

# Challenges and Enablers in Recruiting Maintenance Employees

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**Abstract.** Manufacturing maintenance has always undergone change and development. With Industry 4.0-related technological development, increasingly more complex machining equipment, and an increased focus on sustainability, maybe more so today than ever. This has led to an increased difficulty in finding competent maintenance employees to recruit. Simultaneously, it increases the need for continuous competence development to retain the existing work force up to date with the challenges of future development. The introduction of these new technologies and demands does not reduce the need of competence in basic maintenance skills though, but rather adds new areas of needed competence, making the maintenance profession increasingly more complex. This paper will, through an interview study of maintenance managers in an international manufacturing company located in nine countries, delve into the issues and present both challenges and enablers in how to work with recruitment and competence development within maintenance.

**Keywords.** Manufacturing maintenance, competence, recruitment, basic maintenance, smart maintenance.

## 1. Introduction

Effective maintenance planning and execution is crucial in maintaining high levels of safety for employees, environmental standards, and customer-required quality and availability. When this is delivered at an optimized cost, where direct maintenance cost is balanced against indirect maintenance cost, maintenance can be seen as having a high productivity. Over the years, several maintenance concepts, different maintenance types, and various maintenance tools have been developed and used in industry to varying degrees of success.

With the emergence of Industry 4.0, additional tools such as the Industrial Internet of Things, Cyber-Physical Systems, Big data analysis, and Virtual and Augmented Reality have been added to the toolbox available for use where appropriate. As these tools are also being implemented in production and other support functions, it is necessary for maintenance departments to also adopt digitalization.

Working within manufacturing maintenance requires a specific set of competencies and skills for employees. Proper maintenance not only affects safety for employees, but also implies safety risks during activities, making competence and skills of great

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importance [1]. In addition to safety, maintenance also impacts environmental aspects [1], the quality of produced goods [2], and the availability of production equipment [3]. Furthermore, maintenance activities are performed on various equipment and processes within a factory or site, requiring a wide range of competencies and skills from maintenance employees. The introduction of digitalization tools does not reduce this need for competencies and skills, but rather adds new areas of competence requirements. This also makes the recruitment of new employees increasingly challenging, particularly in finding the desired competencies.

In recent years, with the advent of Industry 4.0, there has been a growing sentiment that there will be a need for a shift in the competencies and skills required for both white-collar and blue-collar workers within industry [4] and maintenance in particular [5]. However, despite training and retraining the workforce being one of the biggest challenges in implementing Industry 4.0, there has been limited attention given to reshaping curriculum at both vocational and higher education levels [6]. As maintenance moves towards increased digitalization the competencies and skills of employees must be upgraded to align with these new tools and strategies. Even though maintenance in Industry 4.0 will involve a higher degree of digitalization, which brings opportunities to optimize many maintenance activities, basic maintenance competencies and skills will still be necessary [7-10]. There is a potential risk that maintenance departments, by focusing solely on future competency and skill development in digitalization, will neglect the need for basic knowledge and skills in mechanical or electrical maintenance tasks. Thus, while new knowledge will be necessary in the future, current or basic knowledge must also be recruited, retained, and developed.

The objective of this paper is to explore the views of competence and recruitment needs within maintenance departments in the manufacturing industry, both currently and in the future. This will be achieved through conducting interviews with maintenance managers of an international manufacturing company.

## **2. Theoretical background**

### *2.1. Maintenance Management*

Maintenance may generally be defined as the “combination of all technical, administrative, and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform its required function” [3, p.8]. In this terminology standard, it is also noted that “Technical maintenance actions include observation and analyses of the item state (e.g., inspection, monitoring, testing, diagnosis, prognosis, etc.) and active maintenance actions (e.g., repair, refurbishment)” [3, p.8].

Maintenance, being a crucial process for the entire manufacturing chain, has undergone various changes and improvements over the years. The latest development can be found within digitization and digitalization as well as Industry 4.0, sometimes referred to as the fourth industrial revolution.

