engineers

31141.1 - avionics inspector

31141.2 - computer hardware engineering technician

31141.3 - computer hardware test technician

31141.4 - instrumentation engineering technician

31141.5 - medical device engineering technician

31141.6 - microelectronics engineering technician

311416.1 Microelectronics maintenance technician

311416.2 Microelectronics process technician

311416.3 Microelectronics test technician

311416.4 Microelectronics operator / inspector

31141.7 - microelectrosystem engineering technician

31141.8 - optoelectronic engineering technician

31141.9 - sensor engineering technician

312 Mining, Manufacturing and Construction Supervisors

313 Process Control Technicians

314 Life Science Technicians and Related Associate Professionals

315 Ship and Aircraft Controllers and Technicians

All profiles identified by METIS as critical for the microelectronics industry and without a corresponding ESCO profile actually have a match in ESCO, but without specifics associated with the microelectronics industry. The 13 new potential ESCO profiles are therefore more precise profiles than profiles already existing on the ESCO platform, and which take into account the specific needs of the microelectronics industry.

For example, the profile "microelectronics engineer" already exists in ESCO, but the sub-profiles "microelectronics analog designer", "microelectronics test engineer", "microelectronics applications engineer / specialist" … does not exist yet.

For three profiles, the distinction between the skills required for the microelectronics industry and the skills of profiles already existing on ESCO may seem particularly tenuous. Accordingly, the paragraphs below provide a detailed analysis of the specifics required for the microelectronics industry. These three profiles are:

1. **<u>Microelectronics software engineer:</u>**

   Compared to the existing ESCO profile "embedded systems software developer":

   - METIS has identified skills that are required for any "embedded systems software developer" but not taken into account currently.
     - Hardware / Software integration.
     - Artificial Intelligence: Machine learning.

  - Cybersecurity / Security. Ability to identify risks, issues, potential defects in any phase of the software life cycle, managing them through closure.
  - Data analytics / big data. Familiar with databases (e.g., SQL), big data technologies (e.g., Spark, Dask). Design and implementation of Big Data architectures and software platforms (e.g., Hadoop or Data Lake).
  - Manage cost and time constraints, develop best practices, routines and innovative solutions to improve software development yield.
- Software engineers for the microelectronics require specific knowledge.
  - Knowledge of ICT hardware / Introduction to microelectronics: products, design, etc.

Therefore, microelectronics software engineers would be embedded systems software developers specialized in microelectronics.

2. **Microelectronics test engineer:**

Compared to the existing ESCO profile "test engineer":

- METIS has identified skills that are required for any "test engineer" but not taken into account currently.
  - CRM - developing / maintaining internal & external customers' needs.
  - Automatic Test Pattern Generation (ATPG) and Diagnostics.
  - Artificial Intelligence: Machine learning.
  - Virtual prototyping.
- Test engineers for the microelectronics require specific knowledge.
  - Knowledge associated to ICT hardware security / cybersecurity.
  - Competences in analog and digital electronics.
  - Microelectronics test station setup: troubleshooting, maintenance & calibration.
  - Design for test (DFT) techniques.
  - Proficient with RF test equipment: Network analyzers, spectrum analyzers and signal generators.
  - Define Test Competencies & Practice - cooperation with concept, design and lab verification engineers.
  - Yield & Bin Pareto Analysis using JMP, Datapower or O+, Synopsis, YieldHub, other tools.
  - Competences in JEDEC, MIPI and other high-speed test standards.
  - Ability to apply theoretical knowledge into manufacturing context (DOE, FMEA, SPC, etc.).

Therefore, microelectronics test engineers would be test engineers specialized in microelectronics.

3. **Microelectronics robotic engineer:**

Compared to the existing ESCO profile "robotic engineer":

- METIS has identified skills that are required for any "robotic engineer" but not taken into account currently.
    - Program and code automated and/or embedded systems, e.g., C, C++, C#, Python, Arduino, Raspberry, PLC Ladder Logic, MS.NET, and Object-Oriented Programming.
    - Program and code, analyse and troubleshoot HMI's – human-machine interfaces.
    - Familiar with industrial safety systems and safety-critical software tools.
    - Train, teach, and coach team members utilizing Lean processes.
- Robotic engineers for the microelectronics require specific knowledge.
    - Knowledge of ICT hardware / Introduction to microelectronics: products, design, etc. to be able to collaborate with other microelectronics engineering departments.

