AUTO CREDIFY

FUTURE-READY SKILLS

June 2026

D2.1 Reports on emerging occupations and specific skills needs

Lisbon (Portugal)

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Contents

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Lists of abbreviations

Abbreviation	Full form
AI	Artificial Intelligence
BIM	Building Information Modelling
DOCDB	EPO Master Documentation Database
EACEA	European Education and Culture Executive Agency
EP	European Patent
EPO	European Patent Office
ESCO	European Skills, Competences, Qualifications and Occupations
EU	European Union
IT	Information Technology
M&R	Maintenance and Repair
NLP	Natural Language Processing

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1 Introduction

The present document reports the activities conducted and results obtained under *Task 2.4 – Conducting a skills anticipation exercise to identify future skills needed in the M&R subsector,* as foreseen by the implementation plan reported in the Application Form.

The assignment (hereinafter also referred to as the Study) focuses on a data-driven skills anticipation exercise that aims at facilitating the design of micro-credentials suitable for testing in three pilot economies: Finland, Portugal, and Spain (with a focus on the Savo region, the Lisbon Metropolitan Area, and Navarra, respectively). The present report focuses on Lisbon, Spain.

To accomplish this, two different data sources have been analysed, exploiting AI-based methodologies:

1) job postings, aiming at mapping arising jobs and related skills requests in the field of Maintenance and Repair;
2) patent literature, which were used to highlight development in relevant technological domains, possibly leading to product/process concurrent innovation in the *M&R subsector*, thus impacting on (new) jobs and skills needs.

Please note that this Study, and the resulting analysis, are intended as an analytical tool and a foundational evidence base to support the design of micro-credentials. Though meaningful and representative, the use of patent and job posting data provides a partial view of labour market and technological dynamics, which are inherently complex and multifaceted.

As such, the findings of this assignment should be interpreted as a **starting point for further exploration and validation**, rather than as a comprehensive or definitive assessment. The design of training programmes and micro-credentials can build upon this analysis, using it as a baseline to be complemented with additional qualitative insights, stakeholder engagement, and contextual expertise.

Note 1: Limitations of the Study.

The report proceeds with the following structure:

- **Chapter 2 Methodology**: this section introduces the analytical framework adopted for the Study, briefly describing how the two data sources have been used for collecting useful insights.
- **Chapter 3 Patent-driven skills and jobs investigation**: here the results of the patent-based analysis are presented, highlighting the technological concepts with the highest innovation intensity and examining how they translate into associated skills requirements and occupational profiles.
- **Chapter 4 Job-postings-driven skills and jobs investigation**: here the results of the job postings analysis are presented, examining how they translate into skills requirements and occupational profiles. Job vacancies complement the patent perspective allowing for a comparison between innovation signals emerging from patents and real-time recruitment dynamics.
- **Chapter 5 Conclusions**: this section synthesises the main findings, putting together the results from and providing a comparison between the patent-driven and the job postings-driven analyses.

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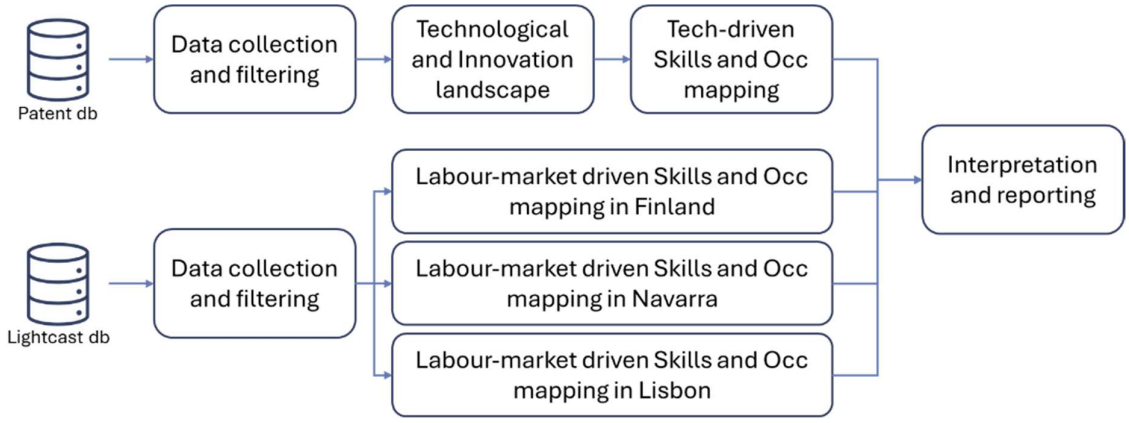
2 Methodology

The Study followed a **multi-stage and multi-source methodology** designed to capture both anticipatory signals and current labour market dynamics. At a high level, patent data are used to provide a forward-looking perspective on emerging technologies, related skill requirements and linked occupations, while job posting data offer an empirical view of current and recent demand for occupations and associated competencies. The overall methodological framework is structured in sequential stages, which are illustrated in Figure 1 and described in detail in the following sections.

Figure 1: Schematic illustration of the key stages of the methodological workflow.



Patent-driven skills and jobs investigation

The Study begins with the **collection of patent data** from an international, worldwide database, which includes over 160 million patent records. Indeed, patent information represents a privileged source for investigating worldwide technology evolution and innovation activity.

> The patent analysis was limited to the past 10 years for two main reasons. Firstly, it ensures consistency with the job vacancies provided by Lightcast, which cover a shorter (specifically, the last six years) and more recent period. Secondly, patent data typically precede market applications, as they reflect early-stage innovation activity. Therefore, the analysis adopts a slightly longer time horizon for patents than for job postings in order to capture pioneering technological developments that may shape future labour market needs. Lastly, given the characteristics of the sector, the selected time window allows for a clearer focus on emerging and innovative technologies.

Note 2: Rationale for limiting patent analytics to a 10-years time frame.

As worldwide economy is constantly evolving and innovating, as soon as a novel advantageous technology is introduced, this is typically adopted quickly by all players in the world, regardless of the country of initial development. Therefore, it is important to look at innovations on a global scale to have a complete picture of the new technologies that are entering or about to enter the M&R sector and that will shape the competencies needed by the labour market in near future. Even adopting a European-scale perspective is not sufficient, as in fact EP patents represent only about 10% of the total research and development production on a global scale in recent times[1].

[1] Source: World Intellectual Property Organization (WIPO) (2025). World Intellectual Property Indicators 2025. Geneva: WIPO. DOI: 10.34667/tind.58959

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Extracting coherent and comparable datasets requires careful cleaning due to factors that span from patents' legalese jargon, variations in documentation standards, classifications, and lack of metadata completeness across different jurisdictions. To overcome the intrinsic challenges of patent research, database querying and dataset cleaning methodologies were applied and refined through proprietary algorithms and more than 10 years of experience. Such step led to the identification of a dataset containing all worldwide patent documents pertaining to the M&R sector.

Next, Natural Language Processing (NLP) techniques were applied to the patent corpus to identify **domain-relevant technological concepts**, both consolidated and emerging, thus enabling the representation of the sector from a technological perspective. These concepts were subsequently assigned a ***Patent Innovation Index***, aiming at synthesizing the level of current and expected future relevance of each technological concept in the sector under review. The *Patent Innovation Index* results from a weighted and normalized combination of two factors:

- the number of inventions produced, at worldwide level, and in the considered 10+ years span;
- the growth rate of inventions production.

The resulting indicator assumes values in the interval [0,1], and therefore represents a relative measure of technologies relevance in a given domain. Technologies with a higher Patent Innovation Index are more likely to have an impact on the sector under analysis and on the demand for skills over the short and medium term. They represent both widely researched and rapidly growing innovations resulting from significant investments in R&D, which will most likely translate into widespread adoption and use. Technologies with lower scores (say, lower than 0.5) are still relevant to consider because of two possible scenarios.

- Significant yet slowing inventive activity (a relatively high number of inventions, with low growth rate). This indicates mainstream technologies for which skills may still need to be updated; or
- Low yet growing inventive activity (a relatively low number of inventions, with high growth rate). This indicates emerging technologies, which could gain importance over the long term.

In addition, **non-technological concepts** were intentionally retained in the analysis, as they represent key enabling factors within the sector. Although these elements do not receive any quantitative score (and are therefore labelled as "N.T." due to their non-technological nature), they encompass both established and emerging concepts that are essential for providing a comprehensive mapping of the skills and occupations relevant to the considered domain. The identified technologies and innovation concepts were then semantically **matched with the ESCO database to capture a list of related skills and occupations**. Professional profiles and competences are also ranked in order of relative potential future demand on the basis of the number of related innovations. In this context, the ESCO framework represents a widely used standard in skills intelligence, and is used to remap occupations and skills in relation to technological evolution, establishing a common language and ensuring alignment with the European reference classification standard.

This technologies-skills-occupations mapping makes it possible to highlight the skills needs for the next future, as well as professions that are most linked to such skills. This kind of intelligence is essential for anticipating priority skill needs, guiding curriculum development, and strengthening cooperation between industry and education providers. Ultimately, this mapping exercise helps reveal where skill gaps are likely to appear and where labour demand may increase in the near future.

Lastly, through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology. The resulting rankings of skills and occupations therefore highlight those profiles that are most strongly linked to high-ranked technologies and innovations, providing a synthetic and forward-looking representation of interconnections between technological evolution, skill requirements, and occupational structures.

Job-postings-driven skills and jobs investigation

Job vacancies complement the patent perspective. While the patent-based analysis provides a technology and innovation-driven view on potential future developments, job postings investigation offers an empirical view

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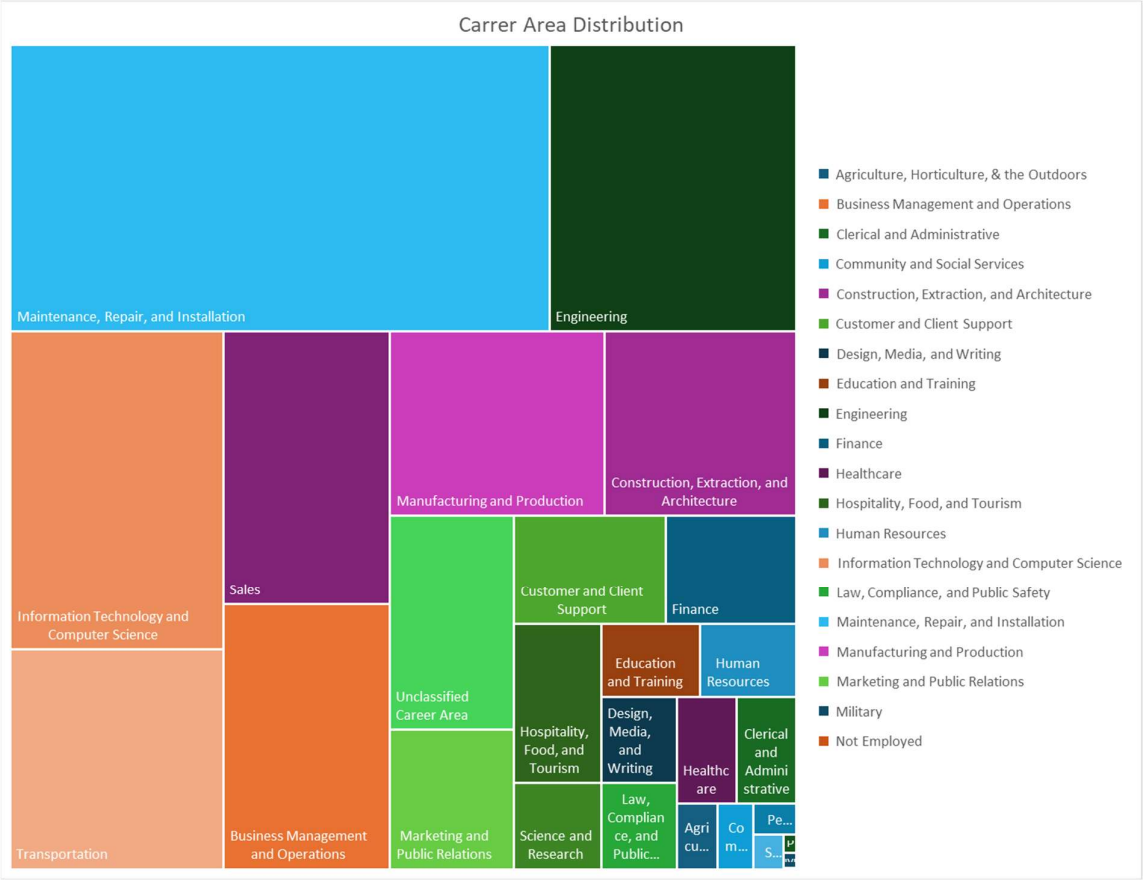
grounded in real labour market dynamics. By examining job postings, it is possible to observe how sectoral transformations translate into concrete hiring needs. This approach therefore provides a real-world perspective on emerging occupations and skills, highlighting patterns in employer demand and offering evidence of how labour markets are evolving in response to technological change.

Job vacancy data was provided by Lightcast[2]. Each job posting is associated with a specific job profile and may include multiple skills. According to this, the analysis first examined the job profile landscape and subsequently explored the connected skills required by employers.

A total of approximately 183,000 job postings were collected, so distributed: Finland 131,912 records; Portugal 38,224 (in particular, Lisbon Metropolitan Area); Spain 13,549 (from the region of Navarre). Differences in absolute values strongly depend on how data were collected. While, for Portugal and Spain, only job vacancies from the Lisbon and Navarra regions, respectively, were retrieved, the situation was different for Finland. Although the initial focus was on the Savo region, the limited availability of data required extending the analysis to the entire national territory in order to ensure the statistical robustness and reliability of the results.

Figure 2: Carrer Area distribution of the job postings' dataset.



An initial exploration of the dataset highlighted the need for a **filtering procedure to ensure data quality and robustness**. Such step was based on a *Career Area* variable provided by Lightcast itself, which indicates each job posting's domain. In particular, those job postings were excluded whose domain was considered less relevant for the scope of the Study. Figure 2 provides an overview of the distribution of career areas within the dataset and their respective frequencies. The size of each rectangle is proportional to the frequency of the corresponding

[2] https://lightcast.io/euro

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career area. As a result, the following areas were excluded from the analysis: *Agriculture, Horticulture, & the Outdoors; Clerical and Administrative; Community and Social Services; Construction, Extraction, and Architecture; Design, Media, and Writing; Education and Training; Finance; Healthcare; Hospitality, Food, and Tourism; Human Resources; Marketing and Public Relations; Military; Performing Arts; Personal Services; Science and Research; Social Analysis and Planning; Not Employed; Unclassified Career Area*.

Subsequently, in order to evaluate the most relevant job occupations and skills from job vacancies, a ranking was performed. Similarly to the aforementioned *Patent Innovation Index*, such ranking was based on a composite score, namely ***Labour Market Index*** combining the absolute frequency and emergence of skills and occupations within the job postings dataset. In more detail:

- The absolute frequency component captures how often a given occupation or skill appears in the job postings dataset. This indicator reflects the current level of demand in the labour market, highlighting roles and competencies that are widely required by employers.
- The second component, referred to as emergence, measures the evolution of demand over time, specifically considering the trend observed in the last years (2020 – 2025). This indicator captures the growth dynamics of occupations and skills, identifying those that are increasing in relevance within job postings and may therefore represent emerging or rapidly expanding labour market needs.

The combination of these two dimensions allows the ranking of occupations and skills considering both their current relevance and their recent growth trajectory. As a result, the highest-ranked items are those that are both frequently mentioned in job postings and characterized by a strong positive trend over time. Conversely, occupations or skills with high frequency but limited growth, as well as those with strong growth and low diffusion, tend to appear lower in the ranking.

Taken together, the two analytical perspectives enabled a comprehensive understanding of emerging labour market trends and future skill requirements.

A further potentially relevant analytical dimension relates to the relationship between enterprise size, occupational profiles, and skills demand. Understanding how skills requirements vary across firms of different sizes could have provided additional insights into labour market dynamics and supported the development of more targeted micro-credentials and training interventions.

Nevertheless, the selected data provider was not able to provide sufficiently robust and consistent information on company size. As a result, and in order to preserve the reliability and validity of the findings, this analytical dimension was not explored further within the scope of the Study.

Note 3: Rationale for limiting patent analytics to a 10-years time frame.

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3 Patent-driven skills and jobs investigation

3.1 Patent-based technological landscape

3.1.1 Worldwide perspective

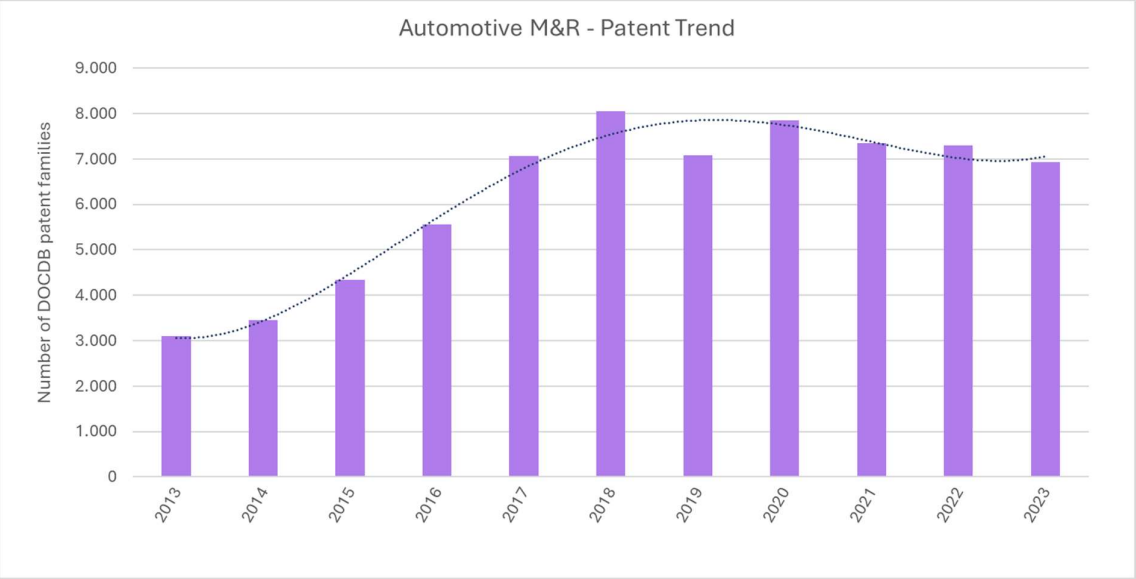
A total of over 127 thousand patent documents, belonging to **approximately 76 thousand DOCDB[3] families, on a global scale have been collected in relation to the *Automotive Maintenance and Repair* domain**. The DOCDB simple patent family is defined by the European Patent Office as "*a collection of patent documents that are considered to cover a single invention. The technical content covered by the applications is considered to be identical*"[4]. Therefore, patent families represent a more valuable unit than single patent applications when studying innovation evolution.

Table 1: Worldwide patent sets dimensions in the Automotive M&R sector.

Sector	Number of worldwide patent documents*	Number of worldwide DOCDB patent families*
Automotive Maintenance and Repair	127,758	76,090

*since 2013

Figure 3: Time series of worldwide patent families' filings in the Automotive M&R sector.



It is also worth noting that patent applications are typically published only after a confidentiality period, which is generally 18 months from the filing date. Consequently, patent data for the most recent two years are incomplete and should not be considered fully reliable for analytical purposes. Given the Study's focus on a ten-year timeframe, the analysis was therefore based on patent data covering the period from 2013 to 2023.

[3] DOCDB is the European Patent Office's master documentation database with worldwide coverage. It contains bibliographic data, abstracts, citations and the DOCDB simple patent family, but no full text or images.
[4] Source: https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families/docdb.html

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Table 1 shows a concise view of the overall patent set, while Figure 3 displays the yearly evolution of inventive activity. Please note that the chart does not display the two last years (2023 – 2025), due to the aforementioned *secrecy period*.

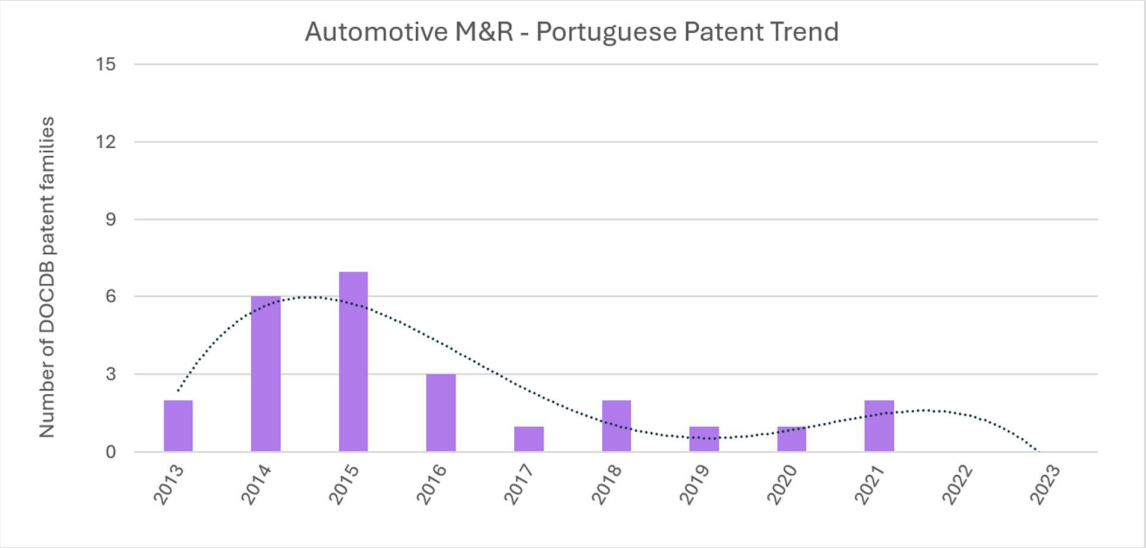
Figure 3 illustrates a strongly increased patent activity from approximately 3,100 novel inventions per year in 2013 to a peak of about 8,000 in 2018, reflecting a period of accelerated innovation and sectoral expansion. After a decline in 2019, filings partially recovered in 2020 but did not regain the previous peak. From 2021 onward, the trend shows a moderate but consistent decrease, reaching roughly 6,900 patent families in 2023. Overall, the data indicate rapid growth followed by stabilization at a comparatively high level, suggesting a maturing yet still innovation-intensive technological field.

3.1.2 Portuguese perspective

Having analysed the Automotive M&R sector from a worldwide perspective, the study now focuses on the Portuguese patent set. Since 2013, this set comprises 28 patent documents belonging to 25 DOCDB patent families, concentrated almost entirely in the first half of the period.