In Industry 4.0, various concepts and tools have been discussed by academics such as Cyber-Physical Systems (CPS) [11], Internet of Things (IoT) [12], Big Data [13], Machine Learning [14], Cloud [15] and Fog Computing [16], human-robot collaboration [17], augmented and virtual reality [18]. In maintenance, these concepts and tools have led to the emergence of new maintenance concepts such as eMaintenance [19], Smart

Maintenance [8], Self-maintenance techniques [20], Predictive and Prescriptive Maintenance [21] and even Maintenance 4.0 [22-23].

Even though some of these maintenance concepts have been around for longer than since Industry 4.0 was first named in 2011 [24], the objectives of these concepts align with the goals of Industry 4.0. However, it is important to note that these technological advancements will not replace basic maintenance concepts and management practices in the future [7-10]. As stated in the note in the maintenance definition presented above, maintenance involves two technical actions. The first action, observation and analysis of equipment, can be enhanced by data-driven maintenance tools such as predictive maintenance. The second action, active maintenance, is the actual result of, for instance, predictive maintenance, where the tools are used to diagnose incipient failures, plan and schedule maintenance actions that align with the production and maintenance department. This action requires manual, mechanical, electrical or other intervention of the equipment.

## *2.2. Competence of maintenance employees and difficulties in recruiting*

The need for training of maintenance employees is well-documented in literature, with studies highlighting the importance of training in various areas such as total productive maintenance [25], building services [26], industry [27], and medical equipment maintenance [28], among others. There have been arguments that many maintenance staff are lacking in appropriate training, both at the time of hiring and throughout their careers [27]. Furthermore, it is also argued that workers are ill-equipped to handle the overload of information associated with Industry 4.0 [27]. Even with the advent of Industry 4.0, tasks requiring experience, intuition, creativity, or decision-making based on uncertainty will still reside with humans, and that training and retraining of the workforce is one of the biggest challenges in implementing Industry 4.0 [6]. In a systematic literature review, [29] highlights managerial challenges and opportunities in implementing Industry 4.0, and they report three areas of human resource challenges: (1) the lack of skilled workers in Industry 4.0, (2) the lack of workers with clear visions and commitment to Industry 4.0, and (3) resistance to competence development.

The concept of competence is recognized as a “proven ability to use knowledge, skills and personal, social and/or methodological abilities...” [1, p.5]. In the context of Industry 4.0, researchers have identified critical competencies for job roles that require higher education in order to effectively and efficiently implement and run Industry 4.0 operations. These competencies include areas such as information systems, information technology and engineering [30]. A strategic literature review by [31] identified 19 competencies specific to maintenance 4.0. Though, an international standard on qualification of maintenance personnel [1] only briefly mentions that maintenance technicians are to use and ensure the use of the ICT (information and communication technology) systems. Further, it states that maintenance supervisors/engineers as well as managers need to base their tasks on current state of technology.

Studies on university level maintenance-related education in engineering programs have found that the content related to maintenance is low, with [32] reporting that only 12% of all engineering programs contain mandatory or elective maintenance-related courses, and this number drops to 9.5% when only looking at mandatory maintenance-related courses. The importance of higher education in helping maintenance workers acquire the skills to execute new ways of working with digitalized technologies in order to increase productivity has been highlighted by [33].

However, it is important to note that focus on higher education may not be enough to meet the competency needs of maintenance in Industry 4.0. It has been argued by [34] that maintenance tasks of manufacturing equipment require several vocational skills, which will be even more needed in Industry 4.0. They also note that there seems to be a lack of focus on vocational skills and vocational education in the world. Further, [10] also emphasizes that troubleshooting and repair as well as maintenance and repair will require skilled workers with occupational training in metal or electrotechnology, and that these skills will never be replaced and will be highly valued, particularly with at least 3-5 years of experience.

In a comprehensive study on the concept of smart maintenance, [8] identified four dimensions: data-driven decision-making, human capital resources, internal integration, and external integration. The dimension of human capital resources contained competence in the plant's production processes and understanding of equipment function. Respondents in the study emphasized the importance of hands-on technical skills, in addition to analytical skills. Similarly, [9] found, through an interview study of maintenance managers in large manufacturing companies in Sweden, that skilled mechanics and electricians are still crucial in the maintenance organization. Also, in [14], domain knowledge was identified as a key element in industrial artificial intelligence. The study performed by [8] emphasized that maintenance employees should not be required to become data scientists, but rather should be proficient in working with and communicating with data scientists.