3) Four new microelectronics ESCO profiles proposed

METIS has proposed 4 new ESCO profiles linked to microelectronics that have been approved and integrated in the ESCO framework:

I. **Microelectronics designer:** Focus on developing and designing systems, from the top packaging level down to the integrated circuit level. System-level understanding with analogue and digital circuit knowledge, integrating the technology processes. Overall outlook in microelectronic sensor basics.

II. **Microelectronics smart manufacturing engineer:** Microelectronics smart manufacturing engineers design, plan and supervise the manufacturing and assembly of electronic devices and products, such as integrated circuits, automotive electronics or smartphones, in an Industry 4.0 compliant environment.

III. **Microelectronics materials engineer:** Design, develop and supervise the production of materials that are required for microelectronics and microelectromechanical systems (MEMS), and can apply them in these devices, appliances and products.

IV. **Microelectronics maintenance technician:** In charge of preventive and corrective maintenance in semiconductor manufacturing.

Below is the description of these 4 profiles:

Microelectronics designer		
Description	Microelectronics designer engineers focus on developing and designing microelectronic systems, from the top packaging level down to the integrated circuit level. Their knowledge incorporates system-level understanding with analogue and digital circuit knowledge, with integrating the technology processes and an overall outlook in microelectronic sensor basics. They work with other engineers, material science specialists and researchers, to enable innovations and continuous development of already existing devices.	
Alternative labels or synonyms	- Microelectronics Circuit Engineer - Microelectronics Circuit Designer - Microelectronics System Designer - Microelectronics System Engineer - Microelectronics Circuit System Engineer - Microelectronics Circuit Design Engineer - Silicon Engineer - Microelectronics Packaging Design Engineer - Microelectronics Packaging Designer	- Microelectronics Hardware Designer - Microelectronics Hardware Engineer - Microelectronics Technology Design Engineer - Microelectronics Manufacturing Design Engineer - Integrated Circuit Hardware Engineer
Scope	The occupational profile of Microelectronics Engineer (2152.1.6) and Integrated circuit design engineer (2152.1.6.1) focus more on the design at semiconductor and chip level. Microelectronics designers have all the knowledge and skills, which are necessary to have a thorough understanding of the microelectronics industry, from packaging to sensor physics and to physical microstructure level of circuits. The microelectronics designer focuses on every level of microelectronics system from the chip level to the product level.	
	Common to engineers	Specific to microelectronics
Essential skills	- Apply technical communication skills - Coordinate engineering teams - Create a product's virtual model - Customize drafts - Draft bill of materials - Provide technical documentation	- Abide by regulations on banned materials - Adjust engineering designs - Approve engineering design - Design electronic systems - Design integrated circuits - Design circuits using CAD - Design prototypes - Design sensors - Develop assembly instructions

	- Use technical drawing software	- Develop product design - Integrate new products in manufacturing - Interpret electronic design specifications - Model sensor - Prepare assembly drawings - Read assembly drawings - Read engineering drawings - Review drafts - Use CAD software - Use CAM software
Optional skills	- Conduct literature research - Perform project management - Train employees - Perform resource planning - Perform scientific research - Write technical reports	- Apply soldering techniques - Assemble electronic units - Conduct quality control analysis - Calibrate electronic instruments - Prepare production prototypes - Solder components onto electronic board - Test sensors
Essential knowledge	- Design drawings - Electrical engineering - Electricity principles - Engineering principles - Environmental engineering - Environmental legislation - Environmental threats - Mathematics - Physics	- CAD software - CAE software - Circuit diagrams - Electronic components - Electronics - Integrated circuit types - Integrated circuits - Manufacturing processes - Microassembly - Microelectronics - Micromechanics - Microsensors - Printed circuit boards - Quality standards - Semiconductors - Sensors
Optional knowledge	- Biomedical engineering - Chemistry - Control engineering - Materials science - Mechanical engineering - Precision mechanics	- Composite materials - Consumer electronics - Electronic equipment standards - Inspect quality of products - Material mechanics - Medical devices - Microoptics - Nanotechnology - Optoelectronics - Power electronics

	- Precision measuring instruments
Hierarchy	2 - Professionals 21 - Science and engineering professionals 215 - Electrotechnology engineers 2152 - Electronics engineers 2152.1 - Electronics engineers 2152.1.x - Microelectronics Designer