Following a modest start in 2013 (2 families), filing activity peaked in the 2014-2015 biennium at 7 families per year, before contracting sharply to 1–2 families per year between 2017 and 2021; no families are recorded thereafter. The limited number of documents, however, prevents any meaningful interpretation of the underlying trend.

Figure 4: Time series of Portuguese patent families' filings in the Automotive M&R sector.



The thematic analysis of the Portuguese patent set reveals a markedly heterogeneous portfolio, with no single dominant technology. The most cohesive cluster concerns connected-vehicle networking and fleet management, reflecting the leading role of Veniam Inc (4 families), active between 2016 and 2019 on data extraction from networks of moving vehicles, service-driven connectivity management and the optimised operation of autonomous vehicle fleets.

Further clusters identified by the analysis include repair and workshop equipment: a windscreen-repair curing unit (Belron); a motorcycle-rim repair machine (Llantacars); an adjustable vehicle-lifting device (Pedro Manuel Almeida Valente); vehicle-access apparatus (Manitou, ASGO). In addition, research over digital service platforms (Vortal's electronic procurement platform, computer-based repair budgeting, auditing and video-surveillance solutions) and vehicle components (power take-off pumps by ABER, belt tensioners, steering-column supports, and sealing, lighting and insulation solutions) was intercepted.

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3.1.3 Technological and innovation concepts in M&R

For studying the technological evolution in a specific domain, the definition of a sector-level patent set represented a fundamental step in the methodology. The application of Natural Language Processing (NLP) to such sets enabled the identification of a list of **domain-specific technological concepts**. These are displayed in Table 2, where the ordering is based on the ***Patent Innovation Index***, aiming at synthesizing the level of relevance of each technological concept in the *Automotive Maintenance and Repair* sector (see Methodology for more details).

Technological and innovation concepts are visualized in Table 2 using a purple colour scale, where darker shades indicate higher Patent Innovation Index values. It should be noted that a set of non-technological concepts were also included, namely *Car emergency* and *Risk management*. These entries are clearly marked with the tag "N.T." and positioned at the bottom of the ranking.

Table 2: List of the technological concepts relevant for the Automotive M&R sector.

Technological and Innovation Concepts	Patent Innovation Index
Diagnostic sensors	1,000
AI and Statistical tools for diagnosis	0,993
Car lifters	0,990
Electric propulsion	0,963
Predictive maintenance	0,951
Robotic workers and Cobots	0,874
Garage digital management	0,862
Vehicle clamping equipment	0,861
Mechanical tools	0,843
3D Scanning	0,799
Internet of Things (IoT)	0,792
Imaging for diagnosis	0,730
High voltage technologies	0,727

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Technological and Innovation Concepts	Patent Innovation Index
Intelligent cabin	0,720
Fuel optimization	0,697
Battery repairing and maintenance	0,680
Electronics and Software for Autonomous drive	0,641
Mechatronics	0,606
Advanced polymers	0,581
Augmented reality	0,555
Hydrogen management and storage	0,517
Automotive components	0,435
3D printing for component replacement and repairment	0,419
Complex transmission	0,328
Spare part management and logistics	0,273
Maintenance cost calculation	0,190
Car emergency	N.T.
Risk management	N.T.

The ranking reveals a clear prioritization of diagnostic and data-driven technologies within the *Automotive Maintenance and Repair* domain. *Diagnostic sensors* lead the ranking, closely followed by *AI and Statistical tools for diagnosis*, *Predictive maintenance*, and *Garage digital management*. Together, these top-performing technological and innovation concepts signal a structural transition from reactive repair models toward predictive, data-supported, and platform-integrated service strategies.

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Rounding out the top tier are mature and operationally indispensable technologies such as *Car lifters* and *Mechanical tools*. Their strong positioning confirms that, despite rapid digitalization, physical workshop infrastructure remains strategically critical. On the other hand, Complementary technologies such as *IoT and telematics* and *Imaging for diagnosis* further reinforce the importance of digital connectivity and real-time information flows, although they rank slightly below core diagnostic infrastructures.

The dominance of fault detection systems, analytical intelligence, and core workshop equipment in the top tier indicates that competitive advantage increasingly derives from the ability to detect, interpret, and act upon vehicle condition data efficiently.

Another distinct high-performing cluster includes *Electric propulsion*, *High-voltage technologies*, and *Battery repairing and maintenance*, clearly reflecting the sector's transition toward vehicle electrification and its associated maintenance technology. When considered alongside *Hydrogen management and storage*, the ranking suggests that repair ecosystems must adapt to alternative propulsion systems. This transformation implies not only technological reconfiguration but also the development of new technical skills, safety standards, and certification frameworks to manage high-voltage systems and next-generation energy carriers.

Mid-ranked technologies such as *Intelligent cabin* and *Electronics and software for autonomous drive* point to the growing complexity of vehicle architectures and the increasing software intensity of modern cars. Their position indicates emerging relevance in maintenance contexts, particularly as repair activities expand beyond mechanical intervention to include software diagnostics, calibration, and system integration. In contrast, *Advanced polymers* and *Augmented reality* suggest steady yet comparatively lower strategic impact, possibly reflecting enabling or supportive roles rather than core maintenance functions.

Examining the bottom tier of the ranking, including *3D printing for component replacement and repair* and *Complex transmission,* technologies appear to remain either niche or context-specific within current repair practices. Traditional operational domains such as *Spare part management and logistics* and *Maintenance cost calculation* occupy the bottom of the ranking, indicating limited direct patent intensity and comparatively lower innovation dynamics.

Finally, the presence of non-technological or governance-oriented concepts such as *Car emergency* and *Risk management* is analytically significant, although not technically ranked. Their appearance in patent-related analyses suggests that innovation in automotive repair is increasingly shaped by regulatory compliance, and safety considerations. These dimensions function as embedded constraints and design parameters within technological development. The trend indicates that innovation is no longer driven solely by performance and functionality, but also by legal robustness, safety assurance, user trust, and long-term sustainability.

Overall, the ranking underscores a pronounced technological convergence toward diagnostics, computational-based maintenance, electrification, and system integration. It portrays a repair ecosystem that is progressively data-centric, automation-enabled, and strategically aligned with predictive and software-defined vehicle paradigms.

3.2 Skills and occupations matches from ESCO database

Applying semantic matching algorithms, the identified technologies and innovation concepts were linked to ESCO skills, competences, knowledge, and occupations.

Through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology (see Methodology for more details).

Figure 5 ranks the top 30 skills associated with technologies likely to impact the *Automotive Maintenance and Repair* sector in the future.

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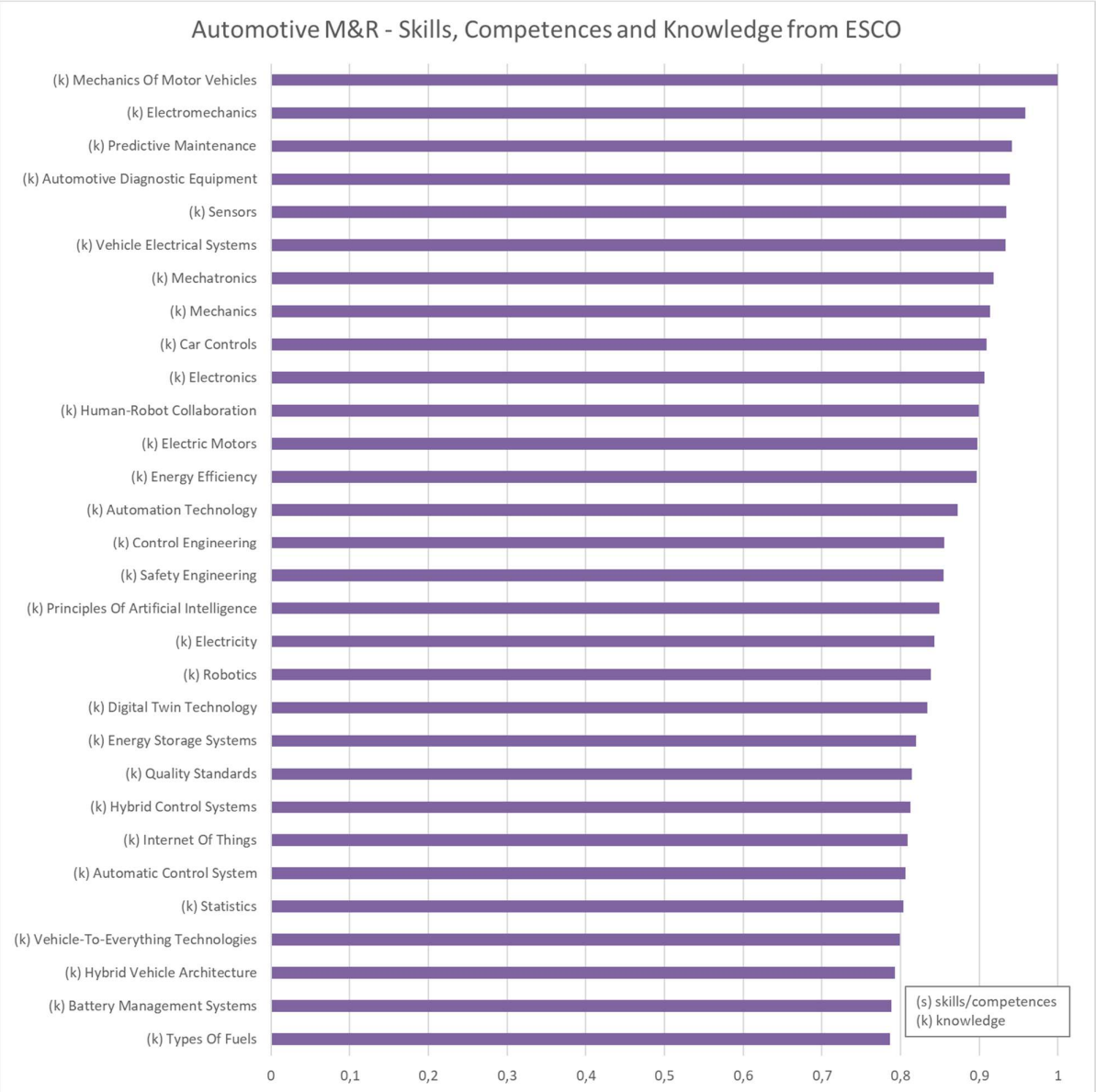
Figure 5: Top 30 ESCO skills, competences and knowledge in the Automotive M&R sector.



The ranking highlights the continued dominance of foundational mechanical and electromechanical knowledge as the core competence base in the analysed domain. *Mechanics of motor vehicles* occupies the top position, followed closely by *Electromechanics*, *Predictive maintenance*, and *Automotive diagnostic equipment*. This confirms that traditional mechanical expertise, combined with diagnostic and predictive capabilities, remains essential to ensure effective and reliable maintenance operations.

Closely following this top tier are competencies related to *Sensors*, *Vehicle electrical systems*, *Mechatronics*, and *Electronics*, reflecting the increasing integration of electrical and electronic architectures within modern vehicles. The strong positioning of these skills indicates that maintenance activities now require a hybrid skill set combining mechanical proficiency with electrical and electronic system understanding. The presence of *Car controls*, *Electric motors*, and *Energy efficiency* further reinforces the growing importance of electrically powered systems and energy optimization in maintenance practices.

A second cluster of highly ranked competences emphasizes automation, intelligent systems, and interdisciplinary integration. Skills such as *Automation technology*, Control engineering, *Safety engineering*, and *Human-robot*

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collaboration highlight the progressive automation of workshop environments and the growing interaction between technicians and automated or robotic systems. The inclusion of *Principles of artificial intelligence*, *Robotics*, and *Digital twin technology* underscores the emergence of data-driven and simulation-based maintenance approaches, which enable predictive diagnostics, system optimization, and remote monitoring.

The ongoing transition toward electrified and connected vehicles evidenced by the presence of *Energy storage systems*, *Hybrid control systems*, and the *Internet of Things*. These technologies require maintenance professionals to understand battery systems, system integration, and real-time data exchange between vehicle components and external platforms. Similarly, *Vehicle-to-everything technologies* and *Battery management systems* indicate the increasing relevance of connectivity and advanced energy management in maintenance contexts.

Lower-ranked, yet still strategically relevant, competences such as *Statistics*, *Hybrid vehicle architecture*, and *Types of fuels* suggest supporting or specialized knowledge areas that complement core technical expertise. Their relatively lower position does not indicate lack of importance, but rather a more contextual or enabling role compared to fundamental diagnostic, mechanical, and electrical competences.

Overall, the ranking reveals a clear evolution of the automotive repair skillset from purely mechanical expertise toward a multidisciplinary competence profile integrating mechanics, electronics, data analytics, automation, and electrification. Confirming the findings in Table 2, this transformation reflects the increasing technological complexity of modern vehicles and highlights the need for maintenance professionals capable of operating at the intersection of physical systems, digital technologies, and intelligent diagnostic environments.

Similarly, Figure 6 provides a synthetic picture of how technological innovation in the *Automotive M&R* sector translates into labour demand, presenting the top 30 ESCO job profiles emerging from the analysis.

The occupation ranking highlights the growing centrality of predictive, electrical, and interdisciplinary engineering roles within the repair and maintenance ecosystem. At the top of the ranking stands the *Predictive Maintenance Expert*, followed closely by the *Automotive Electrician* and the *Motor Vehicle Engine Inspector*. This leadership position reflects the sector's transition toward condition-based and data-driven maintenance models, where the ability to anticipate failures and interpret diagnostic data has become a critical operational capability.

Closely following this top tier are engineering and technical roles such as the *Electromechanical Engineering Technician*, *Maintenance and Repair Engineer*, *Mechatronics Engineer*, and *Sensor Engineering Technician*. The strong positioning of these occupations underscores the increasing importance of hybrid expertise combining mechanical, electrical, and electronic competencies (as highlighted in Figure 5). In particular, the prominence of mechatronics and sensor-related roles confirms that modern maintenance activities rely heavily on integrated systems requiring advanced diagnostic, calibration, and system-level intervention skills.

As revealed by the analysis of the skill ranking (Figure 5), a distinct cluster of highly ranked occupations comprises operational and technical implementation roles, including the *Motor Vehicle Parts Assembler*, *Mechatronics Engineering Technician*, *Powertrain Engineer*, and *Motor Vehicle Engine Tester*. The prominence of these roles underscores the continued importance of hands-on technical expertise and system-level validation functions, which are essential to ensure vehicle performance, operational reliability, and compliance with increasingly stringent technical and safety standards.

Notably, emerging and future-oriented roles such as the *Autonomous Driving Specialist*, *Alternative Fuels Engineer* and *Automotive Battery Technician* occupy mid-to-high positions, highlighting once again the sector's ongoing transition toward software-defined vehicle architectures and alternative propulsion systems. Similarly, the inclusion of the *Embedded Systems Security Engineer* reflects the growing relevance of cybersecurity in vehicle maintenance, as vehicles become progressively connected and reliant on embedded software systems.

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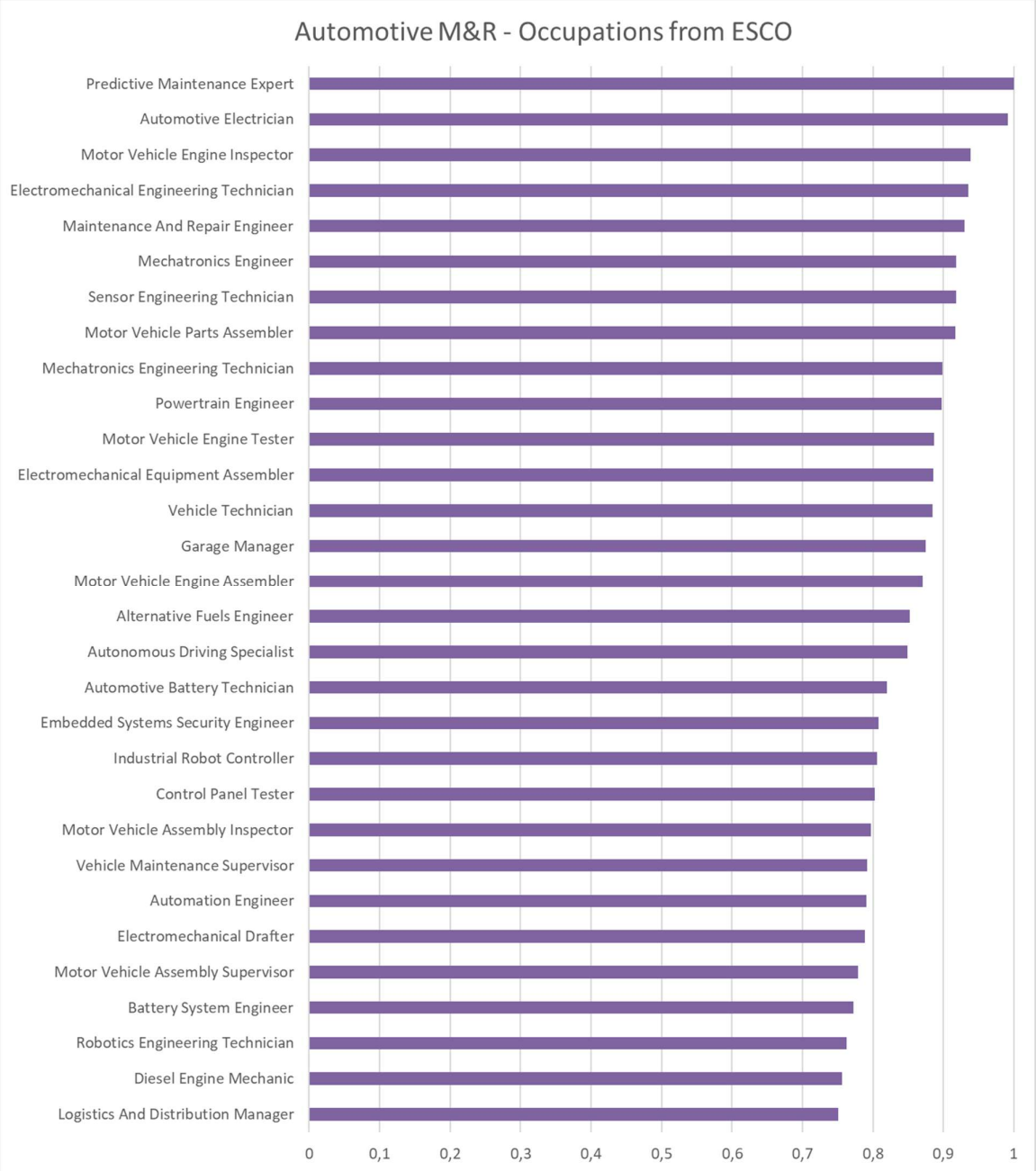
Figure 6: Top 30 ESCO occupations in the Automotive M&R sector.



Further down the occupation ranking, roles such as the *Industrial Robot Controller* and *Automation Engineer* emphasize the gradual integration of automation and robotics into maintenance and production-related activities. These occupations point to the increasing automation of diagnostic procedures, component handling, and repair workflows, requiring technicians capable of interacting with automated systems and robotic platforms.

Lastly, low-ranked occupations such as the *Diesel Engine Mechanic* and the *Logistics and Distribution Manager* remain relevant but reflect comparatively lower strategic intensity in terms of technological innovation. This positioning suggests a gradual shift away from traditional mechanical specializations associated with conventional internal combustion engine technologies, alongside the relative stabilization of logistics functions compared to rapidly evolving technical roles.

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Considering these findings, the occupational ranking (Figure 6) reinforces this transition, evidencing a parallel restructuring of professional roles in response to evolving skill requirements (Figure 5). Traditional mechanically focused occupations are increasingly complemented by interdisciplinary roles that combine expertise in diagnostics, data-driven solutions, electrified systems, embedded electronics, and automated processes. This shift reflects the alignment between emerging competence profiles and the changing technological landscape of the *Automotive Maintenance and Repair* sector (Table 2). Consequently, the sector is witnessing a growing demand for professionals capable of integrating physical intervention with digital analysis, system-level troubleshooting, and data-driven maintenance strategies.

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4 Job-postings-driven skills and jobs investigation

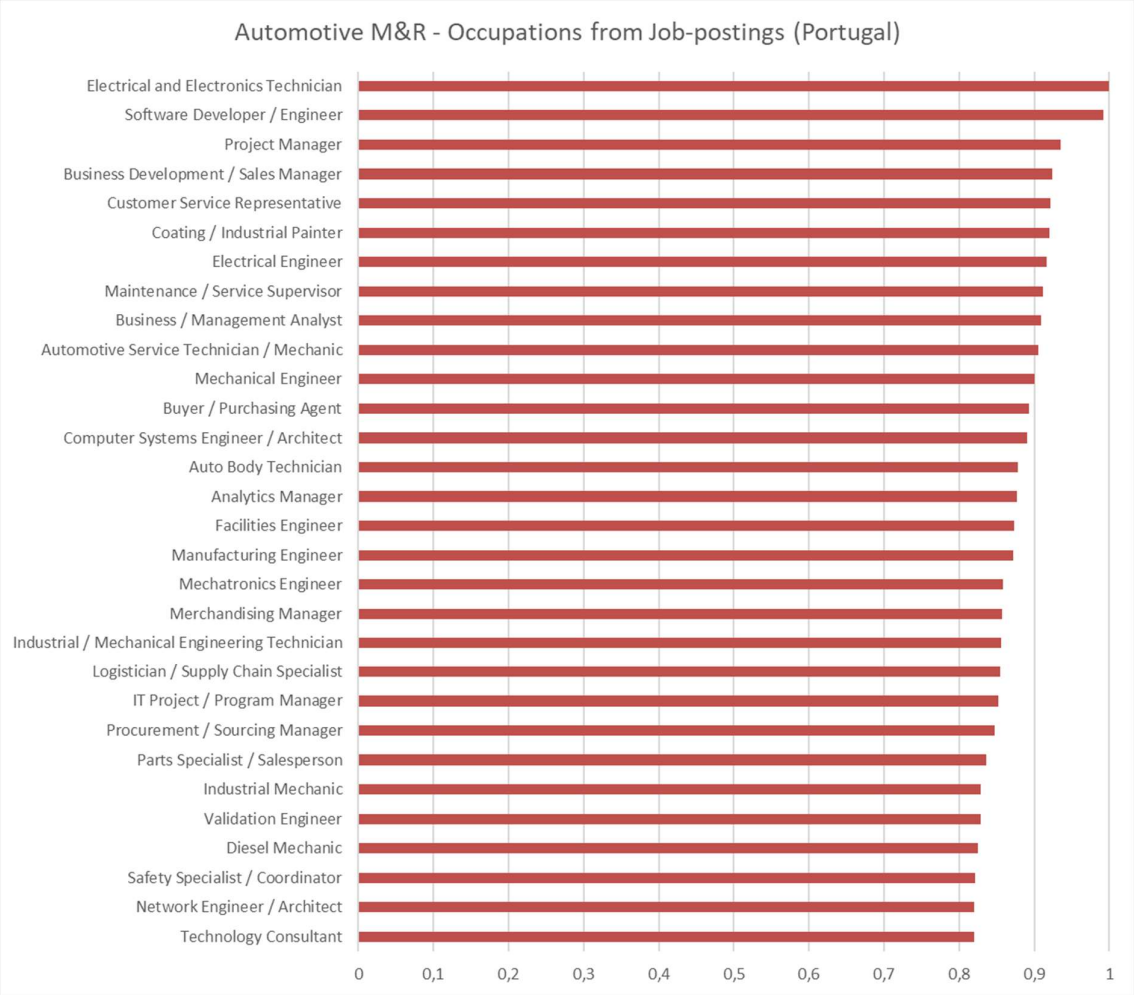
This section presents an investigation of job postings produced in the Lisbon region in Portugal in the six-year period from 2020 to 2025. This part of the Study aims at identifying key patterns and insights related to occupations and skills, enabling a more granular understanding of labour market dynamics, and highlighting both common trends and location-specific characteristics in workforce demand.