Maintenance managers, as reported in the study performed by [9], projected that failure to provide employees with plans for skill development and new responsibilities may result in an increase in personnel turnover in the future. Additionally, some maintenance managers perceived difficulty in attracting new recruits, particularly younger individuals, to their organization [9]. This sentiment is reflected in a yearly Swedish survey on recruitment conducted by the Confederation of Swedish Enterprise [35], in which seven out of ten companies reported difficulty in recruiting. The survey found that half of the required competencies correspond to vocational programs found in upper secondary school, such as operators, electricians, and mechanics. Another report from a Swedish Industry and employers' organization, Teknikföretagen, come to the same conclusion, stating that operations and maintenance technicians are at the top of most difficult professional roles for companies to recruit today and where demand is predicted to increase a lot over the next three years [36]. A third report from the Swedish National Agency for Higher Vocational Education, focusing on the results of educational programs within Industrial production, as well as the demand of future competence verifies the conclusions in above reports. In this report it is illustrated that the higher vocational educational programs that had been performed related to maintenance engineering between the years 2019-2021 only 52-55% of the student attending graduated. Of the graduated students from the maintenance engineering-related programs in 2021, 98% had an employment (in 2023) of which 82% had a good compliance between work and education. Of the years 2020, 2021, and 2022 the percentage of unused places per start year where respectively 37, 42, and 54% [37]. In conclusion, it seems to be difficult to get, often unemployed and young, people interested in maintenance engineering education, it seems difficult to attract people with the correct background or interest to apply and finish the education (high drop-out rate), while it seems like the one who graduates are almost guaranteed work with a good compliance to the education.

Considering the shortage of individuals with the correct level of education and experience, companies have begun to place greater emphasis on personal qualities that

indicate a person's future potential and have also taken on a larger role in competence development [35]. The study performed by [9] also highlighted aspects of diversity, including varying backgrounds, ages, and gender. Furthermore, both the study performed by [9] and the survey performed by [35] emphasized the importance of companies becoming involved and engaged in education in order to address recruitment and challenges related to skill development.

### **3. Research Methodology**

To address the objective, an exploratory interview study has been performed within an international manufacturing company. The context as well as the case company has been sampled from a convenience perspective while the sample of respondents has been performed purposively [38].

#### *3.1. Case company*

The case company is Volvo Construction Equipment and 13 operational sites. The 13 sites are located in Brazil (Pederneiras), China (Shanghai), France (Belley), Germany (2 sites; Hameln, Konz), India (Bangalore), Scotland (Motherwell), South Korea (Changwon), Sweden (4 sites; Arvika, Braås, Eskilstuna, and Hallsberg), and USA (Shippensburg). The case company develops, sells, and manufacture construction equipment for industrial use. The product portfolio consists of core components and complete construction equipment for handling and moving materials (excavators, wheel loaders, haulers etc.) as well as road machinery (pavers etc.) Some of the core manufacturing processes are welding, machining, painting, and final assembly but the processes differ from site to site, so does also the maintenance departments in for example, terms of size, organizational set-up, and strategies.

#### *3.2. Interview study*

The participants in the study were contacted via an Outlook invitation that included a link to a Teams meeting and an overview of the purpose of the interview. The participants were the maintenance manager at each site at the time of the interview, except for the Eskilstuna site, where three managers at a lower level, responsible for recruiting and competencies development of employees within their respective departments, were interviewed instead. To maintain anonymity, the data collected from these three interviews at the Eskilstuna site will be presented as a single interview. The maintenance managers were purposively chosen as respondents as it is their tasks to recruit new employees, work with competence development as well as retain existing work force.

The interviews were conducted and recorded via Teams. The initial interview was conducted by both authors, while subsequent interviews were conducted by a single author (the same author). Prior to the start of the recording, the participants were provided with information about the study, including its purpose, methods of analysis and presentation. During the interview, a PowerPoint presentation with the questions were shown to the respondents. The presentation also included definitions of three different generalized types of competence profiles within maintenance, built on the theoretical background. These were: "Basic and advanced maintenance process and technologies" (referred to as competence a), "Smart maintenance technologies" (competence b), and

“A mixture of a and b” (competence c). The definitions were used to standardize the view of the competences as well as to separate the competences of what may be seen as more of fundamental maintenance competences and more of competences for the future.