Microelectronics smart manufacturing engineer		
Description	Microelectronics smart manufacturing engineers design, plan and supervise the manufacturing and assembly of electronic devices and products, such as integrated circuits, automotive electronics or smartphones, in an Industry 4.0 compliant environment.	
Alternative labels or synonyms	- Microelectronics manufacturing engineer - Microelectronics technology engineer - Microelectronics manufacturing professional - Microelectronics technology consultant - Smart manufacturing engineer - Microelectronics production engineer	- Microelectronics production supervisor - Microelectronics technology expert - Microelectronics productions specialist - Engineer of microelectronics technology - Microelectronics production adviser - Smart production expert
Scope	• The scope of the existing profile of Manufacturing Engineer (2141.3) is much broader and does not focus on microelectronics on the one hand and does not address the rising need of skills related to smart manufacturing in the scope of Industry 4.0 on the other hand. • The occupational profile of Microelectronics Engineer (2152.1.6) focuses on microelectronics in a much broader manner, and the manufacturing is addressed only on the semiconductor level, excluding the manufacturing of electronic devices, appliances, systems. • Similarly, the profile of microsystem engineer (2152.1.7) focuses on the manufacturing solely of microelectromechanical systems (MEMS). • The scope of the proposed profile is limited to the aspects of microelectronics manufacturing, excluding microsystem engineer (2152.1.7).	
	Common to engineers	Specific to microelectronics
Essential skills	- Perform resource planning - Draft bill of materials - Assess the life cycle of resources	- Abide by regulations on banned materials - Read engineering drawings

	- Develop hazardous waste management strategies - Manage discarded products - Ensure health and safety in manufacturing - Liaise with engineers - Monitor plant production - Perform risk analysis - Establish data processes - Manage data collection systems - Execute analytical mathematical calculations - Interpret current data - Report analysis results	- Develop assembly instructions - Assemble printed circuit boards - Apply advanced manufacturing - Apply soldering techniques - Solder electronics - Integrate new products in manufacturing - Prepare assembly drawings - Dispose of soldering waste - Analyse production processes for improvement - Define manufacturing quality criteria - Inspect quality of products - Set quality assurance objectives
Optional skills	- Communicate test results to other departments - Coordinate engineering teams - Perform scientific research - Manage system security - Investigate security issues - Perform data mining - Manage data	- Provide improvement strategies - Recommend product improvements - Use precision tools - Check quality of products on the production line - Check quality of raw materials - Operate scientific measuring equipment - Operate precision machinery - Oversee quality control - Use cad software - Use cam software
Essential knowledge	- Technical drawings - Industrial engineering - Engineering principles - Environmental legislation - Environmental threats - Principles of artificial intelligence - Characteristics of waste - Hazardous waste types - Hazardous waste treatment - Mathematics - Physics - Cyber security - Statistics	- Manufacturing processes - Production processes - Electronic equipment standards - Quality standards - Quality assurance methodologies - Quality assurance procedures - Electronics - Microassembly - Microelectronics - Nanoelectronics
Optional knowledge	- Reverse engineering - Automation technology - Computer engineering - Control engineering - Emergent technologies	- Integrated circuit types - Microelectromechanical systems - Nanotechnology - Non-destructive testing

	- Mechanical engineering - Precision measuring instruments - Audit techniques - Data mining - Data models - Information categorization - Information extraction - Visual presentation techniques
Hierarchy	2 - Professionals 21 - Science and engineering professionals 215 - Electrotechnology engineers 2152 - Electronics engineers 2152.1 - Electronics engineers 2152.1.x - Microelectronics smart manufacturing engineer

Microelectronics materials engineer	
Description	Microelectronics material engineers design, develop and supervise the production of materials that are required for microelectronics and microelectromechanical systems (MEMS), and able to apply them in these devices, appliances, products. Microelectronics material engineers aid the design of microelectronics with physical and chemical knowledge about metals, semiconductors, ceramics, polymers, and composite materials. They conduct research on material structures, perform analysis, investigate failure mechanisms, and supervise research works.
Alternative labels or synonyms	- Microelectronics material designer - Engineer of microelectronics materials - Microelectronics material technology engineering expert - Microelectronics material design engineer - Microelectronics material developer - Microelectronics material engineering expert - Microelectronics material technology engineer - Microelectronics material engineering adviser - Microelectronics material technology engineering specialist - Microelectronics material engineering consultant - Microelectronics material development engineer - Microelectronics material engineering specialist - Engineer specialised in microelectronics materials - Engineer in microelectronics material - Microelectronics material technology engineering consultant - Specialist microelectronics material engineer
Scope	Compared to the existing profile of Materials engineers (2149.9), this occupation focuses only on the materials which are required for microelectronics and