The results in terms of the most required job profiles is captured by Figure 7 which presents the ranking of the most relevant occupations in the Automotive M&R sector in this area (Portugal), based on the Labour Market Index.

At the top of the ranking, *Electrical and Electronics Technician* appears as the most prominent occupation, indicating a strong demand for technical profiles capable of working with electrical systems and electronic components. This reflects the increasing importance of electrification and advanced electronic systems in modern vehicles and industrial automotive equipment.

Closely following are *Software Developer/Engineer* and *Project Manager*, suggesting that the sector increasingly requires digital expertise and project coordination capabilities. The presence of these roles highlights the growing integration of software-driven systems, digital platforms, and complex project management processes within the automotive ecosystem.

Figure 7: Top 30 job-posting occupations in the Automotive M&R sector for Portugal.



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The ranking also includes several business-oriented and customer-facing roles, such as *Business Development / Sales Manager*, *Customer Service Representative*, and *Business / Management Analyst*. Their presence indicates the relevance of commercial activities, service management, and strategic planning within the automotive value chain, particularly in aftermarket services and industrial partnerships.

A significant portion of the ranking is composed of engineering and technical occupations, including *Electrical Engineer, Mechanical Engineer, Mechatronics Engineer,* and *Industrial / Mechanical Engineering Technician*. These roles underline the sector's strong reliance on engineering expertise and technical problem-solving, essential for the design, production, maintenance, and optimization of automotive systems.

In addition, several maintenance and operational roles are present, such as *Automotive Service Technician / Mechanic*, *Auto Body Technician*, *Industrial Mechanic*, and *Diesel Mechanic*. These occupations reflect the continued importance of hands-on technical maintenance and repair activities, which remain a core component of the Automotive M&R sector.

Lastly, the ranking also highlights the presence of supply chain, IT, and managerial roles, including *Logistician / Supply Chain Specialist*, *IT Project / Program Manager*, *Procurement / Sourcing Manager*, and *Technology Consultant*. This indicates that the sector increasingly requires integrated competencies spanning engineering, digital technologies, logistics, and business management.

Overall, the figure suggests that the repair and maintenance labour market in Portugal is characterized by a diverse occupational structure, where traditional mechanical and maintenance roles coexist with engineering, digital, and managerial positions, reflecting the ongoing technological and organizational transformation of the automotive industry.

Moving to the skill analysis, Figure 8 presents the top 30 ranked skills associated with the top 30 occupations listed above.

At the top of the ranking, *Smart Systems* emerges as the most prominent knowledge domain, suggesting the increasing importance of advanced and interconnected technological systems in the automotive sector. This is followed by *Communication* and *English language*, which highlight the relevance of interpersonal and linguistic capabilities in professional environments characterized by international collaboration and complex service networks.

Another relevant group of competences relates to safety, automation, and problem-solving capabilities. Skills such as *Safety standards*, *Automation systems*, and *Problem solving* indicate the importance of ensuring operational reliability, regulatory compliance, and effective technical diagnosis in maintenance and repair activities.

The ranking also features several technical and engineering-related knowledge areas, including *Mechanical systems*, *Technical drawing*, and *Electrical systems*. These competencies reflect the strong technical foundation required in the Automotive M&R sector, where understanding complex mechanical and electrical infrastructures is essential for installation, maintenance, and system optimization.

In addition, a set of organizational and managerial competences appears in the ranking, such as *Project management*, *Leadership*, *Procurement*, *Cross-functional collaboration*, and *Operational efficiency*. These soft skills support coordination across teams, supply chains, and project activities, indicating that the sector increasingly requires integrated management and operational skills alongside technical expertise.

Figure 8 also highlights the presence of customer-oriented and service-related competences, including *After-sales support*, *Customer complaint resolution*, and *Online service provision*. These skills emphasize the relevance of service quality and customer relationship management within the automotive value chain, particularly in aftermarket and maintenance services.

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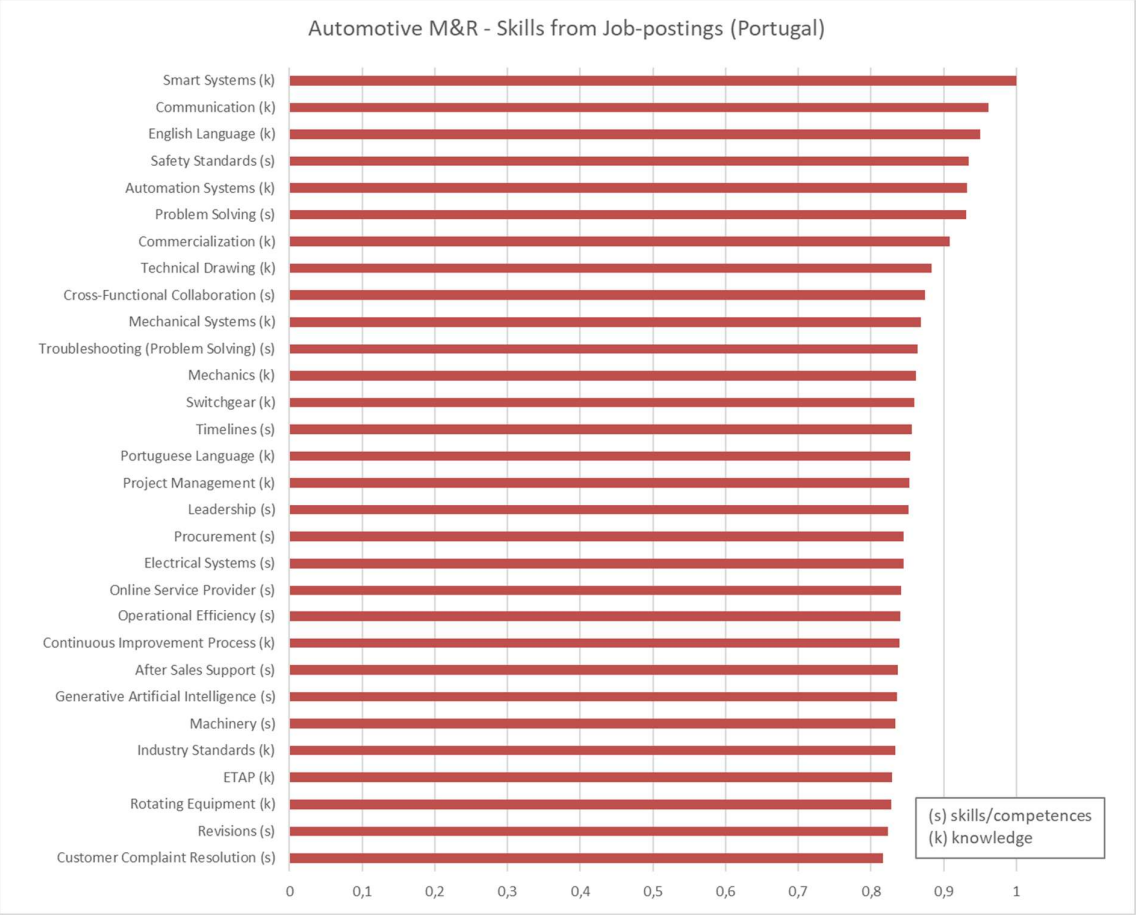
Figure 8: Top 30 job-posting skills, competences and knowledge in the Automotive M&R sector for Portugal.



Lastly, the appearance of *Generative Artificial Intelligence* within the ranking suggests the emerging influence of advanced digital technologies in the sector, potentially linked to data analysis, automation, and digital service solutions.

Overall, the distribution of skills indicates that the Automotive M&R sector in Lisbon Metropolitan Area requires a multidimensional skill set, combining technical engineering knowledge, digital and automation competences, problem-solving abilities, and communication and management skills. This reflects the ongoing transformation of the sector, where traditional maintenance activities are increasingly integrated with smart systems, digital technologies, and service-oriented capabilities.

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5 Conclusions

The **aim of this Study** was to conduct a skills anticipation exercise in the ***Automotive Maintenance and Repair*** *(M&R)* sector with an in-depth look at the Lisbon Metropolitan Area. To accomplish this, the analysis was structured around: (i) the examination of patent developments in key technological domains and their impact on emerging occupations and skill requirements; and (ii) the mapping of job postings to detect emerging job profiles and associated skill demand patterns.

Patent analysis and job posting analysis provide two complementary perspectives on labour market evolution. **Patents** offer a forward-looking and anticipatory view, as they capture emerging technological developments and innovation trajectories that are likely to shape the future structure of the sector. Consequently, patent data help identify the technological domains and professional profiles toward which the industry is expected to evolve. By contrast, **job postings** reflect current and recent labour market demand, providing a view that is inherently retrospective, as it captures the skills and occupations that employers have actively sought in the recent past. Nevertheless, by analysing trends in job postings over time, it is possible to infer the direction and pace of labour market transformation, thereby identifying emerging patterns in skill demand and occupational change. Taken together, these two sources provide a comprehensive understanding of sectoral evolution, combining anticipatory insights from innovation dynamics with empirical evidence from real labour market behaviour.

It is worth noting that while the integration of patent and job posting data provides both anticipatory and empirical insights, it necessarily captures only part of a broader and more complex reality. Therefore, the results should be interpreted as a **starting point**, to be further refined and complemented with additional qualitative insights, stakeholder engagement, and contextual expertise in the development of training programmes and micro-credentials.

Starting from the empirical perspective offered by job postings, the Study examined the Automotive M&R **labour market of the Lisbon Metropolitan Area** over the 2020–2025 period. The vacancies reveal a markedly diversified occupational structure: *Electrical and Electronics Technician* emerges as the most demanded profile, closely followed by *Software Developer/Engineer* and *Project Manager*, while engineering roles (*Electrical, Mechanical,* and *Mechatronics Engineers*), traditional maintenance functions (*Automotive Service Technician/Mechanic, Auto Body Technician,* and *Diesel Mechanic*), and a range of business, logistics, and IT-oriented profiles complete the picture. On the skills side, the rankings reveal a multidimensional demand: *Smart Systems* occupies the highest position, alongside communication and language skills (*Communication* and *English*) and a strong cluster of safety, automation, and problem-solving capabilities (*Safety standards, Automation systems,* and *Problem solving*), complemented by core technical knowledge (*Mechanical systems, Electrical systems,* and *Technical drawing*) and managerial and customer-oriented competences (*Project management, Leadership,* and *After-sales support*). The appearance of *Generative Artificial Intelligence* among the emerging skills further signals the growing penetration of advanced digital technologies. Taken together, these findings indicate that the traditional mechanical expertise of the sector is, in the Lisbon area, already substantially complemented by electrical, digital, organisational, and service-oriented competencies.

Moving to the **patent-based analysis**, the Study examined first the worldwide patent set and subsequently the Portuguese one. From a **global perspective**, the results indicate that foundational mechanical and electromechanical knowledge remains the core competence base, with skills such as *Mechanics of motor vehicles, Electromechanics, Predictive maintenance,* and *Automotive diagnostic equipment* occupying the highest positions. At the same time, the Study highlights a clear technological transition toward electrified, connected, and data-driven vehicle systems, reflected in the relevance of skills related to *Vehicle electrical systems, Sensors, Mechatronics, Energy storage systems,* and *Hybrid control systems*. The emergence of competencies associated with A*utomation technology, Robotics, Artificial intelligence,* and *Digital twin technologies* further signals the growing importance of intelligent and predictive maintenance environments. This transition is also reflected in the occupational landscape, where roles such as *Predictive Maintenance Expert, Automotive Electrician, Electromechanical Engineering Technician,* and *Mechatronics Engineer* emerge. Other profiles including *Autonomous Driving Specialist, Alternative Fuels Engineer,* and *Automotive Battery Technician* indicate the

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sector's progressive shift toward software-defined, electrified, and connected mobility systems, requiring professionals capable of integrating mechanical expertise with digital diagnostics and system-level analysis.

Despite the very limited size of the **Portuguese patent set** (28 documents belonging to 25 DOCDB patent families), the country-level focus revealed a markedly heterogeneous portfolio with no single dominant technology. The most cohesive cluster concerns connected-vehicle networking and fleet management, alongside repair and workshop equipment, digital service platforms, and vehicle components. While the small number of documents prevents any robust interpretation of the underlying trend, the comparatively digital and connectivity-oriented nature of the analysed patent set suggests that the Portuguese case nonetheless overlaps with some of the broader electrification and automation trajectories observed worldwide.

For this reason, jointly examining the patent-based and job-posting evidence allows the sector to be understood in a more structured and comprehensive manner. When considered together, the two analytical perspectives reveal a significant degree of alignment. The Lisbon Metropolitan Area already demonstrates strong demand for several competence domains that are also highlighted by the patent analysis: **electrical and electronic expertise, software-related occupations, automation capabilities, and advanced engineering competences are visible both in current recruitment patterns and in future-oriented innovation signals**. Both perspectives point to a progressive **transformation of the Automotive M&R sector from a predominantly mechanical domain toward a multidisciplinary technological ecosystem**, in which mechanical expertise remains fundamental but is increasingly complemented by electrical, electronic, software-enabled, and data-driven competencies, and in which hybrid professional profiles become increasingly important.

At the same time, the comparison also reveals areas where further workforce development will be required. **The worldwide patent analysis places stronger emphasis on emerging domains such as *Predictive maintenance, AI-enabled diagnostics, Digital twins, Battery management systems, Vehicle connectivity, and Robotics*, which remain only partially reflected in current Lisbon job postings**. As these technologies become more widely deployed, demand for specialised competences related to data analytics, intelligent diagnostics, automation control systems, cybersecurity, and advanced electrification technologies is expected to increase substantially. **This gap suggests that, although the region is comparatively well aligned with ongoing technological trajectories, innovation continues to advance faster than workforce adaptation**, indicating a potential future skills gap that education and training systems could proactively address.

In conclusion, these insights suggest that future workforce development strategies should focus on strengthening interdisciplinary technical competences, integrating mechanical expertise with electrical, digital, and data-driven capabilities, while also reinforcing transversal skills that support collaboration and adaptability in increasingly complex technological environments.

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AUTO CREDIFY

FUTURE-READY SKILLS

June 2026

D2.1 Reports on emerging occupations and specific skills needs

Navarra (Spain)

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Deliverable information

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Responsible Project Partner:	FGB	**Contributing Project Partners:**	All

Document data:	**File name:**	AutoCredify-D2.1 Reports on emerging occupations and specific skills needs		
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Project No.:	101196000		**Output No:**	D2.1
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Keywords:	Emerging skills, technologies, skill needs			
Review by:	All partners		**Review date:**	3 review rounds March-June
Approved by:	Liga Baltina, FGB		**Approval date:**	30/06/2026, with final revisions 10/07/2026

For more information visit project's website.

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Contents

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Lists of abbreviations

Abbreviation	Full form
AI	Artificial Intelligence
BIM	Building Information Modelling
DOCDB	EPO Master Documentation Database
EACEA	European Education and Culture Executive Agency
EP	European Patent
EPO	European Patent Office
ESCO	European Skills, Competences, Qualifications and Occupations
EU	European Union
IT	Information Technology
M&R	Maintenance and Repair
NLP	Natural Language Processing

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1 Introduction

The present document reports the activities conducted and results obtained under *Task 2.4 – Conducting a skills anticipation exercise to identify future skills needed in the M&R subsector,* as foreseen by the implementation plan reported in the Application Form.

The assignment (hereinafter also referred to as the Study) focuses on a data-driven skills anticipation exercise that aims at facilitating the design of micro-credentials suitable for testing in three pilot economies: Finland, Portugal, and Spain (with a focus on the Savo region, the Lisbon Metropolitan Area, and Navarra, respectively). The present report focuses on Navarra, Spain.

To accomplish this, two different data sources have been analysed, exploiting AI-based methodologies:

1) job postings, aiming at mapping arising jobs and related skills requests in the field of Maintenance and Repair;
2) patent literature, which were used to highlight development in relevant technological domains, possibly leading to product/process concurrent innovation in the *M&R subsector*, thus impacting on (new) jobs and skills needs.

Please note that this Study, and the resulting analysis, are intended as an analytical tool and a foundational evidence base to support the design of micro-credentials. Though meaningful and representative, the use of patent and job posting data provides a partial view of labour market and technological dynamics, which are inherently complex and multifaceted.

As such, the findings of this assignment should be interpreted as a **starting point for further exploration and validation**, rather than as a comprehensive or definitive assessment. The design of training programmes and micro-credentials can build upon this analysis, using it as a baseline to be complemented with additional qualitative insights, stakeholder engagement, and contextual expertise.

Note 1: Limitations of the Study.

The report proceeds with the following structure:

- **Chapter 2** Error! Reference source not found.: this section introduces the analytical framework adopted for the Study, briefly describing how the two data sources have been used for collecting useful insights.
- **Chapter 3 Patent-driven skills and jobs investigation**: here the results of the patent-based analysis are presented, highlighting the technological concepts with the highest innovation intensity and examining how they translate into associated skills requirements and occupational profiles.
- **Chapter 4 Job-postings-driven skills and jobs investigation**: here the results of the job postings analysis are presented, examining how they translate into skills requirements and occupational profiles. Job vacancies complement the patent perspective allowing for a comparison between innovation signals emerging from patents and real-time recruitment dynamics.
- **Chapter 5 Conclusions**: this section synthesises the main findings, putting together the results from and providing a comparison between the patent-driven and the job postings-driven analyses.

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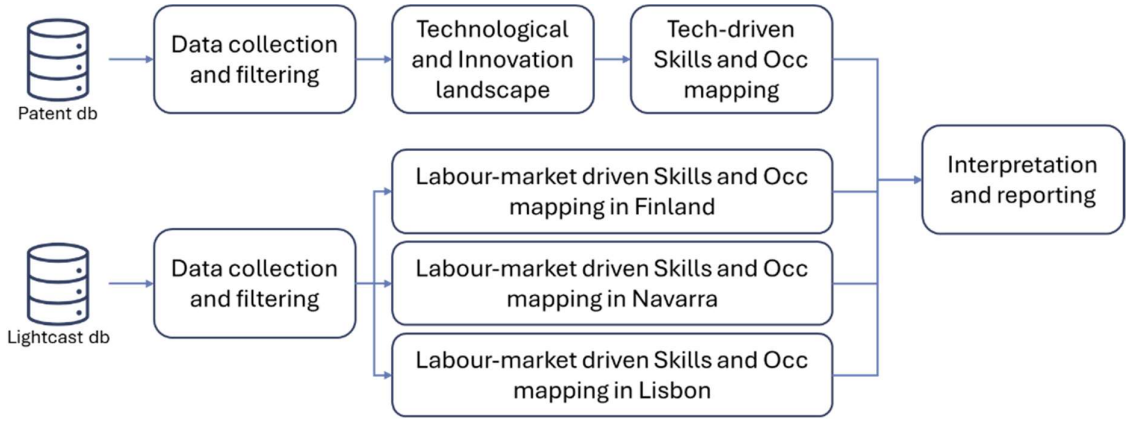
2 Methodology

The Study followed a **multi-stage and multi-source methodology** designed to capture both anticipatory signals and current labour market dynamics. At a high level, patent data are used to provide a forward-looking perspective on emerging technologies, related skill requirements and linked occupations, while job posting data offer an empirical view of current and recent demand for occupations and associated competencies. The overall methodological framework is structured in sequential stages, which are illustrated in Figure 1 and described in detail in the following sections.

Figure 1: Schematic illustration of the key stages of the methodological workflow.



Patent-driven skills and jobs investigation

The Study begins with the **collection of patent data** from an international, worldwide database, which includes over 160 million patent records. Indeed, patent information represents a privileged source for investigating worldwide technology evolution and innovation activity.

> The patent analysis was limited to the past 10 years for two main reasons. Firstly, it ensures consistency with the job vacancies provided by Lightcast, which cover a shorter (specifically, the last six years) and more recent period. Secondly, patent data typically precede market applications, as they reflect early-stage innovation activity. Therefore, the analysis adopts a slightly longer time horizon for patents than for job postings in order to capture pioneering technological developments that may shape future labour market needs. Lastly, given the characteristics of the sector, the selected time window allows for a clearer focus on emerging and innovative technologies.

Note 2: Rationale for limiting patent analytics to a 10-years time frame.

As worldwide economy is constantly evolving and innovating, as soon as a novel advantageous technology is introduced, this is typically adopted quickly by all players in the world, regardless of the country of initial development. Therefore, it is important to look at innovations on a global scale to have a complete picture of the new technologies that are entering or about to enter the M&R sector and that will shape the competencies needed by the labour market in near future. Even adopting a European-scale perspective is not sufficient, as in fact EP patents represent only about 10% of the total research and development production on a global scale in recent times[1].

[1] Source: World Intellectual Property Organization (WIPO) (2025). World Intellectual Property Indicators 2025. Geneva: WIPO. DOI: 10.34667/tind.58959

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Extracting coherent and comparable datasets requires careful cleaning due to factors that span from patents' legalese jargon, variations in documentation standards, classifications, and lack of metadata completeness across different jurisdictions. To overcome the intrinsic challenges of patent research, database querying and dataset cleaning methodologies were applied and refined through proprietary algorithms and more than 10 years of experience. Such step led to the identification of a dataset containing all worldwide patent documents pertaining to the M&R sector.

Next, Natural Language Processing (NLP) techniques were applied to the patent corpus to identify **domain-relevant technological concepts**, both consolidated and emerging, thus enabling the representation of the sector from a technological perspective. These concepts were subsequently assigned a ***Patent Innovation Index***, aiming at synthesizing the level of current and expected future relevance of each technological concept in the sector under review. The *Patent Innovation Index* results from a weighted and normalized combination of two factors:

- the number of inventions produced, at worldwide level, and in the considered 10+ years span;
- the growth rate of inventions production.