The interview consisted of a mix of structured and semi-structured questions. The questions were related to (shortened): 1) the need to recruit maintenance employees currently, 2) the desired competence profile for current recruitment, 3) the most challenging competence profile to find currently, 4) the desired competence profile for recruitment in ten years, 5) the most challenging competence profile to find in ten years, 6) the number of applicants and their qualifications for any externally announced maintenance positions and if any were recruited, 7) recruitment methods other than external announcements, and 8) any additional insights on competences and skills or recruitment within maintenance currently and in the future.

The duration of the interviews ranged between 13 and 48 minutes with an average of approximately 23 minutes. The interviews were conducted between February 4th and March 3rd, 2022.

### *3.3. Data analysis*

As previously mentioned, the interviews were recorded via Teams and the transcription function was utilized for interviews conducted in English. Following the completion of the interview, the recordings were reviewed multiple times and the transcriptions were refined. For interviews conducted in Swedish, transcriptions were created from scratch.

The analysis was conducted in two rounds. In the first round, the interviews were summarized by question and categorization was performed. The authors reviewed the recordings while reading the transcriptions, marking, and comparing interesting findings. Descriptive quotes were highlighted. In the second round, three test participants were selected by the authors for further review to identify challenges and enablers in recruiting the desired competence currently and in the future. The notes from the authors were compared, and similarities were identified. Based on this, one author performed the remaining coding with input and guidance from the other author. The identified challenges and enablers were later categorized as being internal or external to a maintenance organization. Focus is put on the challenges and enablers mentioned by two respondents or more but there will also be elaborations on challenges and enablers mentioned by single respondents.

## **4. Empirical findings and Analysis**

### *4.1. Competence needs now and in ten years*

When queried about the competencies they currently need and those they will require in the next decade, the respondents provided somewhat inconsistent responses. This variability is not unexpected, although the respondents are affiliated with the same company, they are employed at separate manufacturing sites, each with distinct processes (both in terms of manufacturing and maintenance), experiences, staff, etc. However, it is worth noting that none of the sites ruled out the need for basic and advanced maintenance competencies, both in the present and in the future. It is reasonable to conclude that these maintenance managers do not anticipate a complete shift towards a fully digitalized maintenance approach within the next ten years, as there will still be a need for

“traditional” maintenance actions requiring competencies in basic areas such as mechanics and electronics. This observation is supported by the findings of [7-10] which indicate that even with the increased utilization of digitalized tools, there will still be a continued need for personnel with practical skills in performing maintenance tasks within mechanics and electricity, among others.

The respondents anticipate a shift towards increased adoption of smart maintenance technologies in the future. This will likely result in a shift in the type of employees sought after in the future. While none of the respondents explicitly stated that they will be hiring data scientists, they did indicate that they will be seeking employees with knowledge and skills in the aforementioned smart maintenance technologies. However, most respondents emphasized that these employees should still possess a foundation in basic and advanced maintenance competence. This issue is addressed in [8], where it is highlighted that even though maintenance employees do not need to become data scientists, they should possess the necessary skills to effectively communicate with data scientists.

As noted by several respondents (as detailed below), a significant challenge currently and in the future is the difficulty in finding individuals with the appropriate competencies and skills to recruit. These challenges are multifaceted and encompass both internal and external factors. Despite the challenges identified by the respondents, they also identified various enabling factors that can aid in overcoming these challenges. These factors will be further developed in below section.