	microelectromechanical systems, like metals, semiconductors, ceramics, polymers, and composite materials. Compared to the profile of Microelectronics engineers (2152.1.6), this occupation covers all the knowledge about materials, which is necessary to design and develop any kind of microelectronics; however, it does not require an in-depth understanding about microelectronics.	
	Common to engineers	Specific to microelectronics
Essential skills	- Develop hazardous waste management strategies - Record test data - Analyse test data - Report analysis results - Provide technical documentation - Perform data analysis	- Abide by regulations on banned materials - Apply soldering techniques - Join metals - Inspect semiconductor components - Test materials - Dispose of soldering waste - Test microelectromechanical systems - Read engineering drawings - Perform laboratory tests - Perform chemical experiments - Work with chemicals
Optional skills	- Advise on pollution prevention - Advise on waste management procedures - Use technical drawing software - Create technical plans - Conduct literature research - Perform scientific research	- Integrate new products in manufacturing - Adjust engineering designs - Design prototypes - Develop microelectromechanical system test procedures - Develop material test procedures - Define manufacturing quality criteria - Use cad software - Use cam software - Use precision tools - Operate scientific measuring equipment
Essential knowledge	- Electrical engineering - Mechanical engineering - Mathematics - Physics - Chemistry - Environmental legislation - Environmental threats - Characteristics of waste	- Electronics - Semiconductors - Manufacturing processes - Semiconductors - Microelectronics - Microassembly - Microsystem test procedures - Sensors

	- Hazardous waste types - Hazardous waste treatment - Types of metal - Types of plastic - Basic chemicals	- Precision measuring instruments
Optional knowledge	- Materials science - Electricity - Material mechanics - Engineering processes - Precision mechanics - Laboratory techniques	- Microsensors - Micromechanics - Composite materials - Nanotechnology - CAE software - Microoptics - Optoelectronics - Quality standards
Hierarchy	2 - Professionals 21 - Science and engineering professionals 215 - Electrotechnology engineers 2152 - Electronics engineers 2152.1 - Electronics engineers 2152.1.x Microelectronics materials engineers	

Microelectronics maintenance technician		
Description	Microelectronics maintenance technicians are responsible for maintaining preventive and corrective (daily, weekly, yearly) and troubleshoot of the microelectronic systems and devices. Diagnose and detect malfunctions in microelectronic systems, products, and components and remove, replace, or repair these components when necessary. Execute preventative equipment maintenance tasks.	
Alternative labels or synonyms	- Maintenance and repair technician - Industrial maintenance technician	
Scope	The maintenance is already present in the figure 31141.6 - "microelectronic engineering technician" but it is drowned compared to the other tasks while in companies the "microelectronic maintenance technician" is a specialized figure and foresees a career progression linked to the raising of the competence of the action maintenance which includes only preventive maintenance in the junior phase (Maintenance agent), then corrective maintenance with experience and finally management of the maintenance process (Senior Maintenance Technician). The specialized figure "microelectronic engineering technician" is also in great demand and difficult to find on the job market.	
	Common to engineers	Specific to microelectronics
Essential skills	- Use technical documentation - Understand written English - Conduct inter-shift communication - Understand spoken English	- Conduct routine machinery checks (equipment, signals – alarms) - Test microelectronics - Maintain microelectronics

	- Write reports	- Solder components onto electronic board - Work safely with machines - Troubleshoot
Optional skills	- Program Firmware - Collaborate with engineers	-
Essential knowledge	- Mathematics - Physics - Mechanics - Robotics - Surface-mount technology - Quality standards - Quality assurance procedures - Environmental legislation - English	- Electronics - CAD Software - CAM Software - Integrated circuits - Microelectronics - Microassembly - Manufacturing processes production
Optional knowledge	- Firmware	
Digital Skills	- Firmware - Basic knowledge in Word, Excel, Outlook - Basic data analysis skills	
Hierarchy	31141 electronics engineers 31141.1 - avionics inspector 31141.2 - computer hardware engineering technician 31141.3 - computer hardware test technician 31141.4 - instrumentation engineering technician 31141.5 - medical device engineering technician 31141.6 - microelectronics engineering technician 311416.1 Microelectronics maintenance technician 31141.7 - microelectrosystem engineering technician 31141.8 - optoelectronic engineering technician 31141.9 - sensor engineering technician	