The resulting indicator assumes values in the interval [0,1], and therefore represents a relative measure of technologies relevance in a given domain. Technologies with a higher Patent Innovation Index are more likely to have an impact on the sector under analysis and on the demand for skills over the short and medium term. They represent both widely researched and rapidly growing innovations resulting from significant investments in R&D, which will most likely translate into widespread adoption and use. Technologies with lower scores (say, lower than 0.5) are still relevant to consider because of two possible scenarios.

- Significant yet slowing inventive activity (a relatively high number of inventions, with low growth rate). This indicates mainstream technologies for which skills may still need to be updated; or
- Low yet growing inventive activity (a relatively low number of inventions, with high growth rate). This indicates emerging technologies, which could gain importance over the long term.

In addition, **non-technological concepts** were intentionally retained in the analysis, as they represent key enabling factors within the sector. Although these elements do not receive any quantitative score (and are therefore labelled as "N.T." due to their non-technological nature), they encompass both established and emerging concepts that are essential for providing a comprehensive mapping of the skills and occupations relevant to the considered domain. The identified technologies and innovation concepts were then semantically **matched with the ESCO database to capture a list of related skills and occupations**. Professional profiles and competences are also ranked in order of relative potential future demand on the basis of the number of related innovations. In this context, the ESCO framework represents a widely used standard in skills intelligence, and is used to remap occupations and skills in relation to technological evolution, establishing a common language and ensuring alignment with the European reference classification standard.

This technologies-skills-occupations mapping makes it possible to highlight the skills needs for the next future, as well as professions that are most linked to such skills. This kind of intelligence is essential for anticipating priority skill needs, guiding curriculum development, and strengthening cooperation between industry and education providers. Ultimately, this mapping exercise helps reveal where skill gaps are likely to appear and where labour demand may increase in the near future.

Lastly, through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology. The resulting rankings of skills and occupations therefore highlight those profiles that are most strongly linked to high-ranked technologies and innovations, providing a synthetic and forward-looking representation of interconnections between technological evolution, skill requirements, and occupational structures.

Job-postings-driven skills and jobs investigation

Job vacancies complement the patent perspective. While the patent-based analysis provides a technology and innovation-driven view on potential future developments, job postings investigation offers an empirical view

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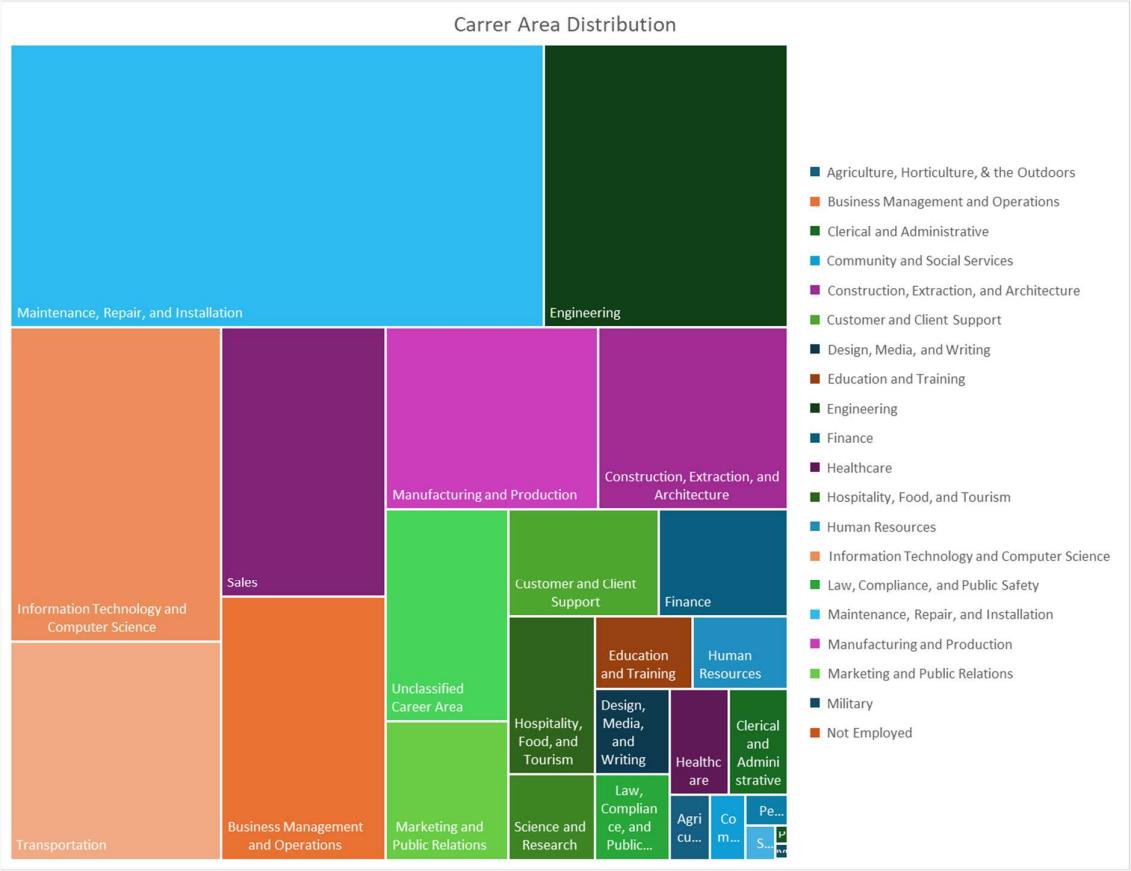
grounded in real labour market dynamics. By examining job postings, it is possible to observe how sectoral transformations translate into concrete hiring needs. This approach therefore provides a real-world perspective on emerging occupations and skills, highlighting patterns in employer demand and offering evidence of how labour markets are evolving in response to technological change.

Job vacancy data was provided by Lightcast[2]. Each job posting is associated with a specific job profile and may include multiple skills. According to this, the analysis first examined the job profile landscape and subsequently explored the connected skills required by employers.

A total of approximately 183,000 job postings were collected, so distributed: Finland 131,912 records; Portugal 38,224 (in particular, Lisbon Metropolitan Area); Spain 13,549 (from the region of Navarre). Differences in absolute values strongly depend on how data were collected. While, for Portugal and Spain, only job vacancies from the Lisbon and Navarra regions, respectively, were retrieved, the situation was different for Finland. Although the initial focus was on the Savo region, the limited availability of data required extending the analysis to the entire national territory in order to ensure the statistical robustness and reliability of the results.

Figure 2: Carrer Area distribution of the job postings' dataset.



An initial exploration of the dataset highlighted the need for a **filtering procedure to ensure data quality and robustness**. Such step was based on a *Career Area* variable provided by Lightcast itself, which indicates each job posting's domain. In particular, those job postings were excluded whose domain was considered less relevant for the scope of the Study. Figure 2 provides an overview of the distribution of career areas within the dataset and their respective frequencies. The size of each rectangle is proportional to the frequency of the corresponding career area. As a result, the following areas were excluded from the analysis: *Agriculture, Horticulture, & the*

[2] https://lightcast.io/euro

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Outdoors; Clerical and Administrative; Community and Social Services; Construction, Extraction, and Architecture; Design, Media, and Writing; Education and Training; Finance; Healthcare; Hospitality, Food, and Tourism; Human Resources; Marketing and Public Relations; Military; Performing Arts; Personal Services; Science and Research; Social Analysis and Planning; Not Employed; Unclassified Career Area.

Subsequently, in order to evaluate the most relevant job occupations and skills from job vacancies, a ranking was performed. Similarly to the aforementioned *Patent Innovation Index*, such ranking was based on a composite score, namely ***Labour Market Index*** combining the absolute frequency and emergence of skills and occupations within the job postings dataset. In more detail:

- The absolute frequency component captures how often a given occupation or skill appears in the job postings dataset. This indicator reflects the current level of demand in the labour market, highlighting roles and competencies that are widely required by employers.
- The second component, referred to as emergence, measures the evolution of demand over time, specifically considering the trend observed in the last years (2020 – 2025). This indicator captures the growth dynamics of occupations and skills, identifying those that are increasing in relevance within job postings and may therefore represent emerging or rapidly expanding labour market needs.

The combination of these two dimensions allows the ranking of occupations and skills considering both their current relevance and their recent growth trajectory. As a result, the highest-ranked items are those that are both frequently mentioned in job postings and characterized by a strong positive trend over time. Conversely, occupations or skills with high frequency but limited growth, as well as those with strong growth and low diffusion, tend to appear lower in the ranking.

Taken together, the two analytical perspectives enabled a comprehensive understanding of emerging labour market trends and future skill requirements.

A further potentially relevant analytical dimension relates to the relationship between enterprise size, occupational profiles, and skills demand. Understanding how skills requirements vary across firms of different sizes could have provided additional insights into labour market dynamics and supported the development of more targeted micro-credentials and training interventions.

Nevertheless, the selected data provider was not able to provide sufficiently robust and consistent information on company size. As a result, and in order to preserve the reliability and validity of the findings, this analytical dimension was not explored further within the scope of the Study.

Note 3: Rationale for limiting patent analytics to a 10-years time frame.

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3 Patent-driven skills and jobs investigation

3.1 Patent-based technological landscape

3.1.1 Worldwide perspective

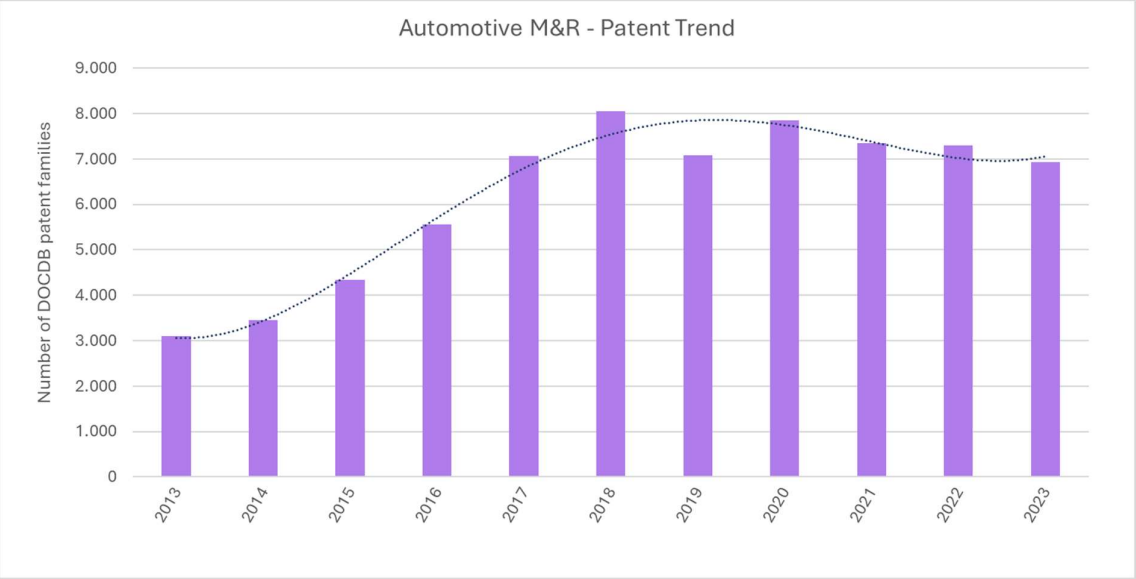
A total of over 127 thousand patent documents, belonging to **approximately 76 thousand DOCDB[3] families, on a global scale have been collected in relation to the *Automotive Maintenance and Repair* domain**. The DOCDB simple patent family is defined by the European Patent Office as "*a collection of patent documents that are considered to cover a single invention. The technical content covered by the applications is considered to be identical*"[4]. Therefore, patent families represent a more valuable unit than single patent applications when studying innovation evolution.

Table 1: Worldwide patent sets dimensions in the Automotive M&R sector.

Sector	Number of worldwide patent documents*	Number of worldwide DOCDB patent families*
Automotive Maintenance and Repair	127,758	76,090

*since 2013

Figure 3: Time series of worldwide patent families' filings in the Automotive M&R sector.



It is also worth noting that patent applications are typically published only after a confidentiality period, which is generally 18 months from the filing date. Consequently, patent data for the most recent two years are incomplete and should not be considered fully reliable for analytical purposes. Given the Study's focus on a ten-year timeframe, the analysis was therefore based on patent data covering the period from 2013 to 2025.

[3] DOCDB is the European Patent Office's master documentation database with worldwide coverage. It contains bibliographic data, abstracts, citations and the DOCDB simple patent family, but no full text or images.
[4] Source: https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families/docdb.html

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Table 1 shows a concise view of the overall patent set, while Figure 3 displays the yearly evolution of inventive activity. Please note that the chart does not display the two last years (2023 – 2025), due to the aforementioned *secrecy period*.

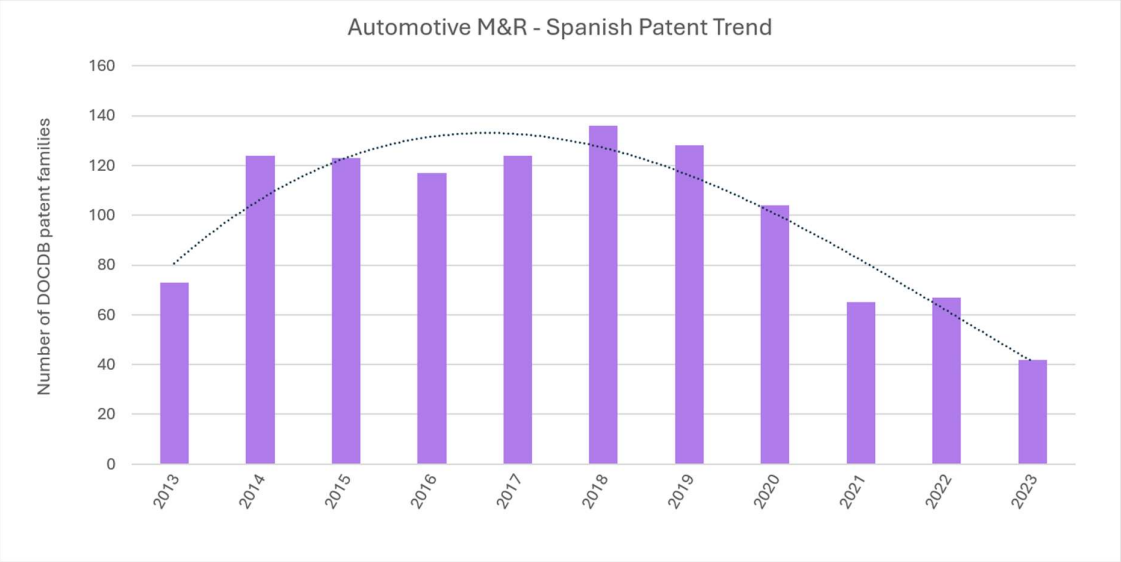
Figure 3 illustrates a strongly increased patent activity from approximately 3,100 novel inventions per year in 2013 to a peak of about 8,000 in 2018, reflecting a period of accelerated innovation and sectoral expansion. After a decline in 2019, filings partially recovered in 2020 but did not regain the previous peak. From 2021 onward, the trend shows a moderate but consistent decrease, reaching roughly 6,900 patent families in 2023. Overall, the data indicate rapid growth followed by stabilization at a comparatively high level, suggesting a maturing yet still innovation-intensive technological field.

3.1.2 Spanish perspective

Having analysed the Automotive M&R sector from a worldwide perspective, the study now focuses on the Spanish patent set. Sin 2013, this set comprises 1,245 patent documents belonging to 1,127 DOCDB patent families.

Following an initial 73 families in 2013, filing activity (Figure 4) settled on a remarkably stable plateau of 117-136 families per year throughout 2014-2019, peaking in 2018 at 136 families. A gradual contraction began in 2020 (104 families) and accelerated thereafter (42 families in 2023) although the most recent figures are largely attributable to the publication lag of recent applications.

Figure 4: Time series of Spanish patent families' filings in the Automotive M&R sector.



The thematic analysis of the Spanish patent set identifies lifting technologies as the largest cluster, with elevator-related families accounting for roughly one third of annual filings during the plateau years. This pattern reflects the leading role of the multinational elevator groups patenting in Spain – Otis (139 documents), Inventio (73), KONE (56) and Wittur (17) – alongside domestic specialists such as Orona, Aplicaciones Electromecánicas Gervall and Acces y Elevadores Valencia.

Within the strictly Automotive M&R perimeter, further clusters identified by the analysis span workshop and repair equipment (tyre-mounting and repair machinery by Nexion, KT Projektentwicklungs and Llantacars), refinish coatings (BASF Coatings) and original-equipment-manufacturer (OEM) serviceability solutions, with SEAT (33 documents) patenting fixing and fastening structures, electric-charging service management systems and bodywork paint-repair methods, followed by Stellantis/PSA and the motorcycle manufacturers Piaggio, Yamaha and KTM.

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In recent years, the post-2020 decline is driven primarily by the progressive withdrawal of the elevator groups, only partially offset by the persistence of workshop-equipment and tyre-service, which characterise the residual activity observed after 2022.

Since 2022, a number of emerging digital themes have also surfaced: data platforms for damage appraisal and inspection and for the estimation of repair-related emissions (Solera, Bridgestone), EV-charging infrastructure and services (wireless charging, charge-port solutions and charging-station maintenance), connected and software-defined vehicle architectures (Sonatus, Ford, Volkswagen) and robotics and autonomous platforms for maintenance (Pavasal, Phenomenon Robotics). These remain, however, at modest absolute volumes – with the 2024-2025 figures still affected by the publication lag – so this growth should be read as a qualitative tendency rather than a numerical one.

3.1.3 Technological and innovation concepts in M&R

For studying the technological evolution in a specific domain, the definition of a sector-level patent set represented a fundamental step in the methodology. The application of Natural Language Processing (NLP) to such sets enabled the identification of a list of **domain-specific technological concepts**. These are displayed in Table 2, where the ordering is based on the ***Patent Innovation Index***, aiming at synthesizing the level of relevance of each technological concept in the *Automotive Maintenance and Repair* sector (see Methodology for more details).

Technological and innovation concepts are visualized in Table 2 using a purple colour scale, where darker shades indicate higher Patent Innovation Index values. It should be noted that a set of non-technological concepts were also included, namely *Car emergency* and *Risk management*. These entries are clearly marked with the tag "N.T." and positioned at the bottom of the ranking.

Table 2: List of the technological concepts relevant for the Automotive M&R sector.

Technological and Innovation Concepts	Patent Innovation Index
Diagnostic sensors	1,000
AI and Statistical tools for diagnosis	0,993
Car lifters	0,990
Electric propulsion	0,963
Predictive maintenance	0,951
Robotic workers and Cobots	0,874
Garage digital management	0,862
Vehicle clamping equipment	0,861
Mechanical tools	0,843

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Technological and Innovation Concepts	Patent Innovation Index
3D Scanning	0,799
Internet of Things (IoT)	0,792
Imaging for diagnosis	0,730
High voltage technologies	0,727
Intelligent cabin	0,720
Fuel optimization	0,697
Battery repairing and maintenance	0,680
Electronics and Software for Autonomous drive	0,641
Mechatronics	0,606
Advanced polymers	0,581
Augmented reality	0,555
Hydrogen management and storage	0,517
Automotive components	0,435
3D printing for component replacement and repairment	0,419
Complex transmission	0,328
Spare part management and logistics	0,273
Maintenance cost calculation	0,190

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Technological and Innovation Concepts	Patent Innovation Index
Car emergency	N.T.
Risk management	N.T.

The ranking reveals a clear prioritization of diagnostic and data-driven technologies within the *Automotive Maintenance and Repair* domain. *Diagnostic sensors* lead the ranking, closely followed by *AI and Statistical tools for diagnosis*, *Predictive maintenance*, and *Garage digital management*. Together, these top-performing technological and innovation concepts signal a structural transition from reactive repair models toward predictive, data-supported, and platform-integrated service strategies.

Rounding out the top tier are mature and operationally indispensable technologies such as *Car lifters* and *Mechanical tools*. Their strong positioning confirms that, despite rapid digitalization, physical workshop infrastructure remains strategically critical. On the other hand, Complementary technologies such as *IoT and telematics* and *Imaging for diagnosis* further reinforce the importance of digital connectivity and real-time information flows, although they rank slightly below core diagnostic infrastructures.

The dominance of fault detection systems, analytical intelligence, and core workshop equipment in the top tier indicates that competitive advantage increasingly derives from the ability to detect, interpret, and act upon vehicle condition data efficiently.

Another distinct high-performing cluster includes *Electric propulsion*, *High-voltage technologies*, and *Battery repairing and maintenance*, clearly reflecting the sector's transition toward vehicle electrification and its associated maintenance technology. When considered alongside *Hydrogen management and storage*, the ranking suggests that repair ecosystems must adapt to alternative propulsion systems. This transformation implies not only technological reconfiguration but also the development of new technical skills, safety standards, and certification frameworks to manage high-voltage systems and next-generation energy carriers.

Mid-ranked technologies such as *Intelligent cabin* and *Electronics and software for autonomous drive* point to the growing complexity of vehicle architectures and the increasing software intensity of modern cars. Their position indicates emerging relevance in maintenance contexts, particularly as repair activities expand beyond mechanical intervention to include software diagnostics, calibration, and system integration. In contrast, *Advanced polymers* and *Augmented reality* suggest steady yet comparatively lower strategic impact, possibly reflecting enabling or supportive roles rather than core maintenance functions.

Examining the bottom tier of the ranking, including *3D printing for component replacement and repair* and *Complex transmission,* technologies appear to remain either niche or context-specific within current repair practices. Traditional operational domains such as *Spare part management and logistics* and *Maintenance cost calculation* occupy the bottom of the ranking, indicating limited direct patent intensity and comparatively lower innovation dynamics.

Finally, the presence of non-technological or governance-oriented concepts such as *Car emergency* and *Risk management* is analytically significant, although not technically ranked. Their appearance in patent-related analyses suggests that innovation in automotive repair is increasingly shaped by regulatory compliance, and safety considerations. These dimensions function as embedded constraints and design parameters within technological development. The trend indicates that innovation is no longer driven solely by performance and functionality, but also by legal robustness, safety assurance, user trust, and long-term sustainability.

Overall, the ranking underscores a pronounced technological convergence toward diagnostics, computational-based maintenance, electrification, and system integration. It portrays a repair ecosystem that is progressively

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data-centric, automation-enabled, and strategically aligned with predictive and software-defined vehicle paradigms.