## *4.2. Challenges in and enablers to recruiting needed competences*

### *4.2.1. Challenges*

According to the data presented in Table 1, 10 out of 13 respondents from the sites interviewed reported that they will need to recruit new employees in the coming years due to retirements. This presents a double challenge as the retiring employee often possesses a high level of experience and expertise, whereas the new hires are likely to have less experience. Two respondents also highlighted the difficulty in arranging an overlap between the new employee and the retiree to facilitate knowledge transfer. Additionally, several respondents identified challenges in recruiting individuals with basic maintenance skills (mentioned by 11 respondents) and that recruitment processes take a long time (mentioned by 3 respondents), with some suggesting that many unqualified applicants contribute to this issue (mentioned by 6 respondents). Four respondents noted that basic maintenance competence will always be necessary, and four respondents emphasized the growing importance of basic competence in electricity. These findings are supported by the work of [10], who argues that there will be a continued need for skilled workers with training in fields such as metal or electrotechnology in the future. Furthermore, two respondents pointed out that a lack of education in basic maintenance at educational institutions may contribute to the difficulty in finding competent employees. This challenge may be further exacerbated in smaller maintenance organizations, as the few individuals recruited are expected to have a wider knowledge base and be more versatile (mentioned by 3 respondents). Additionally, four respondents noted that individuals with basic competence and experience tend to be content with their current employment and therefore not interested in changing jobs. Finding employees with dual competencies in both basic and advanced maintenance processes and technologies, as well as smart maintenance, is considered rare and expensive (mentioned by 2 respondents). Furthermore, several respondents expressed

concerns about the future willingness of the younger generations to work in the manufacturing industry, and in maintenance specifically (mentioned by 6 respondents). Four respondents attributed this trend to a rise in higher education, leading to fewer individuals interested in working in basic manufacturing roles. Additionally, four respondents believed that the public holds a negative or distorted perception of maintenance and maintenance work, contributing to this challenge. This view corresponds to the Swedish report on higher vocational education which illustrated that more than 50% of the available student positions were not filled concerning maintenance-engineering related programs commencing in the year 2022 [37].

**Table 1.** Internal and external challenges in recruiting needed competences within maintenance.

Internal/ external	Challenges	Mentions by number of respondents
Internal	Many retirements in the near future	10
	Basic competence in maintenance will always be necessary	4
	Important to have basic competence in electricity	4
	Small factories/teams make wide knowledge necessary	3
	Recruitment process take long time	3
	A competence shift towards smart maintenance technologies is necessary	3
	No overlap when people leave	2
External	Difficult to find people with basic maintenance skills	11
	Will future generation want to work in maintenance	6
	Unqualified people apply for positions, takes up time	6
	People with basic competence tend to have jobs and be satisfied	4
	Young people are well educated, reducing interest in basic maintenance	4
	The public has a poor/distorted view of maintenance	3
	People with dual competence is expensive	2
Few educational institutions teach basic maintenance	2	

In addition to the challenges previously discussed, challenges that were only mentioned by a single respondent include for instance. One respondent noted that it is currently difficult to find women to employ, both in terms of competence and interest in working in maintenance. Another respondent mentioned that it, in the future, will take longer time to make newly recruited employees independent. One respondent questioned the readiness of individuals educated in smart maintenance technologies at higher education institutions to work independently in manufacturing and whether they would require additional education in basic maintenance upon being hired. One respondent further noted that through their apprenticeship programs and in-house competence development, their employees have become highly employable in the marketplace and that their primary concern is retaining the existing workforce. This issue is discussed in [9], where maintenance managers expressed concerns about potential increased personnel turnover in the future. The same respondent, though, also acknowledged that this presents a double-edged sword for him as he is also actively seeking to recruit employees from other companies.

#### 4.2.2. Enablers

Many of the enablers discussed are of an internal nature, as indicated in Table 2. For example, nine respondents discussed the possibility of recruiting internally from other departments. It appears to be most common to recruit employees from production and assembly departments, but there were also testimonials of employees being recruited from the tools department, planning function, as well as student interns and external



contractors. Recruiting internally necessitates internal competence development, as noted by six respondents regarding basic maintenance competencies and by four respondents regarding smart maintenance technologies. Recruiting students and interns also assumes that the sites are open to welcoming students and interns, which six respondents considered increasingly important in the future, this does not only apply to university students but also students from upper secondary schools and vocational training schools. Additionally, recruiting internally or recruiting students and interns most likely means that the new employees will have limited experience or may not be fully qualified for the job, therefore the hiring managers and human resource departments may have to place more emphasis on personal qualities rather than experience and competence. This is noted by three respondents and is also something that [35] points out as becoming more common among companies. Additionally, it is important for at least two respondents to ensure that there are internal career paths to become a more attractive employer, this also includes internal and external competence development. At least two of the respondents use recruitment companies to find the necessary competencies, which saves them time in sorting through unqualified applicants. The challenge of not being able to recruit with an overlap in case of retirement is noted by four respondents as an enabler to competence development for newly recruited personnel. At least five respondents mention that embracing the possibilities of smart maintenance technologies currently available and in the future is also a possible enabler to find and recruit the necessary competence. Four respondents mention that there are already well-educated individuals in smart maintenance technologies that can be employed with some internal competence development on basic maintenance. Three respondents mention that their sites need to become better at cooperating with local educational institutions concerning both basic competences and smart maintenance technologies. The issue of industrial companies working together and cooperating with higher education institutions is noted by [9, 33] and on vocational levels in the survey performed by [35]. Three respondents point out that there are already many educational institutions teaching about smart maintenance technologies. Lastly, five respondents propose that the maintenance community need to become better at promoting maintenance as an interesting and rewarding workplace, where creativity, computers, and other technical tools are being utilized daily.