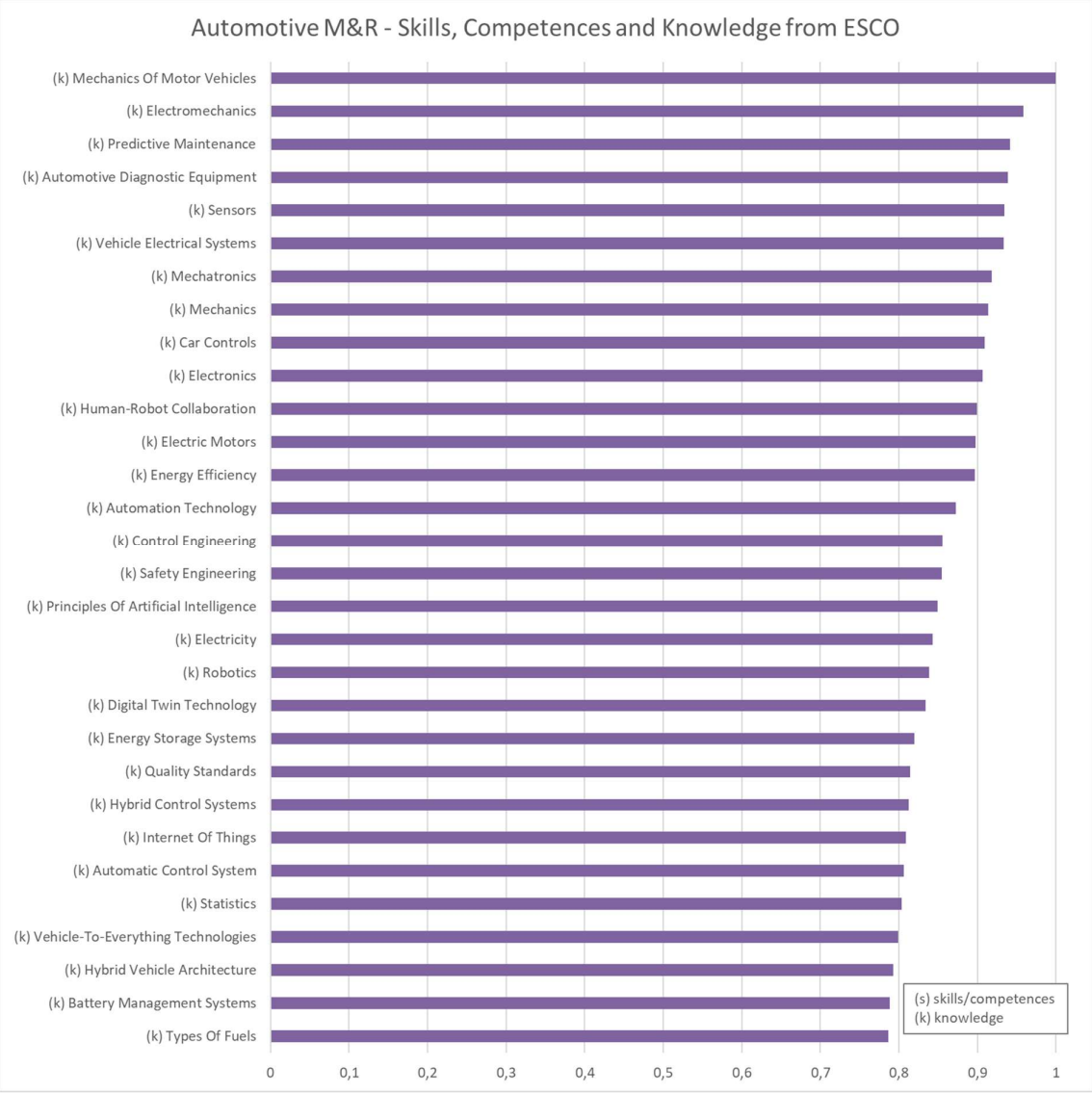
3.2 Skills and occupations matches from ESCO database

Applying semantic matching algorithms, the identified technologies and innovation concepts were linked to ESCO skills, competences, knowledge, and occupations.

Through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology (see Methodology for more details).

Figure 5 ranks the top 30 skills associated with technologies likely to impact the *Automotive Maintenance and Repair* sector in the future.

Figure 5: Top 30 ESCO skills, competences and knowledge in the Automotive M&R sector.



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The ranking highlights the continued dominance of foundational mechanical and electromechanical knowledge as the core competence base in the analysed domain. *Mechanics of motor vehicles* occupies the top position, followed closely by *Electromechanics*, *Predictive maintenance*, and *Automotive diagnostic equipment*. This confirms that traditional mechanical expertise, combined with diagnostic and predictive capabilities, remains essential to ensure effective and reliable maintenance operations.

Closely following this top tier are competencies related to *Sensors*, *Vehicle electrical systems*, *Mechatronics*, and *Electronics*, reflecting the increasing integration of electrical and electronic architectures within modern vehicles. The strong positioning of these skills indicates that maintenance activities now require a hybrid skill set combining mechanical proficiency with electrical and electronic system understanding. The presence of *Car controls*, *Electric motors*, and *Energy efficiency* further reinforces the growing importance of electrically powered systems and energy optimization in maintenance practices.

A second cluster of highly ranked competences emphasizes automation, intelligent systems, and interdisciplinary integration. Skills such as *Automation technology*, Control engineering, *Safety engineering*, and *Human-robot collaboration* highlight the progressive automation of workshop environments and the growing interaction between technicians and automated or robotic systems. The inclusion of *Principles of artificial intelligence*, *Robotics*, and *Digital twin technology* underscores the emergence of data-driven and simulation-based maintenance approaches, which enable predictive diagnostics, system optimization, and remote monitoring.

The ongoing transition toward electrified and connected vehicles evidenced by the presence of *Energy storage systems*, *Hybrid control systems*, and the *Internet of Things*. These technologies require maintenance professionals to understand battery systems, system integration, and real-time data exchange between vehicle components and external platforms. Similarly, *Vehicle-to-everything technologies* and *Battery management systems* indicate the increasing relevance of connectivity and advanced energy management in maintenance contexts.

Lower-ranked, yet still strategically relevant, competences such as *Statistics*, *Hybrid vehicle architecture*, and *Types of fuels* suggest supporting or specialized knowledge areas that complement core technical expertise. Their relatively lower position does not indicate lack of importance, but rather a more contextual or enabling role compared to fundamental diagnostic, mechanical, and electrical competences.

Overall, the ranking reveals a clear evolution of the automotive repair skillset from purely mechanical expertise toward a multidisciplinary competence profile integrating mechanics, electronics, data analytics, automation, and electrification. Confirming the findings in Table 2, this transformation reflects the increasing technological complexity of modern vehicles and highlights the need for maintenance professionals capable of operating at the intersection of physical systems, digital technologies, and intelligent diagnostic environments.

Similarly,

Figure 6 provides a synthetic picture of how technological innovation in the *Automotive M&R* sector translates into labour demand, presenting the top 30 ESCO job profiles emerging from the analysis.

The occupation ranking highlights the growing centrality of predictive, electrical, and interdisciplinary engineering roles within the repair and maintenance ecosystem. At the top of the ranking stands the *Predictive Maintenance Expert*, followed closely by the *Automotive Electrician* and the *Motor Vehicle Engine Inspector*. This leadership position reflects the sector's transition toward condition-based and data-driven maintenance models, where the ability to anticipate failures and interpret diagnostic data has become a critical operational capability.

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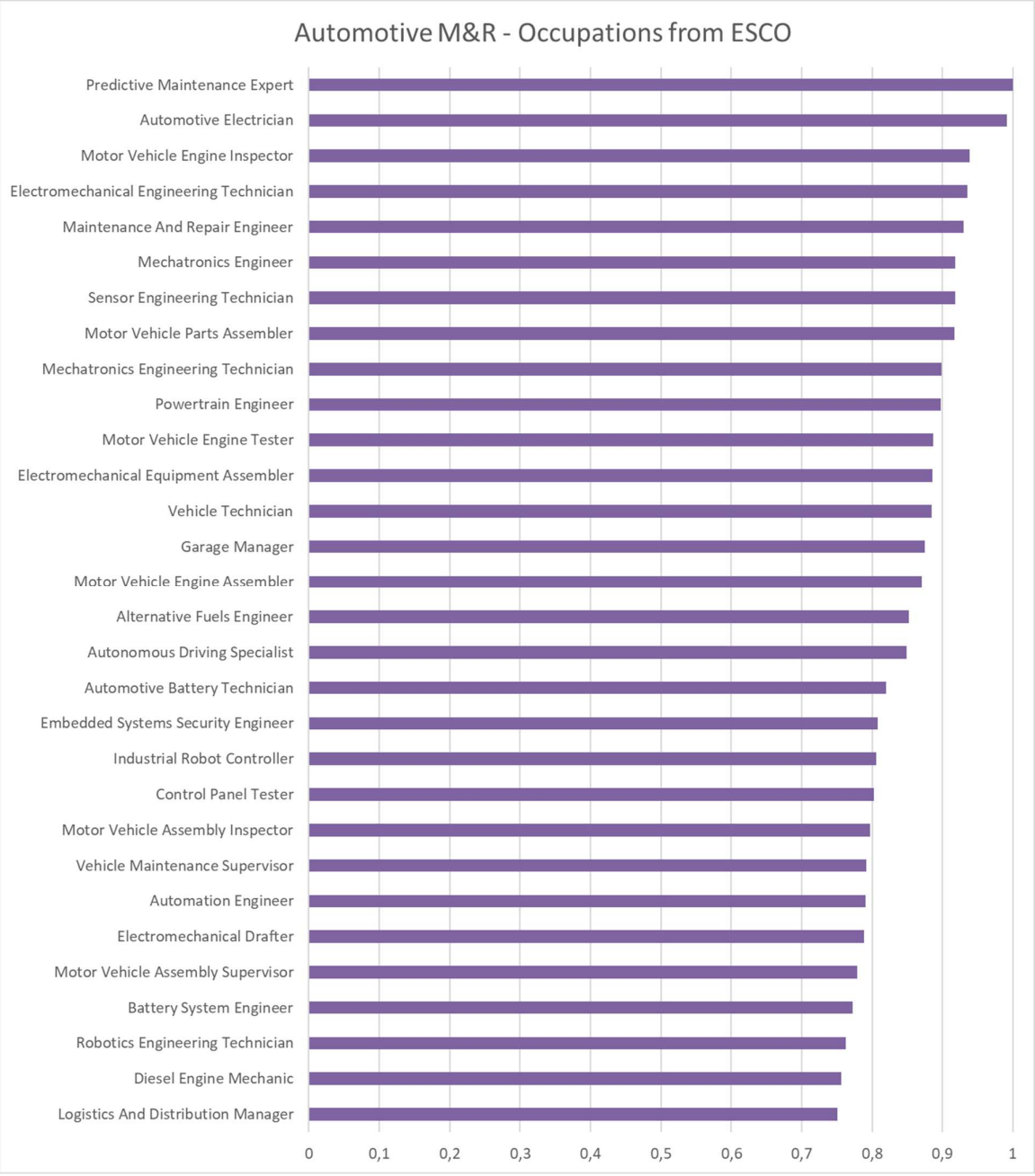
Figure 6: Top 30 ESCO occupations in the Automotive M&R sector.



Closely following this top tier are engineering and technical roles such as the *Electromechanical Engineering Technician*, *Maintenance and Repair Engineer*, *Mechatronics Engineer*, and *Sensor Engineering Technician*. The strong positioning of these occupations underscores the increasing importance of hybrid expertise combining

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mechanical, electrical, and electronic competencies (as highlighted in Figure 5). In particular, the prominence of mechatronics and sensor-related roles confirms that modern maintenance activities rely heavily on integrated systems requiring advanced diagnostic, calibration, and system-level intervention skills.

As revealed by the analysis of the skill ranking (Figure 5), a distinct cluster of highly ranked occupations comprises operational and technical implementation roles, including the *Motor Vehicle Parts Assembler*, *Mechatronics Engineering Technician*, *Powertrain Engineer*, and *Motor Vehicle Engine Tester*. The prominence of these roles underscores the continued importance of hands-on technical expertise and system-level validation functions, which are essential to ensure vehicle performance, operational reliability, and compliance with increasingly stringent technical and safety standards.

Notably, emerging and future-oriented roles such as the *Autonomous Driving Specialist*, *Alternative Fuels Engineer* and *Automotive Battery Technician* occupy mid-to-high positions, highlighting once again the sector's ongoing transition toward software-defined vehicle architectures and alternative propulsion systems. Similarly, the inclusion of the *Embedded Systems Security Engineer* reflects the growing relevance of cybersecurity in vehicle maintenance, as vehicles become progressively connected and reliant on embedded software systems.

Further down the occupation ranking, roles such as the *Industrial Robot Controller* and *Automation Engineer* emphasize the gradual integration of automation and robotics into maintenance and production-related activities. These occupations point to the increasing automation of diagnostic procedures, component handling, and repair workflows, requiring technicians capable of interacting with automated systems and robotic platforms.

Lastly, low-ranked occupations such as the *Diesel Engine Mechanic* and the *Logistics and Distribution Manager* remain relevant but reflect comparatively lower strategic intensity in terms of technological innovation. This positioning suggests a gradual shift away from traditional mechanical specializations associated with conventional internal combustion engine technologies, alongside the relative stabilization of logistics functions compared to rapidly evolving technical roles.

Considering these findings, the occupational ranking (Figure 6) reinforces this transition, evidencing a parallel restructuring of professional roles in response to evolving skill requirements (Figure 5). Traditional mechanically focused occupations are increasingly complemented by interdisciplinary roles that combine expertise in diagnostics, data-driven solutions, electrified systems, embedded electronics, and automated processes. This shift reflects the alignment between emerging competence profiles and the changing technological landscape of the *Automotive Maintenance and Repair* sector (Table 2). Consequently, the sector is witnessing a growing demand for professionals capable of integrating physical intervention with digital analysis, system-level troubleshooting, and data-driven maintenance strategies.

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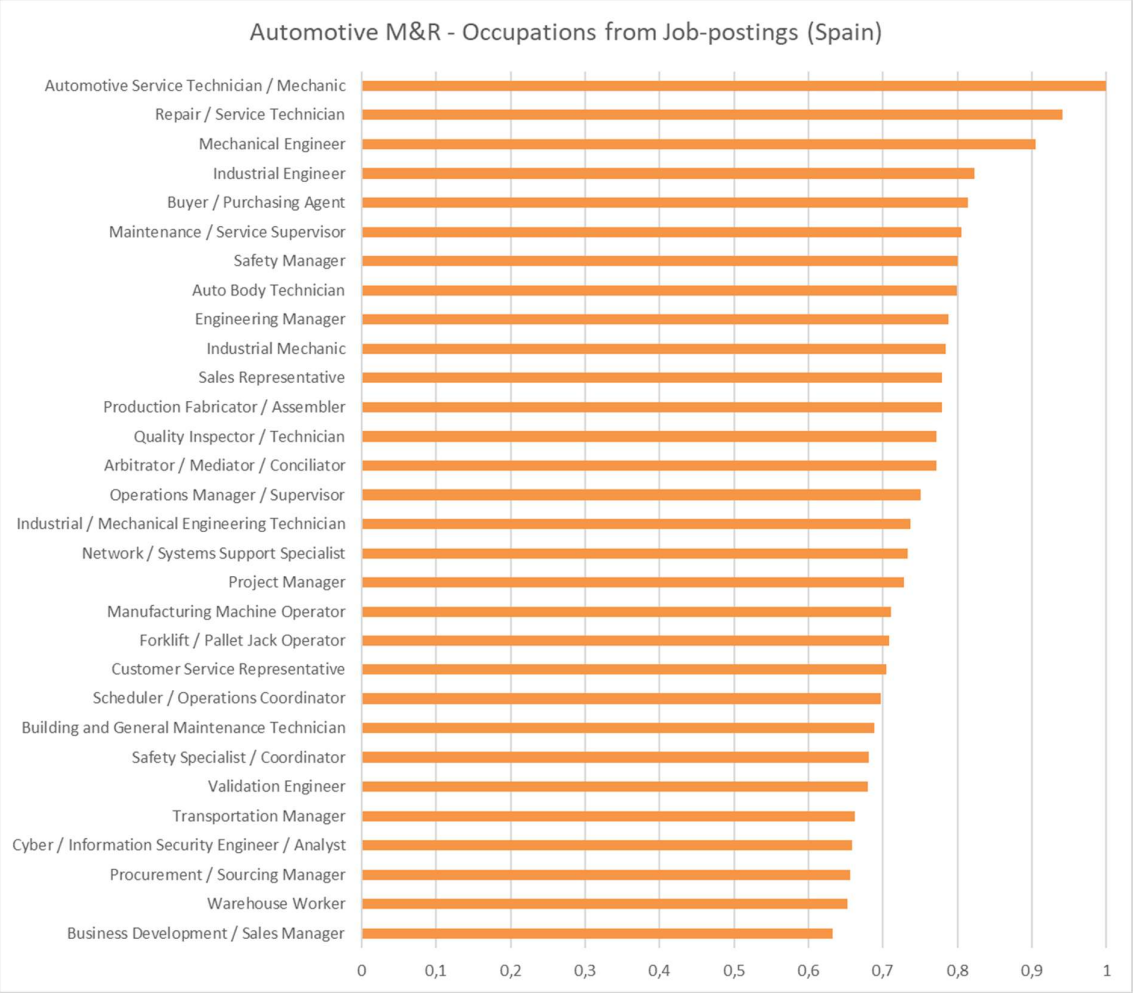
4 Job-postings-driven skills and jobs investigation

This section presents an investigation of job postings produced in the Navarra region in Spain in the six-year period from 2020 to 2025. This part of the Study aims at identifying key patterns and insights related to occupations and skills, enabling a more granular understanding of labour market dynamics, and highlighting both common trends and location-specific characteristics in workforce demand. The results in terms of the most required job profiles is captured by Figure 7.

Figure 7: Top 30 job-posting occupations in the Automotive M&R sector for Spain.



At the top of the ranking, *Automotive Service Technician / Mechanic* appears as the most prominent occupation, confirming the central role of maintenance and repair activities within the Spanish automotive labour market. This is followed by *Repair / Service Technician*, further highlighting the strong demand for technical professionals responsible for diagnostics, maintenance, and servicing of automotive systems.

Several engineering profiles also occupy high positions in the ranking, including *Mechanical Engineer, Industrial Engineer,* and *Engineering Manager*. Their presence reflects the importance of engineering expertise in the design, optimization, and supervision of production and maintenance processes within the sector. Similarly, roles such as *Industrial / Mechanical Engineering Technician* and *Validation Engineer* indicate the need for specialized technical knowledge supporting industrial and quality assurance activities.

The ranking also includes a significant number of operational and technical support roles, such as *Industrial Mechanic, Production Fabricator / Assembler,* and *Manufacturing Machine Operator*. These occupations

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underline the relevance of hands-on operational activities related to manufacturing, assembly, and maintenance processes.

In addition, several management and coordination roles appear in the dataset, including *Maintenance / Service Supervisor, Operations Manager / Supervisor, Project Manager,* and *Scheduler / Operations Coordinator*. These positions highlight the importance of organizational and supervisory competences for coordinating technical teams and ensuring the efficiency of production and maintenance operations.

The figure also reflects the presence of logistics, procurement, and commercial roles, such as *Buyer / Purchasing Agent, Procurement / Sourcing Manager, Warehouse Worker, Transportation Manager,* and *Sales Representative*. These occupations indicate the relevance of supply chain management and commercial activities within the automotive value chain.

Lastly, the ranking includes roles related to safety, quality, and digital infrastructure, such as *Safety Manager, Safety Specialist / Coordinator, Quality Inspector / Technician, Network / Systems Support Specialist,* and *Cyber / Information Security Engineer / Analyst*. Their presence highlights the growing importance of compliance, quality assurance, and digital systems management in the evolving automotive sector.

Overall, Figure 7 suggests that the *Automotive M&R* labour market in Navarra is characterized by a balanced occupational structure, combining core maintenance roles, engineering and technical expertise, operational manufacturing positions, and managerial and support functions. This reflects the complexity of the automotive ecosystem, where traditional repair activities coexist with increasingly integrated industrial, logistical, and digital processes.

Figure 8 presents the ranking of the most relevant skills in terms of absolute frequency and emergence. At the top of the ranking, *Communication* and *Teamwork* emerge as the most relevant competences. Their prominence highlights the importance of collaboration and effective information exchange in technical environments where maintenance activities often involve coordinated work across multidisciplinary teams, as well the growing demand for soft skills in today's job market. Closely following are *Troubleshooting* and *Preventive Maintenance* capabilities, which are essential for diagnosing faults and ensuring the efficient operation of automotive systems.

A second cluster of highly ranked competences relates to core technical and engineering knowledge, including *Mechanics, Machinery, Mechanical systems, Mechatronics,* and *Electromechanics*. These domains represent the foundational technical expertise required for maintenance, repair, and optimization of automotive components and systems.

The ranking also includes competences associated with safety and operational standards, such as *Safety standards, Quality control,* and *Track and trace*. These elements reflect the importance of regulatory compliance, monitoring, and quality assurance processes within automotive production and maintenance environments.

Several skills directly related to maintenance practices and industrial operations are also present, including *Preventive maintenance, Corrective maintenance, Industrial repair and maintenance*, and the use of *Hand tools* and *Pneumatics*. These competences underline the operational dimension of the sector, where ensuring equipment reliability and minimizing downtime are key priorities.

In addition,

Figure 8 highlights the presence of emerging technological domains, such as *Industrial robotics, Autonomous systems,* and *Automation*. Their appearance suggests the increasing integration of advanced manufacturing technologies and automated systems within automotive-related activities.

Lastly, competences such as *Management, Continuous improvement processes,* and *Reporting solutions* point to the growing relevance of organizational and process optimization skills, which support the coordination and efficiency of maintenance and production activities.

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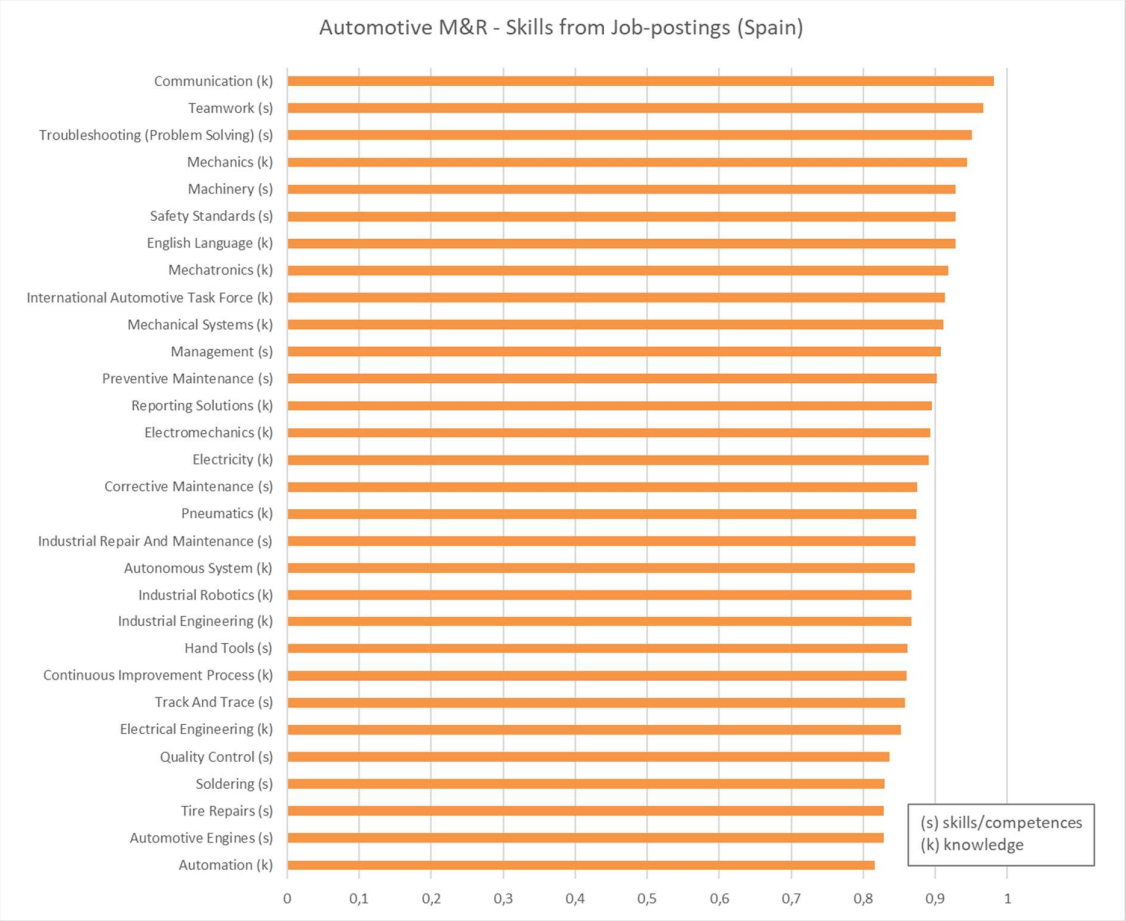
Figure 8: Top 30 job-posting skills, competences and knowledge in the Automotive M&R sector for Spain.



Overall, the skill distribution indicates that the *Automotive M&R* sector in Navarra has been requesting a balanced combination of technical expertise, operational maintenance capabilities, and transversal competences such as communication, teamwork, and problem-solving. At the same time, the presence of automation and robotics-related knowledge reflects the ongoing technological transformation of the sector, where traditional mechanical expertise is increasingly complemented by digital and automated systems.

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5 Conclusions

The **aim of this Study** was to conduct a skills anticipation exercise in the ***Automotive Maintenance and Repair*** *(M&R)* sector with an in-depth look at the Navarra region in Spain. To accomplish this, the analysis was structured around: (i) the examination of patent developments in key technological domains and their impact on emerging occupations and skill requirements; and (ii) the mapping of job postings to detect emerging job profiles and associated skill demand patterns.

Patent analysis and job posting analysis provide two complementary perspectives on labour market evolution. **Patents** offer a forward-looking and anticipatory view, as they capture emerging technological developments and innovation trajectories that are likely to shape the future structure of the sector. Consequently, patent data help identify the technological domains and professional profiles toward which the industry is expected to evolve. By contrast, **job postings** reflect current and recent labour market demand, providing a view that is inherently retrospective, as it captures the skills and occupations that employers have actively sought in the recent past. Nevertheless, by analysing trends in job postings over time, it is possible to infer the direction and pace of labour market transformation, thereby identifying emerging patterns in skill demand and occupational change. Taken together, these two sources provide a comprehensive understanding of sectoral evolution, combining anticipatory insights from innovation dynamics with empirical evidence from real labour market behaviour.

It is worth noting that while the integration of patent and job posting data provides both anticipatory and empirical insights, it necessarily captures only part of a broader and more complex reality. Therefore, the results should be interpreted as a **starting point**, to be further refined and complemented with additional qualitative insights, stakeholder engagement, and contextual expertise in the development of training programmes and micro-credentials.

Starting from the empirical perspective offered by job postings, the Study examined the Automotive M&R **labour market of the Navarra region** over the 2020-2025 period. The vacancies reveal a balanced occupational structure: *Automotive Service Technician/Mechanic* emerges as the most demanded profile, followed by *Repair/Service Technician*, while engineering and technical roles (*Mechanical* and *Industrial Engineers, Engineering Managers, Validation Engineers*), operational manufacturing positions (*Industrial Mechanic, Production Fabricator/Assembler, Machine Operator*), and a broad range of managerial, logistics, and quality- and safety-related functions complete the picture. On the skills side, *Communication* and *Teamwork* occupy the highest positions, immediately followed by *Troubleshooting* and *Preventive maintenance*, alongside a solid core of technical competences (*Mechanics, Machinery, Mechatronics, Electromechanics*) and compliance- and quality-oriented skills (*Safety standards, Quality control*). The appearance of *Industrial robotics, Autonomous systems*, and *Automation* among the ranked competences signals the gradual penetration of advanced manufacturing technologies. Taken together, these findings indicate that the Navarra labour market remains strongly anchored in traditional maintenance and industrial activities, while transversal and emerging digital competences are progressively gaining ground.

Moving to the **patent-based analysis**, the Study examined first the worldwide patent set and subsequently the Spanish one. From a **global perspective**, the results indicate that foundational mechanical and electromechanical knowledge remains the core competence base, with skills such as *Mechanics of motor vehicles, Electromechanics, Predictive maintenance,* and *Automotive diagnostic equipment* occupying the highest positions. At the same time, the Study highlights a clear technological transition toward electrified, connected, and data-driven vehicle systems, reflected in the relevance of skills related to *Vehicle electrical systems, Sensors, Mechatronics, Energy storage systems,* and *Hybrid control systems*. The emergence of competencies associated with A*utomation technology, Robotics, Artificial intelligence,* and *Digital twin technologies* further signals the growing importance of intelligent and predictive maintenance environments. This transition is also reflected in the occupational landscape, where roles such as *Predictive Maintenance Expert, Automotive Electrician, Electromechanical Engineering Technician,* and *Mechatronics Engineer* emerge. Other profiles including *Autonomous Driving Specialist, Alternative Fuels Engineer,* and *Automotive Battery Technician* indicate the sector's progressive shift

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toward software-defined, electrified, and connected mobility systems, requiring professionals capable of integrating mechanical expertise with digital diagnostics and system-level analysis.

The analysis of the **Spanish patent documents** reveals a thematic dominance of traditional M&R (lifting technologies, workshop and repair equipment, refinish coatings, and serviceability solutions). Since 2022, a number of emerging digital themes have surfaced – damage-appraisal data platforms, EV-charging infrastructure, connected and software-defined vehicle architectures, and robotics for maintenance – albeit still at modest volumes, so this growth should be read as a qualitative tendency rather than a numerical one.

For this reason, jointly examining the patent-based and job-posting evidence allows the sector to be understood in a more structured and comprehensive manner. When considered together, the two analytical perspectives reveal several converging trends. Both point to a progressive transformation of the Automotive M&R sector from a predominantly mechanical domain toward a multidisciplinary technological ecosystem. **Mechanical and electromechanical expertise remains fundamental – and is strongly demanded across Navarra's industrial base – but it is increasingly complemented by competencies in electrical systems, electronics, automation, robotics, and data-driven maintenance approaches**. In addition, both analyses highlight the **importance of hybrid professional profiles, capable of combining practical technical intervention with system-level understanding and digital analytical capabilities**.

At the same time, the comparison also reveals important areas of divergence between technological evolution and current labour market demand. **The worldwide patent analysis — and, increasingly, the emerging tail of the Spanish set — places stronger emphasis on domains such as *Predictive maintenance, AI-enabled diagnostics, Vehicle electrification and Battery management, Connectivity,* and *Robotics*, which remain only partially reflected in current Navarra job postings**. By contrast, **labour market demand remains strongly concentrated on operational maintenance roles, established engineering and manufacturing functions, and transversal organisational skills**. This gap suggests that technological innovation is advancing faster than workforce adaptation, with some emerging competencies not yet fully translated into widespread hiring demand. Such misalignment is likely explained by the longer adoption and diffusion cycles of new automotive technologies and indicates a potential future skills gap that education and training systems could proactively address.

In conclusion, these insights suggest that future workforce development strategies should focus on strengthening interdisciplinary technical competences, integrating mechanical expertise with electrical, digital, and data-driven capabilities, while also reinforcing transversal skills that support collaboration and adaptability in increasingly complex technological environments.

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AUTO CREDIFY

FUTURE-READY SKILLS

June 2026

D2.1 Reports on emerging occupations and specific skills needs

Finland

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Contents

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Lists of abbreviations

Abbreviation	Full form
AI	Artificial Intelligence
BIM	Building Information Modelling
DOCDB	EPO Master Documentation Database
EACEA	European Education and Culture Executive Agency
EP	European Patent
EPO	European Patent Office
ESCO	European Skills, Competences, Qualifications and Occupations
EU	European Union
IT	Information Technology
M&R	Maintenance and Repair
NLP	Natural Language Processing

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1 Introduction

The present document reports the activities conducted and results obtained under *Task 2.4 – Conducting a skills anticipation exercise to identify future skills needed in the M&R subsector,* as foreseen by the implementation plan reported in the Application Form.

The assignment (hereinafter also referred to as the Study) focuses on a data-driven skills anticipation exercise that aims at facilitating the design of micro-credentials suitable for testing in three pilot economies: Finland, Portugal, and Spain (with a focus on the Savo region, the Lisbon Metropolitan Area, and Navarra, respectively). The present report focuses on Finland.

To accomplish this, two different data sources have been analysed, exploiting AI-based methodologies:

1) job postings, aiming at mapping arising jobs and related skills requests in the field of Maintenance and Repair;
2) patent literature, which were used to highlight development in relevant technological domains, possibly leading to product/process concurrent innovation in the *M&R subsector*, thus impacting on (new) jobs and skills needs.

Please note that this Study, and the resulting analysis, are intended as an analytical tool and a foundational evidence base to support the design of micro-credentials. Though meaningful and representative, the use of patent and job posting data provides a partial view of labour market and technological dynamics, which are inherently complex and multifaceted.

As such, the findings of this assignment should be interpreted as a **starting point for further exploration and validation**, rather than as a comprehensive or definitive assessment. The design of training programmes and micro-credentials can build upon this analysis, using it as a baseline to be complemented with additional qualitative insights, stakeholder engagement, and contextual expertise.

Note 1: Limitations of the Study.

The report proceeds with the following structure:

- **Chapter 2 Methodology**: this section introduces the analytical framework adopted for the Study, briefly describing how the two data sources have been used for collecting useful insights.
- **Chapter 3 Patent-driven skills and jobs investigation**: here the results of the patent-based analysis are presented, highlighting the technological concepts with the highest innovation intensity and examining how they translate into associated skills requirements and occupational profiles.
- **Chapter 4 Job-postings-driven skills and jobs investigation**: here the results of the job postings analysis are presented, examining how they translate into skills requirements and occupational profiles. Job vacancies complement the patent perspective allowing for a comparison between innovation signals emerging from patents and real-time recruitment dynamics.
- **Chapter 5 Conclusions**: this section synthesises the main findings, putting together the results from and providing a comparison between the patent-driven and the job postings-driven analyses.

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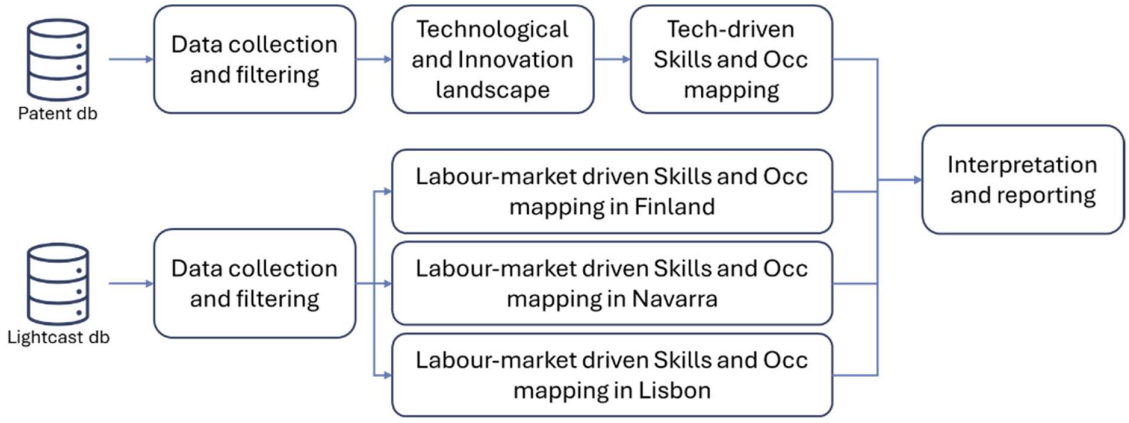
2 Methodology

The Study followed a **multi-stage and multi-source methodology** designed to capture both anticipatory signals and current labour market dynamics. At a high level, patent data are used to provide a forward-looking perspective on emerging technologies, related skill requirements and linked occupations, while job posting data offer an empirical view of current and recent demand for occupations and associated competencies. The overall methodological framework is structured in sequential stages, which are illustrated in Figure 1 and described in detail in the following sections.

Figure 1: Schematic illustration of the key stages of the methodological workflow.



Patent-driven skills and jobs investigation

The Study begins with the **collection of patent data** from an international, worldwide database, which includes over 160 million patent records. Indeed, patent information represents a privileged source for investigating worldwide technology evolution and innovation activity.

> The patent analysis was limited to the past 10 years for two main reasons. Firstly, it ensures consistency with the job vacancies provided by Lightcast, which cover a shorter (specifically, the last six years) and more recent period. Secondly, patent data typically precede market applications, as they reflect early-stage innovation activity. Therefore, the analysis adopts a slightly longer time horizon for patents than for job postings in order to capture pioneering technological developments that may shape future labour market needs. Lastly, given the characteristics of the sector, the selected time window allows for a clearer focus on emerging and innovative technologies.

Note 2: Rationale for limiting patent analytics to a 10-years time frame.

As worldwide economy is constantly evolving and innovating, as soon as a novel advantageous technology is introduced, this is typically adopted quickly by all players in the world, regardless of the country of initial development. Therefore, it is important to look at innovations on a global scale to have a complete picture of the new technologies that are entering or about to enter the M&R sector and that will shape the competencies needed by the labour market in near future. Even adopting a European-scale perspective is not sufficient, as in fact EP patents represent only about 10% of the total research and development production on a global scale in recent times[1].

[1] Source: World Intellectual Property Organization (WIPO) (2025). World Intellectual Property Indicators 2025. Geneva: WIPO. DOI: 10.34667/tind.58959

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Extracting coherent and comparable datasets requires careful cleaning due to factors that span from patents' legalese jargon, variations in documentation standards, classifications, and lack of metadata completeness across different jurisdictions. To overcome the intrinsic challenges of patent research, database querying and dataset cleaning methodologies were applied and refined through proprietary algorithms and more than 10 years of experience. Such step led to the identification of a dataset containing all worldwide patent documents pertaining to the M&R sector.

Next, Natural Language Processing (NLP) techniques were applied to the patent corpus to identify **domain-relevant technological concepts**, both consolidated and emerging, thus enabling the representation of the sector from a technological perspective. These concepts were subsequently assigned a ***Patent Innovation Index***, aiming at synthesizing the level of current and expected future relevance of each technological concept in the sector under review. The *Patent Innovation Index* results from a weighted and normalized combination of two factors:

- the number of inventions produced, at worldwide level, and in the considered 10+ years span;
- the growth rate of inventions production.

The resulting indicator assumes values in the interval [0,1], and therefore represents a relative measure of technologies relevance in a given domain. Technologies with a higher Patent Innovation Index are more likely to have an impact on the sector under analysis and on the demand for skills over the short and medium term. They represent both widely researched and rapidly growing innovations resulting from significant investments in R&D, which will most likely translate into widespread adoption and use. Technologies with lower scores (say, lower than 0.5) are still relevant to consider because of two possible scenarios.

- Significant yet slowing inventive activity (a relatively high number of inventions, with low growth rate). This indicates mainstream technologies for which skills may still need to be updated; or
- Low yet growing inventive activity (a relatively low number of inventions, with high growth rate). This indicates emerging technologies, which could gain importance over the long term.

In addition, **non-technological concepts** were intentionally retained in the analysis, as they represent key enabling factors within the sector. Although these elements do not receive any quantitative score (and are therefore labelled as "N.T." due to their non-technological nature), they encompass both established and emerging concepts that are essential for providing a comprehensive mapping of the skills and occupations relevant to the considered domain. The identified technologies and innovation concepts were then semantically **matched with the ESCO database to capture a list of related skills and occupations**. Professional profiles and competences are also ranked in order of relative potential future demand on the basis of the number of related innovations. In this context, the ESCO framework represents a widely used standard in skills intelligence, and is used to remap occupations and skills in relation to technological evolution, establishing a common language and ensuring alignment with the European reference classification standard.

This technologies-skills-occupations mapping makes it possible to highlight the skills needs for the next future, as well as professions that are most linked to such skills. This kind of intelligence is essential for anticipating priority skill needs, guiding curriculum development, and strengthening cooperation between industry and education providers. Ultimately, this mapping exercise helps reveal where skill gaps are likely to appear and where labour demand may increase in the near future.

Lastly, through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology. The resulting rankings of skills and occupations therefore highlight those profiles that are most strongly linked to high-ranked technologies and innovations, providing a synthetic and forward-looking representation of interconnections between technological evolution, skill requirements, and occupational structures.

Job-postings-driven skills and jobs investigation

Job vacancies complement the patent perspective. While the patent-based analysis provides a technology and innovation-driven view on potential future developments, job postings investigation offers an empirical view

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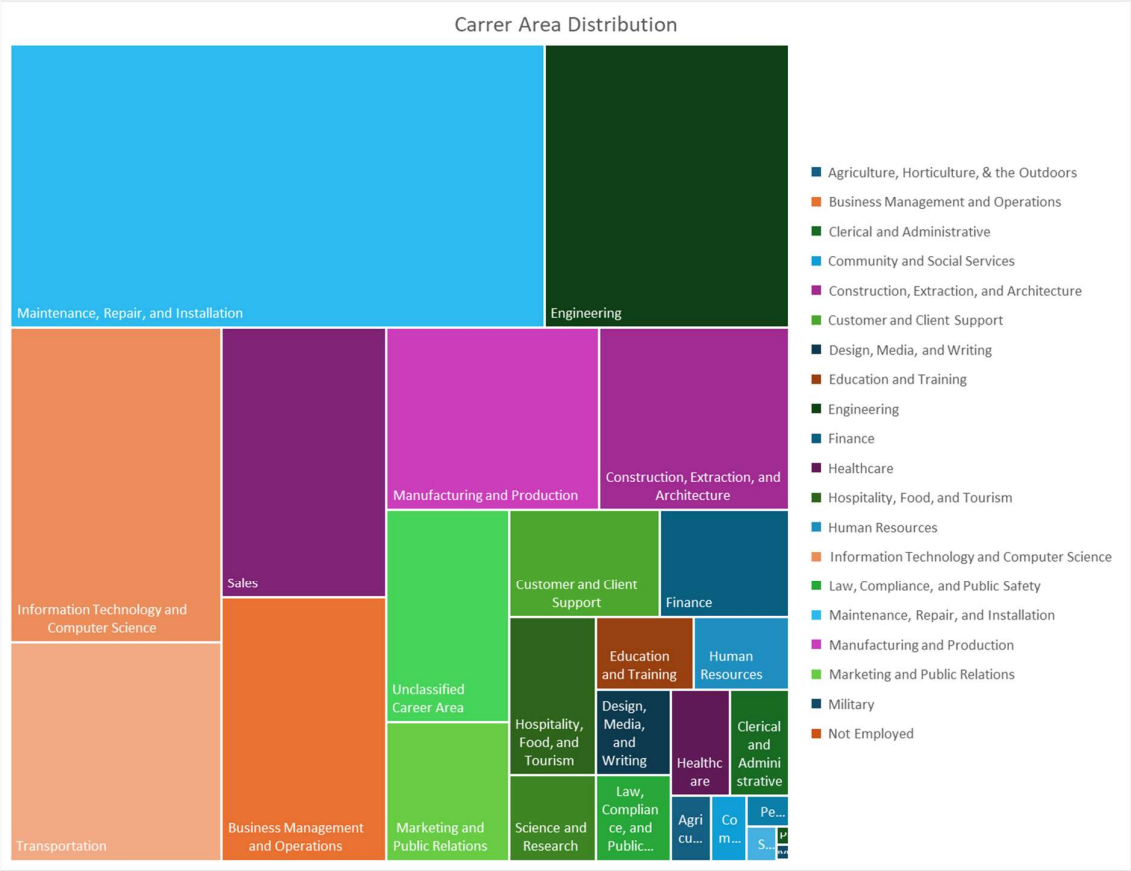
grounded in real labour market dynamics. By examining job postings, it is possible to observe how sectoral transformations translate into concrete hiring needs. This approach therefore provides a real-world perspective on emerging occupations and skills, highlighting patterns in employer demand and offering evidence of how labour markets are evolving in response to technological change.

Job vacancy data was provided by Lightcast[2]. Each job posting is associated with a specific job profile and may include multiple skills. According to this, the analysis first examined the job profile landscape and subsequently explored the connected skills required by employers.

A total of approximately 183,000 job postings were collected, so distributed: Finland 131,912 records; Portugal 38,224 (in particular, Lisbon Metropolitan Area); Spain 13,549 (from the region of Navarre). Differences in absolute values strongly depend on how data were collected. While, for Portugal and Spain, only job vacancies from the Lisbon and Navarra regions, respectively, were retrieved, the situation was different for Finland. Although the initial focus was on the Savo region, the limited availability of data required extending the analysis to the entire national territory in order to ensure the statistical robustness and reliability of the results.

Figure 2: Carrer Area distribution of the job postings' dataset.



An initial exploration of the dataset highlighted the need for a **filtering procedure to ensure data quality and robustness**. Such step was based on a *Career Area* variable provided by Lightcast itself, which indicates each job posting's domain. In particular, those job postings were excluded whose domain was considered less relevant for the scope of the Study. Figure 2 provides an overview of the distribution of career areas within the dataset and their respective frequencies. The size of each rectangle is proportional to the frequency of the corresponding career area. As a result, the following areas were excluded from the analysis: *Agriculture, Horticulture, & the*

[2] https://lightcast.io/euro

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Outdoors; Clerical and Administrative; Community and Social Services; Construction, Extraction, and Architecture; Design, Media, and Writing; Education and Training; Finance; Healthcare; Hospitality, Food, and Tourism; Human Resources; Marketing and Public Relations; Military; Performing Arts; Personal Services; Science and Research; Social Analysis and Planning; Not Employed; Unclassified Career Area.