**Table 2.** Internal and external enablers to recruiting needed competences within maintenance.

<b>Internal/ external</b>	<b>Enablers</b>	<b>Mentions by number of respondents</b>
Internal	Recruit internally	9
	Welcome students and interns	6
	Internal competence development (basic)	6
	Embrace possibilities of new smart maintenance technologies	5
	Recruit with overlap	4
	Internal competence development (smart maintenance technologies)	4
	Recruit people based on personal qualities (ability to learn)	3
	Internal career paths	2
	Use recruitment firms	2
	External	Sell maintenance as an attractive place to work
Young people are well educated, see possibilities in hiring them		4
Cooperation with educational institutions		3
Many educational institutions focus on smart maintenance technologies		3

In addition to the enablers previously discussed, enablers that were only mentioned by a single respondent include for instance. One respondent suggested that it could be

beneficial to actively seek to recruit more women, as this would increase the pool of applicants for future recruitment. This issue was also mentioned by maintenance managers in the study presented in [9]. One respondent mentioned that he uses referrals from current employees to find new employees. At least one respondent highlighted that they work with local service providers, which is noted as a common solution to recruitment difficulties by [35]. One respondent mentioned that they work with retirees staying another year or two past their retirement age to retain experienced employees.

## **5. Discussions and conclusions**

We identify three key areas of future competence and skills development within manufacturing-related maintenance that require attention today. First, even though we will see tremendous advances in data collection, analysis, and digital visualization and training in the future, active maintenance actions will still be necessary. Therefore, there will always be a need for employees with competencies and skills in basic maintenance processes and technologies, including knowledge of electronics, mechanics, and measurements etc. Second, new machines and equipment that will be installed in the future will have more advanced technical abilities and will be more connected than ever before, resulting in more complex hard and soft components of manufacturing systems. Production and logistics will also likely see an increase in automation levels. As a result of this, employees with competence and skills in advanced maintenance processes and technologies will be important also in the future. Third, the digitalization of manufacturing maintenance will continue to increase, and it will be essential for employees to have the skills to utilize the outputs of this digitalization, preferably working in close collaboration with IT employees to collect and analyze data. Employees with knowledge and skills in basic and advanced maintenance processes and technologies must be trained to also work with this task. Additionally, other employees not directly involved in data collection and analysis must be trained to use the information generated by these systems to properly plan maintenance actions, these skills are referred to as smart maintenance technologies. Furthermore, employees working with data analysis from an IT perspective should also benefit from learning more about basic maintenance competencies. As such, we believe that, in the future, the maintenance functions within manufacturing industries will take on a bigger scope. This will most likely increase the need for more maintenance employees in the future which will create an even larger need for recruitment and competence development of all levels and skills within maintenance.

Based on our study and the cited earlier research, we recommend maintenance managers and employees within the manufacturing industry to prepare for the future by:

- Acting as ambassadors to educate the public about the rewarding, dynamic, challenging nature of the maintenance profession and the need for innovation
- Preparing for and investing in the use of smart maintenance technologies while also recognizing the importance of basic maintenance tasks and the competencies required for them
- Including sections on competence development (external and internal education) and recruitment plans in your short- and long-term strategy
- Getting involved with local education providers, starting from earlier levels, if possible, but at least in upper secondary education, vocational training schools, and university education

- Welcoming student interns to provide them with practical experience and expose them to the maintenance profession

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