Subsequently, in order to evaluate the most relevant job occupations and skills from job vacancies, a ranking was performed. Similarly to the aforementioned *Patent Innovation Index*, such ranking was based on a composite score, namely ***Labour Market Index*** combining the absolute frequency and emergence of skills and occupations within the job postings dataset. In more detail:

- The absolute frequency component captures how often a given occupation or skill appears in the job postings dataset. This indicator reflects the current level of demand in the labour market, highlighting roles and competencies that are widely required by employers.
- The second component, referred to as emergence, measures the evolution of demand over time, specifically considering the trend observed in the last years (2020 – 2025). This indicator captures the growth dynamics of occupations and skills, identifying those that are increasing in relevance within job postings and may therefore represent emerging or rapidly expanding labour market needs.

The combination of these two dimensions allows the ranking of occupations and skills considering both their current relevance and their recent growth trajectory. As a result, the highest-ranked items are those that are both frequently mentioned in job postings and characterized by a strong positive trend over time. Conversely, occupations or skills with high frequency but limited growth, as well as those with strong growth and low diffusion, tend to appear lower in the ranking.

Taken together, the two analytical perspectives enabled a comprehensive understanding of emerging labour market trends and future skill requirements.

A further potentially relevant analytical dimension relates to the relationship between enterprise size, occupational profiles, and skills demand. Understanding how skills requirements vary across firms of different sizes could have provided additional insights into labour market dynamics and supported the development of more targeted micro-credentials and training interventions.

Nevertheless, the selected data provider was not able to provide sufficiently robust and consistent information on company size. As a result, and in order to preserve the reliability and validity of the findings, this analytical dimension was not explored further within the scope of the Study.

Note 3: Rationale for limiting patent analytics to a 10-years time frame.

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3 Patent-driven skills and jobs investigation

3.1 Patent-based technological landscape

3.1.1 Worldwide perspective

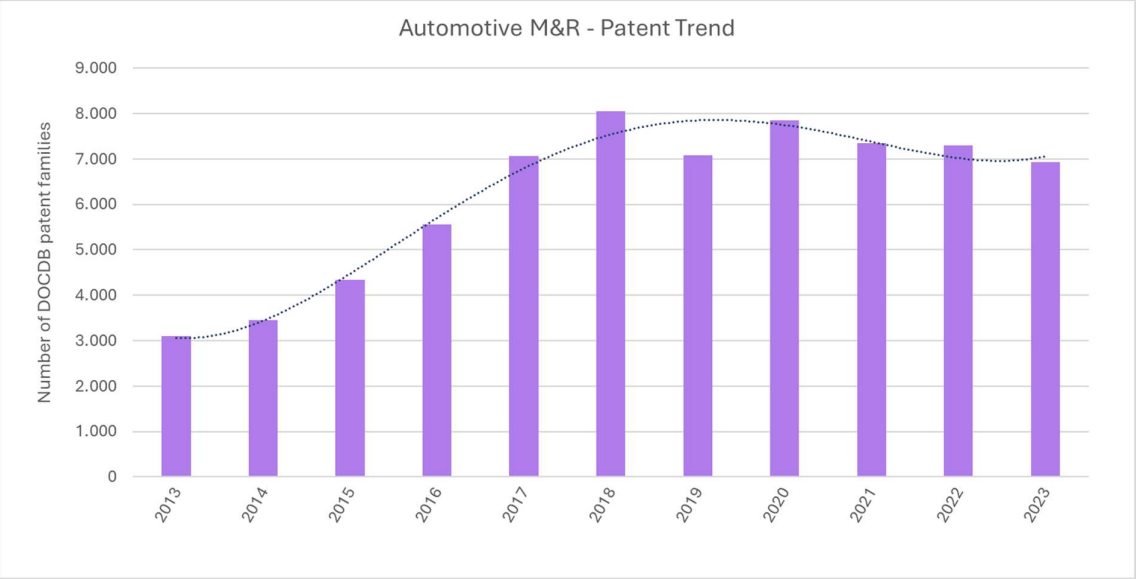
A total of over 127 thousand patent documents, belonging to **approximately 76 thousand DOCDB[3] families, on a global scale have been collected in relation to the *Automotive Maintenance and Repair* domain**. The DOCDB simple patent family is defined by the European Patent Office as "*a collection of patent documents that are considered to cover a single invention. The technical content covered by the applications is considered to be identical*"[4]. Therefore, patent families represent a more valuable unit than single patent applications when studying innovation evolution.

Table 1: Worldwide patent sets dimensions in the Automotive M&R sector.

Sector	Number of worldwide patent documents*	Number of worldwide DOCDB patent families*
Automotive Maintenance and Repair	127,758	76,090

*since 2013

Figure 3: Time series of worldwide patent families' filings in the Automotive M&R sector.



It is also worth noting that patent applications are typically published only after a confidentiality period, which is generally 18 months from the filing date. Consequently, patent data for the most recent two years are incomplete and should not be considered fully reliable for analytical purposes. Given the Study's focus on a ten-year timeframe, the analysis was therefore based on patent data covering the period from 2013 to 2023.

[3] DOCDB is the European Patent Office's master documentation database with worldwide coverage. It contains bibliographic data, abstracts, citations and the DOCDB simple patent family, but no full text or images.
[4] Source: https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/patent-families/docdb.html

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Table 1 shows a concise view of the overall patent set, while Figure 3 displays the yearly evolution of inventive activity. Please note that the chart does not display the two last years (2023 – 2025), due to the aforementioned *secrecy period*.

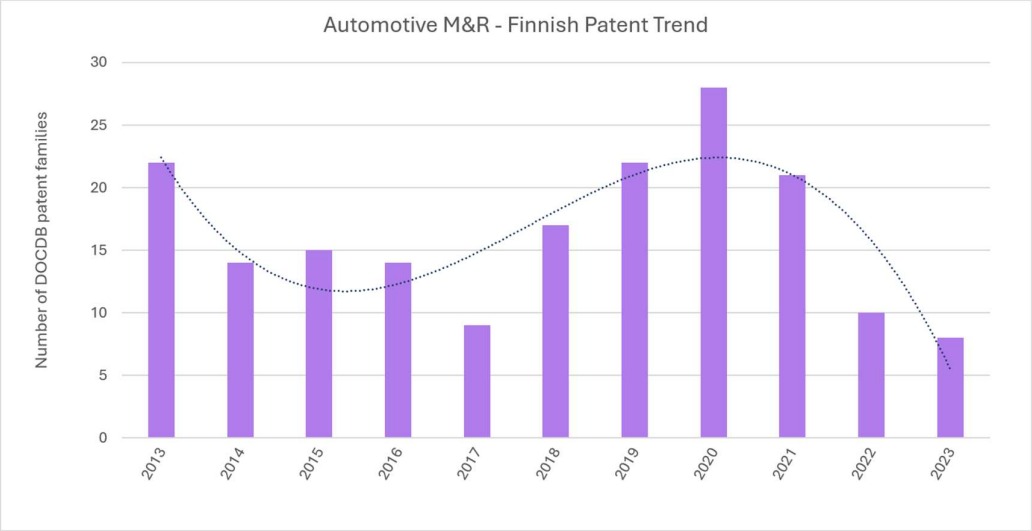
Figure 3 illustrates a strongly increased patent activity from approximately 3,100 novel inventions per year in 2013 to a peak of about 8,000 in 2018, reflecting a period of accelerated innovation and sectoral expansion. After a decline in 2019, filings partially recovered in 2020 but did not regain the previous peak. From 2021 onward, the trend shows a moderate but consistent decrease, reaching roughly 6,900 patent families in 2023. Overall, the data indicate rapid growth followed by stabilization at a comparatively high level, suggesting a maturing yet still innovation-intensive technological field.

3.1.2 Finnish perspective

Having analysed the Automotive M&R sector from a worldwide perspective, the study now focuses on the Finnish patent set. Since 2013, this set comprises 216 patent documents belonging to 188 DOCDB patent families.

Following a relatively strong start in 2013 (22 families), filing activity shown in Figure 4 stabilised at 14-15 families per year between 2014 and 2016, before recovering over the 2018–2020 triennium and peaking in 2020 at 28 families. A progressive contraction followed, although figures for the most recent years may be partially affected by the publication lag of patent applications.

Figure 4: Time series of Finnish patent families' filings in the Automotive M&R sector.



The thematic analysis of the Finnish patent set indicates a portfolio dominated by lifting technologies and their applications in vehicle maintenance. This pattern reflects the leading role of KONE (58 families) and TK Elevator (17 families). KONE is the foremost assignee, active throughout the period on the maintenance, safety and diagnostics of lifting installations used for vehicle M&R. Similarly, TK Elevator's patenting activity focuses on elevator system engineering and safe operation in the field of vehicle-lifting devices.

Further clusters identified by the analysis include vehicle-lifting devices (Autorobot Finland, Finnkis, NT Liftec), workshop equipment and protective arrangements (Go Parts), tyre handling (Arsca) and a digital/diagnostic component (Radiant Bytes, Nokia, Kempower).

In recent years (since 2022), innovation activity has continued to focus on vehicle lifting and workshop/tyre equipment. Albeit at modest absolute volumes, the analysis also identifies a residual digital/services tail at lower intensity (*e.g.* cloud services and path estimation).

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3.1.3 Technological and innovation concepts in M&R

For studying the technological evolution in a specific domain, the definition of a sector-level patent set represented a fundamental step in the methodology. The application of Natural Language Processing (NLP) to such sets enabled the identification of a list of **domain-specific technological concepts**. These are displayed in Table 2, where the ordering is based on the ***Patent Innovation Index***, aiming at synthesizing the level of relevance of each technological concept in the *Automotive Maintenance and Repair* sector (see Methodology for more details).

Technological and innovation concepts are visualized in Table 2 using a purple colour scale, where darker shades indicate higher Patent Innovation Index values. It should be noted that a set of non-technological concepts were also included, namely *Car emergency* and *Risk management*. These entries are clearly marked with the tag "N.T." and positioned at the bottom of the ranking.

Table 2: List of the technological concepts relevant for the Automotive M&R sector.

Technological and Innovation Concepts	Patent Innovation Index
Diagnostic sensors	1,000
AI and Statistical tools for diagnosis	0,993
Car lifters	0,990
Electric propulsion	0,963
Predictive maintenance	0,951
Robotic workers and Cobots	0,874
Garage digital management	0,862
Vehicle clamping equipment	0,861
Mechanical tools	0,843
3D Scanning	0,799
Internet of Things (IoT)	0,792
Imaging for diagnosis	0,730
High voltage technologies	0,727

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Technological and Innovation Concepts	Patent Innovation Index
Intelligent cabin	0,720
Fuel optimization	0,697
Battery repairing and maintenance	0,680
Electronics and Software for Autonomous drive	0,641
Mechatronics	0,606
Advanced polymers	0,581
Augmented reality	0,555
Hydrogen management and storage	0,517
Automotive components	0,435
3D printing for component replacement and repairment	0,419
Complex transmission	0,328
Spare part management and logistics	0,273
Maintenance cost calculation	0,190
Car emergency	N.T.
Risk management	N.T.

The ranking reveals a clear prioritization of diagnostic and data-driven technologies within the *Automotive Maintenance and Repair* domain. *Diagnostic sensors* lead the ranking, closely followed by *AI and Statistical tools for diagnosis*, *Predictive maintenance*, and *Garage digital management*. Together, these top-performing technological and innovation concepts signal a structural transition from reactive repair models toward predictive, data-supported, and platform-integrated service strategies.

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Rounding out the top tier are mature and operationally indispensable technologies such as *Car lifters* and *Mechanical tools*. Their strong positioning confirms that, despite rapid digitalization, physical workshop infrastructure remains strategically critical. On the other hand, Complementary technologies such as *IoT and telematics* and *Imaging for diagnosis* further reinforce the importance of digital connectivity and real-time information flows, although they rank slightly below core diagnostic infrastructures.

The dominance of fault detection systems, analytical intelligence, and core workshop equipment in the top tier indicates that competitive advantage increasingly derives from the ability to detect, interpret, and act upon vehicle condition data efficiently.

Another distinct high-performing cluster includes *Electric propulsion*, *High-voltage technologies*, and *Battery repairing and maintenance*, clearly reflecting the sector's transition toward vehicle electrification and its associated maintenance technology. When considered alongside *Hydrogen management and storage*, the ranking suggests that repair ecosystems must adapt to alternative propulsion systems. This transformation implies not only technological reconfiguration but also the development of new technical skills, safety standards, and certification frameworks to manage high-voltage systems and next-generation energy carriers.

Mid-ranked technologies such as *Intelligent cabin* and *Electronics and software for autonomous drive* point to the growing complexity of vehicle architectures and the increasing software intensity of modern cars. Their position indicates emerging relevance in maintenance contexts, particularly as repair activities expand beyond mechanical intervention to include software diagnostics, calibration, and system integration. In contrast, *Advanced polymers* and *Augmented reality* suggest steady yet comparatively lower strategic impact, possibly reflecting enabling or supportive roles rather than core maintenance functions.

Examining the bottom tier of the ranking, including *3D printing for component replacement and repair* and *Complex transmission,* technologies appear to remain either niche or context-specific within current repair practices. Traditional operational domains such as *Spare part management and logistics* and *Maintenance cost calculation* occupy the bottom of the ranking, indicating limited direct patent intensity and comparatively lower innovation dynamics.

Finally, the presence of non-technological or governance-oriented concepts such as *Car emergency* and *Risk management* is analytically significant, although not technically ranked. Their appearance in patent-related analyses suggests that innovation in automotive repair is increasingly shaped by regulatory compliance, and safety considerations. These dimensions function as embedded constraints and design parameters within technological development. The trend indicates that innovation is no longer driven solely by performance and functionality, but also by legal robustness, safety assurance, user trust, and long-term sustainability.

Overall, the ranking underscores a pronounced technological convergence toward diagnostics, computational-based maintenance, electrification, and system integration. It portrays a repair ecosystem that is progressively data-centric, automation-enabled, and strategically aligned with predictive and software-defined vehicle paradigms.

3.2 Skills and occupations matches from ESCO database

Applying semantic matching algorithms, the identified technologies and innovation concepts were linked to ESCO skills, competences, knowledge, and occupations.

Through text-mining and ranking procedures, skills and occupations are further prioritised according to their expected future demand, taking into account both skill-technology and occupation-skill matches and the Patent Innovation Index of each technology (see Methodology for more details).

Figure 5 ranks the top 30 skills associated with technologies likely to impact the *Automotive Maintenance and Repair* sector in the future.

Figure 5: Top 30 ESCO skills, competences and knowledge in the Automotive M&R sector.

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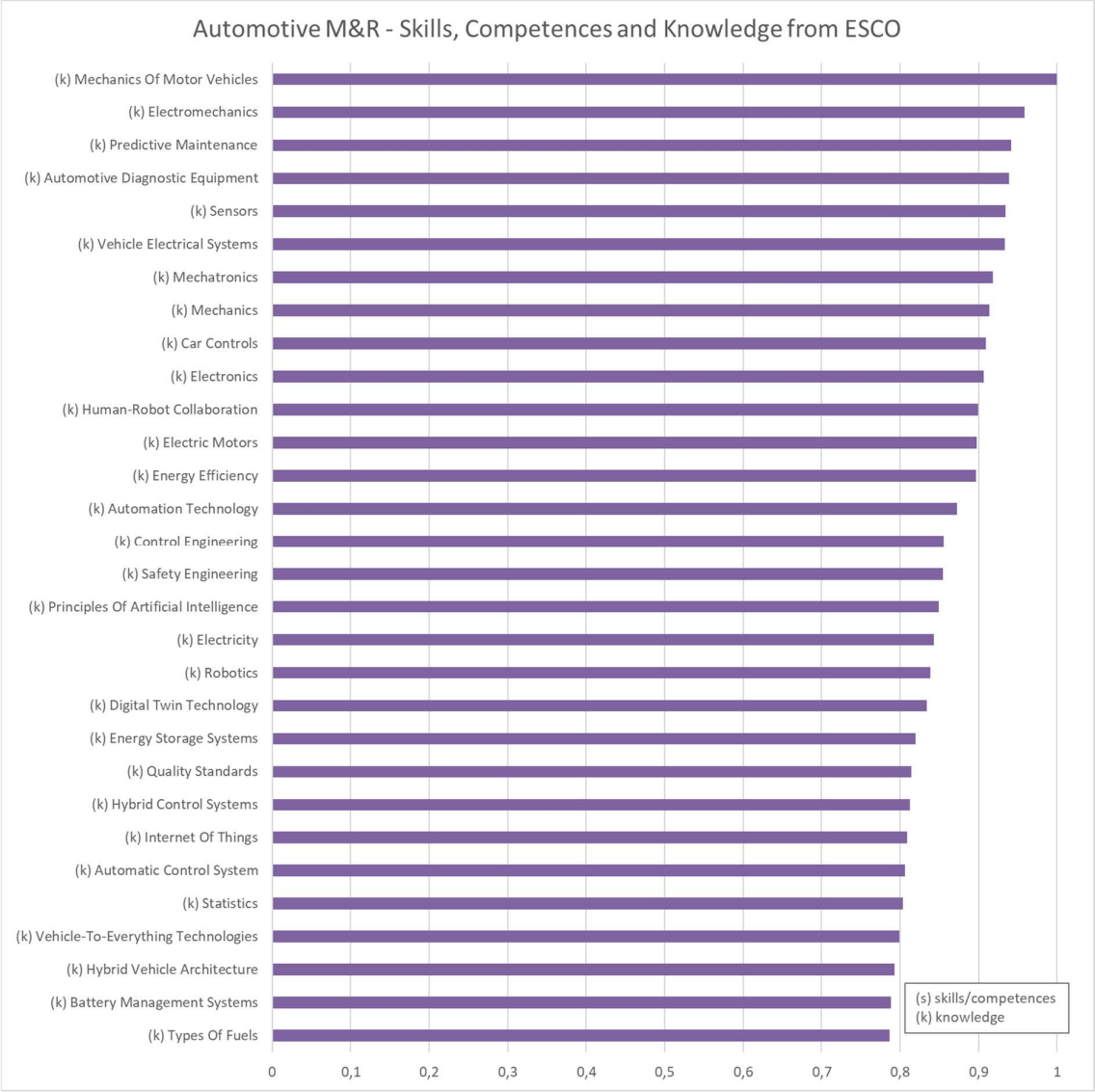

The ranking highlights the continued dominance of foundational mechanical and electromechanical knowledge as the core competence base in the analysed domain. *Mechanics of motor vehicles* occupies the top position, followed closely by *Electromechanics*, *Predictive maintenance*, and *Automotive diagnostic equipment*. This confirms that traditional mechanical expertise, combined with diagnostic and predictive capabilities, remains essential to ensure effective and reliable maintenance operations.

Closely following this top tier are competencies related to *Sensors*, *Vehicle electrical systems*, *Mechatronics*, and *Electronics*, reflecting the increasing integration of electrical and electronic architectures within modern vehicles. The strong positioning of these skills indicates that maintenance activities now require a hybrid skill set combining mechanical proficiency with electrical and electronic system understanding. The presence of *Car controls*, *Electric motors*, and *Energy efficiency* further reinforces the growing importance of electrically powered systems and energy optimization in maintenance practices.

A second cluster of highly ranked competences emphasizes automation, intelligent systems, and interdisciplinary integration. Skills such as *Automation technology*, Control engineering, *Safety engineering*, and *Human-robot collaboration* highlight the progressive automation of workshop environments and the growing interaction between technicians and automated or robotic systems. The inclusion of *Principles of artificial intelligence*,

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Robotics, and *Digital twin technology* underscores the emergence of data-driven and simulation-based maintenance approaches, which enable predictive diagnostics, system optimization, and remote monitoring.

The ongoing transition toward electrified and connected vehicles evidenced by the presence of *Energy storage systems*, *Hybrid control systems*, and the *Internet of Things*. These technologies require maintenance professionals to understand battery systems, system integration, and real-time data exchange between vehicle components and external platforms. Similarly, *Vehicle-to-everything technologies* and *Battery management systems* indicate the increasing relevance of connectivity and advanced energy management in maintenance contexts.

Lower-ranked, yet still strategically relevant, competences such as *Statistics*, *Hybrid vehicle architecture*, and *Types of fuels* suggest supporting or specialized knowledge areas that complement core technical expertise. Their relatively lower position does not indicate lack of importance, but rather a more contextual or enabling role compared to fundamental diagnostic, mechanical, and electrical competences.

Overall, the ranking reveals a clear evolution of the automotive repair skillset from purely mechanical expertise toward a multidisciplinary competence profile integrating mechanics, electronics, data analytics, automation, and electrification. Confirming the findings in Table 2, this transformation reflects the increasing technological complexity of modern vehicles and highlights the need for maintenance professionals capable of operating at the intersection of physical systems, digital technologies, and intelligent diagnostic environments.

Similarly, Figure 6 provides a synthetic picture of how technological innovation in the *Automotive M&R* sector translates into labour demand, presenting the top 30 ESCO job profiles emerging from the analysis.

The occupation ranking highlights the growing centrality of predictive, electrical, and interdisciplinary engineering roles within the repair and maintenance ecosystem. At the top of the ranking stands the *Predictive Maintenance Expert*, followed closely by the *Automotive Electrician* and the *Motor Vehicle Engine Inspector*. This leadership position reflects the sector's transition toward condition-based and data-driven maintenance models, where the ability to anticipate failures and interpret diagnostic data has become a critical operational capability.

Closely following this top tier are engineering and technical roles such as the *Electromechanical Engineering Technician*, *Maintenance and Repair Engineer*, *Mechatronics Engineer*, and *Sensor Engineering Technician*. The strong positioning of these occupations underscores the increasing importance of hybrid expertise combining mechanical, electrical, and electronic competencies (as highlighted in Figure 5). In particular, the prominence of mechatronics and sensor-related roles confirms that modern maintenance activities rely heavily on integrated systems requiring advanced diagnostic, calibration, and system-level intervention skills.

As revealed by the analysis of the skill ranking (Figure 5), a distinct cluster of highly ranked occupations comprises operational and technical implementation roles, including the *Motor Vehicle Parts Assembler*, *Mechatronics Engineering Technician*, *Powertrain Engineer*, and *Motor Vehicle Engine Tester*. The prominence of these roles underscores the continued importance of hands-on technical expertise and system-level validation functions, which are essential to ensure vehicle performance, operational reliability, and compliance with increasingly stringent technical and safety standards.

Notably, emerging and future-oriented roles such as the *Autonomous Driving Specialist*, *Alternative Fuels Engineer* and *Automotive Battery Technician* occupy mid-to-high positions, highlighting once again the sector's ongoing transition toward software-defined vehicle architectures and alternative propulsion systems. Similarly, the inclusion of the *Embedded Systems Security Engineer* reflects the growing relevance of cybersecurity in vehicle maintenance, as vehicles become progressively connected and reliant on embedded software systems.

Figure 6: Top 30 ESCO occupations in the Automotive M&R sector.

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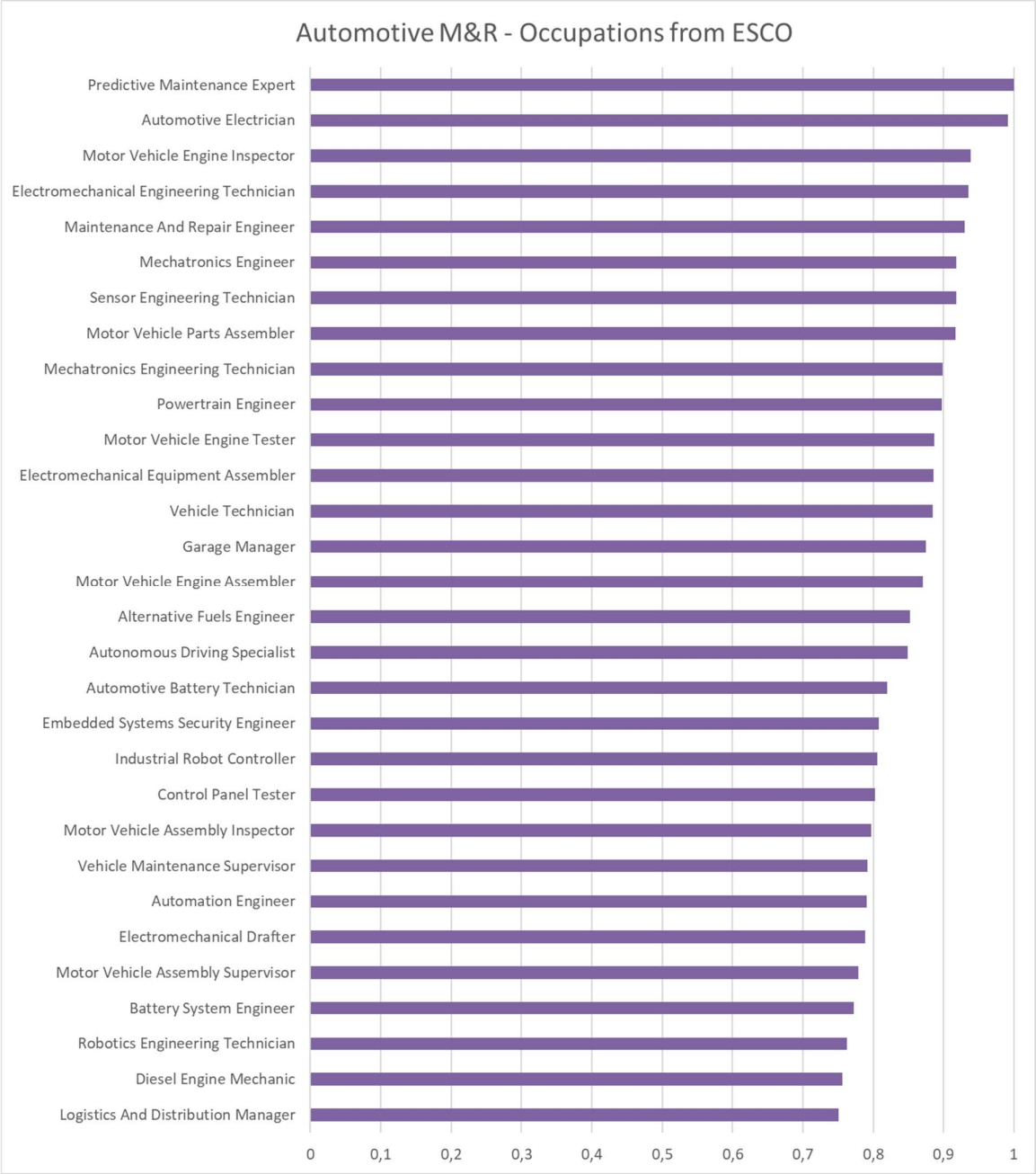

Further down the occupation ranking, roles such as the *Industrial Robot Controller* and *Automation Engineer* emphasize the gradual integration of automation and robotics into maintenance and production-related activities. These occupations point to the increasing automation of diagnostic procedures, component handling, and repair workflows, requiring technicians capable of interacting with automated systems and robotic platforms.

Lastly, low-ranked occupations such as the *Diesel Engine Mechanic* and the *Logistics and Distribution Manager* remain relevant but reflect comparatively lower strategic intensity in terms of technological innovation. This positioning suggests a gradual shift away from traditional mechanical specializations associated with conventional internal combustion engine technologies, alongside the relative stabilization of logistics functions compared to rapidly evolving technical roles.

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Considering these findings, the occupational ranking (Figure 6) reinforces this transition, evidencing a parallel restructuring of professional roles in response to evolving skill requirements (Figure 5). Traditional mechanically focused occupations are increasingly complemented by interdisciplinary roles that combine expertise in diagnostics, data-driven solutions, electrified systems, embedded electronics, and automated processes. This shift reflects the alignment between emerging competence profiles and the changing technological landscape of the *Automotive Maintenance and Repair* sector (Table 2). Consequently, the sector is witnessing a growing demand for professionals capable of integrating physical intervention with digital analysis, system-level troubleshooting, and data-driven maintenance strategies.

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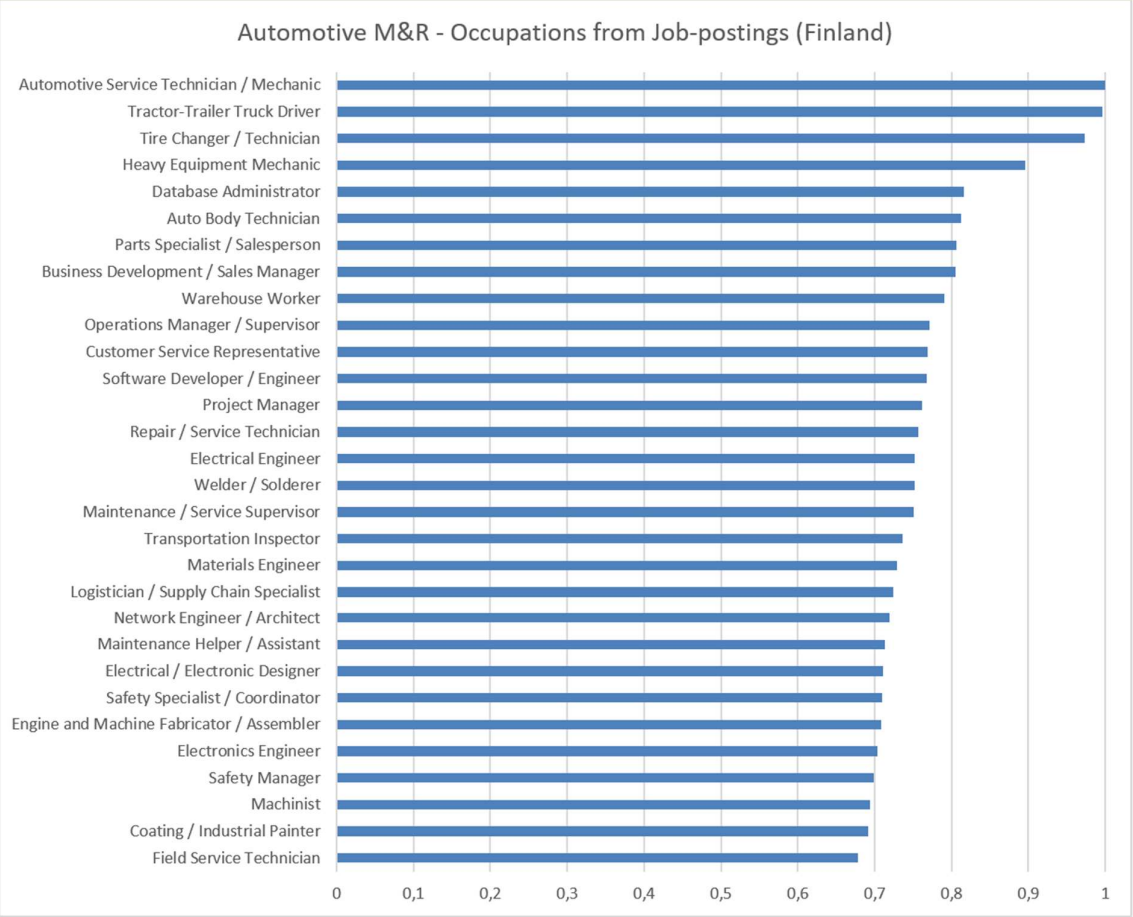
4 Job-postings-driven skills and jobs investigation

This section presents an investigation of job postings produced in Finland in the six-year period from 2020 to 2025. This part of the Study aims at identifying key patterns and insights related to occupations and skills, enabling a more granular understanding of labour market dynamics, and highlighting both common trends and location-specific characteristics in workforce demand.

Figure 7 presents the occupation ranking identified in job postings related to the *M&R* sector in Finland. The ranking is based on the ***Labour Market Index*** (see Methodology for more details). Overall, the results show a strong concentration of technical and operational roles, with the highest values associated with *Automotive Service Technician/Mechanic, Tractor-Trailer Truck Driver, and Tire Changer/Technician*. These occupations appear as the most demanded roles, indicating the central importance of maintenance and vehicle operation activities within the Finnish automotive labour market.

Figure 7: Top 30 job-posting occupations in the Automotive M&R sector for Finland.



The prominence of the *Tire Changer/Technician* role warrants a specific clarification. In Finland, tyres are changed twice a year, as summer and winter tyres differ in quality, generating intense but highly seasonal demand for workers over very brief periods each spring and autumn. This demand is therefore largely structural and seasonal in nature, and bears little relation to the anticipation of new or emerging skills.

The chart also highlights the presence of supporting technical and digital roles, such as *Database Administrator, Software Developer/Engineer, and Network Engineer/Architect*, reflecting the growing integration of digital technologies and IT systems within automotive maintenance and logistics operations.

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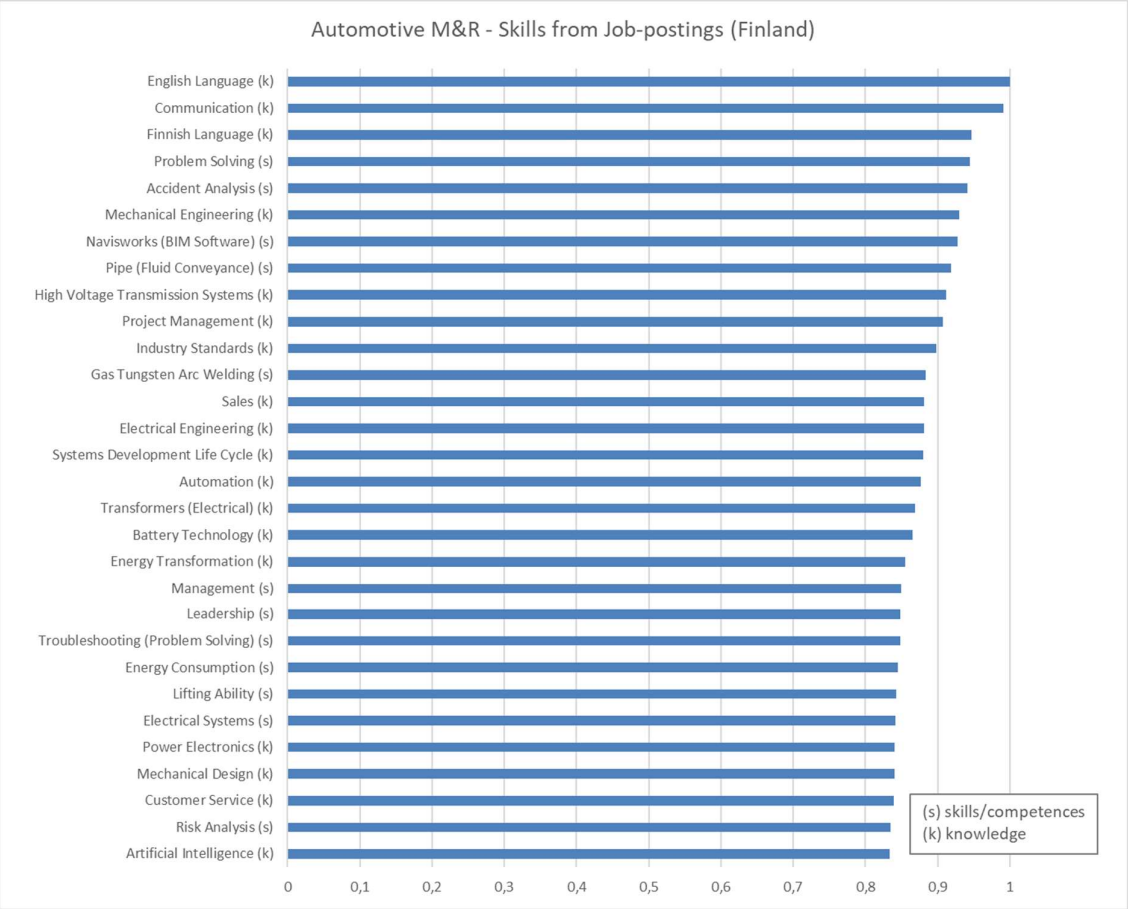
In addition, logistics, management, and operational support roles – including *Warehouse Worker, Operations Manager/Supervisor, Project Manager, and Logistician/Supply Chain Specialist* – appear in the dataset, indicating that the automotive *M&R* sector requires not only technical skills but also competencies related to supply chain management, coordination, and business operations.

Finally, several engineering and safety-related occupations, such as *Software Developer/Engineer, Electronics Engineer, Materials Engineer, Safety Specialist/Coordinator*, and *Safety Manager*, further illustrate the multidisciplinary nature of the sector: as revealed by patent-driven analysis, contamination from the software world and the advent of electric vehicles will inevitably change the professional profile of workers in the repair and maintenance sector.

Comprehensively, the Finnish job postings' analysis highlights a labour market structure in which mechanical and maintenance-related occupations dominate, while engineering, digital, logistics, and managerial roles complement the core technical workforce, reflecting the increasing complexity and technological integration of the automotive maintenance and repair ecosystem in Finland.

Figure 8: Top 30 job-posting skills, competences and knowledge in the Automotive M&R sector for Finland.



In line with the dataset structure, where each job posting is associated with a specific occupation and may include multiple skills, the skill analysis is derived from occupation examination. In particular, all the skills associated with the top 30 ranked occupations were first collected and then processed, ensuring coherence with the data schema and focusing on the competencies most closely linked to the most relevant occupational profiles identified in the job postings. The results are shown in Figure 8, which ranks of the most relevant skills associated with the top occupations in the *Automotive Maintenance and Repair* sector in Finland.

At the top of the ranking, language and communication-related competences appear particularly relevant. *English language*, *Communication*, and *Finnish language* occupy the highest positions, highlighting the

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importance of effective interaction in technical environments, international supply chains, and customer-facing activities. This suggests that, beyond purely technical expertise, soft skills and linguistic capabilities are essential requirements in the sector.

A second group of highly ranked competences includes analytical and problem-solving capabilities, such as *Problem solving, Accident analysis*, and *Troubleshooting*. These skills reflect the operational nature of maintenance and repair activities, where diagnosing faults, ensuring safety, and resolving technical issues efficiently are critical tasks.

The ranking also highlights a strong presence of engineering and technical knowledge domains, including *Mechanical engineering, Electrical engineering, Power electronics, Mechanical design*, and *High-voltage transmission systems*. These competencies indicate the growing technological complexity of automotive systems, particularly in relation to electrification, advanced power systems, and integrated mechanical–electrical architectures.

In addition, several digital and systems-oriented competences appear in the ranking, such as *Navisworks (BIM software), Automation, Systems development life cycle,* and *Artificial intelligence*. Their presence suggests the increasing integration of digital tools, software-driven processes, and data-based technologies within industrial and automotive maintenance environments.

Finally, the figure also shows the relevance of management and operational competences, including *Project management, Leadership, Sales,* and *Customer service*. These roles support coordination, service delivery, and interaction with clients and suppliers across the automotive value chain.

Overall, the distribution of skills indicates that the Automotive *M&R* sector in Finland requires a multidisciplinary skill set, combining technical engineering knowledge, digital capabilities, problem-solving competences, and communication skills. This reflects the broader transformation of the sector, where traditional mechanical expertise is increasingly complemented by electrical, digital, and organizational competencies.

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5 Conclusions

The **aim of this Study** was to conduct a skills anticipation exercise in the ***Automotive Maintenance and Repair*** *(M&R)* sector with an in-depth look at Finland. To accomplish this, the analysis was structured around: (i) the examination of patent developments in key technological domains and their impact on emerging occupations and skill requirements; and (ii) the mapping of job postings to detect emerging job profiles and associated skill demand patterns.

Patent analysis and job posting analysis provide two complementary perspectives on labour market evolution. **Patents** offer a forward-looking and anticipatory view, as they capture emerging technological developments and innovation trajectories that are likely to shape the future structure of the sector. Consequently, patent data help identify the technological domains and professional profiles toward which the industry is expected to evolve. By contrast, **job postings** reflect current and recent labour market demand, providing a view that is inherently retrospective, as it captures the skills and occupations that employers have actively sought in the recent past. Nevertheless, by analysing trends in job postings over time, it is possible to infer the direction and pace of labour market transformation, thereby identifying emerging patterns in skill demand and occupational change. Taken together, these two sources provide a comprehensive understanding of sectoral evolution, combining anticipatory insights from innovation dynamics with empirical evidence from real labour market behaviour.

It is worth noting that while the integration of patent and job posting data provides both anticipatory and empirical insights, it necessarily captures only part of a broader and more complex reality. Therefore, the results should be interpreted as a **starting point**, to be further refined and complemented with additional qualitative insights, stakeholder engagement, and contextual expertise in the development of training programmes and micro-credentials.

Starting from the empirical perspective offered by job postings, the Study examined the **Finnish Automotive M&R labour market** over the 2020-2025 period. The vacancies confirm the central importance of technical and operational roles, with *Automotive Service Technician/Mechanic, Tractor-Trailer Truck Driver,* and *Tire Changer/Technician* emerging as the most demanded occupations, complemented by supporting digital, logistics, and managerial profiles that reflect the growing complexity of the sector. On the skills side, the rankings reveal a markedly multidisciplinary demand: core engineering and maintenance competences (*Mechanical engineering, Electrical engineering, Power electronics*) sit alongside analytical and problem-solving capabilities (*Troubleshooting, Problem solving, Accident analysis*) and language and communication skills (*English, Finnish,* and *Communication*), which together occupy the highest positions. Digital and systems-oriented competences such as *Automation* and *Artificial intelligence*, together with managerial capabilities, such as *Project management*, *Leadership*, and *Customer service*, increasingly permeate this skill set. Taken together, these findings indicate that the traditional mechanical expertise of the Finnish M&R sector is increasingly complemented by electrical, digital, organisational, analytical, and communication competencies, confirming the sector's progressive technological and operational integration.

Moving to the **patent-based analysis**, the Study examined first the worldwide patent set and subsequently the Finnish one. From a **global perspective**, the results indicate that foundational mechanical and electromechanical knowledge remains the core competence base, with skills such as *Mechanics of motor vehicles, Electromechanics, Predictive maintenance,* and *Automotive diagnostic equipment* occupying the highest positions. At the same time, the Study highlights a clear technological transition toward electrified, connected, and data-driven vehicle systems, reflected in the relevance of skills related to *Vehicle electrical systems, Sensors, Mechatronics, Energy storage systems,* and *Hybrid control systems*. The emergence of competencies associated with A*utomation technology, Robotics, Artificial intelligence,* and *Digital twin technologies* further signals the growing importance of intelligent and predictive maintenance environments. This transition is also reflected in the occupational landscape, where roles such as *Predictive Maintenance Expert, Automotive Electrician, Electromechanical Engineering Technician,* and *Mechatronics Engineer* emerge. Other profiles including *Autonomous Driving Specialist, Alternative Fuels Engineer,* and *Automotive Battery Technician* indicate the sector's progressive shift

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toward software-defined, electrified, and connected mobility systems, requiring professionals capable of integrating mechanical expertise with digital diagnostics and system-level analysis.

Despite the limited size of the **Finnish patent set** (216 documents), the country-level focus revealed a core interest in lifting technologies and their applications in vehicle maintenance. The shift toward electrified and data-driven systems was captured only partially and at low intensity. This concentration reflects a distinctively national pattern of innovation, in which the broader electrification and automation trends observed worldwide remain, for the time being, only marginally represented, according to the limited set of patents retrieved.

For this reason, jointly examining the patent-based and job-posting evidence allows the sector to be understood in a more structured and comprehensive manner. When considered together, the two analytical perspectives reveal several converging trends. Both the patent-based and job posting analyses point to a progressive transformation of the Automotive M&R sector from a predominantly mechanical domain toward a multidisciplinary technological ecosystem. **Mechanical expertise remains fundamental, but it is increasingly complemented by competencies in electrical systems, electronics, software-enabled diagnostics, automation, and data-driven maintenance approaches**. In addition, both analyses highlight the **importance of hybrid professional profiles, capable of combining practical technical intervention with system-level understanding and digital analytical capabilities**.

At the same time, the comparison also reveals important areas of divergence between technological evolution and current labour market demand. **The worldwide patent analysis places stronger emphasis on emerging domains such as *Predictive maintenance, AI-enabled diagnostics, Digital twins, Battery management systems,* and *Autonomous driving technologies*, areas that appear more marginal or only partially reflected in current Finnish job postings**. By contrast, **labour market demand remains strongly concentrated on operational maintenance roles, traditional mechanical functions**, **as confirmed by the Finnish patent set analysis, and transversal organisational skills.** This gap suggests that technological innovation is advancing faster than workforce adaptation, with some emerging competencies not yet fully translated into widespread hiring demand. Such misalignment is likely explained by the longer adoption cycles of new automotive technologies and indicates a potential future skills gap that education and training systems could proactively address.

In conclusion, these insights suggest that future workforce development strategies should focus on strengthening interdisciplinary technical competences, integrating mechanical expertise with electrical, digital, and data-driven capabilities, while also reinforcing transversal skills that support collaboration and adaptability in increasingly complex technological environments.

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